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RESEARCH NEWS

Bioengineers Hope to Build Life

April 29, 2008 · 7:00 AM ET
Heard on The Bryant Park Project

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TRANSCRIPT

Students of bioengineering at the Massachusetts Institute of Technology work with the organic building blocks of life. As Robert Krulwich and Jad Abumrad of Radio Lab report, the science could someday create new forms.

http://youtu.be/W7DUaxCPMt8

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What has our class been about?

Students successfully completing BIOE/ENGR.80 will have a working understanding for how to approach the systematic engineering of living systems to benefit all people and the planet.

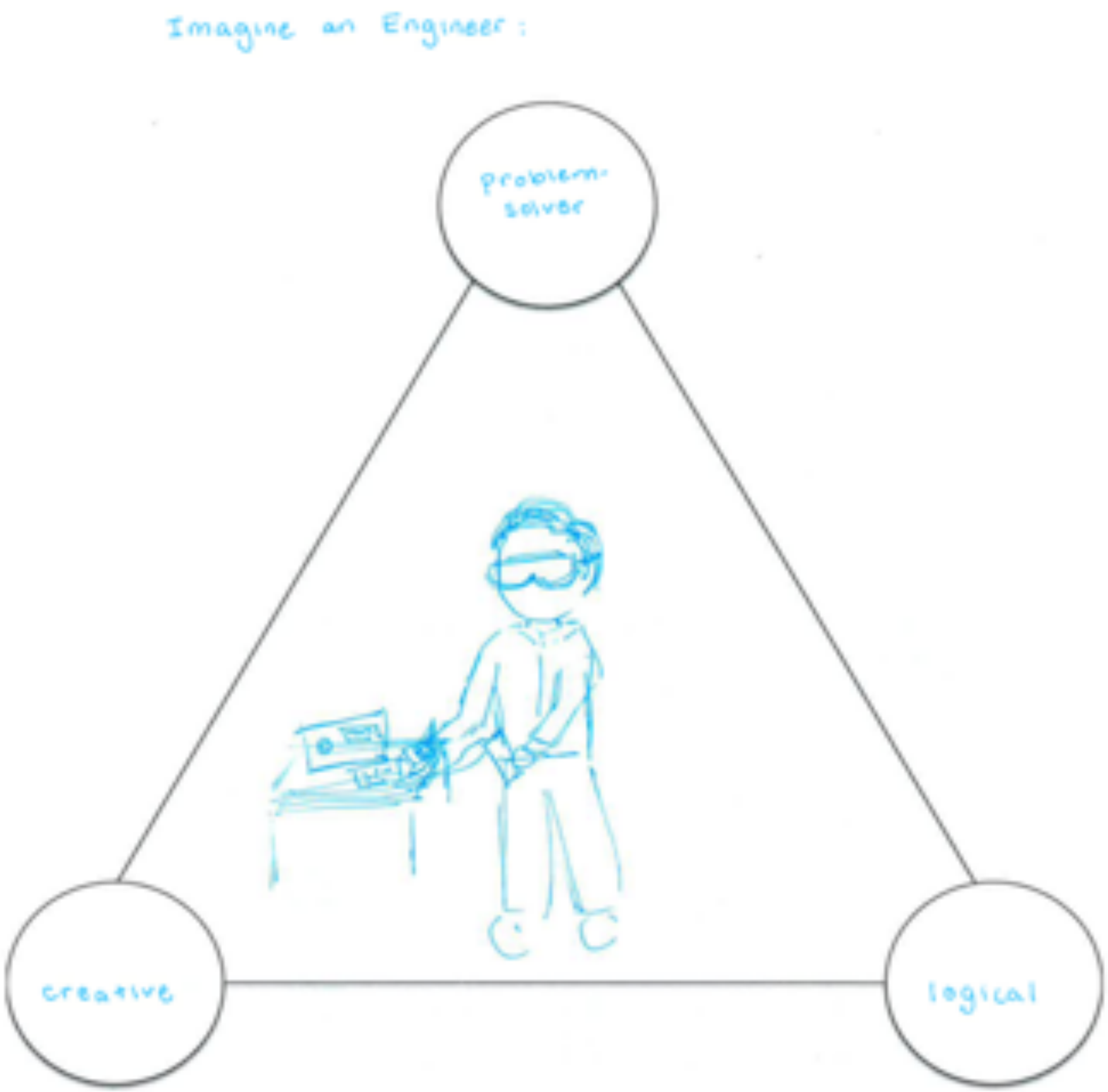
Our main goals for the quarter are:

(1) to help you learn ways of thinking about engineering living matter,

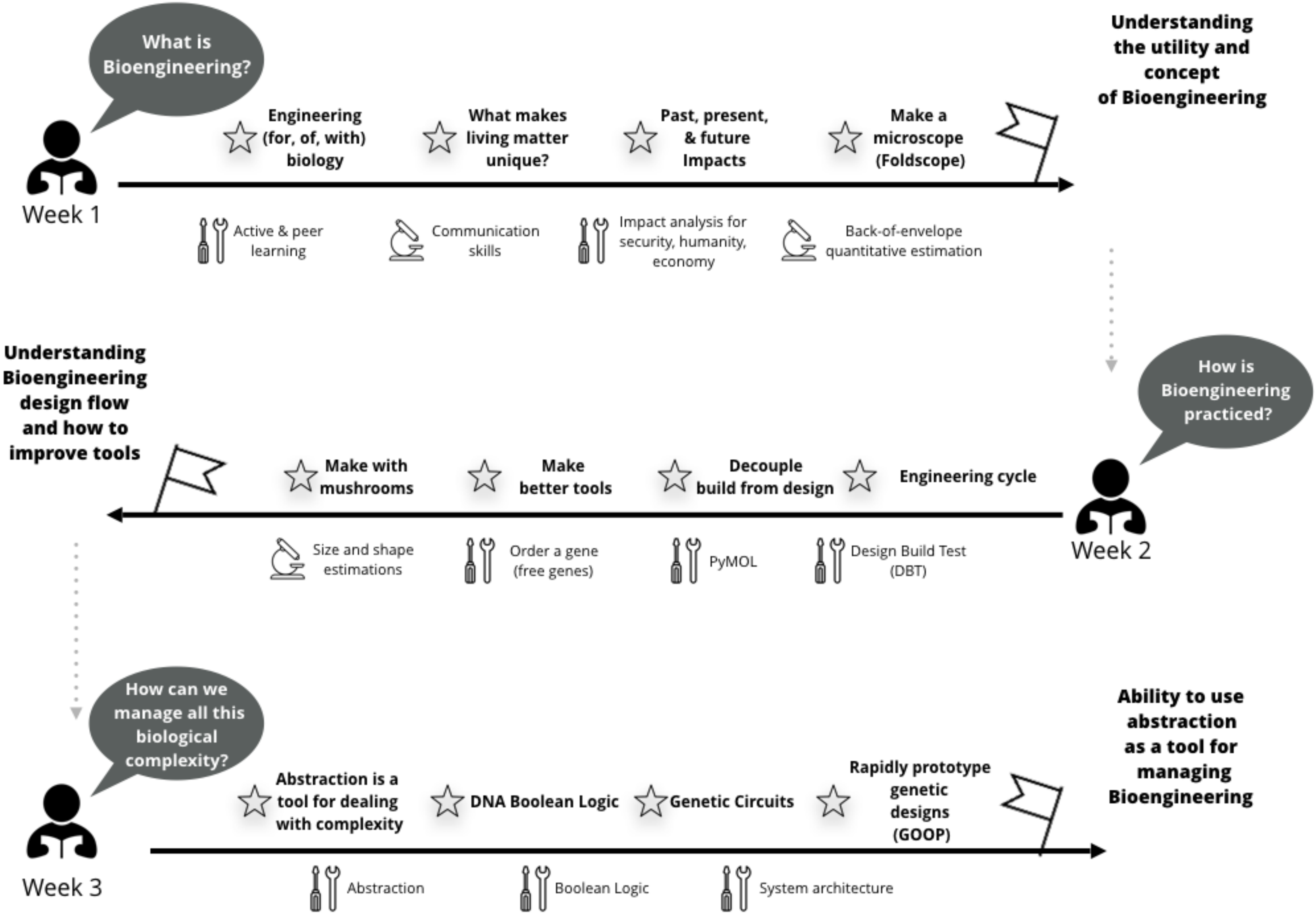
(2) for you to become more capable of learning and explaining bioengineering to yourself and others,

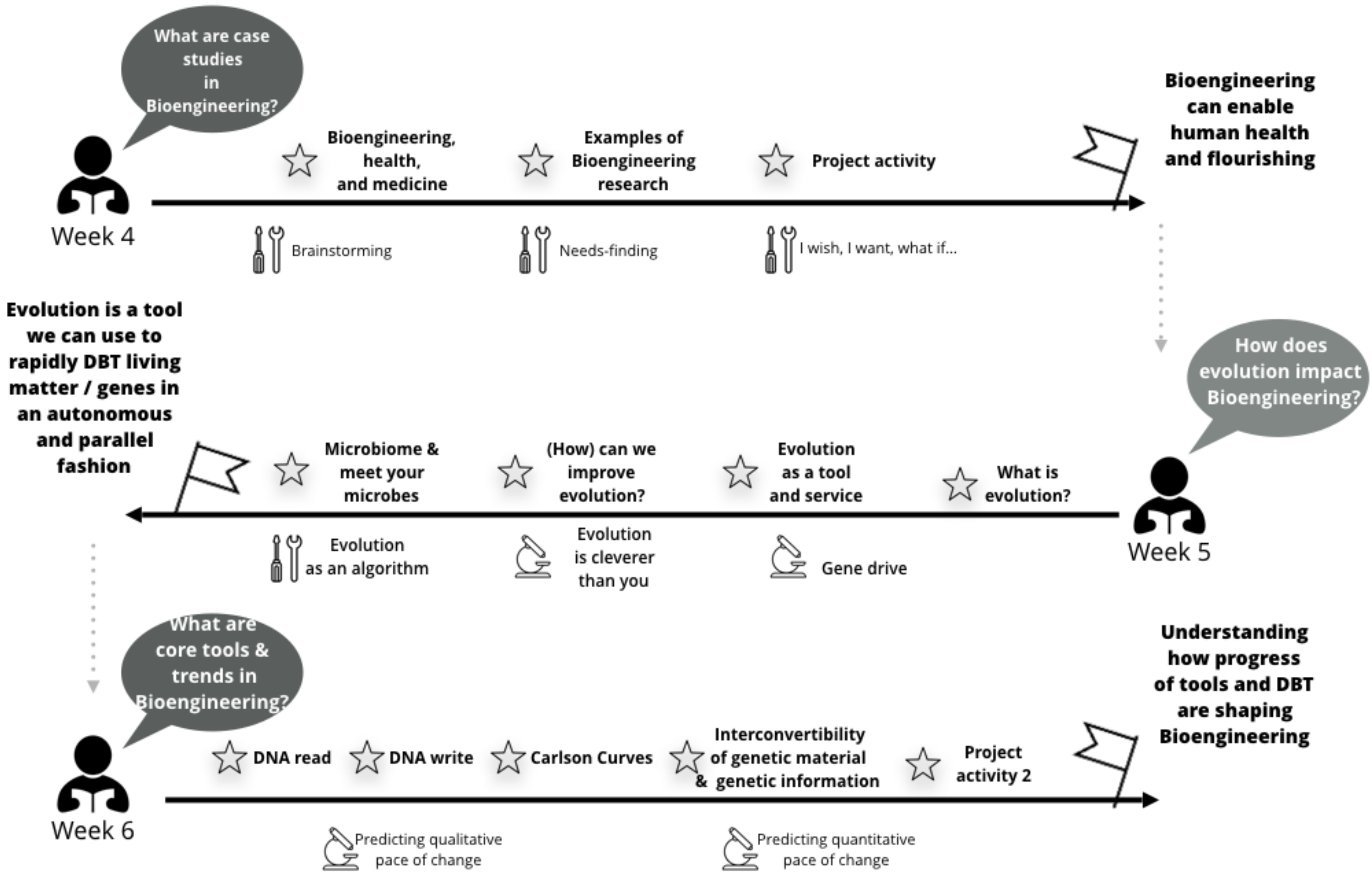
(3) for you to be capable of leading discussions of the broader ramifications of engineering the living world.

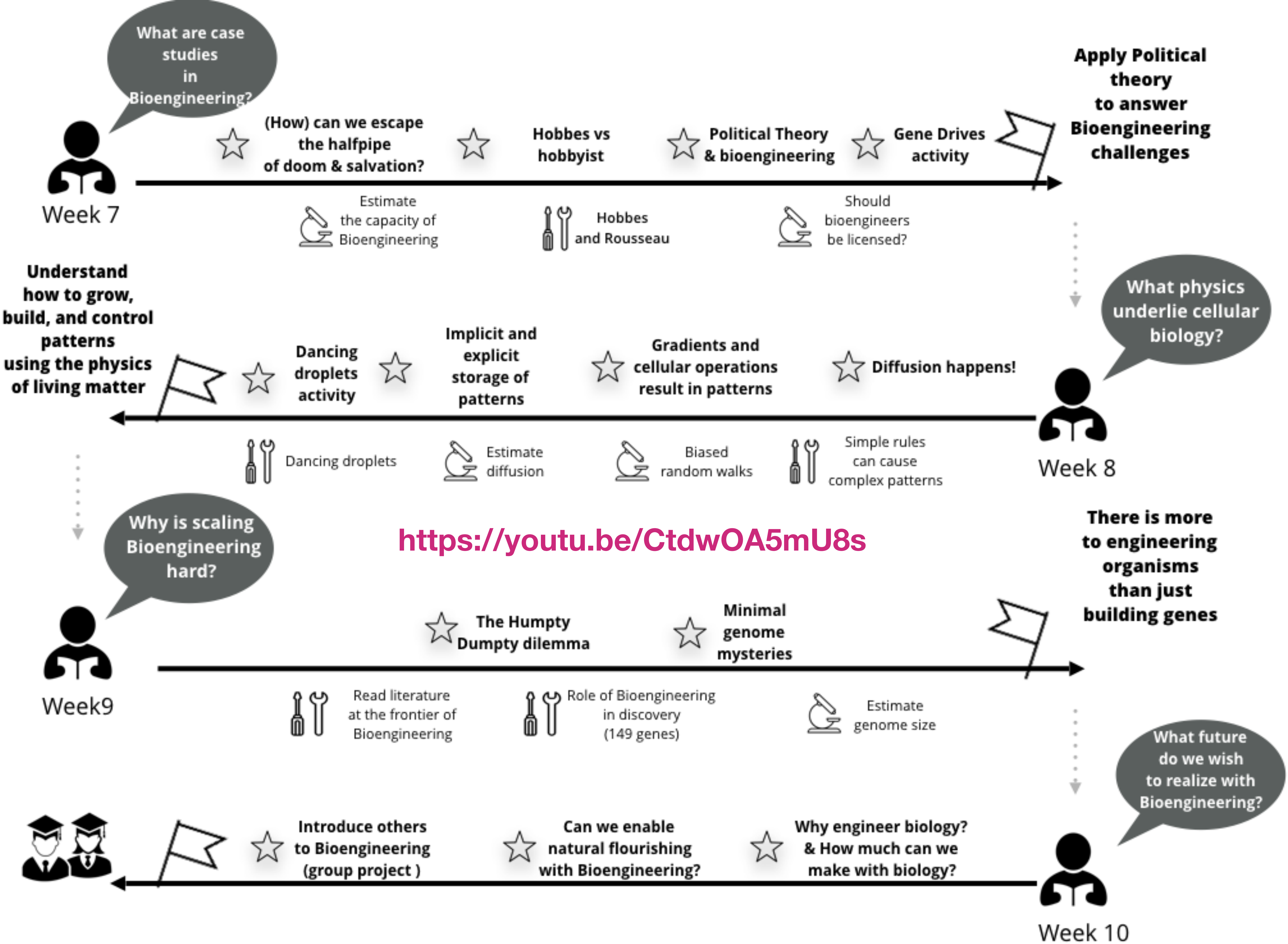
Imagine a bioengineer…



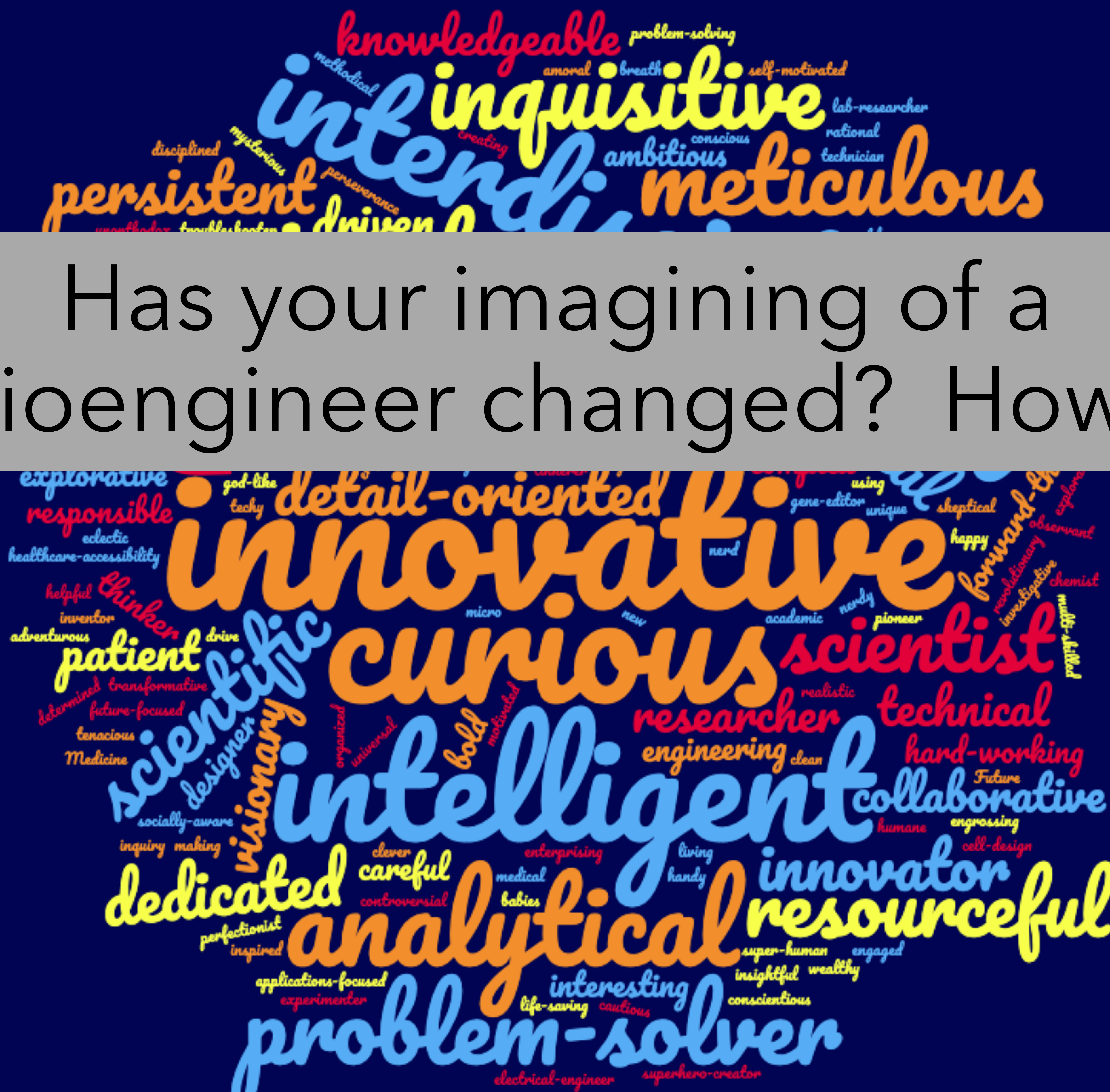

innovative
creative
interdisciplinary
curious
intelligent
analytical
problem-solver
smart
passionate
inquisitive
meticulous
biology
scientific
scientist
impactful
resourceful
innovator
dedicated
persistent
detail-oriented
ethical
forward-thinking
knowledgeable
visionary
researcher
technical
collaborative
patient
driven
ambitious
explorative
responsible
complex
thinker
designer
bold
engineering
hard-working
careful
interesting
maker
problem-solving
methodical
amoral
breath
self-motivated
lab-researcher
rational
conscious
technician
disciplined
mysterious
creating
perseverance
unorthodox
troubleshooter
adaptable
outdoors
intuiting
applied
capable
thoughtful
mathy
knowledge
risk-taking
long-range
adaptive
groundbreaking
open
Practical
caring
life
inventive
innovation
hardworking
breakthrough
creativity
engineer
editor
imaginative
tinkerer
gene
using
god-like
exploration
techy
gene-editor
unique
skeptical
observant
eclectic
healthcare-accessibility
nerd
happy
revolutionary
chemist
helpful
investigative
micro
nerdy
inventor
new
academic
pioneer
multi-skilled
adventurous
drive
determined
transformative
realistic
future-focused
motivated
organized
universal
tenacious
Medicine
clean
Future
socially-aware
humane
engrossing
inquiry
making
clever
enterprising
living
cell-design
medical
handy
controversial
babies
perfectionist
inspired
super-human
engaged
applications-focused
insightful
wealthy
experimenter
life-saving
cautious
conscientious
electrical-engineer
superhero-creator


What is Bioengineering?
Week 1
Engineering (for, of, with) biology
What makes living matter unique?
Past, present, & future Impacts
Make a microscope (Foldscope)
Understanding the utility and concept of Bioengineering
Active & peer learning
Communication skills
Impact analysis for security, humanity, economy
Back-of-envelope quantitative estimation
How is Bioengineering practiced?
Week 2
Engineering cycle
Decouple build from design
Make better tools
Make with mushrooms
Understanding Bioengineering design flow and how to improve tools
Design Build Test (DBT)
PyMOL
Order a gene (free genes)
Size and shape estimations
How can we manage all this biological complexity?
Week 3
Abstraction is a tool for dealing with complexity
DNA Boolean Logic
Genetic Circuits
Rapidly prototype genetic designs (GOOP)
Ability to use abstraction as a tool for managing Bioengineering
Abstraction
Boolean Logic
System architecture


What are case studies in Bioengineering?
Week 4
Bioengineering, health, and medicine
Examples of Bioengineering research
Project activity
Bioengineering can enable human health and flourishing
Brainstorming
Needs-finding
I wish, I want, what if...
How does evolution impact Bioengineering?
Week 5
What is evolution?
Evolution as a tool and service
(How) can we improve evolution?
Microbiome & meet your microbes
Evolution is a tool we can use to rapidly DBT living matter / genes in an autonomous and parallel fashion
Gene drive
Evolution is cleverer than you
Evolution as an algorithm
What are core tools & trends in Bioengineering?
Week 6
DNA read
DNA write
Carlson Curves
Interconvertibility of genetic material & genetic information
Project activity 2
Understanding how progress of tools and DBT are shaping Bioengineering
Predicting qualitative pace of change
Predicting quantitative pace of change



What are case studies in Bioengineering?
Week 7
(How) can we escape the halfpipe of doom & salvation?
Hobbes vs hobbyist
Political Theory & bioengineering
Gene Drives activity
Apply Political theory to answer Bioengineering challenges
Estimate the capacity of Bioengineering
Hobbes and Rousseau
Should bioengineers be licensed?
What physics underlie cellular biology?
Week 8
Diffusion happens!
Gradients and cellular operations result in patterns
Implicit and explicit storage of patterns
Dancing droplets activity
Understand how to grow, build, and control patterns using the physics of living matter
Dancing droplets
Estimate diffusion
Biased random walks
Simple rules can cause complex patterns
Why is scaling Bioengineering hard?
Week9
https://youtu.be/CtdwOA5mU8s
The Humpty Dumpty dilemma
Minimal genome mysteries
There is more to engineering organisms than just building genes
Read literature at the frontier of Bioengineering
Role of Bioengineering in discovery (149 genes)
Estimate genome size
What future do we wish to realize with Bioengineering?
Week 10
Why engineer biology? & How much can we make with biology?
Can we enable natural flourishing with Bioengineering?
Introduce others to Bioengineering (group project)



Has your imagining of a bioengineer changed? How?

Stanford Digital Repository

Core Course Companions and Curriculum Opportunities, Bachelor of Science in Bioengineering, Stanford University, 2018

PREFERRED CITATION Siavash Ahrar, Veronica R Brand, Drew Endy, Kara H. Rogers, and Ross D. Venook. Core Course Companions and Curriculum Opportunities, Bachelor of Science in Bioengineering, Stanford University, 2018. Stanford Digital Repository. Available at: https://purl.stanford.edu/ks811bm4485 https://doi.org/10.25740/KS811BM4485

COLLECTION Bioengineering

1 Core Course Companions v10.pdf
3.78 MB

Access conditions

Core Course Companions and Curriculum Opportunities

Bachelor of Science in Bioengineering

Stanford University

Source: snsf.stanford.edu

Authors: Siavash Ahrar, Veronica R. Brand, Drew Endy, Kara H. Rogers, & Ross D. Venook

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Last Update: 20 March 2019
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Drs. Ahrar and Brand serve as **Science and Engineering Education Fellows** in the Department of Bioengineering. They work closely with faculty and lecturers under the guidance of the department's Undergraduate Curriculum Committee and with support from the office of the Vice Provost for Teaching and Learning. Ahrar and Brand's work is focused on realizing an active, effective, inclusive, and accessible curriculum for the discipline of Bioengineering.

PREFACE

Bioengineering as an academic practice has developed and renewed itself in three waves, each of which remain important and contribute to human flourishing. Historically, the first wave was powered by the application of established engineering methods to human needs, primarily found in the medical clinic or agricultural field. The second wave arose in response to the emergence of tools for collecting overwhelming amounts of quantitative data about living systems, initially DNA sequence-based but increasingly diverse in type and complexity. The third wave began with the invention of genetic engineering a generation ago and is accelerating towards realizing operational mastery of living matter from both an analytical and synthetic perspective.

Both the Stanford Bioengineering department and our undergraduate major arose after the emergence of all three waves. We started fresh in terms of organization and activities. We celebrate all opportunities to contribute to human flourishing, regardless of precedent or extrinsic framing. We both believe and can articulate that “enough is known already of the diverse applications of biology for us to recognize the birth of a coherent body of technique, which we call bioengineering... Whether living matter is used for manufacturing, medicine, music, or other purposes, the structure of bioengineering practice is much the same.”[1] Additionally and practically, we can clearly describe how the physical materials bioengineers encounter and work with, biology, are qualitatively distinct from other types of materials now mastered by other fields of engineering, as is needed to frame a distinct discipline and resulting course of study.

Practically, our bioengineering major was approved in perpetuity by the Stanford University Faculty Senate in 2015. We engage ~100 students per year in our introductory courses. Each course is led by idiosyncratic faculty working alone or in pairs, all of whom enjoy full autonomy in terms of both course content and delivery. Our thriving department culture and collegiality allow us to coordinate and make adjustments over time. Collectively, our current offerings arose by implementing a third set of improvements to a second major revision of our program (i.e., 'version 2c'). Having just completed the analysis presented herein, the first of its kind, we anticipate the next six months will involve discussions regarding whether a third revision to the program is warranted and practical (i.e., 'version 3').

Biology as both a science and technology is profound and practically powerful. Working together to learn how to best advance the practice of bioengineering education should be a collective endeavour. What should bioengineers learn? How should they learn it? Who should have the option of becoming a bioengineer? To enable all to learn and work together we are making all of our materials and analysis herein freely available. We ask only that you share your thoughts, critiques, suggestions, and wishes, in return. Let's be great together!

BIOE.44, *Fundamentals for Engineering Biology Lab*

Student course companion link, (Page: 22 - 27)

Instructor opportunities for consideration link, (Page: 28 - 30)

Lab, 4 units

BIOE.101, *Systems Biology*

Student course companion link, (Page: 31 - 38)

Instructor opportunities for consideration link, (Page: 40 - 42)

Lecture, 3 units

BIOE.42, *Physical Biology*

Student course companion link, (Page: 43 - 50)

Instructor opportunities for consideration link, (Page: 51 - 53)

Lecture, 4 units

BIOE.123, *Bioengineering System Prototyping Lab*

Student course companion link, (Page: 54 - 61)

Instructor opportunities for consideration link, (Page: 62 - 65)

Lab, 4 units

BIOE.103, *Systems Physiology and Design*

Student Course Companion link, (Page: 66 - 78)

Instructor Opportunities for Consideration link, (Page: 79 - 81)

Lecture, 4 units

BIOE.131, *Ethics in Bioengineering*

Student Course Companion link, (Page: 82 - 89)

Instructor Opportunities for Consideration link, (Page: 90 -93)

Lecture, 3 units

BIOE.141A/B, *Senior Capstone Design*

Student Course Companion link, (Page: 94 - 102)

Instructor Opportunities for Consideration link, (Page: 103 - 104)

Lecture and Lab, 4/4 units

Be your own bioengineer!

Self assess in class

Course assess post class