Recitation 01

Principles, Ethics, & Practices

Agenda

Semester Preview & Homework 01 Requirements - 1 min (David, Ronan)
Atlas Training - 5 min (Suvin)
Principles, Ethics, Practices HW - 10 min (Sebastian)
Small Group Discussion - 10 min (Students)
Student Website Live Demo - 25 min (Greg)
Discourse Introduction - 10 min (Derek)
Homework 01 Requirements Review - 2 min (Ronan)
Lab Safety Training - 30 min, Bldg 68 (All)

Semester Preview

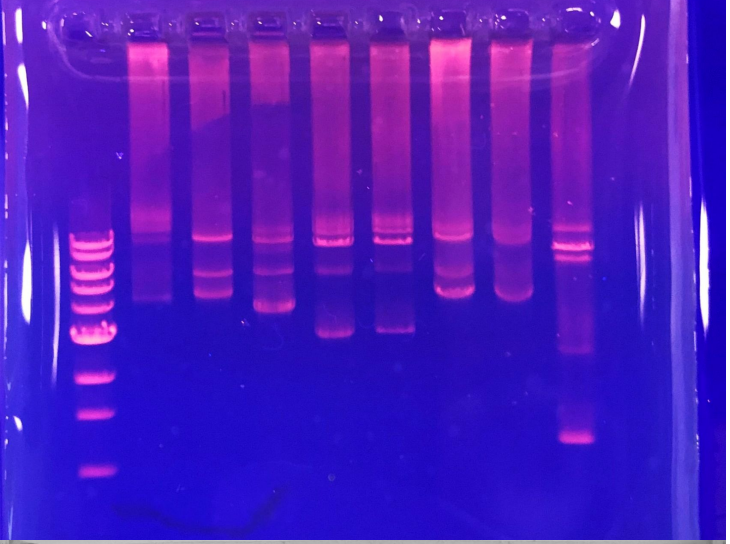
Week 01

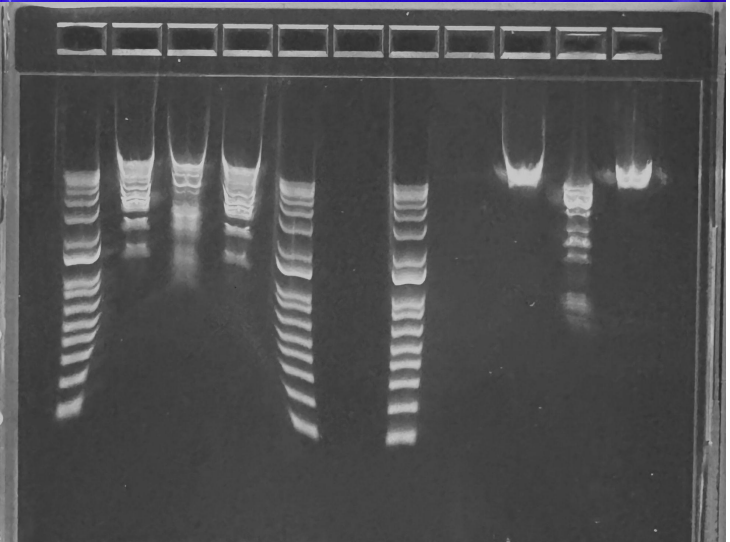
Safety & Liquid Handling Fundamentals

Introduction to laboratory liquid handling tools and ethical considerations in synthetic biology

Lab Skills

- Biological and chemical lab safety
- Establish student website portfolios
- Optional: Liquid handling fundamentals (e.g. pipetting)





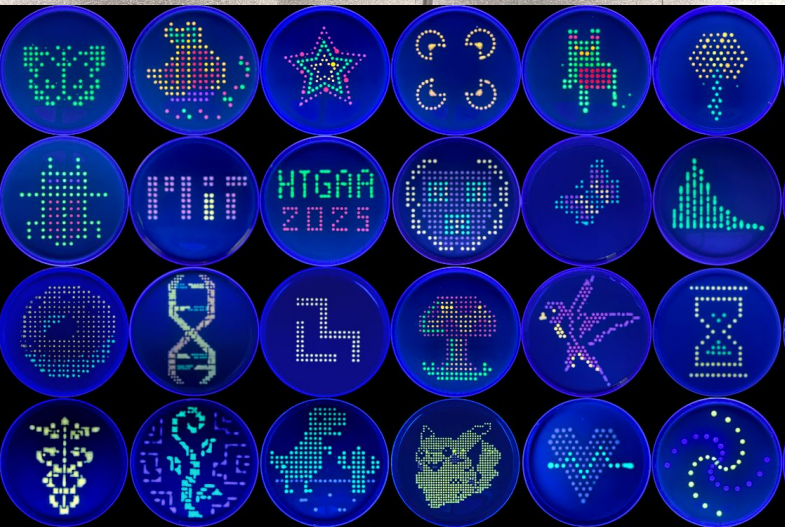
Week 02

DNA Manipulation

Edit DNA using restriction enzyme digestion to generate patterns visualized on gel electrophoresis

Lab Skills

- Benchling for DNA digests
- Restriction enzymes
- DNA gel electrophoresis
- Fluorescence imaging



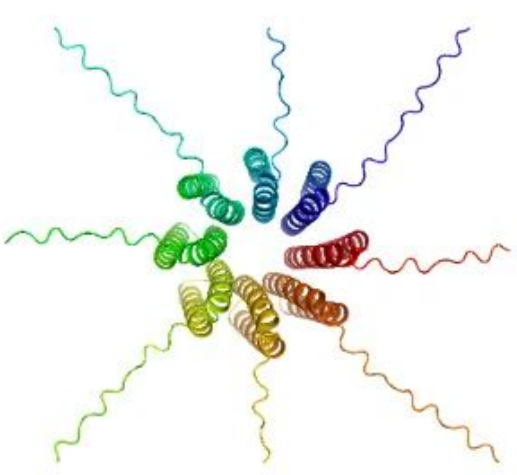
Week 03

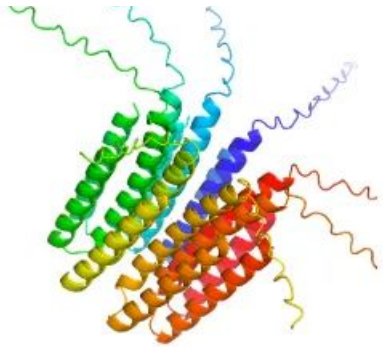
Lab Automation & Liquid Handling Robots

Program the Opentrons liquid handling robots to generate pixel arrays of fluorescent bacteria

Lab Skills

- Python and Jupyter notebooks
- Opentrons robot programming
- Bacterial culture and glycerol stocks
- Agar plate preparation and autoclaving
- Fluorescence imaging





Weeks 04-05

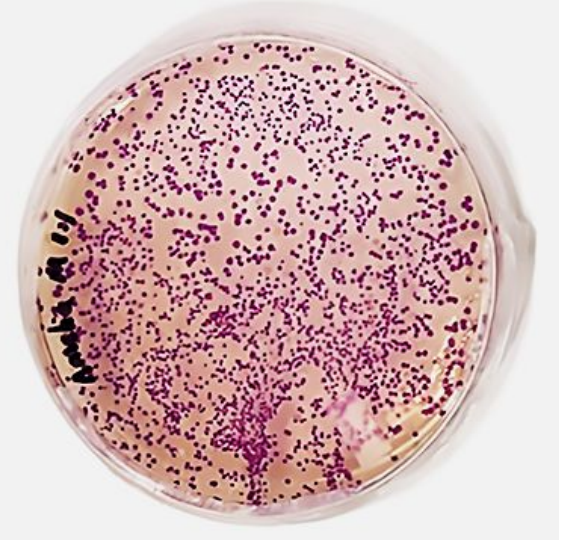
Protein Designs Parts 1 & 2

Use AlphaFold, ESMFold, and Rosetta to study and model protein folding in silico

Lab Skills

- Deep learning–based structure prediction
- RMSD calculation and structural alignment
- Interface and binding-site prediction
- Protein design and optimization
- Multiple sequence alignment (MSA)
- MS2 bacteriophage lysis/coat protein mutations

Figure created by HTGAA TA Ben Arias-Almeida



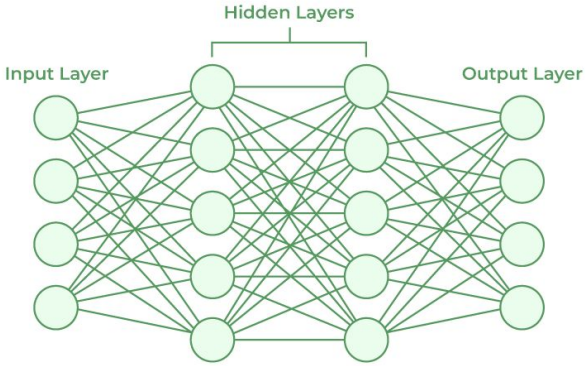
Week 06

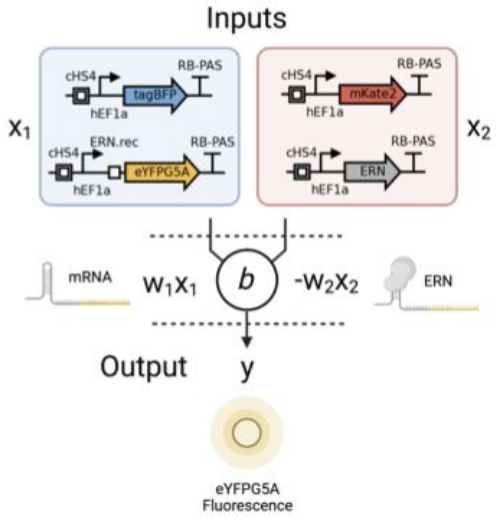
The Chromophore Color Cloning Quest: DNA Design & Assembly

Change the color of the amilCP chromoprotein using PCR mutagenesis

Lab Skills

- DNA primer design (Benchling)
- Polymerase Chain Reaction (PCR)
- DNA assembly (Gibson Assembly)
- DNA transformations
- Bacterial agar plating





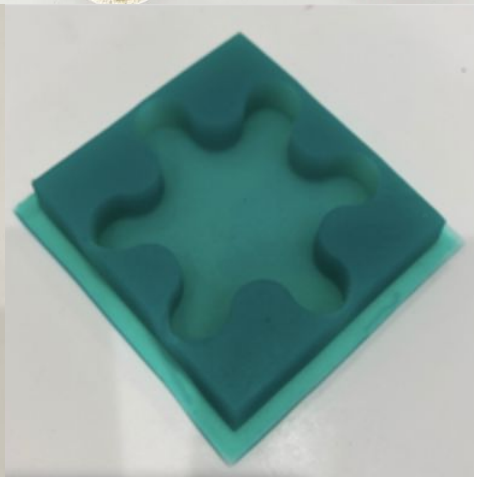
Week 07

Neuromorphic Circuits Lab

Design, simulate, assemble, and test a special type of genetic circuit, neuromorphic circuits, with mammalian transfection and flow cytometry

Lab Skills

- Neuromorphic circuit design and simulation
- DNA assembly (Gibson Assembly)
- Liquid-handling robot mediated assembly
- Transfection and flow cytometry for circuit testing



Week 07.5

Living Materials Lab

Design and fabricate a 3D living material artifact made from mycelium

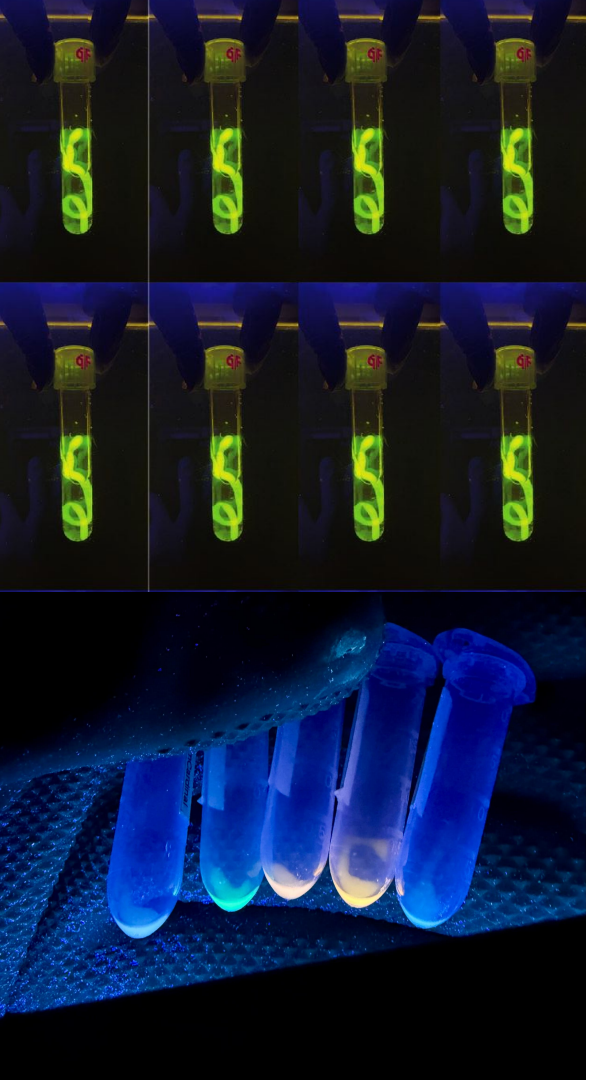
Lab Skills

- Computer-aided design
- 3D printing
- Mycelium based living materials

Week 08

MIT Spring Break

You'll rest and dream about your final projects



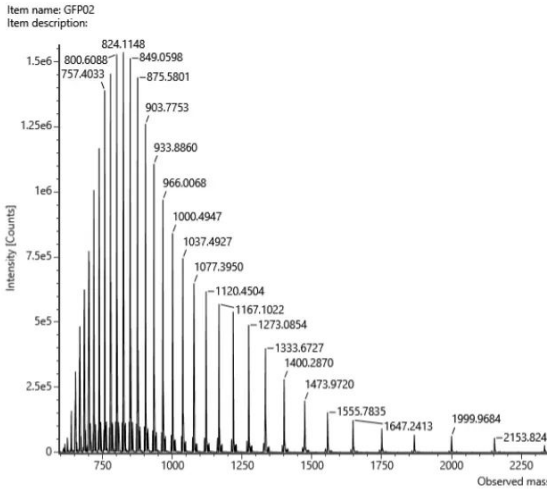
Week 09

Cell-Free Protein Expression

Cell-free protein synthesis to produce fluorescent proteins, removing the need for living organisms

Lab Skills

- Cell-free protein synthesis reactions
- Reagent optimization
- Standard curve preparation
- Quantitative fluorescence measurements
- Data analysis
- Protein purification



Week 10

Advanced Imaging & Measurement Technology

Work with purified and unpurified cell-free proteins under denaturing conditions to measure molecular weights at Waters (Immerse Cambridge)

Lab Skills

- LC-MS charge states and m/z to calculate molecular weight
- Trypsin digestion to cleave proteins into predictable peptides
- Peptide mapping & mass accuracy

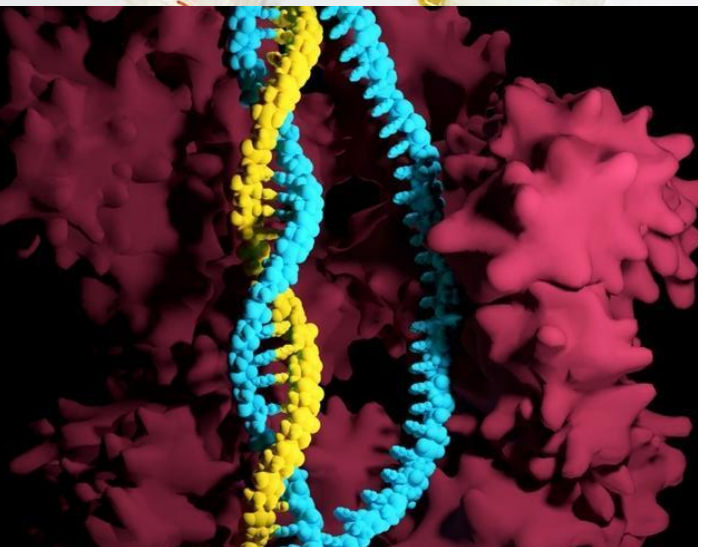
Week 11

Cloud Laboratories

Program the Ginkgo Bioworks cloud laboratory to conduct autonomous experiments

Lab Skills

- Remote protocol creation and deployment
- Experiment standardization & reproducibility
- High-throughput cell-free assay development



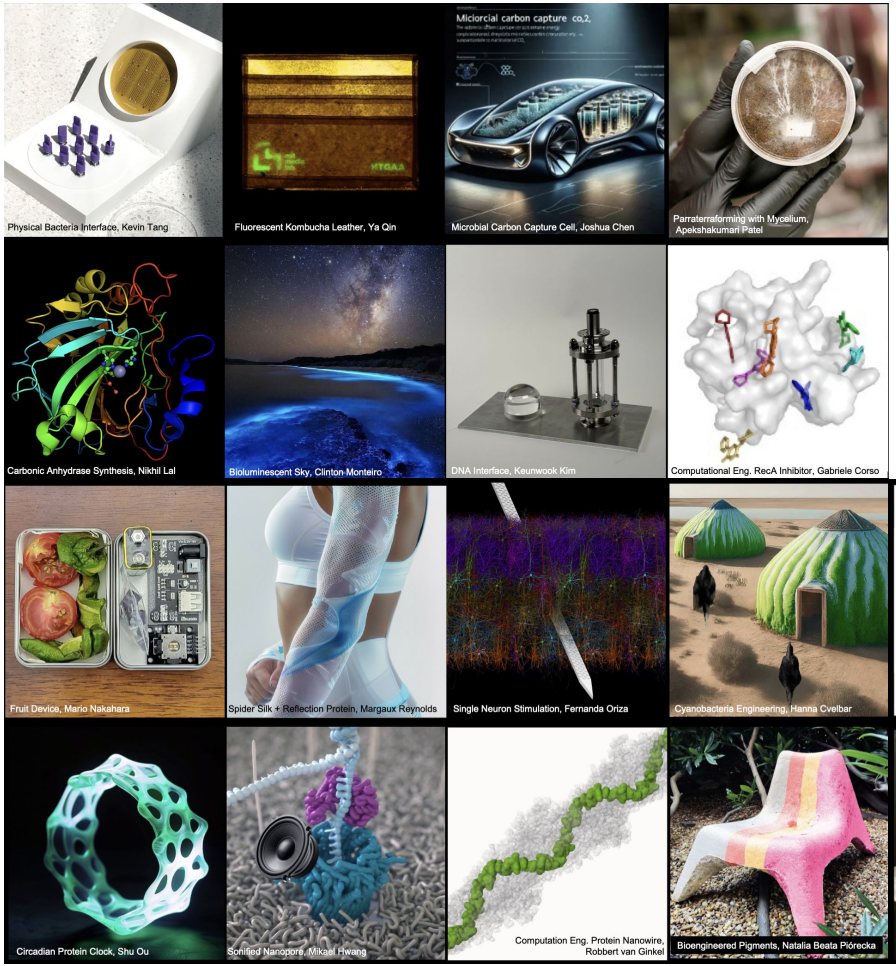
Week 12

CRISPRa Metabolic Engineering

Use CRISPRa for combinatorial pathway programming of biopterin bioproduction

Lab Skills

- CRISPR fundamentals
- Dual plasmid transformation
- Analyzing growth patterns
- Quantitative spectrophotometric measurements



Week 13

Final Projects

Conduct lab work for your final project utilizing the skills and techniques developed throughout the semester

Images from Dr. David Kong's slides

Homework 01 Requirements

Homework I Requirements

Homework I (All MIT/Harvard students and Committed Listeners) Due: **Due: Feb 10** (Before lecture)

- Set up your student webpage
- Propose a biological engineering application, then design and compare multiple governance/policy strategies to ensure it is developed and used ethically and safely
- Before next week lecture on “DNA Read, Write, and Edit”:
  - Answer pre-lecture questions from Dr. Jacobson, Dr. LeProust, Dr. George Church
  - Review the associated papers referenced in the week 2 slides

Lab Safety Training (MIT/Harvard Students)

- Complete Lab Specific Training in Person. **Due: Feb 3** (we will complete as a group after this recitation)
- Complete Safety Training in Atlas **Due: Feb 4** (required for enrollment)
  - Navigate to atlas.mit.edu and on the right-hand side, click “Learning Center”
  - Head to the Course Catalog and find the following two courses:
    - General Biosafety for Researchers (EHS00260w)
    - Managing Hazardous Waste (EHS00501w)

atlas.mit.edu

1. Go to Learning Center
2. Click on the Course Catalog Tab:
   - General Biosafety for Researchers (EHS00260W)
   - Managing Hazardous Waste (EHS00501W)

MENU edit

Time and Vacation Entry
Buying
My Reimbursements
Service Requests
Learning Center
Event Planning

FULL MENU

General Biosafety for Researchers

TRAINING NEED

My Training Needs / My Training

You successfully completed this training need.

REFERENCE CODE	PRIORITY	STATUS	EXPIRATION DATE
EHS00260	Required	COMPLETED	No Expiration

REASON FOR REQUIREMENT

Activity: Use biological materials (including microorganisms, plants, animals, recombinant or synthetic DNA/RNA, etc.), requiring BL1 or BL2 containment.

ASSIGNMENT FULFILLMENT OPTIONS (You must complete ONE of the following)

General Biosafety for Researchers (Web-Based)

WEB-BASED

Course Code: EHS00260w

General Biosafety for Researchers CR (Classroom)

CLASSROOM

Course Code: EHS00260c

NO CLASSES CURRENTLY SCHEDULED

Click through for more information and/or to Prebook for the next session

Principles, Ethics, Practices HW

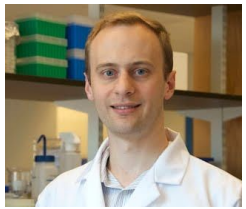

YOU WERE SO PREOCCUPIED WITH WHETHER OR NOT YOU COULD
YOU DIDN'T STOP TO THINK IF YOU SHOULD

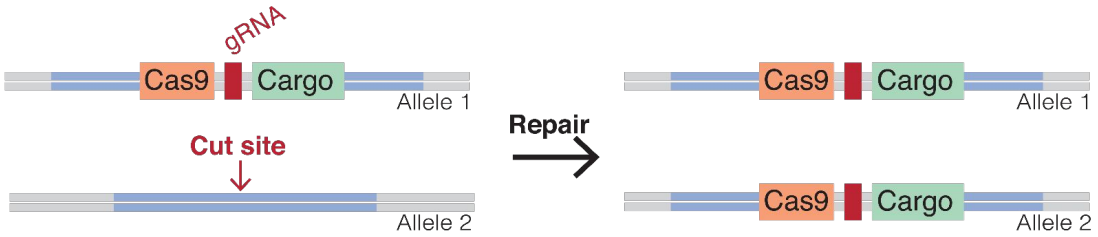
1

Describe a biological engineering application or tool you want to develop and why.

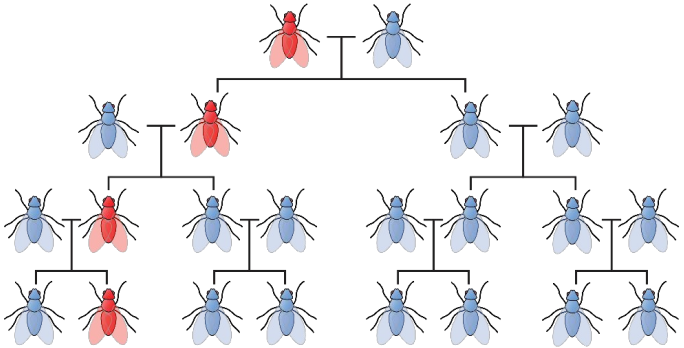
An idea for your HTGAA final project
Your current research
A topic you are curious about

Gene drives



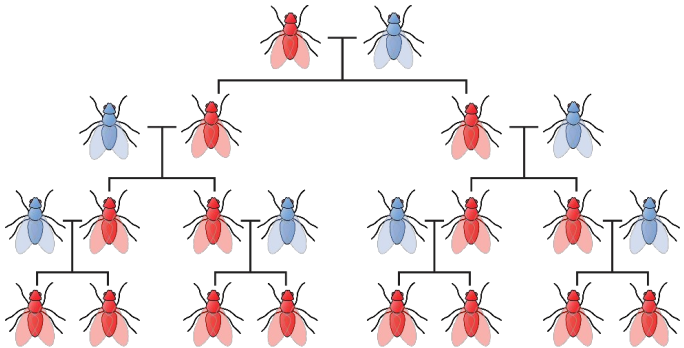


Normal inheritance



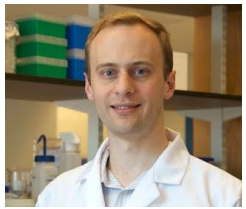
Altered gene does not spread

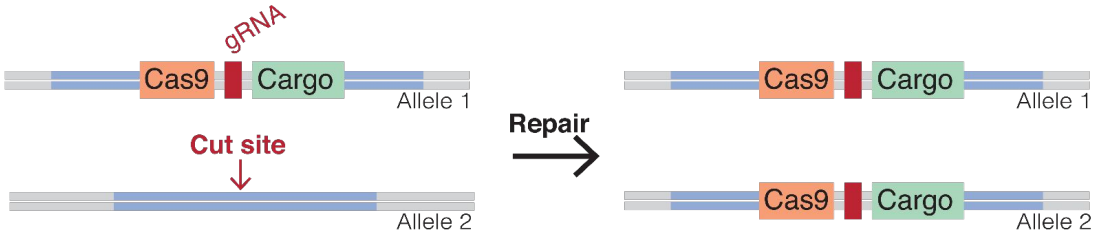
Gene drive inheritance



Altered gene is always inherited

Gene drives





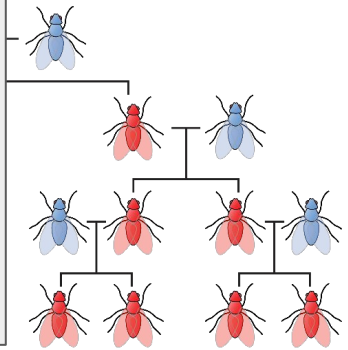
Science
JOURNALS AAAS

Regulating gene drives

Regulatory gaps must be filled before gene drives could be used in the wild

KENNETH A. OYE , KEVIN ESVELT, EVAN APPLETON, FLAMINIA CATTERUCCIA, GEORGE CHURCH, TODD KUIKEN, SHLOMIYA BAR-YAM LIGHTFOOT, JULIE MCNAMARA, ANDREA SMIDLER, AND JAMES P. COLLINS Authors Info & Affiliations

heritance



Altered gene does not spread

Altered gene is always inherited

“Virus hunting”

2

Describe one or more governance policy goals related to ensuring this application contributes to an ethical future & prevents harm.

Consider policy goals:

-ensure safety & security
-promote constructive uses
-promote equity & autonomy

3

Describe at least three different potential governance actions by considering the purpose, design, assumptions, and risks of failures & “success”

Draw upon your existing knowledge and a little additional digging, and feel free to use analogies to other domains such as 3D printing, drones, financial system, etc.

Purpose: What is done now and what changes are you proposing?

Design: What is needed to make it “work”? Consider the actor(s) involved - who must opt in, fund, approve, or implement?

Assumptions: What could you have wrong? Incorrect assumptions? Uncertainties?

Risks of Failures & Success: How might this fail, including any unintended consequences of the “success” of your proposed actions?

4

Score each of your governance actions against your rubric of policy goals.

You can score from 1-3, 1 as best, or n/a

Governance Actions

Policy Goals

Your context: Does the option	Option 1:	Option 2:	Option 3:
Enhance Biosecurity		**Scores**	
• By preventing incidents			
• By helping respond			
Foster Lab Safety			
• By preventing incident			
• By helping respond			
Protect the environment			
• By preventing incidents			
• By helping respond			
Other considerations			
• **Minimizing costs and burdens to stakeholders**			
• **Feasibility?**			
• **Not impede research**			
• **Promote constructive applications**			

5

Based on scores, describe which governance option or combination of options, you would prioritize, and why.

Outline any trade-offs you considered as well as assumptions and uncertainties.

Think about your audience - very local (MIT, Cambridge Mayoral Office), to national (President or Head of a Federal Agency), to international (United Nations Office of the Secretary-General)

Lenni’s week 1 homework

STAKEHOLDERS & ACTIONS

R

RESEARCHERS/
ACADEMICS

R1. Establish best practices to handle bacteria and enzyme

R2. Compile database and share clImate specific strategies

R3. Develop strategies to evaluate and track bacteria in the ilderness and built environment

I

INDUSTRIAL
RECYCLING COMPANIES

I1. Undergo annual review with researchers and regulators

I2. Compile manual for enzyme use

I3. Develop framework for commercial distribution of enzymes for approval

L

LAW ENFORCEMENT /
REGULATORS

L1. Ensure that researchers and industrial parties register their bacterial and enzymic quantities

L2. Ensure educational on best practices are held for the general public

L3. Carry out routine environmental inspection of the deployed areas

C

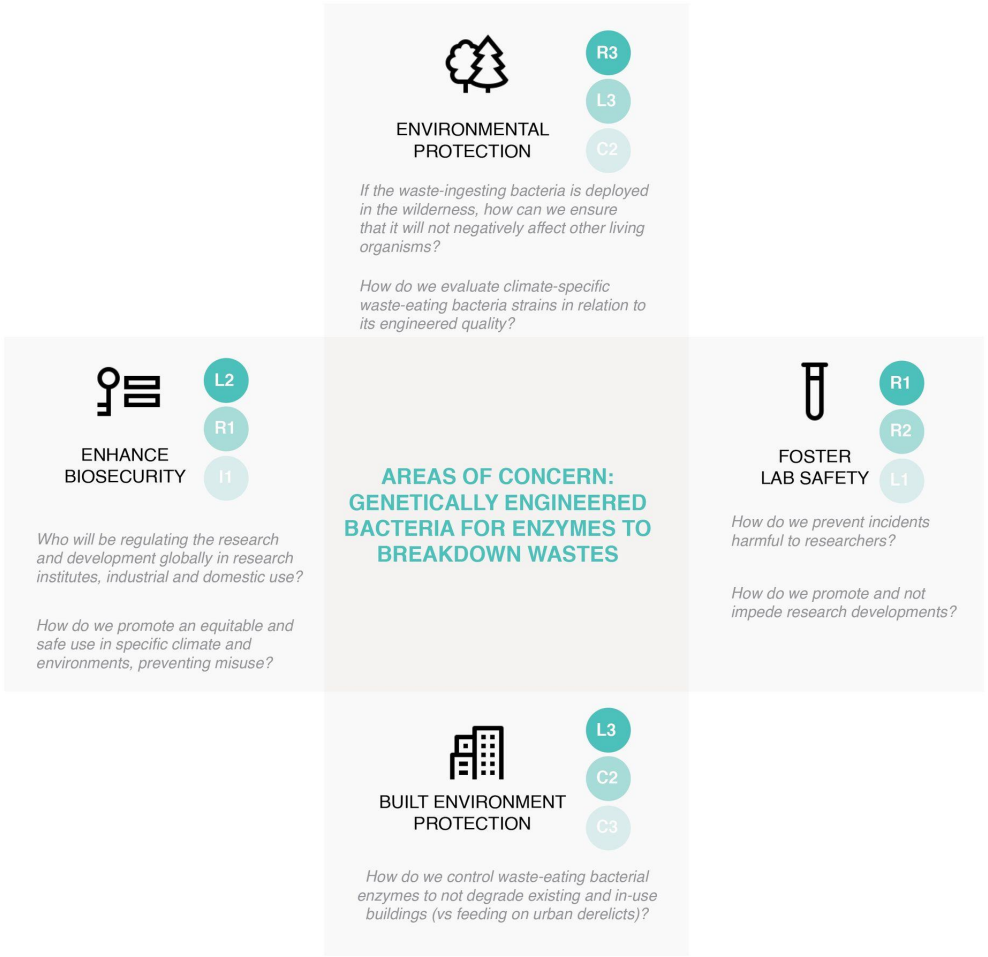
CITIZEN /
USERS

C1. Be educated about current best practices

C2. Contribute to monitoring and responding efforts for bacteria deployed in the environment

C3. Register DIY home enzymic 'composting' into monitored

Amelia Gan - local deployment of bacteria that produce plastic-ingesting enzyme (PETase)



Amelia Gan - local deployment of bacteria that produce plastic-ingesting enzyme (PETase)

BIOSECURITY CONCERNS

> If engineered bacteria can be used to solidify the ground can it be used to cause instability?

> Can genetically engineered bacterial soils negatively affect soil fertility?

EQUITY CONCERNS

> Who has the ability to use the engineered bacterial soils?

> Who regulates the use of engineered bacterial soils at different scales/ in different countries?

ENVIRONMENTAL CONCERNS

> How is microbial activity in soils affected in the immediate and surrounding contexts?

> How do we evaluate the cons/pros when you consider non-human needs? Will non-human organisms benefit or be harmed?

GENETICALLY ENGINEERED BACTERIA TO ALTER SOILS

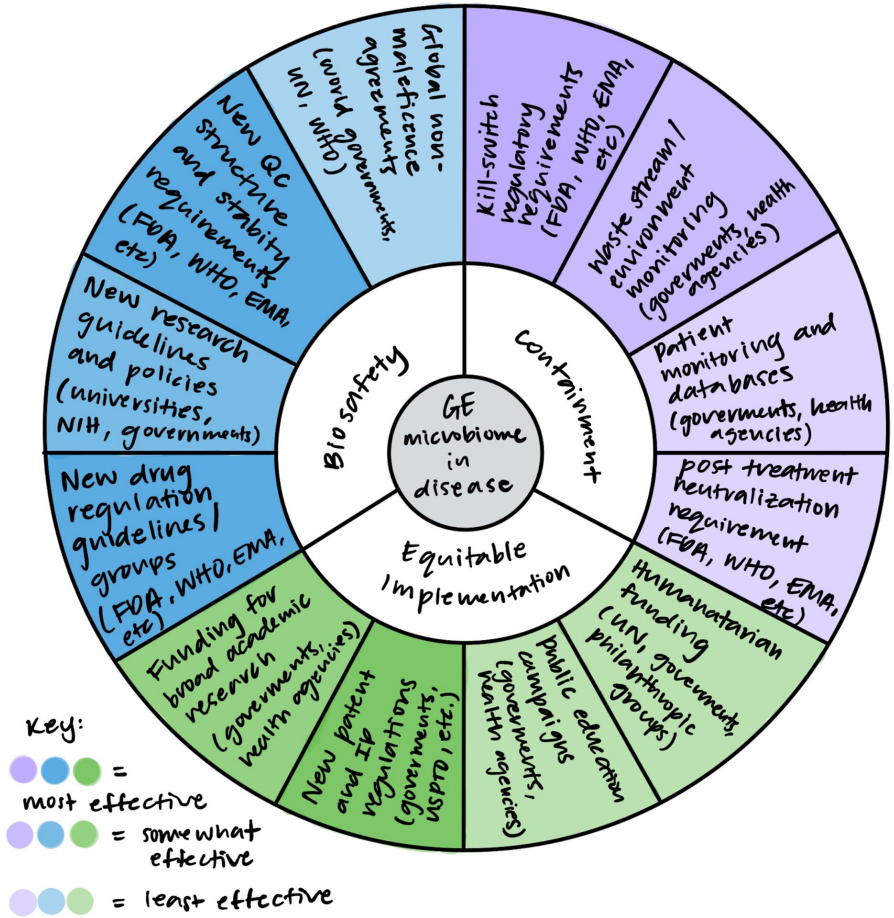
	RESEARCHERS				MANUFACTURERS			INDUSTRY			ORGANIZATIONS	
	Educate on risks & best practices	Community outreach & creation of workshops	Develop & promote tracking strategies	Create a database for equipment & people	Screening of purchases	Verify people placing orders	Logging of projects & implementations	Provide publicly available data on use	Yearly check-ins with community & orgs	Establish best practice procedures	Establish local, national, international oversight	Create programs for licensure
ENHANCE BIOSECURITY												
Monitoring	○	○	○	○	○	○	○	○	○	○	●	○
Response			○	●			○	○			○	
ENSURE EQUITABLE USE												
Monitoring	○	●		○				○	○			○
Response	○	●		○				○	○			○
PROTECT ENVIRONMENT												
Monitoring	○	○	●	○			○	○	○	○	○	
Response	○	○		○			●	○		○	○	

KEY

● Most Effective ○ Moderately Effective ○ Minimally Effective

Researchers include academic (university) researchers along with researchers at community labs.
Manufacturers include producers of the genetically engineered bacteria. They would be the source for the bacteria.
Industry includes registered users and can vary in scale from design/construction companies, to indiv. farmers or ceramicist.
Organizations include committees and advisory boards that establish and enforce legislation at various scales.

Laura Maria Gonzalez - Locally Biocementing w/Bacteria



Jenna Houle - engineered bacteria for the detection and treatment of cholera

Weekly Assignments

1) Outline any ethical concerns that arose, especially any that were new to you.
2) Propose any governance actions you think might be appropriate to address those issues.
3) Include the governance actions on your class page for that week.

Final Project Assignments

As part of your final project, design one or more strategies to ensure that your project, and what it enables, contributes to growing an ethical biological future.

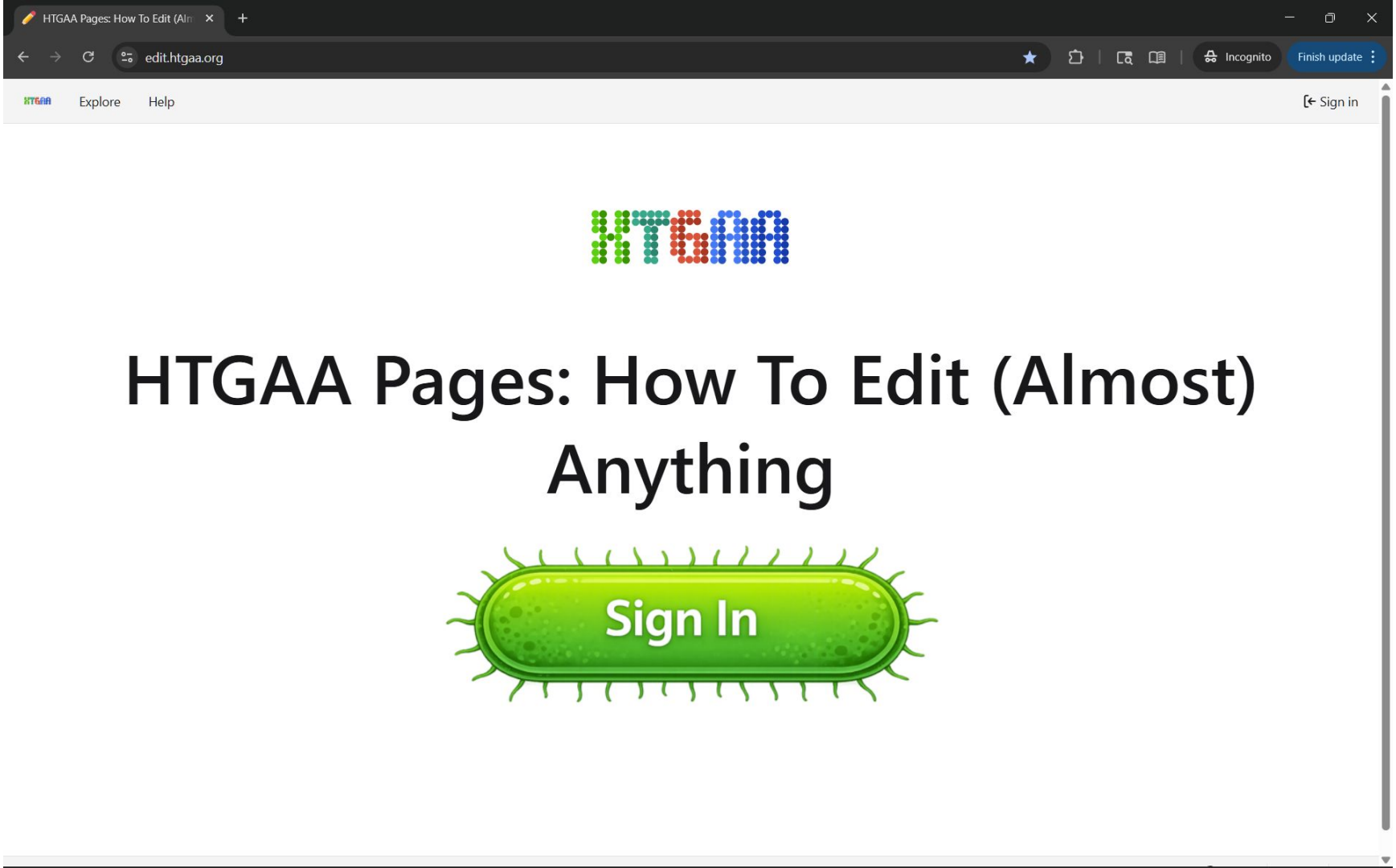
Small Group Discussion

Introduce yourself to the person on your left & right!

Share a synthetic biology project idea & related governance actions

JOIN A ZOOM BREAKOUT ROOM PLEASE!

Student Website Live Demo


HTGAA Pages: How To Edit (Alm
edit.htgaa.org
Incognito
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Explore
Help
Sign in
HTGAA
HTGAA Pages: How To Edit (Almost) Anything
Sign In

webpages/content at main - 20

edit.htgaa.org/2026a-recitation-demo/webpages/src/branch/main/content

Incognito | Finish update

main | Add file | webpages / content | History

Search code... | Exact

Spring 2026 Recitation De... 1912e7828e	Initial commit	two days ago
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homework	Initial commit	two days ago
labs	Initial commit	two days ago
projects	Initial commit	two days ago
_index.md	Initial commit	two days ago
README.md	Initial commit	two days ago

README.md

Your HTGAA site

This is the top level of your HTGAA site - this diretory contains your homepage and directories inside it contain all of the other pages on your site.
(We recommend you bookmark this page so you can come directly here to edit.)

Click _index.md here (or above) to edit the homepage of your HTGAA site, or click homework, labs, or projects to work on those.
Follow the guidance in the READMEs in those locations, and refer to the HTGAA Markdown Editing Guide for tips on markdown, images, tools, and more.

Find your published pages at https://pages.htgaa.org/2026a-recitation-demo/ once you start adding content here.

Homework assignments

To start a new week's homework assignment:

1. Right above the box which says `Search code…` click on `Add file` → `New file` and give it a name with the pattern `<week-name>/_index.md`, such as `week-01-hw-principles-and-practices/_index.md`. (For convenience, see some suggested `<week-name>`s below.)
2. Inside that new file, make the first few lines of your file contain something like this: (including the `---`)

   ```
   ---
   title: 'Week 1 HW: Principles and Practices'
   weight: 10
   ---
   ```

   The weight values are used to order the weeks; a good default is 10 * week number (so 10, 20, 30, ...).
3. Then write your homework assignment using markdown! (And for reference see the HTGAA Editing Guide.)
4. Don't forget to scroll down and click the `Commit changes` button to save after making some additions or edits. After saving while you're still on that `_index.md`'s page you can click the pencil icon (next to the trash can on the far right) to go back into the editor.

To make it easier the first time around, Week 1 has already been started for you.

Remember, once you save you can view your published pages at https://pages.htgaa.org/2026a-recitation-demo/

Extra customization:

1. To add **images** to your pages,
   i. Upload the image: after you've saved your `_index.md`, click on the red `<week-name>` directory link a few lines down from the top.
   ii. There, you can click on `Add file` → `Upload file` and either upload an image file you have locally or when it asks for a filename try giving it a URL to the image.
   iii. Back inside your document (click on `_index.md` and edit it) you can include the image by using its filename in an image link (e.g. `![](myimage.jpg)`)
   iv. Remember, if you put the word `feature` anywhere in an image's filename (e.g. `featured-wooly-mammoth.webp` or `david-george-joe.jpg-feature`) that image will automatically be placed inside the "card" for that page in a `{{% children type="card" %}}` (or `childrenof`) card listing (such as a list of all your homework, if you are specifying `type="card"`).
2. Page summaries are listed in cards or page listings; long ones are automatically generated, but you can create your own short description for those listings by adding between the `---` lines at the top of your markdown document a line such as:

   ```
   description: 'whatever you want the summary to be'
   ```

Markdown
Tools
New pages
Images

EDITING GUIDE

emojis | icons | cheat sheet | full guide | shortcodes | mermaid

Markdown

In your **_index.md** files you mainly write "Markdown", which is an easy way to add simple formatting to a document just by typing. If you just write text it will get displayed as text (without any special formatting). By adding simple punctuation you can mark portions of text as **bold**, *italic*, highlighted, `quoted`, lists, headings of a half dozen levels, inlined images, web links, and more.

- You can copy-paste into your markdown any emoji (😁) or type its name (`:grin:`) from the official emoji list
- Icons can be included via `{{% icon <icon-name> %}}` using **<icon-name>**s which you can search for in the official icon directory (be sure the "Free" box on the right, below the search bar, is selected). If the "Web Awesome" code has a **family** name listed (e.g. if you click the "Web Awesome" tab for this icon you see the family name is **brands**), enter that after the icon name, e.g. `{{% icon google brands %}}`.
- See a basic markdown cheat sheet
- Or refer to a more complete markdown guide with many more advanced features (navigate using the Table of Contents by clicking the icon at top on the left side)

Tools

The markdown you write is processed using the Hugo Relearn Theme.[1] For advanced layout of your pages you can use their many "shortcodes" – a few to call out are:

- For layout & formatting, use cards and notices; also buttons can provide colorful links.
- For organization, you can group related pages into directories and use children to automatically display titles & optional descriptions of all pages below in various formats. We also provide a custom version of it, `{{% childrenof path="/projects" ... %}}` which takes all the same parameters as `children` but only lists

Student Website Editing

Start editing your HTGAA Website!

Good places to begin include:

- Your homepage: `content/_index.md`
- Your Week 1 Homework submission:
  `content/homework/week-01-hw-principles-and-practices/_index.md`

editing mechanics: directories, files, & headers

- Homework should go under `content/homework`, labs under `content/labs`
  - Inside those directories a README.md is displayed giving more detailed instructions
- Make a directory for each webpage (e.g. for one homework, for one lab, etc)
  - Put the content (markdown) in the file `_index.md` in that directory
  - Add images for the page into that directory
  - Within it you can have subdirectories with their own `_index.md` and image files if you like
- At the top of your `_index.md` files add a header which looks like this: (with the "`---`")

```
---
title: 'Week 1 HW: Principles and Practices'
weight: 10
---
```

- Scroll down and click the "Commit changes" button to save your edits
- Tips:
  - Get content in first – just type text! – then add markdown for formatting later.
  - Add/change a bit at a time; save ("Commit") often and view the results right away.
  - Browse & copy markdown/layout tricks freely from anyone – BUT NOT CONTENT!

help!

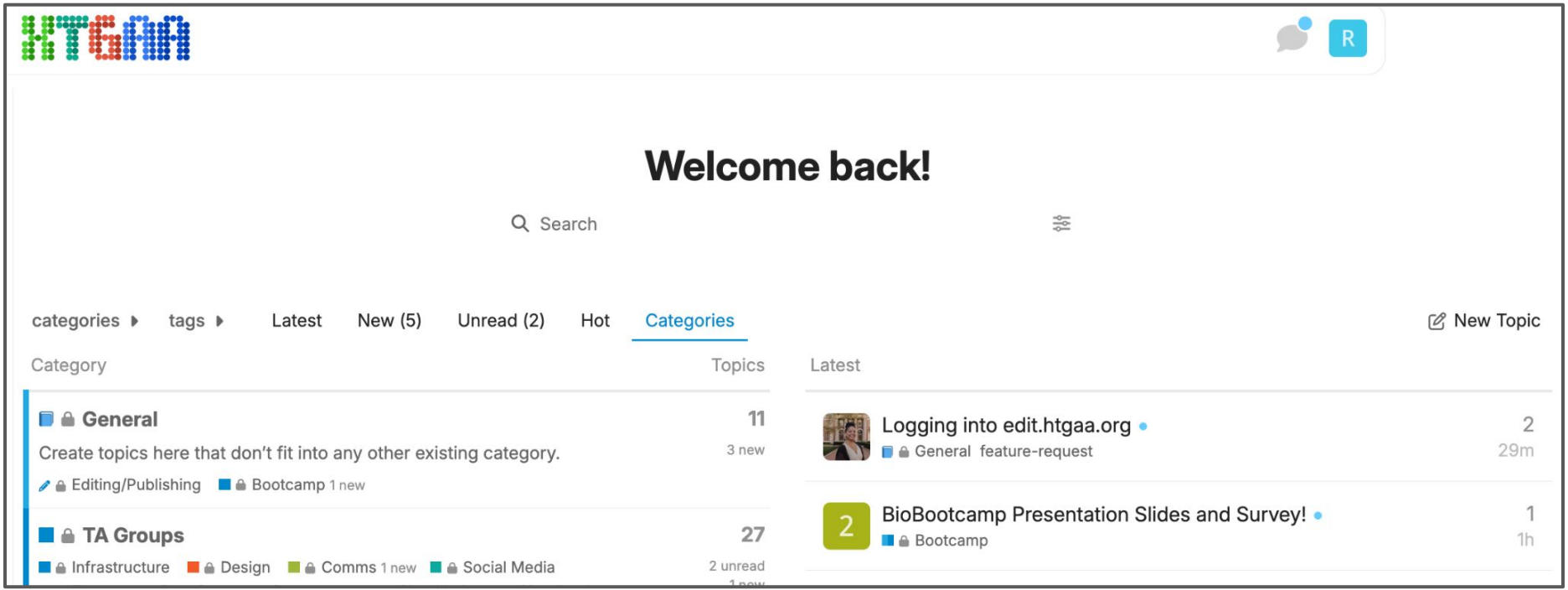
- Not seeing the change you expected? Wait 5 secs, reload, check Build Failure Log.
- Build is all-or-nothing – a breaking mistake on one page will prevent all your pages from being built/redeployed!
- Unexpected line break? Check for >=2 trailing spaces on end of previous line.
- Icon not displaying? Be sure it's free, not pro. Does it need a second "family" name?
- Mysterious  or  ? You have an image link with an incorrect filename or path.
- On a markdown page in edit.htgaa.org is the pencil icon not clickable to edit / does it say "You must fork this repository…"? You're not logged in.

- Need some markdown tips? See the HTGAA Editing Guide, which also links to a Markdown Cheat Sheet and an extensive Markdown Guide.
    - This is linked from every one of your generated pages: "Resources" (lower left) -> "Editing Guide"
- ASK FOR HELP! in the Editing/Publishing category on forum.htgaa.org.
  Don't spend days on a problem someone can help solve in minutes!

Great Student Websites from previous years

Laura Maria Gonzalez (2021)
Rosalie Lin (2022)
Kevin Huang (2023)
Jocelyn Keyser (2023)
Alison Cabrera (2025)
Tanisha Shaw (2025)

Discourse Introduction



https://forum.HTGAA.org

Homework 01 Requirements Review

Homework I Requirements

Homework I (All MIT/Harvard students and Committed Listeners) Due: **Due: Feb 10** (Before lecture)

- Set up your student webpage
- Propose a biological engineering application, then design and compare multiple governance/policy strategies to ensure it is developed and used ethically and safely
- Before next week lecture on “DNA Read, Write, and Edit”:
  - Answer pre-lecture questions from Dr. Jacobson, Dr. LeProust, Dr. George Church
  - Review the associated papers referenced in the week 2 slides

Lab Safety Training (MIT/Harvard Students)

- Complete Lab Specific Training in Person. **Due: Feb 3** (we will complete as a group after this recitation)
- Complete Safety Training in Atlas **Due: Feb 4** (required for enrollment)
  - Navigate to atlas.mit.edu and on the right-hand side, click “Learning Center”
  - Head to the Course Catalog and find the following two courses:
    - General Biosafety for Researchers (EHS00260w)
    - Managing Hazardous Waste (EHS00501w)

atlas.mit.edu

1. Go to Learning Center
2. Click on the Course Catalog Tab:
   - General Biosafety for Researchers (EHS00260W)
   - Managing Hazardous Waste (EHS00501W)

Lab Safety Training

Walk over to building 68-089!

Lab 1: Introduction to Wet Lab Liquid Handling

- **Understand Units and Conversions:** moles (mol), molarity (M), and conversions between nL, µL, mL, and L.
- **Gain Pipetting Proficiency:** Operate P20, P200, and P1000 pipettes accurately for volume transfers.
- **Perform Serial Dilutions:** Learn the stepwise dilution process to achieve specific solution concentrations.
- **Visualize Mixing Outcomes:** Use colors and absorbance measurements to observe concentration gradients.

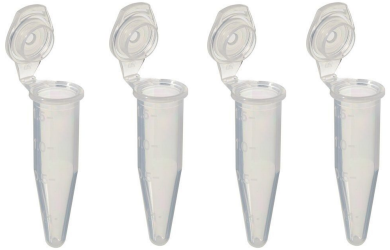
Starting concentration

Final concentration

$$C_1 V_1 = C_2 V_2$$

Starting volume

Final volume



Recitation 01