Note this text was (almost) wholly stolen from the tutorial on Noisebridge Hackerspace website for a project called the BioBoard. Original document can be found at: https://www.noisebridge.net/wiki/BioBoard/Documentation/Optical_loss

Introduction to optical loss

When light travels through a substance, whether it's solid, liquid or gaseous, the intensity of the light is reduced; this is called optical loss. Measuring how much the light intensity is reduced at different wavelengths is called spectrophotometry, and can be used to determine many different properties of the substance, such as concentration of a solution or opacity of a glass pane. To do this, you need a photometer, which is essentially a combination of a light source of known intensity and wavelength, and a light sensor which measures how much light was absorbed and/or scattered by the sample over a fixed gap.

Spectrophotometry may also be applied to gain information about biological processes. Especially in microbiology, where most work is done with organisms that are too small and too numerous to easily count individually, optical loss is often used as a proxy for cell density or biomass. For instance, measuring the light absorption of chlorophyll in an algae vat may be used as a direct proxy for the algal density.
In industrial production systems, such as large-scale alcohol fermentation, insulin production, etc., biological growth is often monitored using in-line ('live') sensors, which measure optical loss, usually at wavelengths in the near-infrared (NIR) or IR-A spectrum (700-1400nm). The inspiration for the home-built NIR probe described in the rest of this wiki is a single-channel NIR sensor from Optek, which emits and detects at 850nm, and is designed for in-line monitoring of yeast fermentations.
[edit]Building a NIR probe

When building a near-infrared sensor, the first important choice is that of light source (photoemitter) and sensor (photosensor). Important considerations include:
what's the appropriate wavelength(s) for your purposes?
how much circuitry do you want to build?
how much can you afford to invest?
This design uses an 850nm plastic LED (Everlight HIR204 - under $1) as the photoemitter, and a matching phototransistor (Optek OP506B - under $1) as the photosensor, both of which are available at a variety of online electronics stores, at least in the U.S. - any equivalent pair should work as well, but resistance on the circuitry and parts of the Arduino code may need tweaking. For the HIR204/OP506B couple, the required circuitry is limited to a couple of resistors.

Things to keep in mind

When designing a probe for measuring biological processes, it's important to use biologically inert materials; this means that the materials you use should be non-toxic, but also non-biodegradable. Acrylic, polycarbonate and stainless steel all fit the bill, but vary considerably in price, availability and workability. PVC is opposed by some, on the

grounds that species of bacteria have been discovered that can degrade it rapidly - whether these are likely to be present in your specific culture is an open question.
Food safety is another consideration. We've used hot glue for our initial prototypes, because although hot glue is probably not food safe (can't find any sources to verify / falsify this), in this design it is encased in acrylic. We will switch to aquarium glue in the final edition, though, on the assumption that as fish are extremely sensitive to water quality and don't suffer ill effects from it, it's likely to be safe for humans, too.
Last, but not least: this should go without saying, but make sure you don't get a glue with anti-fungal / bacterial / microbial properties - you want those critters to live so you can study them, right?

What you need

- 1x IR LED EL-HIR204 (Mouser) (datasheet http://bit.ly/1UlFkiy)
- 1x Phototransistor OP506 (Mouser) (datasheet http://bit.ly/1UlEZfA)
- 1x 1kΩ resistor
- 1x 100Ω resistor
- 1x Soldering iron + solder
- Shrink tube
- Superglue cement (thick)
- Wire
- Aquarium glue/hot glue
- Optional: PVC
- Optional: cell-phone motor (Bubble Shaker)

How to build it

(note add pics of parts)

Step 1: Print probe body

Using the provided STL, produce at least one body. We have had good luck with a FormLabs resin printer.

Step 2: Soldering wires

Cut the leads on both the LED and the phototransistor about 30% shorter. Solder wires onto the leads, and make sure to note down what colour wire you use for the different leads! These are polar devices and won't work if you wire them up backwards. We suggest you use red for both power / emitter leads, black for the ground lead on the LED, and white for the collector lead on the phototransistor (Note: on the OP506 this is the flat side of the device).

Step 3: Assembling

Insert the LED and phototransistor in the holes; I prefer to use use a pair of needle nose pliers to snugly insert the component. Both should give a little resistance and then seat tightly. Carefully apply a small amount of thick body super glue to the back side of the component and set them aside to cure. Note DO NOT let the super glue pass through and coat the lens of the component.

Step 4: Waterproofing
Waterproof each chamber on the probe outsides completely by filling it out with aquarium / hot glue. Leave to cure, this will take a few days.

Step 5: Blocking sunlight with PVC (optional)
Since sunlight includes lots of infrared radiation, it may be necessary to shield your probe. A very simple way of doing this is to take length of PVC tube with a tight-fitting cap, make a hole in the cap for wires, and simply pull the tube + cap over your NIR probe like a lampshade. Making sure the phototransistor is pointing downwards also helps.

Bonus level: Building the Bubble Shaker(optional)
Some biological processes form gas (usually C02), which may cause bubbles to form on the surface of the LED and phototransistor and throw off your measurements. To solve this problem, Noisebridge recommended a small off-set motor ('buzzer') extracted from an old cell phone, encased in a short piece of acrylic tube plugged with aquarium / hot glue on both ends.

To build one yourself, the first thing you'll have to do is find an old cell phone somewhere, crack it open, and extract the motor - get as much of the wires as you can, it'll make life easier for you when you have to solder extensions on. Solder about 2 ft / 60cm of additional wire (remember the colours) to both leads. Then take a piece of acrylic tube big enough to fit the motor and about 1/2" / 13mm wire and plug one end with glue. Insert the motor in the tube - make sure fits tightly by wrapping the fixed part in electrical / gaffer tape, taking care not to block the rotor. Plug the other end of the tube carefully with glue, covering the soldered joint for extra strength.

Attach the Bubble Shaker to your NIR probe by grinding one side of the tube flat, doing the same to the LED end of the probe, and glueing the two together with super glue cement.

Interfacing and measuring

After assembling the probe, you'll need to wire it up to some kind of microcontroller; we've used an Arduino clone called BoArduino, and will use that as example, but you can use any type you like.

1. Start out by connecting the 5V and GND pins on the Arduino to the power (+ / red) and ground (- / blue / black) strips on the breadboard.
2. Wire the LED to 5V and GND across a 150Ω resistor.
3. Connect the collector lead on the phototransistor to 5V
4. Connect the emitter lead to an empty strip on the breadboard
5. Wire that strip to the A1 pin on the Arduino and to ground with a 100Ω resistor.
6. If you've built the bonus version, you'll also need to wire your BubbleShaker to 5V and GND.

Then you're ready to hook the Arduino board up to your computer, program it and start recording.

In order to program the the BoArduino, you have to download and install the Arduino software first. Once this is done, you're ready to connect your board - in some cases, this requires a special cable, so make sure you've got the right one! Now open this Arduino sketch and hit upload. Open the serial monitor to see the print-out of the data being transmitted from the probe, which ought to look more or less like this: @NIR:0:0.99$.