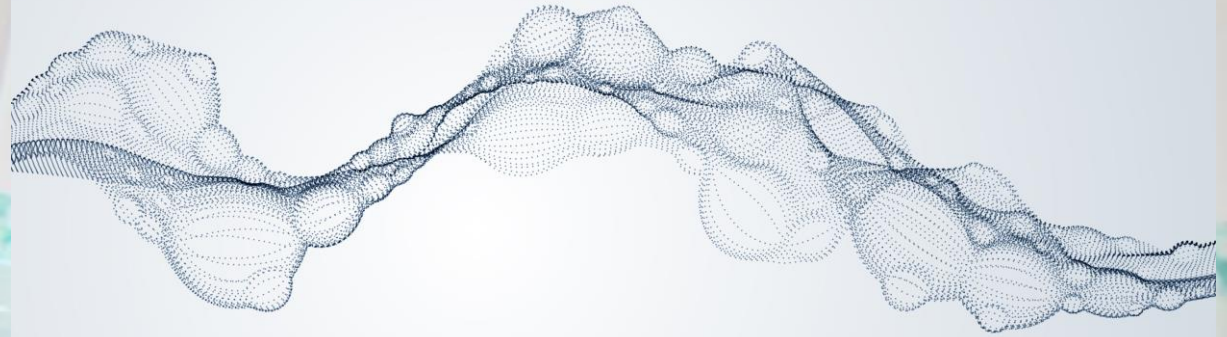


Exploring Three-dimensional Bioprinting to Detect and Characterize Pathogens

Anne Arnold
Materials Scientist | National Security Directorate
December 14th, 2021, 5:00 PM PST

Pacific Northwest NATIONAL LABORATORY

Community
SCIENCE & TECHNOLOGY
Seminar Series

Image courtesy of Andrea Starr

DOE's 17 **national laboratories** tackle critical scientific challenges

Pacific Northwest NATIONAL LABORATORY

A regional, national, and international **scientific resource**

Pacific Northwest NATIONAL LABORATORY

PNNL is DOE's **most diverse national laboratory**

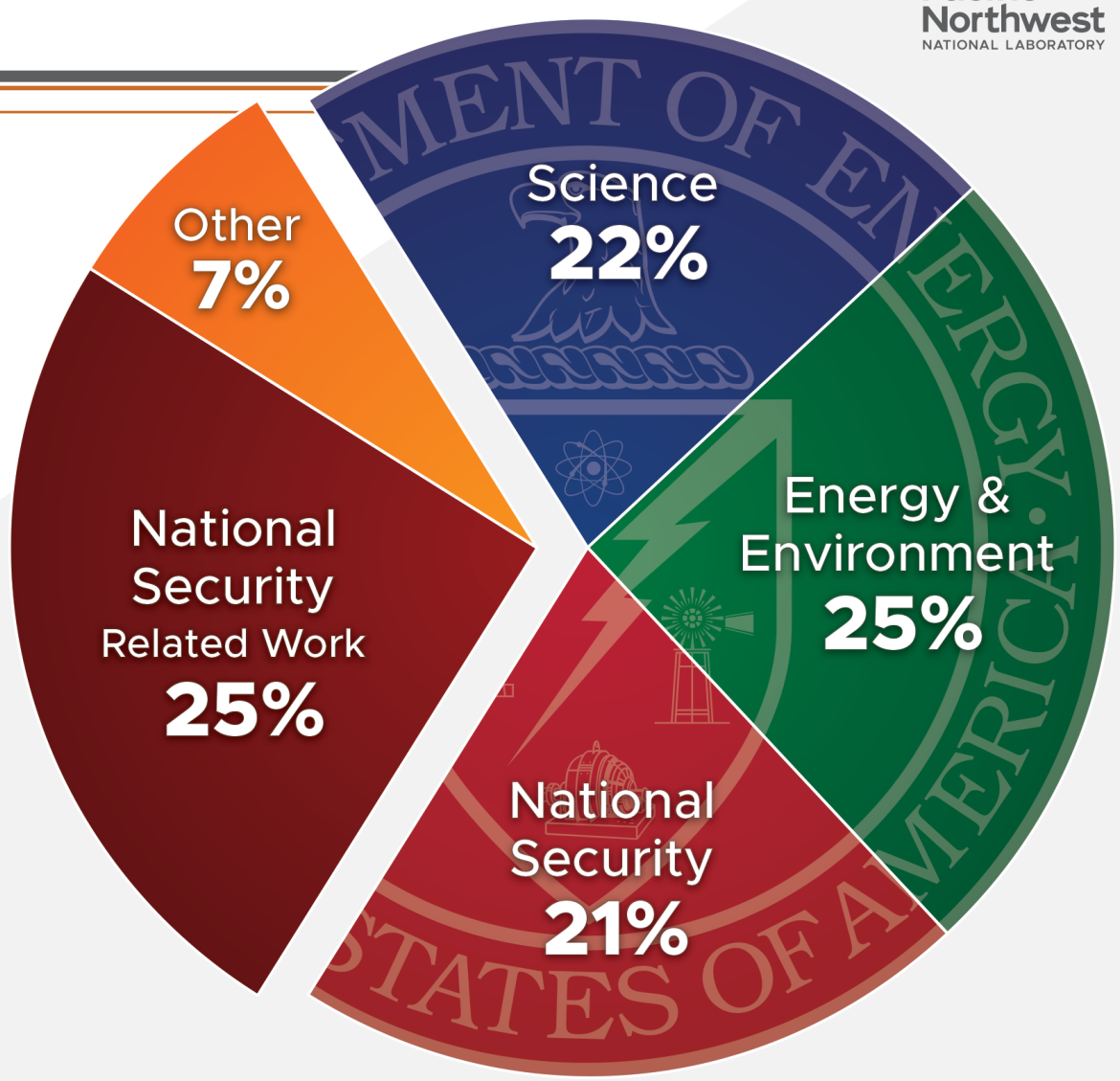
Pacific Northwest NATIONAL LABORATORY

5,300 Staff

$1.24B Spending

1,755 Peer-reviewed Publications

247 Invention Disclosures



FY 2021 Staff

PNNL's **Science** mission advances understanding of the world around us

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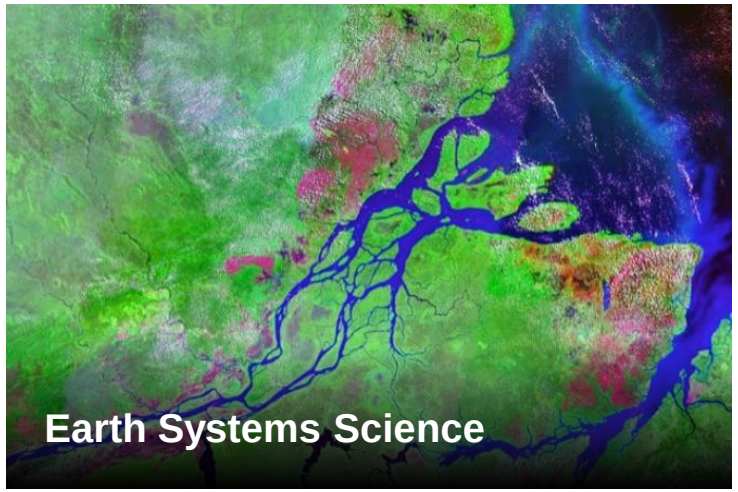

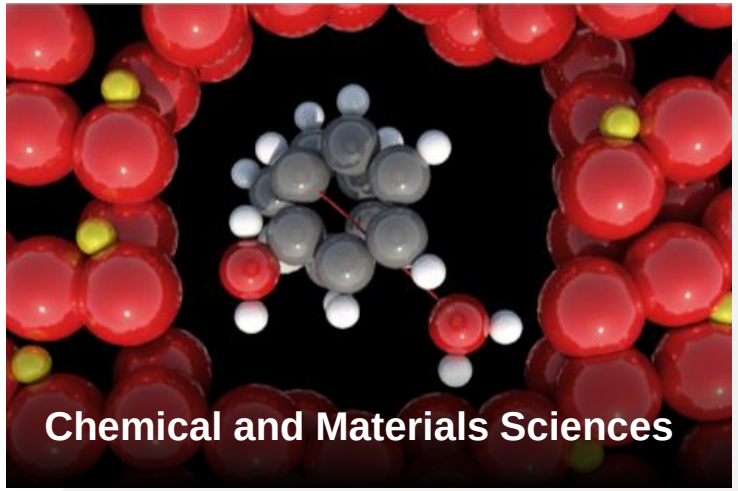

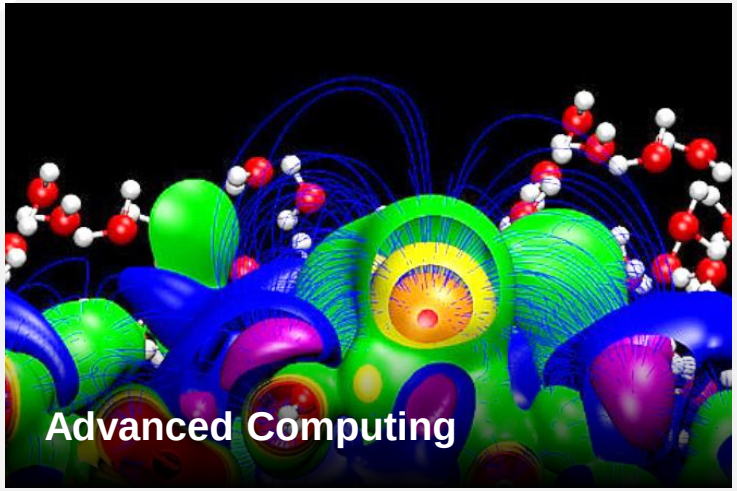

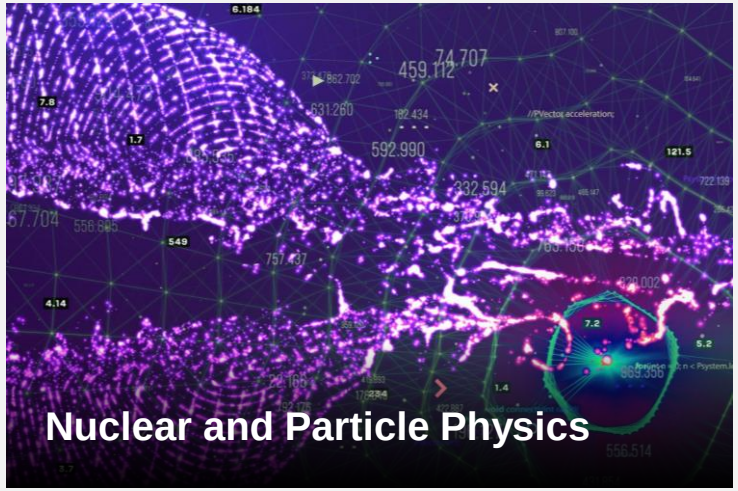

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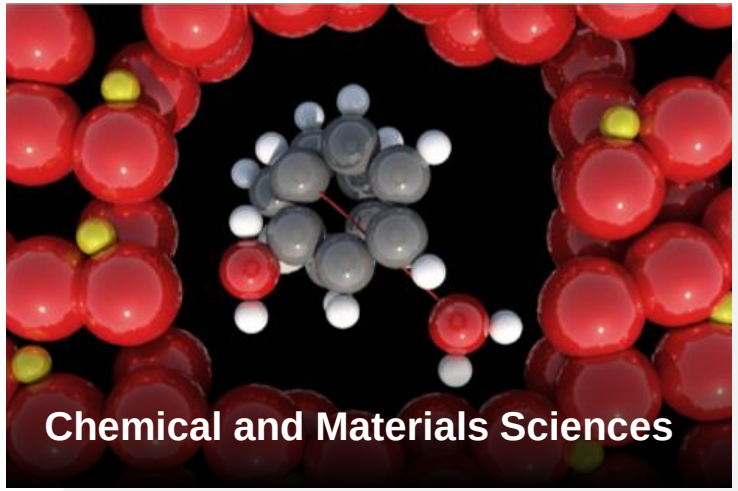

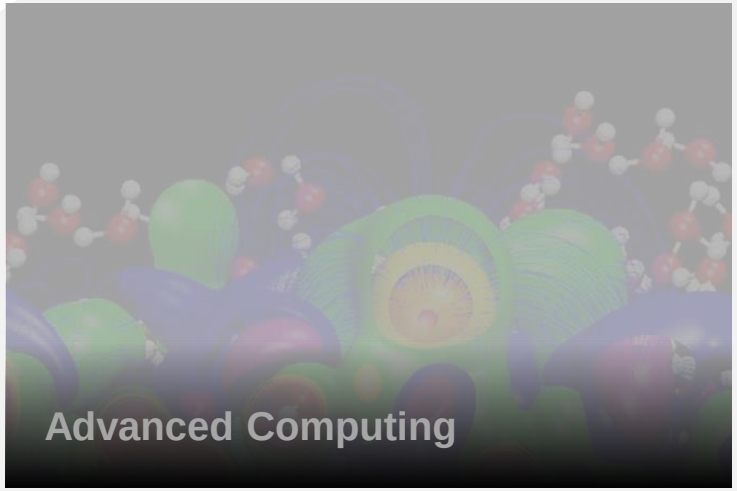

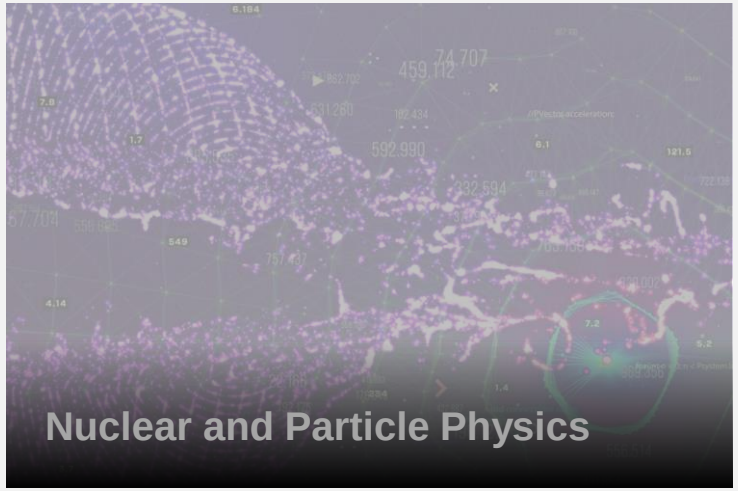

Exploring **Three-dimensional Bioprinting** to detect and characterize **Pathogens**

Pacific Northwest NATIONAL LABORATORY

1 Motivation

» Critical need for more sophisticated methods to detect and study pathogens that cause disease

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Critical need for more sophisticated methods to detect and study pathogens that cause disease

Royalty-free stock illustration ID: 286201517 by Lightspring

Royalty-free stock illustration ID: 1495983119 by Lightspring

Image courtesy of Andrea Starr

Biosensors: Nature-inspired detection

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Biosensor: A device that uses a living organism (or a piece) to detect if there is a compound of interest present

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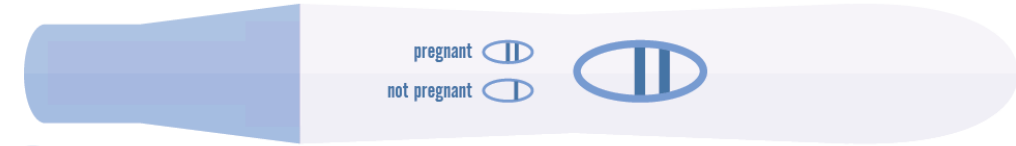
Over-the-counter pregnancy test



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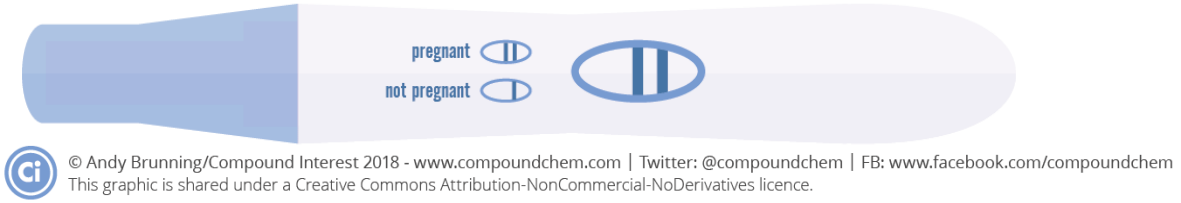
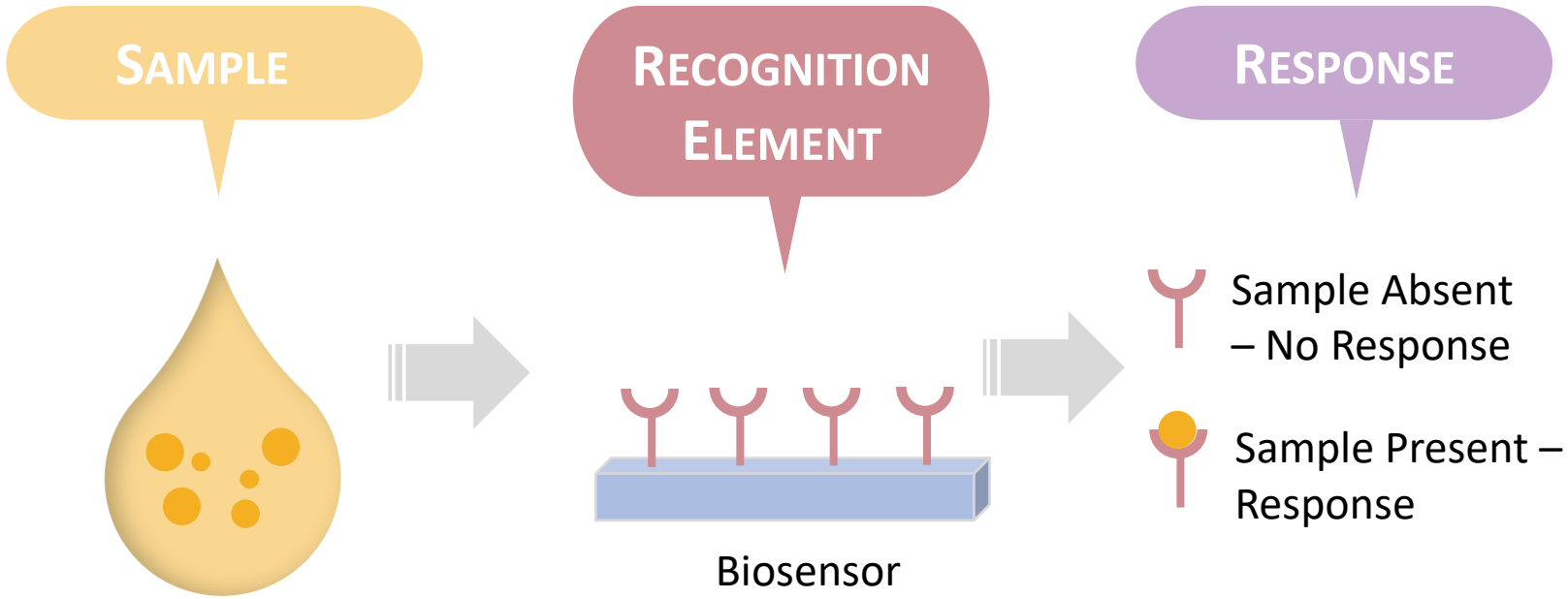
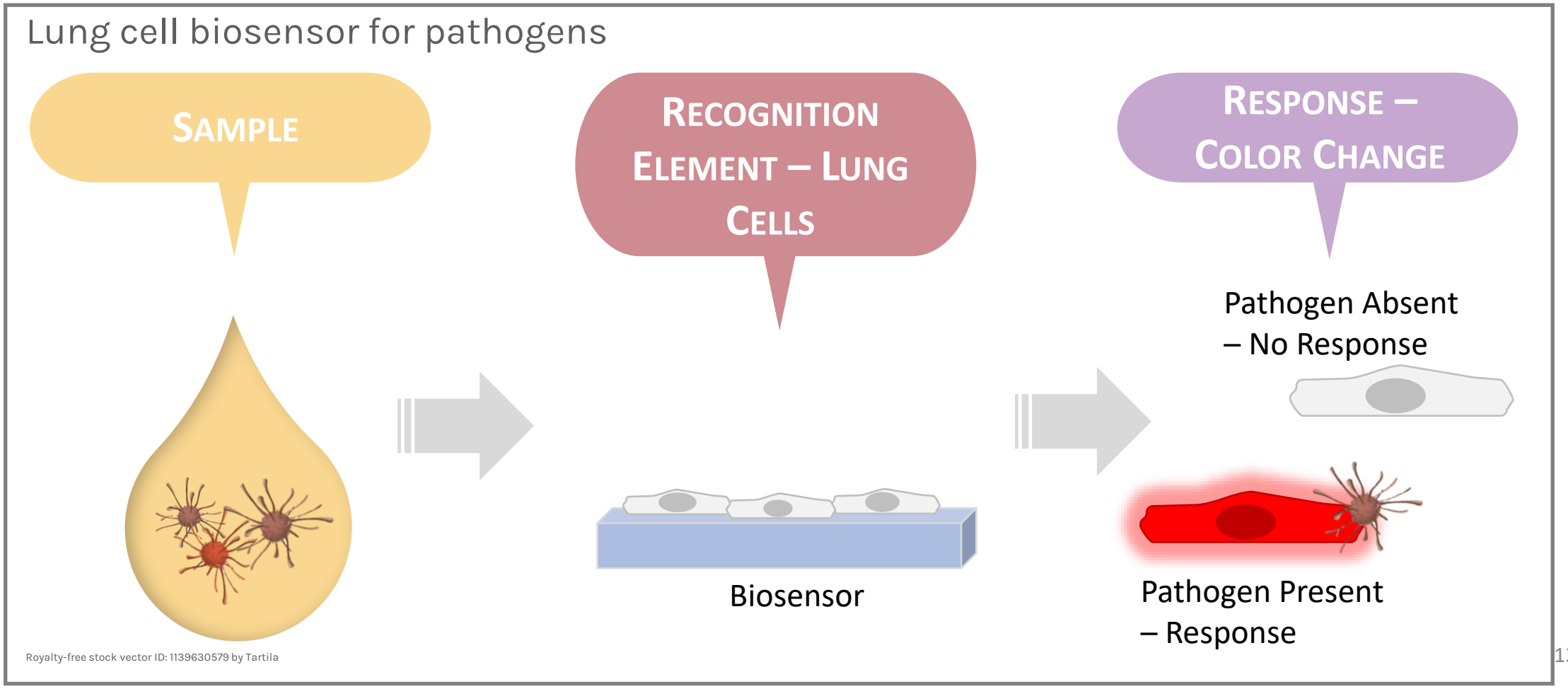


Basic biosensor components



Exploiting **human lung cells** to design **biosensors** for pathogen detection

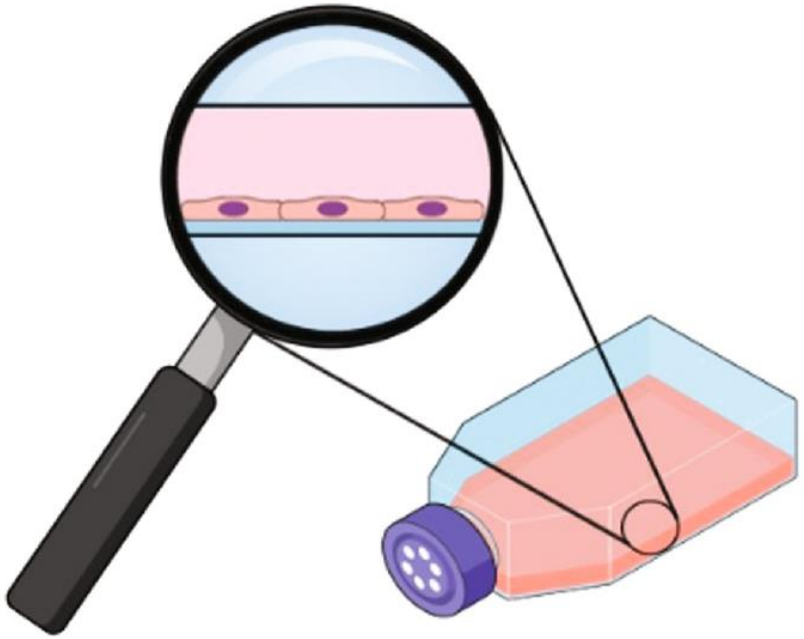
Biosensor: A device that uses a living organism (or a piece) to detect if there is a compound of interest present



Cell-based biosensors are traditionally **2D**

Biosensor: A device that uses a living organism (or a piece) to detect if there is a compound of interest present

Two-dimensional cell growth in a laboratory



Cell Growth Lab

V. Charwat, D Egger. Cell Culture Technology, 2018. “The Third Dimension in Cell Culture: From 2D to 3D Culture Formats.”

3D biosensors create new opportunities to study disease transmission

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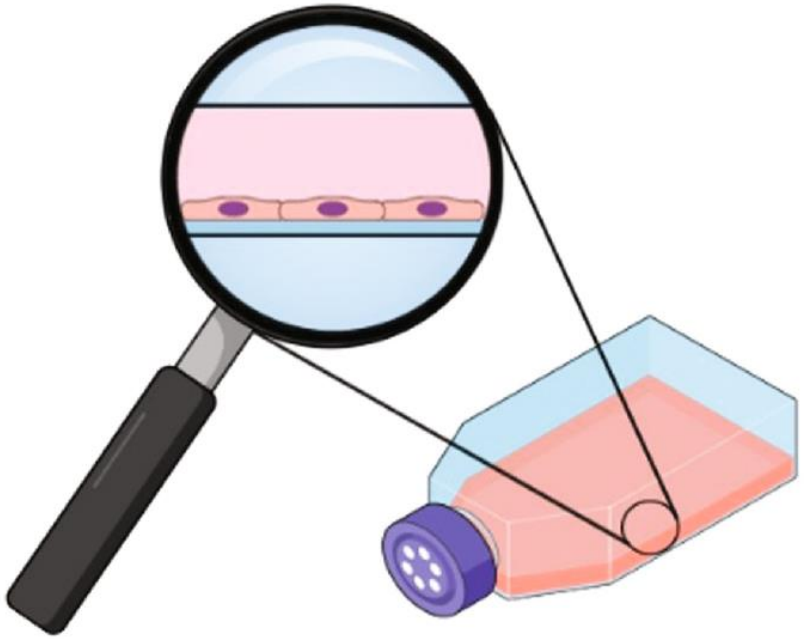
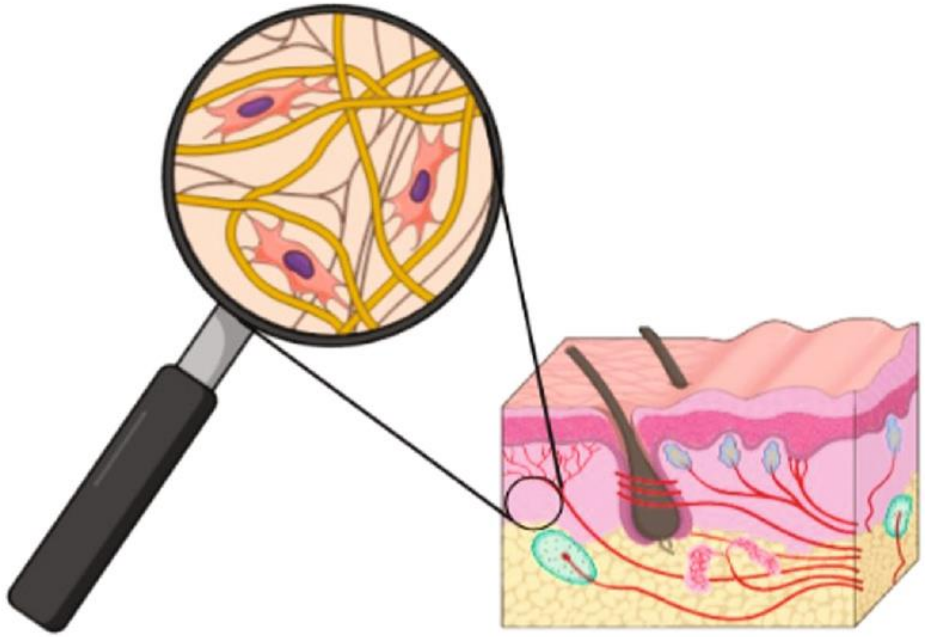


Three-dimensional cell growth in a tissue



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3D Printing: New technology to create detailed, 3D objects of **any shape** or **size**

https://www.youtube.com/watch?v=WRGJUXVXoj8

https://gfycat.com/gifs/search/3doodler+printing+pen

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Traditional, plastic-based 3D printer

https://interestingengineering.com/7-3d-printers-to-start-your-3d-printing-journey-in-2019

3D printers that use **plastic** are **not compatible** with **cells**

Plastic filament for a 3D printer

https://3dprinting.com/tips-tricks/choosing-a-good-filament/

Not compatible with printing cells

1) Requires high heat to print

2) Lacks necessary permeability

3D Bioprinting: Bioinks are used as a replacement for plastics to 3D print synthetic tissue

Pacific Northwest NATIONAL LABORATORY

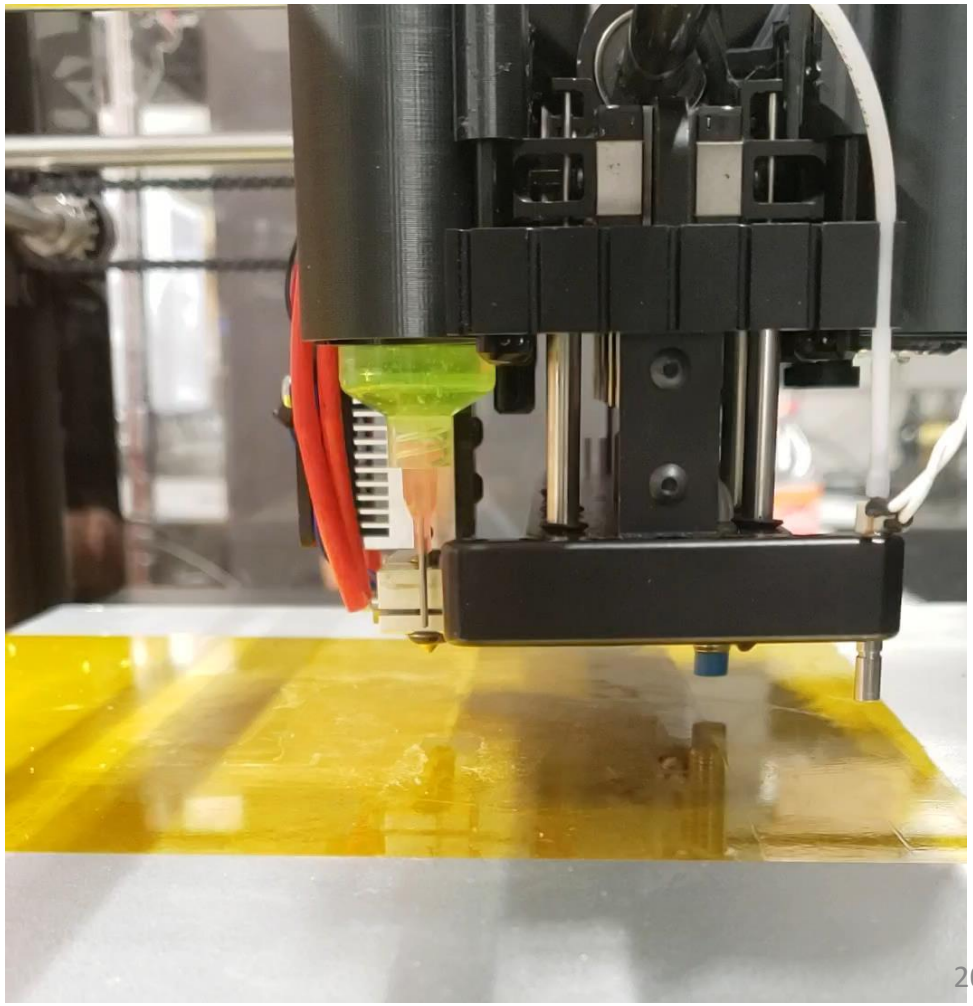
Bioink: A thick liquid that can be combined with cells and printed into 3D shapes

Example of viscous liquids

https://energyfactor.exxonmobil.asia/science-technology/how-viscosity-helps-the-engine-go-round/

https://www.primogif.com/p/SZMzyHawXVmMw

3D bioprinting a bioink



Bioink **composition** is **dictated by** the **application**

Bioink: A thick **liquid** that can be combined with **cells** and printed into 3D shapes

"**Liquid**" component of a bioink

Materials harvested from nature

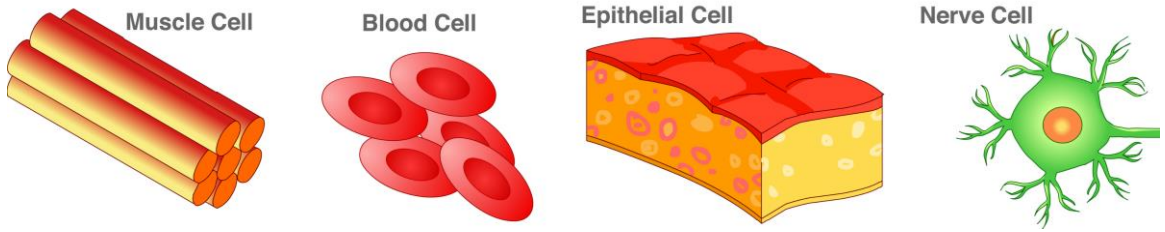
Gelatin

Royalty-free stock photo ID: 1840600699 by Ahanov Michael

Synthetic materials

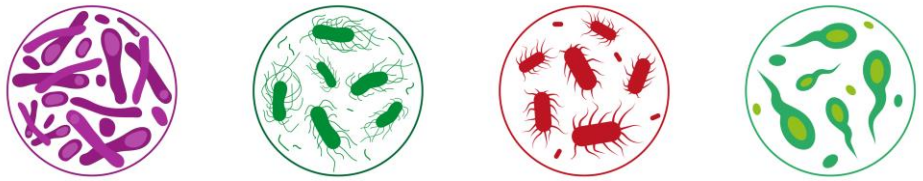
"**Cell**" component of a bioink

Human cells



Royalty-free stock vector ID: 1544771027 by grayjay

Bacterial cells



Royalty-free stock vector ID: 1496096153 by Elena Istomina

Bioink **composition** is **dictated by application**

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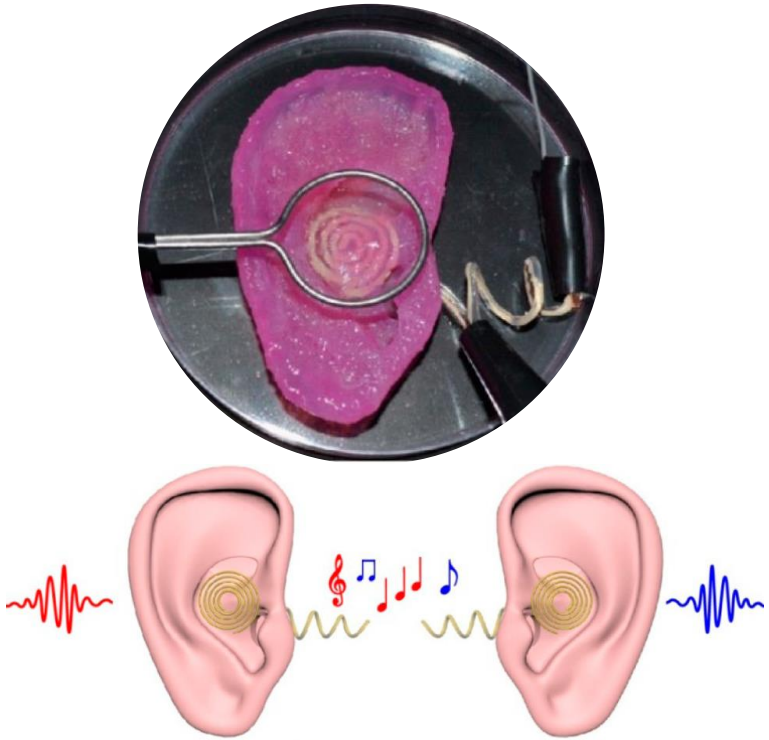
3D printed bionic ears

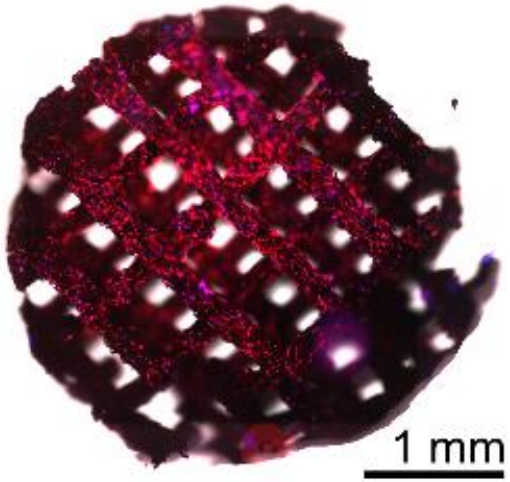


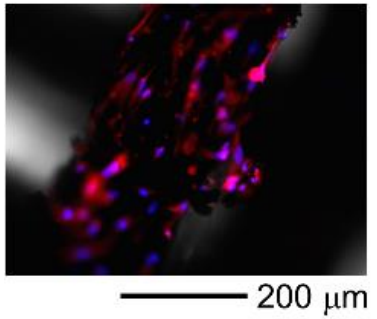
Nano Lett. 2013, 13, 6, 2634-2639

3D printed human heart

ACS Biomater. Sci. Eng. 2020, 6, 11, 6453-6459

3D printed bone





L. Daneshmandi, et al. Unpublished

Our **bioink** is composed of **alginate**, a naturally-derived polymer

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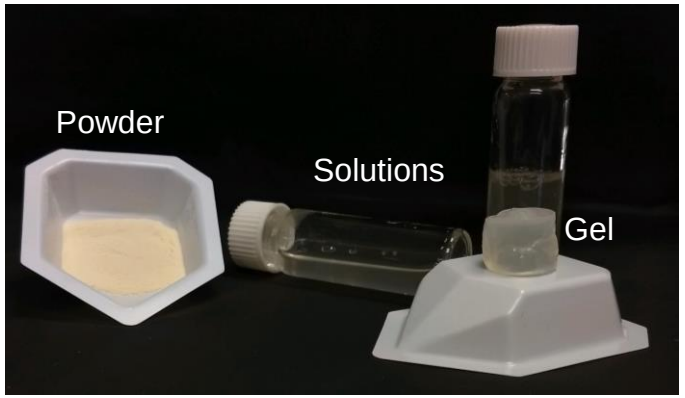
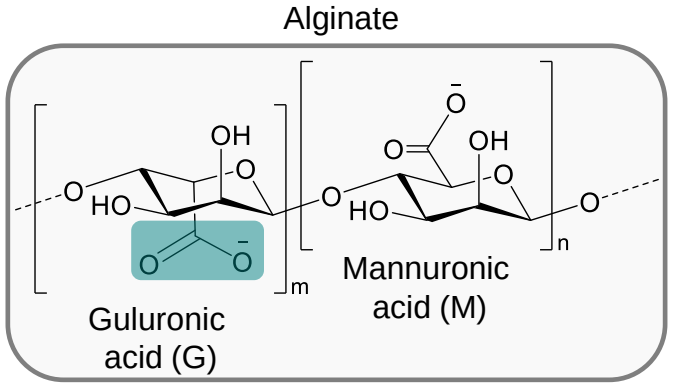
Brown seaweed

Public Domain, https://commons.wikimedia.org/w/index.php?curid=408029





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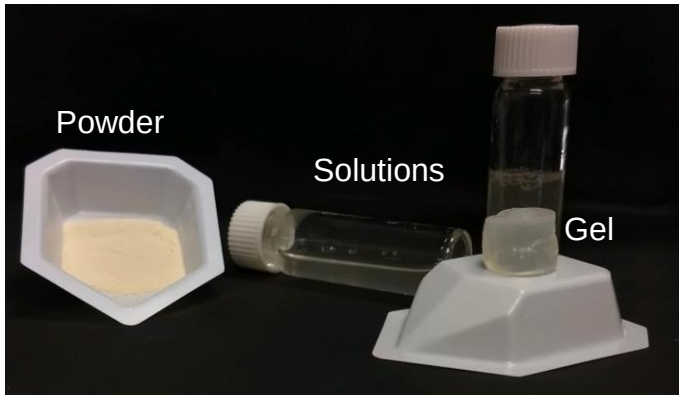

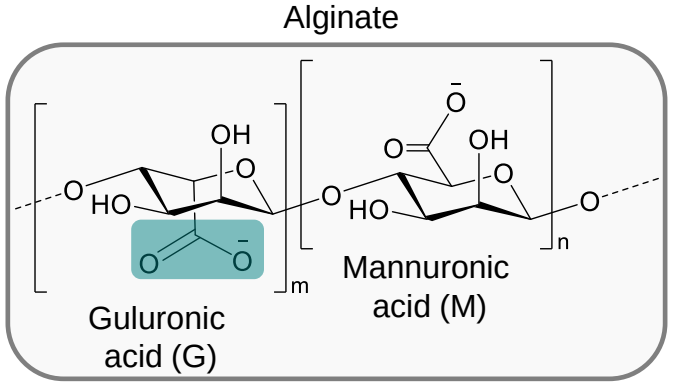

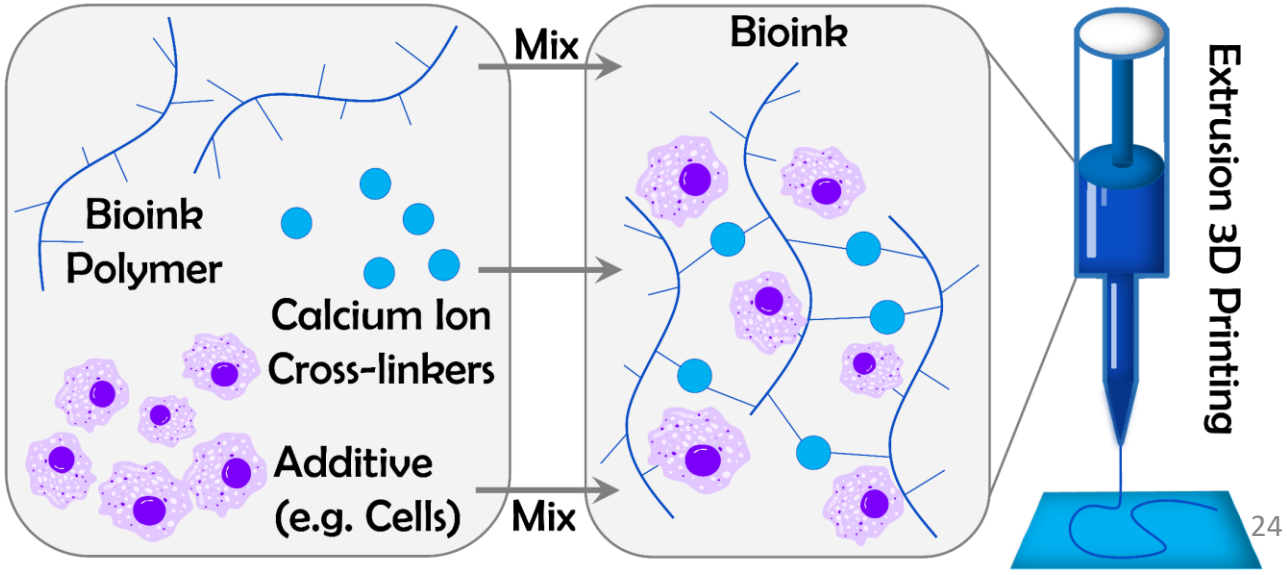

Significant work to **refine bioink** formulation for our application

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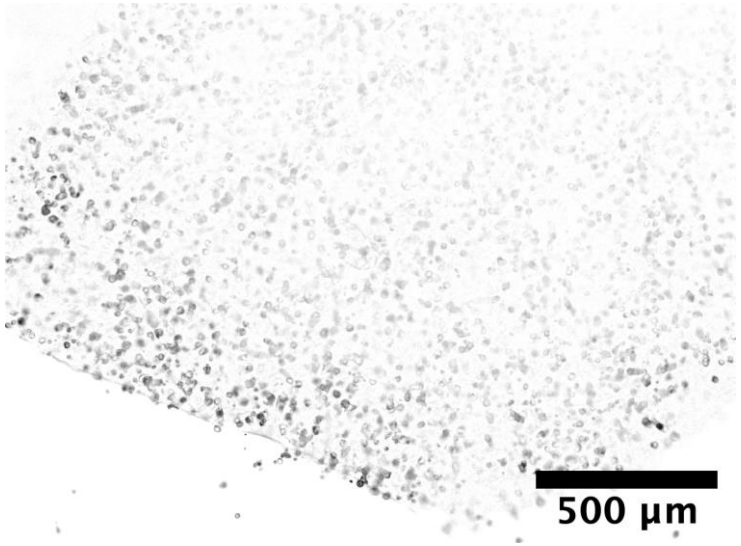
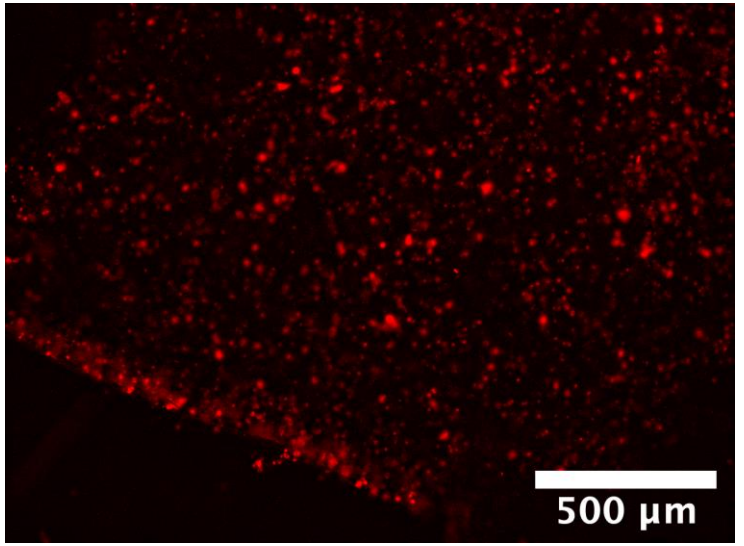
Early bioink recipe

Lung cells inside bioink





Refined bioink recipe

Significant work to **refine bioink** formulation for our application

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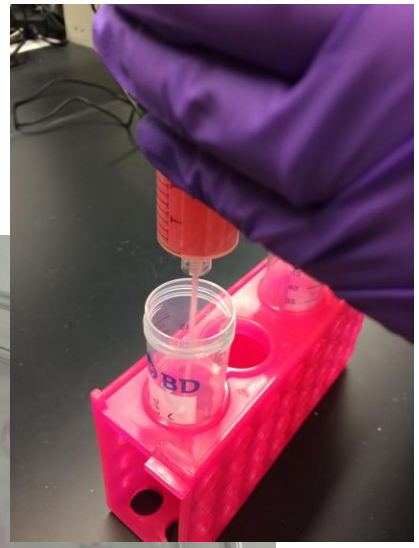
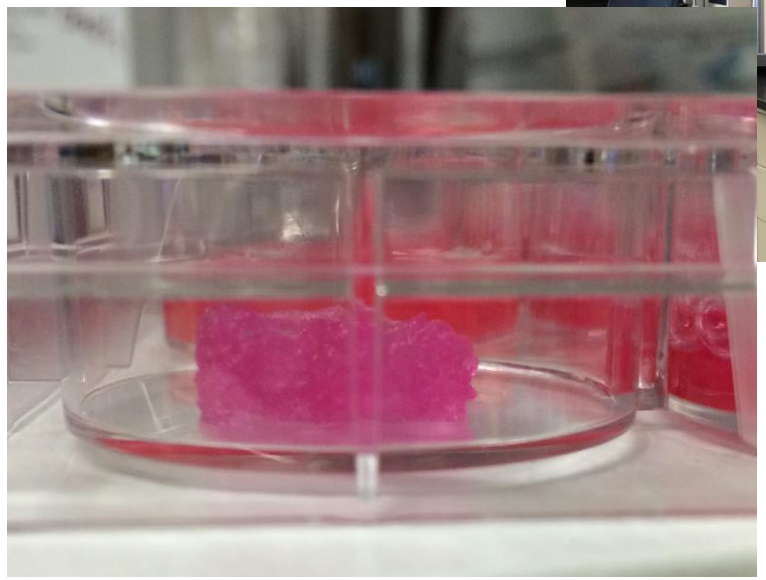
Refined bioink recipe



Synthetic tissue prints



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Developed a **3D bioprinting platform** to print synthetic lung tissue for disease detection

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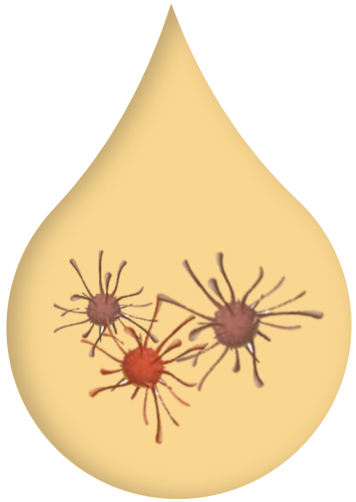
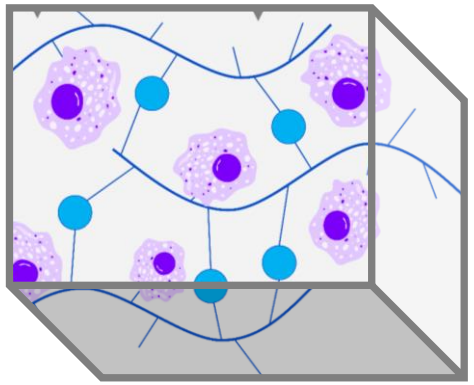
Biosensor: A device that uses a living organism (or a piece) to detect if there is a compound of interest present

SAMPLE



Royalty-free stock vector ID: 1139630579 by Tartila

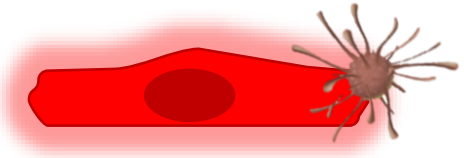
RECOGNITION ELEMENT – LUNG CELLS



3D Tissue Biosensor

RESPONSE – COLOR CHANGE

Pathogen Absent – No Response



Pathogen Present – Response

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Increasing **knowledge** and **interest** in **STEM** through hands-on learning with PNNL's **STEM Ambassadors**

Photo taken before the COVID-19 pandemic

Transforming our **bioink** recipe into **STEAM educational tools**

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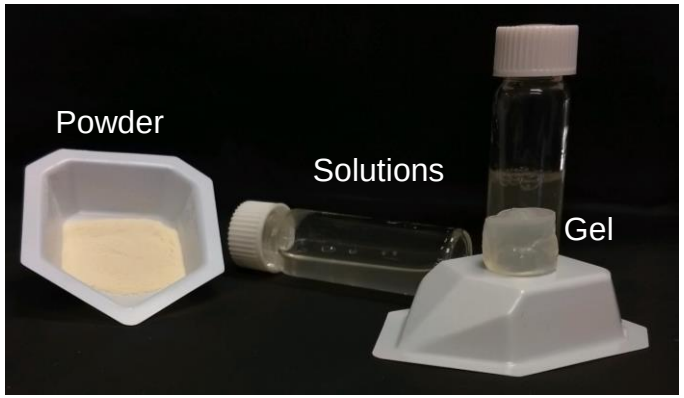
Alginate bioink



Mica powders

Vibrantly colored bioinks

Images courtesy of Andrea Starr

Transforming our **bioink** recipe into **STEAM educational tools**

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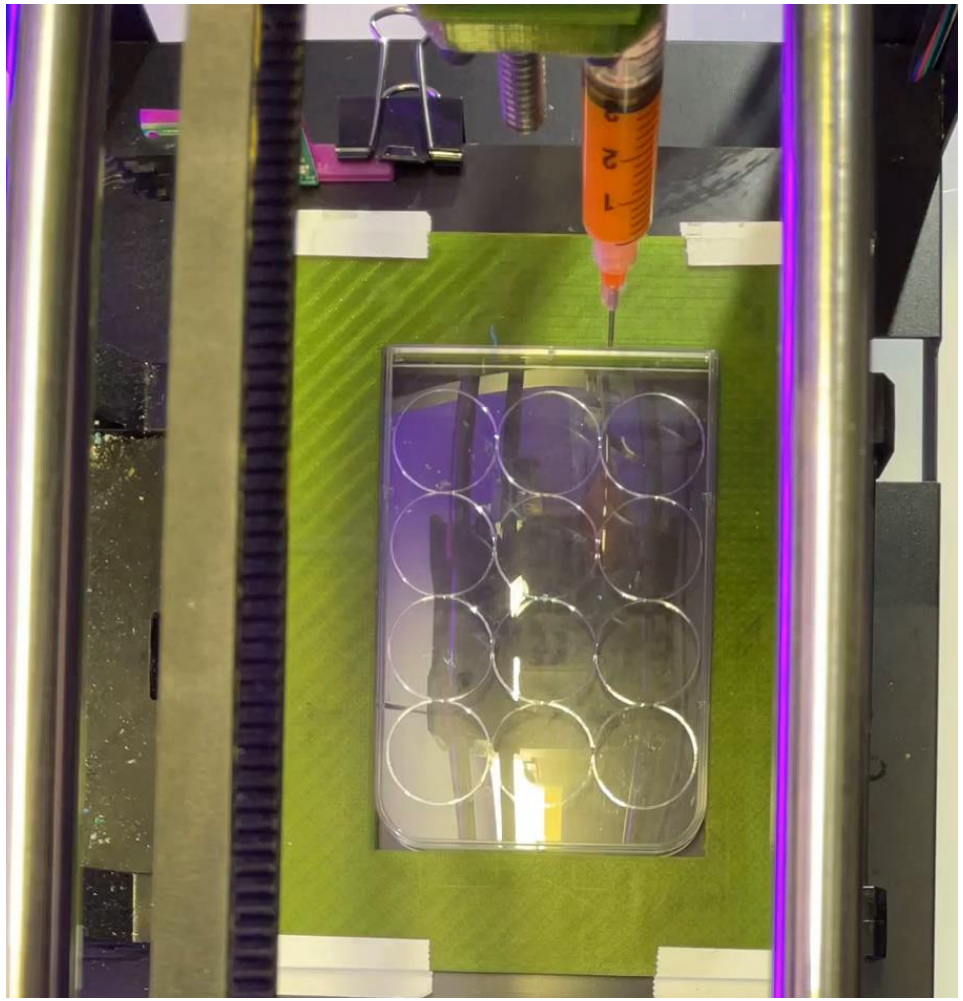
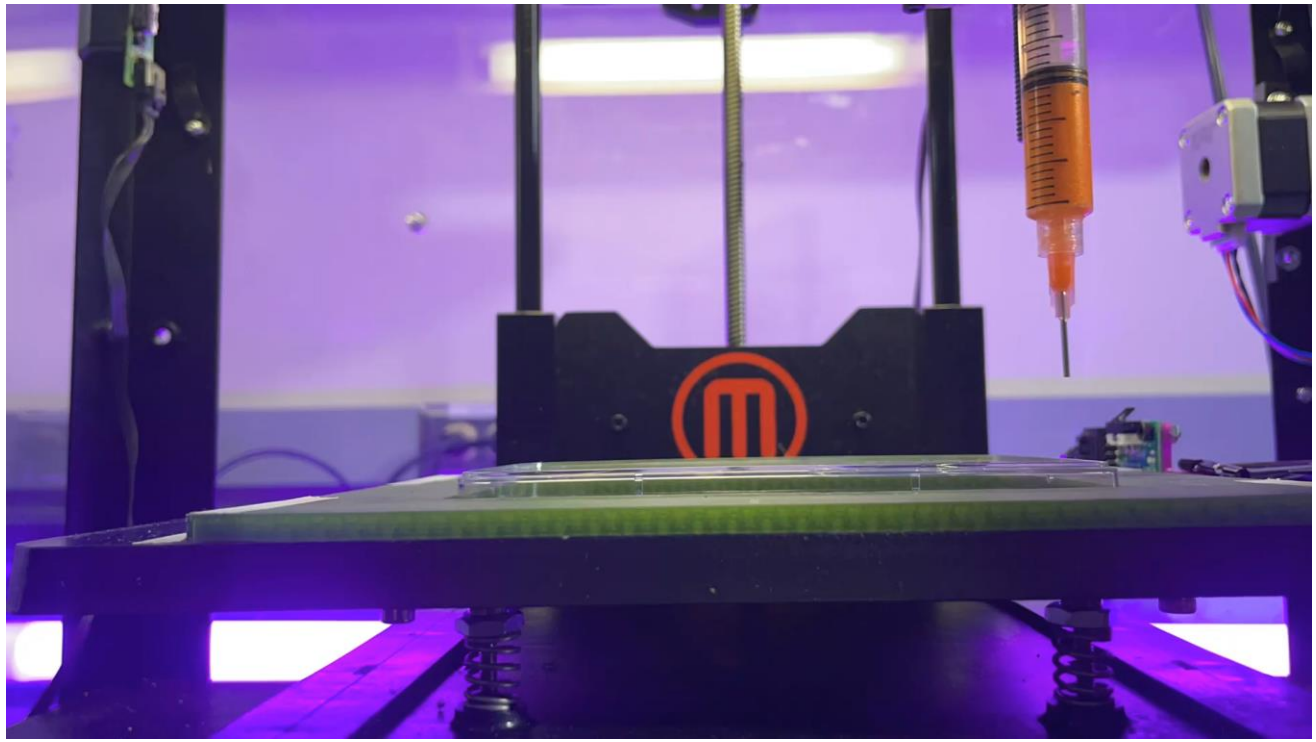
3D printing bioink art media





Videos courtesy of Graham Bourque

Transforming our **bioink** recipe into **STEAM educational tools**

3D printing bi

Videos courtesy of Graham Bourque

Image courtesy of Andrea Starr

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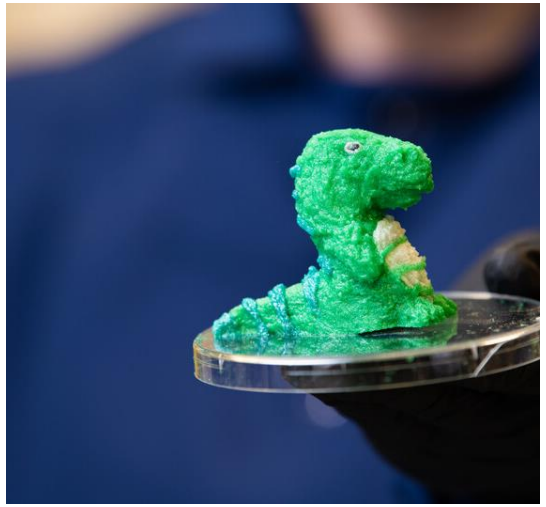

Images courtesy of Andrea Starr

Our PNNL Team

- **Janine Hutchison – Project Lead**
- **Shelby Phillips – New Hire**
- **Carson Bergstrom – New Hire**
- **Fatous Ndiaye – MSIP intern**
- Becky Hess
- Sef Christ
- **Michelle Fenn – Junior Staff**
- Zack Kennedy
- **Loreen Stromberg – New Hire**
- Rebecca Erikson

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Thank you

Image courtesy of Andrea Starr