EMERGENCY PREPAREDNESS – A MESSAGE FROM PURDUE

To report an emergency, call 911. To obtain updates regarding an ongoing emergency, sign up for Purdue Alert text messages, view www.purdue.edu/ea.

There are nearly 300 Emergency Telephones outdoors across campus and in parking garages that connect directly to the PUPD. If you feel threatened or need help, push the button and you will be connected immediately.

If we hear a fire alarm during class we will immediately suspend class, evacuate the building, and **proceed outdoors to the Grassy Area in front of SMITH HALL (Northeast)**. **If inclement weather**, **meet inside SMITH Hall**. Do not use the elevator.

If we are notified during class of a Shelter in Place requirement for a tornado warning, we will suspend class and **move to the Basement corridor**.

If we are notified during class of a Shelter in Place requirement for a hazardous materials release, or a civil disturbance, including a shooting or other use of weapons, we will suspend class and shelter in the classroom, shutting the door and turning off the lights.

Please review the Emergency Preparedness website for additional information. http://www.purdue.edu/ehps/emergency_preparedness/index.html

ABE 591- Principles of Systems & Synthetic Biology

Instructor: Prof. **K. Solomon Ph.D.**

Assistant Professor

Agricultural & Biological Engineering

Laboratory for Renewable Resources Engineering

Fall 2018

How do you engineer a cell?

DNA is the programming language of life

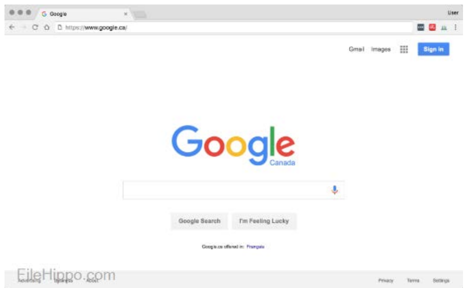
DNA → RNA → Protein → Function

Successes of recombinant technology:

- Insulin production
- Vaccine development
- Improved crop production

Paradigm shift: Biology as modular systems

DNA ⟶ RNA ⟶ Protein ⟶ Function



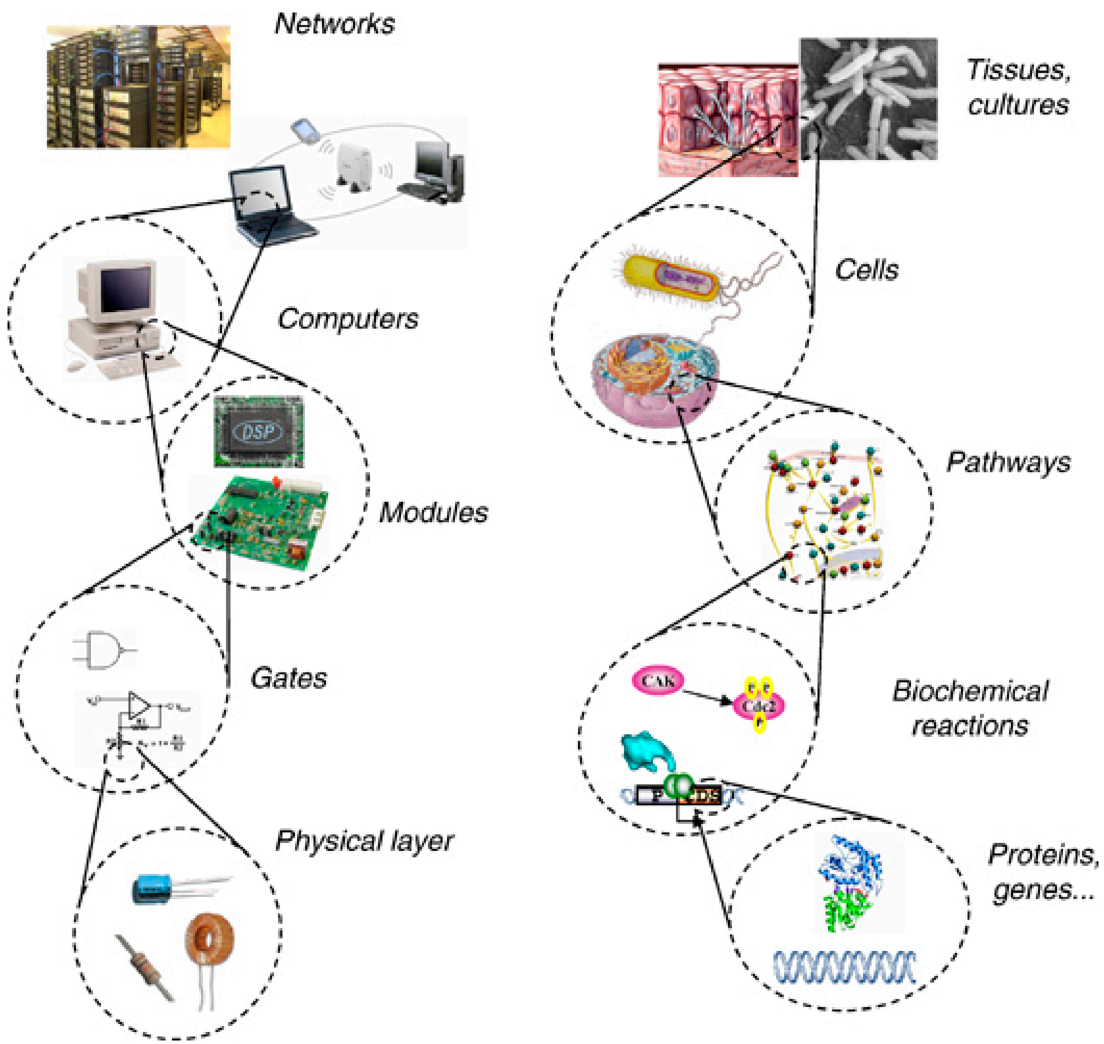
We can abstract or re-use modules with a specific functions

What is Synthetic Biology?

*"engineering of **<u>living</u>** biological systems"*

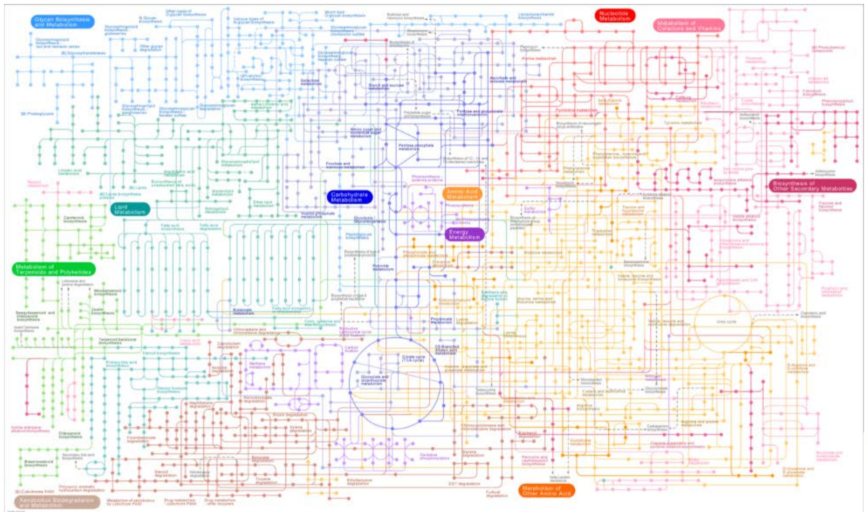
Goal: to design living systems using standard engineering practices to solve practical problems

A possible hierarchy for synthetic biology is inspired by computer engineering.



Ernesto Andrianantoandro et al. Mol Syst Biol 2006;2:2006.0028

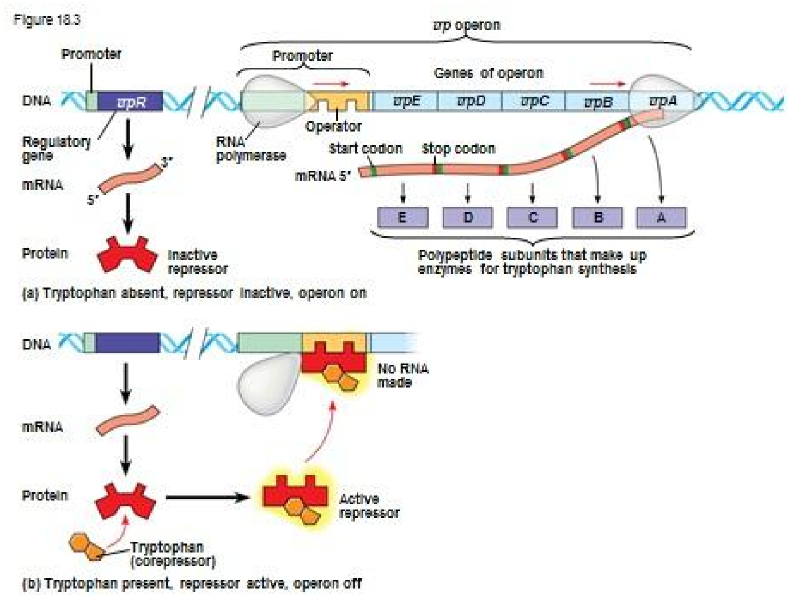
Why engineer biology?



KEGG

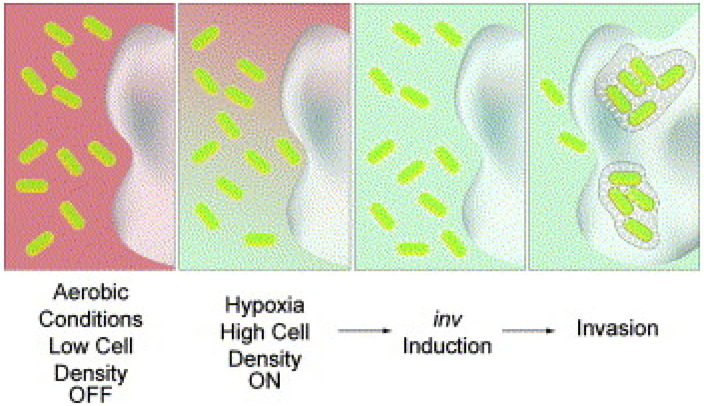
Cells are powerful chemical factories

Living systems sense their environment and respond to stimuli



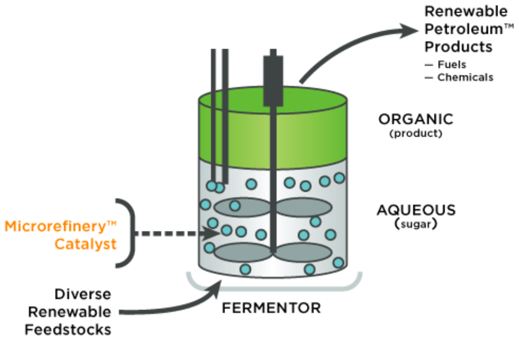
Campbell Biology

(Some) Applications of synthetic biology

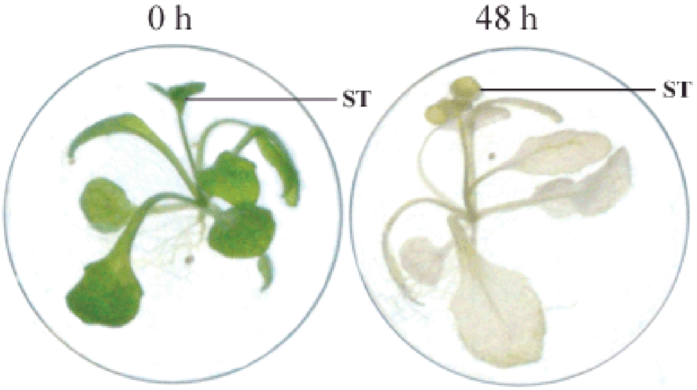


Cancer fighting bacteria

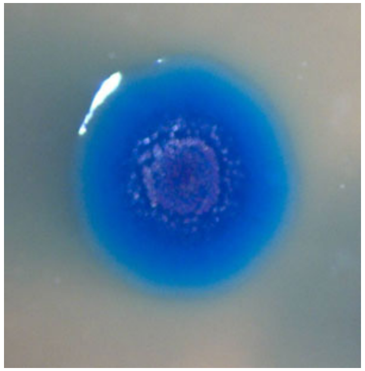
Bacterial photography



Nextgen biofuels



Bomb detecting plants



Study of biological systems

SynBio Industry

Synbiobeta.com

Dow AgroSciences
Cargill
Agilent Technologies
EVONIK INDUSTRIES
genomatica sustainable chemicals
TWIST BIOSCIENCE
AUTODESK
GINKGO BIOWORKS™ THE ORGANISM COMPANY

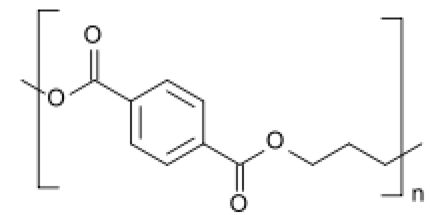
Industrial applications: Sorona® & Hytrel® (Dupont)

Biopolymers from microbial 1,3-propanediol

– 100M pounds/yr

– $100M plant in TN

– 25% of annual revenue



Sorona®

More sustainable

– 30% ↓ energy

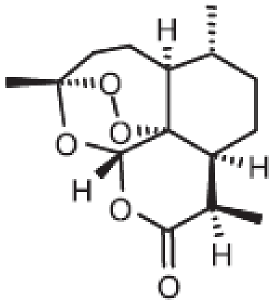
– 63% ↓ greenhouse gas emission

– Renewable corn feedstock

More economical

– Less expensive than petroleum

Industrial applications: Artemisinin (Amyris)

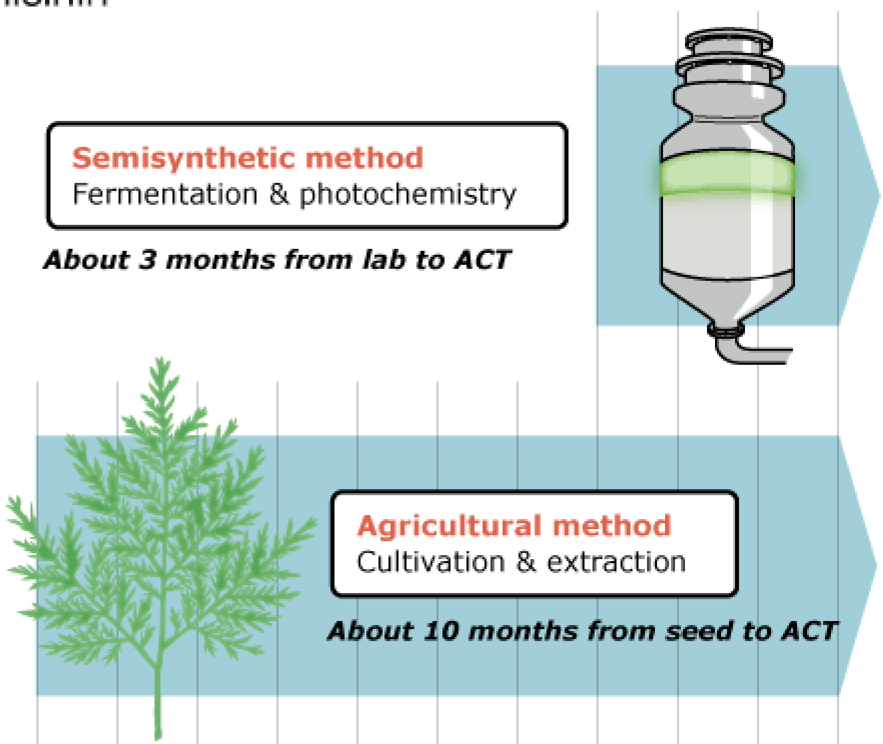


Artemisinin

- Leading treatment of malaria
- 300 – 500 M malaria cases worldwide
- Difficult to make synthetically

Microbial fermentation
- Fast production
- Produced anywhere

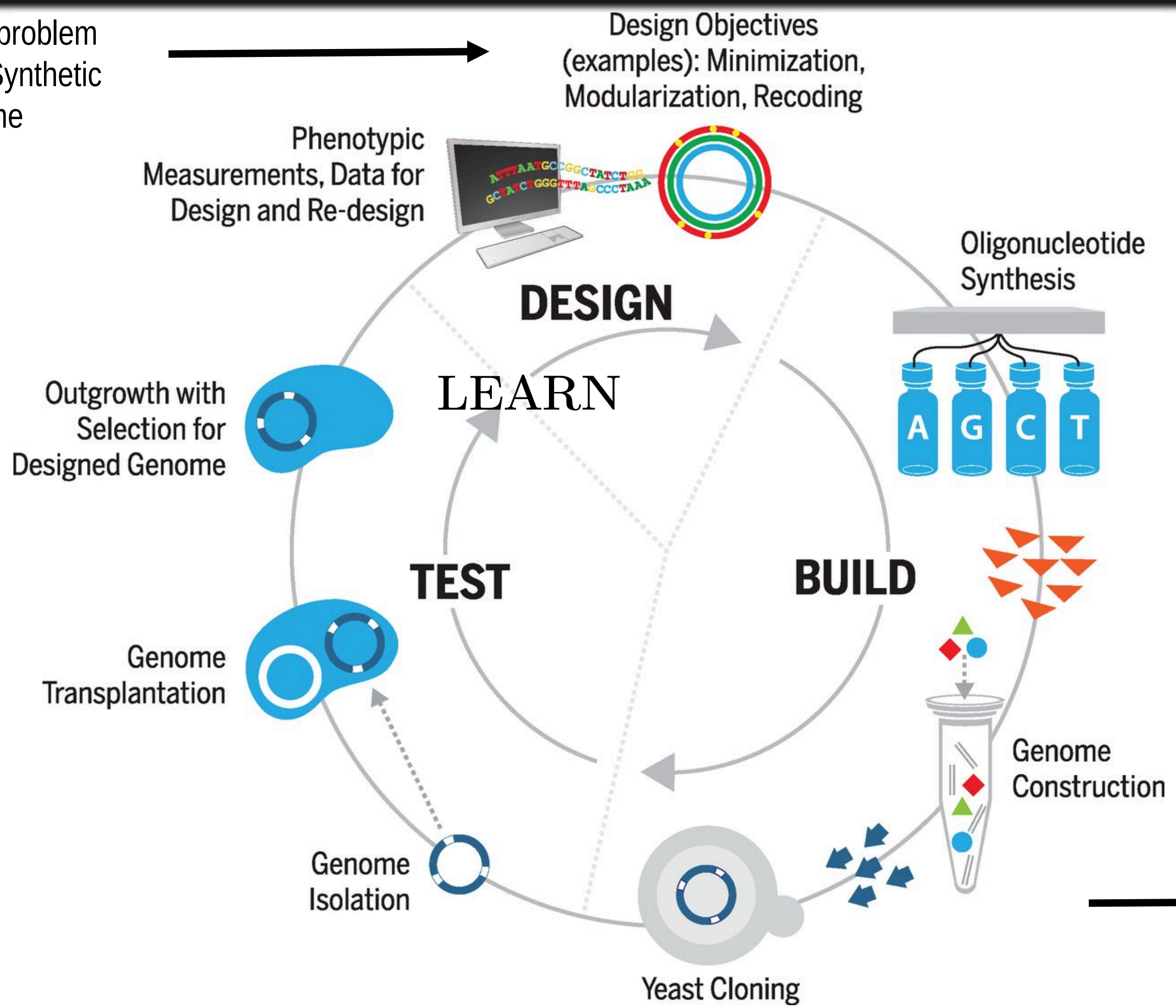
Traditional production via Chinese Sweet Wormwood plant
- Limited production
- Sensitive to climate
- Expensive



Sanofi-Pasteur & Amyris → 150M treatments/a

SynBio follows an iterative Design-Build-Test-Learn Cycle

Specify the problem (example): Synthetic genome



Working prototype

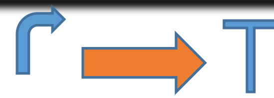
Adapted from: Hutchinson et al. *Science, 2016*

Week 1	Engineering Biology Overview + Ethics
DESIGN	
Week 2	Programming Biology
Week 3	Properties of biological systems
Week 4	Network Motifs
Week 5	Nonlinear systems and emergent phenomena
Week 6	BioCAD
BUILD	
Week 7	Test 1
Week 8	DNA Assembly
Week 9	DNA Assembly Cont'd
Week 10	Genome Engineering
Week 11	Genome Scale Assembly
Week 12	Applications – Metabolic Engineering
Week 13	SynBio Frontiers – Microbial communities and directed evolution
TEST/LEARN	
Week 14	Test 2/Thanksgiving
Week 15	Learning from Nature +-omics
Week 16	Design Projects

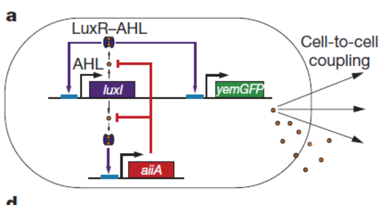
SYLLABUS

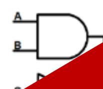
Course overview

1. What are biological parts?
   - How do we design/define new parts?



2. How do parts function together?





RESPONSIBLE SCIENCE

3. Describe the qua… …or of systems

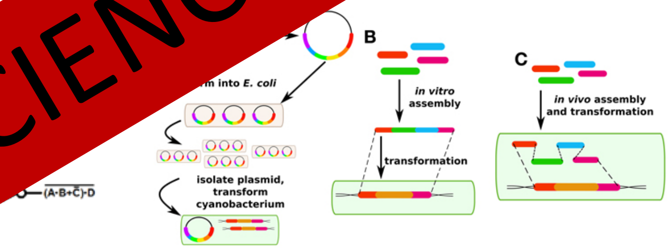
$$\frac{\partial A}{\partial t} \; \ldots \; ,t) - \frac{\gamma_A A}{1+f(A+I)}$$

$$\frac{\partial I}{\partial t} = \; \ldots \; a_0)^4]\, P(\alpha,\tau) - \frac{\gamma_I I}{1+f(A+I)}$$

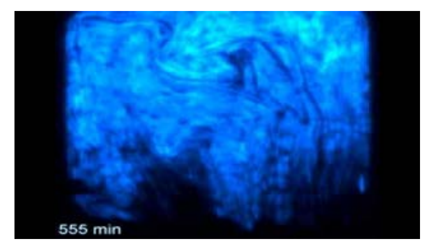
$$\frac{\partial H_i}{\partial t} = \; \ldots \frac{I}{1+kI} - \frac{\gamma_H A H_i}{1+gA} + D(H_e - H_i)$$

$$\frac{\partial H_e}{\partial t} = -\frac{d}{1-d} D(H_e - H_i) - \mu H_e + D_1 \frac{\partial^2 H_e}{\partial x^2}$$

4. How d… …e synthesize these sy…



5. Design & test systems for specific applications



What <u>should</u> we engineer?

Best practices are to minimize risk and weigh potential good vs harm

Multiple perspectives:

Scientists/ Experts

Investors

Government

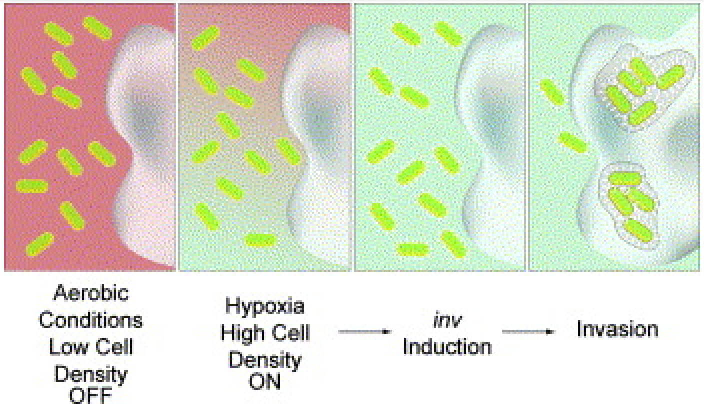
Public

Technical Risks & Ethical/Legal/Social Concerns

1. **Biosafety**
   - Toxins? Ecosystem damage? Biological harm
2. **Biosecurity**
   - Dual-use? Increased lethality? Proliferation?
3. **Justice and fairness**
   - Who benefits?
4. **Socioeconomic**
   - IP? How disruptive is tech?
5. **Eugenics/Playing God**
   - Should we be tampering with nature?

Which risks are most important to the different stakeholders?

Example



Cancer fighting bacteria

- To hunt down tumors, need to evade immune system → potential for “dual use”
- Will treatment be accessible?
- Safe? Accurate?

Scientists need:

- to be aware of risks (technical or not)
- address risks where possible in design
  - e.g. ‘kill’ switches to prevent survival in wild (nutrient auxotrophies, non standard amino acids)
- Engage public to effectively communicate risk