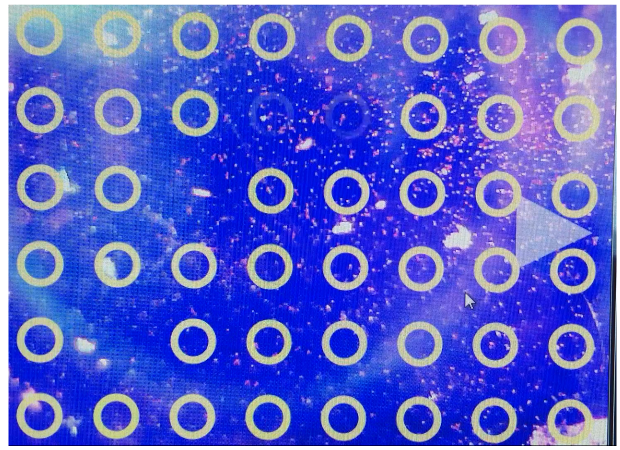
Biotech Research—Paramecium Symphony

Biotechnology is a fast-paced field with new research emerging constantly. New technologies must go through rigorous testing before we see them on the market. This includes discussing the ethics and safety of such technology. How would you use the paramecium activity in biotechnology research? What issues might the public have using this kind of technology?

Try this!

1. Gently pipette a small amount of paramecium-filled liquid into the sample well.
2. Confirm there are paramecia by viewing the microscope.
3. Using the joystick, control the electric field in the sample well by moving the joystick left, right, up and down.
4. The paramecium will react to the change in the electric field and swim in the direction (and sometimes opposite direction!) of the joystick.
5. Create your paramecium symphony and complete optional "Challenges"
6. Discuss what possible applications this technology may have in biotechnology and how is can affect your daily lives.



Move swimming paramecium through a musical grid

What's going on?

A paramecium is a ciliated ("hairy"), single-celled organism that can be found naturally in the environment, e.g. ponds, puddles, lakes, and rivers. "Single-celled" means that a paramecium has only one cell for its entire body. Most plants and animals have more cells than you can count.

Paramecia respond to external electric fields by swimming with the flow of electricity, a phenomenon termed **galvanotaxis**. Scientists are still trying to understand why a paramecium cell has this reaction, whether it is a chemical or physical reaction. Many biological samples respond to electricity in some form, even the human skin has a mild electric field.

An **electrode** is a conductor that passes an electrical current from one medium to another. In the case of a direct (DC) current, electrodes become positive and negative. When a voltage is applied to an electrode, an electric field is produced and flows in a direction from the negative electrode to the positive electrode, similar to a closed circuit. Most species of paramecia will react and move in the direction of the electricity flow. However, living organisms can be complex, and some species of paramecia will act abnormally, which is very normal!

Paramecium are so tiny, you need a microscope to see them.
Photo by Proyecto Agua, Flickr

How is this biotech?

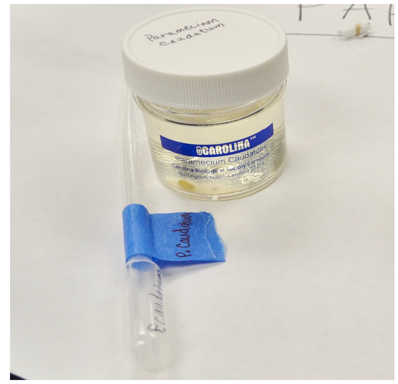
Scientists and engineers interact with biological samples to better understand how we use biotechnology to improve our lives. Understanding how and why microorganisms behave the way they do is vital for developing new biotechnology. Scientists have discovered that cells in the body move to heal wounds in response to the naturally occurring electrical signals found at wounds. The scientists also found that varying the voltage of the electric fields made a difference, affecting the speed in which the wound healed.

Other research in manipulating small molecules include maneuvering micro-organisms through the body through chemical signals instead of electrical signals to deliver medicine to diseases, like tumors and cancers, with minimal damage to surrounding healthy tissue.

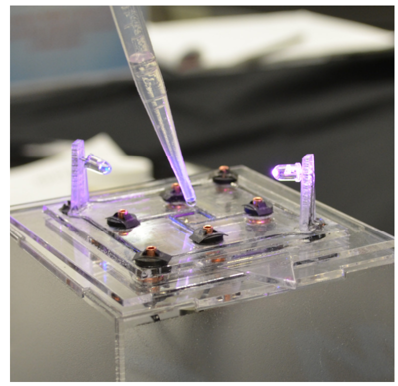
Photo left: Research suggests that electric fields may expedite healing at wounds.

Visual Step-by-step Procedure

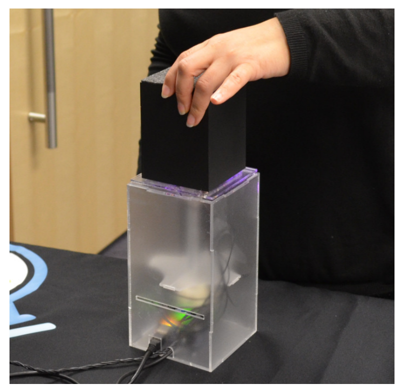
1. Use a pipette to take a small sample from the paramecium jar.
   *You can aerate the sample before you draw up liquid in the pipette.



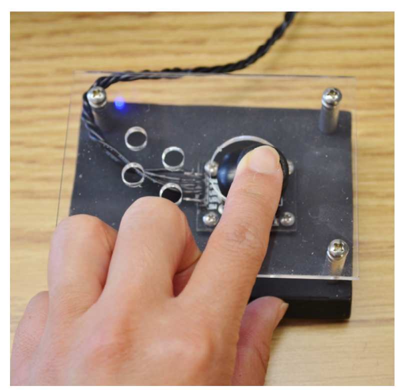
2. Deposit the sample into the sample well. Make sure the liquid touches all four (4) electrodes without overflowing the well.



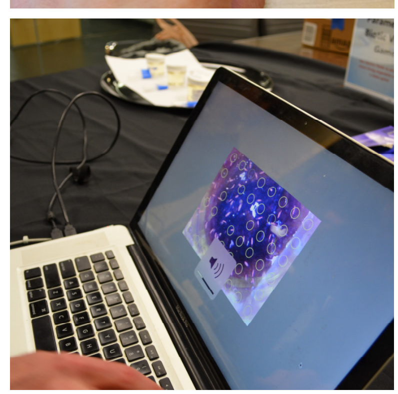
3. Place the blackout cover over the sample.



4. Gently use the joystick to move the paramecium in an up, down, left, or right direction. It may take a few seconds for the paramecium to react to the electric field.



5. Create a symphony by maneuvering the paramecia through the grid of circles on the computer screen. Try additional challenges and discuss the real world applications of this technology!



Biotech Research—Paramecium Symphony Presenter Guide

Learning Objectives

1. Scientists and engineers interact and experiment with biological samples to advance biotechnology

Materials

Provided with kit:

- Paramecium Symphony tower (includes usb microscope, Arduino Uno board, cables, magnetic sample platform, LEDs, electrodes, blackout cover)
- Joystick
- Paramecium Symphony computer program
- Cotton tips
- Graphical materials

NOT provided with kit:

- Paramecium Caudatum living sample
- Liquid waste container
- Paper towels
- Optional: Audio speakers
- Optional: TV monitor or projector
- Optional: Microscope for viewing paramecium

Activity Diagram

Set-up
15 minutes

Program
1-5 minutes

Clean up
10 minutes

Notes to the Presenter

SAFETY: Paramecia are living samples. While the microorganisms are relatively harmless, do not ingest samples and rinse areas with water that were in direct contact with the sample fluid (e.g. eyes, skin, etc).

Activity set up: Connect all cables to the lap top and TV monitor/projector (optional). Gently aerate the paramecium sample with a plastic pipette and transfer a small amount into the sample well. Make sure the inverted microscope is in focus by carefully moving the microscope up and down. Do not use the microscope's built-in light source. Cover the sample well with the blackout cover for better imaging.

Optional: Set up a microscope next to the paramecium activity to allow visitors to view live paramecium through the eyepiece.

Tips:

- Prevent sample contamination:
    - Avoid skin contact with the sample liquid – bacteria, oils, and other contaminants found naturally on skin can destroy the paramecium sample.
    - Do not place old samples back in the sample jar. Have a designated waste container for old samples.
    - Follow any care and handling instructions from the paramecium culture provider.
- To avoid damaging cells during pipetting, use scissors to cut pipette tips to enlarge orifice. Gently draw up and release liquid samples from pipettes to prevent shearing cell walls.

- Samples should last for approximately 20 min or longer in the sample well. The heat generated from the LEDs may vary the life span of the paramecium in the sample well.
- Paramecium cultures can last several weeks with proper care, however, imaging quality of the sample tends to deteriorate after 5 days of receipt due to the increase in bacteria population that the paramecium feed on.
- If the paramecium population is not dense enough, use mild centrifuge to concentrate paramecium at the bottom of a microcentrifuge tube.
- Use the keyboard keys to adjust the sensitivity of the tracking program if the paramecia do not trigger the sound grid.
- Manage visitor expectations by explaining in advance that the paramecium may take a few seconds to react to the electric field. Hold the joystick in the direction you want the paramecium to swim until you see them orient with the electric field. In some cases the paramecia may not respond or may swim in the opposite direction. This is a good example of the difficulties of working with living biological samples.
- Mute the volume when changing out samples to avoid loud noises.
- Engage visitors in questions about how this activity can apply to real world applications in biotechnology:
- Emphasize to visitors that paramecia are single-celled organisms that can be found in common bodies of water like ponds, puddles, rivers, lakes, etc. The microorganisms lack a brain and the capacity to feel pain and are used in countless classroom experiments.

Cleanup: Store the paramecium in a climate controlled environment away from direct sunlight and keep the lid loose to allow oxygen flow. Do not use soap to clean the sample well as soap residue can kill the cells. Dispose used pipettes. Wipe down tables and equipment used in the activity.

Related Educational Resources

The World Biotech Tour (WBT) website (www.worldbiotechtour.org/activities) contains additional resources to introduce visitors to biotechnology and the tools researchers use:

- WBT activities: *Biotech & Society – Let's Talk, Biotech Skills – Take a Cellfie!, Biotech Research – Virus Slayer*
- Other versions and explanations of the Paramecium Symphony:
  - http://bio.academany.org/labs/luzern/ How to Grow (almost) Anything in GuadiLabs-Switzerland, "Class 9: Synthetic development biology"
  - http://making.do/paramecium/index.html and http://making.do/paramecium/build.html Opensource instructions for using brain sensor to control electrical field
  - http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002110 An alternate version using light to control the movement of Euglena, a single-celled organism.

Credits and Rights

The Paramecium Symphony activity was designed by Ryan Hammond, Baltimore Underground Science Space and adapted from several works:

- *Design, engineering and utility of biotic games*, Ingmar Riedel-Kruse et al, Lab Chip (2011), 11, 14-22
- *Arduino Wet Pong workshop,* Sarah Choukah, Keith Comito, and Oliver Medvedik, Genspace, NY, NY
- *WetPONG*, Dr. Marc Dusseiller
- *How to Grow (almost) Anything*, GaudiLabs, Luvern, Switzerland

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Images courtesy of the Association of Science-Technology Centers, Carlin Hsueh. 2016

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