Northwestern | CENTER FOR SYNTHETIC BIOLOGY

Deconstructing Synthetic Biology – Biotechnology Case Studies Across Scales

Final Project: Deconstructing a Synthetic Biology Technology that Addresses a Global Challenge

Assessment: 30% of final grade.

Prompt: Throughout this course we are developing an understanding of the 'scales' framework for deconstructing a synthetic biology technology into the components that must work together to achieve an engineering goal. This final project will give you an opportunity to apply this framework in more depth. The purpose is to demonstrate your understanding of the importance of synthetic biology technologies for addressing global challenges, the scales of synthetic biology technologies and the challenges that arise between these scales, and your ability to articulate these concepts using literature support. You will prepare a presentation that represents your analysis and a brief digest presentation of your creation to the class. You are encouraged to be as creative as you wish while thoroughly discussing the key elements below in your presentation. Clarity of your communication is also important.

Start by picking a synthetic biology technology that you are interested in that addresses a global challenge–it could be a technology that you explored in earlier assignments, a focus of your research, or a topic you want to learn about, but it should not be a topic we have gone over in depth in class, such as bacterial nitrogen fixation, CAR-T cell therapies and CRISPR gene drives. Note: this technology may not yet exist (i.e., it could be a new technology idea that solves a major global challenge that you can deconstruct what is needed to make it a reality). In your creation, you will want to introduce your technology and explain the importance of societal problem or challenge it addresses (i.e., the overall goals of the technology).

Now reflect on this technology and use the scales framework to deconstruct it. What are the biological functions within the molecular, network, cell/cell-free systems, and biological communities scales needed for this technology? Analyze how engineering choices made at one scale can affect biological function at every other scale – i.e. for the six interfaces between scales (molecular:network, molecular:cell/cell-free systems, molecular:biological communities, network:cell/cell-free systems, network:biological communities, cell/cell-free systems: biological communities) identify challenges at each. What about the societal scale – what are the ethical or societal challenges that arise when thinking about developing or deploying this technology? Finally, which of the molecular, network, cell/cell-free systems, or biological communities scales creates the most challenges when interfaced with the societal scale. Use literature to support your findings. Refer to the rubric at the end of the assignment to see in detail how the project will be evaluated.

Format: Two PowerPoint slide decks: one full-length and one brief for class presentation. For the long format, similar to what we have done in class, your slides could include images, schematics, and text to illustrate your points. Suggested length is 15 slides, though you can use more if necessary. You are welcome to use presenter notes to explain more details behind the slide content if necessary. Organize your slides in a logical flow according to the technology

introduction, the scales and challenges that you will discuss, and references to support your ideas. Please use the PowerPoint template found on Canvas for the final assignment. For your class presentation, you will have **3 minutes** to highlight what your technology is, a few details about two scales you found to be important, one challenge between those two scales that you identified, and your reflection about your project and what you learned in the course. Your brief version should be 3 slides (feel free to use portions of your longer slide deck) that you will use for your in-class presentation (see Submission).

Reflection: Comparing to how you started at the beginning of the course, what do you now know about deconstructing synthetic biology solutions 'along scales'? How has your thinking changed/developed? Include a brief response as a separate document (~1 paragraph).

Note: Make sure to include references to support your ideas.

Submission: Everyone will briefly present their final project topic, a key finding, and their reflection in class. The complete final project (both slide decks and reflection document), including a full deconstruction of your chosen technology (i.e., not just the subset that you will be presenting) is due at the end of the quarter.

Rubric: (72 points maximum): Students will be assessed on introducing the technology and its goals for solving a global challenge; clearly identifying and explaining biological functions within the molecular, network, cell/cell-free systems, and cellular communities scales, and including identifying potential challenges at the societal scale; and seven separate challenges that arise (or justifications why challenges do not arise) at the interfaces of molecular:network, molecular:cell/cell-free systems, molecular:biological communities, network:cell/cell-free systems, network:biological communities, cell/cell-free systems:biological communities scales and a key interface between the societal scale and one of the other scales. More points are given for more details – i.e. explaining why a particular function is needed for the technology, how these functions combine together within the technology, why an interface between two scales presents a particular challenge for this technology (or not), and using details and literature citations to support your reasoning. Additional points are given for the clarity of the presentation (either prose or images).

Scales	**(0 pts)** **Missing** *Criterion is missing*	**(1 pt)** **Beginning** *Little or no evidence of outcome*	**(2pts)** **Developing** *Beginning of/some evidence of outcome*	**(3 pts)** **Accomplished** *Detailed and consistent evidence of outcome*	**(4 pts)** **Mastery** *Expert understanding of evidence and outcome*
Evidence of technology introduction and its goals for solving a global challenge	Introduction is **not** present	• Introduction is present • Lacking a description of its goals for solving a global challenge • Not supported with appropriate evidence from literature	• Introduction is present • A description of its goals for solving a global challenge is present • Not supported with appropriate evidence from literature	• Introduction is present • A description of its goals for solving a global challenge is present • Supported with appropriate evidence from literature (i.e. citations for the need for a solution to this challenge)	• Introduction is present • A description of its goals for solving a global challenge is present • Supported with appropriate evidence from literature with **multiple** sources (i.e. citations for the need for a solution to this challenge)
Evidence of identifying a biological function at the **molecular scale** important for that application.	Scale is **not** mentioned	• Scale is mentioned • Biological function is not clearly articulated • No explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Some explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with appropriate evidence from literature (i.e. specific molecule/cell strain name with literature reference)	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with extensive evidence from literature (**multiple** sources) • Sophisticated communication of concepts at this scale needed for the technology
Evidence of identifying a biological function at the **network** scale important for that application.	Scale is **not** mentioned	• Scale is mentioned • Biological function is not clearly articulated • No explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Some explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with appropriate evidence from literature (i.e. specific molecule/cell strain name with literature reference)	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with extensive evidence from literature (**multiple** sources) • Sophisticated communication of concepts at this scale needed for the technology
Evidence of identifying a biological function at the **cell/cell-free system** scale important for that application.	Scale is **not** mentioned	• Scale is mentioned • Biological function is not clearly articulated • No explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Some explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with appropriate evidence from literature (i.e. specific molecule/cell strain name with literature reference)	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with extensive evidence from literature (**multiple** sources) • Sophisticated communication of concepts at this scale needed for the technology

Evidence of identifying a biological function at the **biological communities** scale important for that application.	Scale is **not** mentioned	• Scale is mentioned • Biological function is not clearly articulated • No explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Some explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with appropriate evidence from literature (i.e. specific molecule/cell strain name with literature reference)	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with extensive evidence from literature (**multiple** sources) • Sophisticated communication of concepts at this scale needed for the technology
Evidence of identifying a challenge at the **societal** scale important for that application.	Scale is **not** mentioned	• Scale is mentioned • Biological function is not clearly articulated • No explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Some explanation of why the function is needed • Scale and function are not supported with appropriate evidence from literature	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with appropriate evidence from literature (i.e. specific molecule/cell strain name with literature reference)	• Scale is mentioned • Biological function is clearly articulated • Detailed explanation of why the function is needed • Scale and function are supported with extensive evidence from literature (**multiple** sources) • Sophisticated communication of concepts at this scale needed for the technology

Challenges	**(0 pts)** **Missing** *Criterion is missing*	**(1 pt)** **Beginning** *Little or no evidence of outcome*	**(2pts)** **Developing** *Beginning of/some evidence of outcome*	**(3 pts)** **Accomplished** *Detailed and consistent evidence of outcome*	**(4 pts)** **Mastery** *Expert understanding of evidence and outcome*
Evidence of describing a challenge (or justified lack of a challenge) between the **molecular: network** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology
Evidence of describing a challenge (or justified lack of a challenge) between the **molecular: cell/cell-free systems** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology

Evidence of describing a challenge (or justified lack of a challenge) between the **molecular: biological communities** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology
Evidence of describing a challenge (or justified lack of a challenge) between the **network: cell/cell-free systems** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology
Evidence of describing a challenge (or justified lack of a challenge) between the **network: biological communities** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology
Evidence of describing a challenge (or justified lack of a challenge) between the **cell/cell-free systems: biological communities** scales.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology
Evidence of describing a challenge (or justified lack of a challenge) between the **societal scale and one of the other scales of your choice**.	Interface and challenge are **not** mentioned	• Interface is mentioned • Challenge is not clearly articulated	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are not supported with appropriate evidence from literature	• Interface is mentioned • Challenge is clearly articulated • Interface and challenge are supported with appropriate evidence from literature	• Interface is mentioned • Challenge (or lack thereof) is clearly articulated • Interface and challenge (or lack thereof) are supported with **multiple** appropriate evidence from literature • Sophisticated communication of concepts related to this interface/challenge for the technology

Presentation	(6 pt) Needs Work	(12 pts) Proficient	(18 pts) Excellent
Clarity of communication	• Writing is unclear • Descriptions are poorly constructed • Language/image use is at times inappropriate • Prose (if present) is choppy or inconsistent, and contains many errors in grammar, spelling, citations and formatting	• Descriptions are generally clear, but have some flaws (wordy, contain run-on sentences, incomplete thoughts, etc.) • Conveys minor errors in grammar spelling, citations, formatting	• Descriptions are clear, concise and compelling • Language/images display nuance and convey ideas clearly • No errors in grammar, spelling, citations, formatting

Reflection	(0 pts) Absent	(2 pts) Present
Reflection included	• Reflection absent	• Reflection present