Scope and Sequence



BioTechBuilder APPLICATIONS

TOPIC: BIOMANUFACTURING
TOPIC: SYNTHETIC BIOLOGY

This module introduces students to industrial applications and professional practices that enable commercialization of biotechnologies.



TOPIC: BIOMANUFACTURING

This topic explores the life cycle for production and manufacturing of bioproducts from upstream processing to downstream processing. What it means to be GMP compliant and differences between Quality Assurance and Quality Control is emphasized. The labs include seed train process, viability assays, and product activity tests while students document every step using batch production records.

LESSON	LAB ACTIVITY	ADDITIONAL RESOURCES
1. Biomanufacturing Overview	Prepare Starter Culture	Slides, Set-up, Homework
Students investigate commercially available bioproducts and discuss their benefits and importance in the current market.		
2. Fermentation I	Expand Seed Train to 10 ml	Slides
Students learn about the stepwise process for growing large cell volumes, and then expand a cell stock into a 10 ml culture.		
3. Fermentation II	Concentration vs Viability	Slides, Homework, Batch Record
Students are introduced to Good Manufacturing Practices and Batch Records.		
4. Fermentation III	Cell Expansion with VCD	Slides
Students calculate the # and % of viable cells, then seed a 100 ml culture with a known number of viable cells.		
5. Fermentation IV	TCD and Viability	Slides, Homework, Batch Record
Students calculate cell viability and are introduced to hemocytometer-based cell counting.		
6. Fermentation V	Hemocytometer Counts	Slides, Quiz Review
Using an online simulation, students perform hemocytometer-based cell counting and data analysis.		
7. Quiz I	Assessment	Slides, Answer Key
Students use sample data to calculate cell concentration and viability in a microbial and mammalian cell sample.		
8. Lab Practical I	Assessment	Slides, Set-Up, Answer Key
Students use OD600 data to determine TCD and VCD, then determine viable cells needed for the next expansion culture.		

TOPIC: BIOMANUFACTURING

LESSON	LAB ACTIVITY	ADDITIONAL RESOURCES
9. Measuring Bioproduct I	Overnight Induced Culture	Slides, Homework, Batch Record
Students induce a bioproduct (β-galactosidase) and learn about SOPs for Quality Assurance.		
10. Measuring Bioproduct II	Solutions and Batch Records	Slides, Homework
Students follow SOP to make solutions for an enzyme activity assay, record their work in BPR forms, and distinguish Quality Assurance and Quality Control.		
11. Measuring Bioproduct III	Activity Measurement	Slides, Batch Record
Students measure the activity of the bioproduct to ensure the scaled-up *E. coli* cells are behaving as expected.		
12. Industrial Fermentation I	Bioreactor Simulation	Slides, Homework
Students learn bioreactor types and parameters to monitor, then use an online simulation of a 2000 liter bioreactor.		
13. Industrial Fermentation II	Writing an SOP	Slides, Quiz Review
Students develop an SOP as an in-class activity then learn about biosafety cabinet form and function.		
14. Quiz II	Assessment	Slides, Answer Key
Students demonstrate their knowledge and understanding of GMP regulation, QA, and QC.		
15. Lab Practical II	Assessment	Slides, Set-Up, Answer Key
Students identify the errors in Batch Record form, SOP, and a calculation.		
16. Downstream Processing I	Separation Simulation	Slides, Homework
Students consider extracellular vs intracellular localization, and simulate harvesting techniques based on this property.		
17. Downstream Processing II	Purifying Lysozyme	Slides, Set-Up
Students learn about chemical, mechanical, and temperature-dependent cell disruption techniques.		
18. Downstream Processing III	Lysozyme Activity Assay	Slides
Students learn about protein purification methods including chromatography and tangential flow filtration.		
19. Downstream Processing IV	Gowning for Cleanroom	Slides, Quiz Review
Students consider product formulation and packing, cleanrooms to prevent contamination, and protein purification data.		
20. Quiz III	Assessment	Slides, Answer Key
Students are asked about downstream processing from lysate preparation to purification to concentration and packaging.		
21. Lab Practical III	Assessment	Slides, Answer Key
Students must trace the production of a novel product and troubleshoot errors in workflow.		

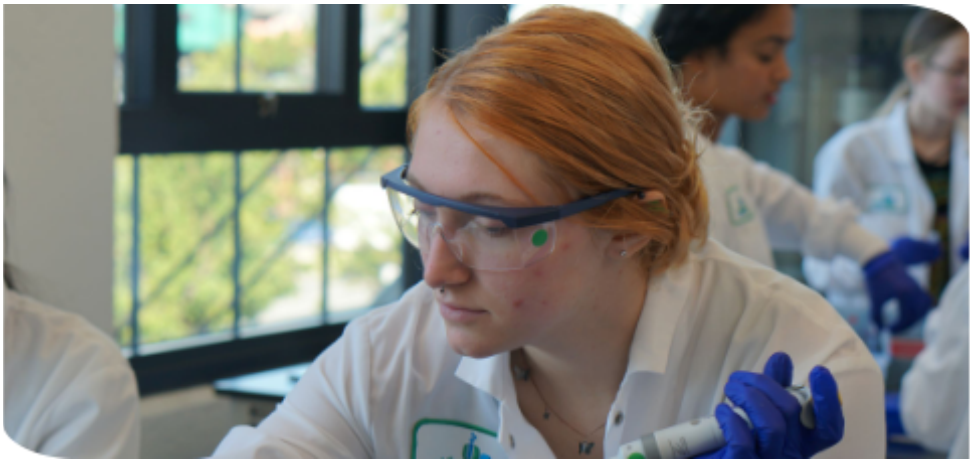
TOPIC: SYNTHETIC BIOLOGY

This topic allows students to explore each stage of the engineering "Design-Build-Test-Learn" (DBTL) cycle, first using existing BioBuilder kits and then through the application of BioBuilder's abstraction hierarchy to design a novel biotechnology of their own. Lab skills focus on microbial culturing, transformation of both bacteria and yeast, and measurement of cellular outputs.

LESSON	LAB ACTIVITY	ADDITIONAL RESOURCES
1. Synthetic Biology Overview	Streaking Isolated Colonies	Slides, Homework
Students are introduced to the Design-Build-Test-Learn cycle and an abstraction hierarchy for biodesign.		
2. Design Cycle I	Growing Overnight Cultures	Slides, Homework
Students consider the design process that invented a banana-smelling bacteria.		
3. Design Cycle II	Growing Larger Volumes	Slides, Homework
Students examine the genetic elements that were engineered to control banana-scent production.		
4. Design Cycle III	Smell and Density Data	Slides, Quiz Review
Students discuss and collect qualitative and quantitative data and consider appropriate graphical representation.		
5. Quiz I	Assessment	Slides, Answer Key
Students apply the design process to specify a plastic eating bacteria and design a preliminary experiment.		
6. Build Cycle I	Streaking Isolated Colonies	Slides, Homework
Students consider the design process that invented a color-generating bacteria, then streak two strains on solid media.		
7. Build Cycle II	Solution Preparation	Slides
Students explore the concept of cellular chassis, then prepare solutions for bacterial transformation.		
8. Build Cycle III	Transformation	Slides, Homework
Students discuss positive and negative controls, then transform two plasmids into two host strains.		
9. Build Cycle IV	Patching Cells	Slides, Evaluation Rubric
Students analyze transformation data and develop protocol variation to improve results.		
10. Lab Practical I	Assessment	Slides, Rubric, Set-Up
Students repeat bacterial transformation under different experimental conditions.		

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LESSON	LAB ACTIVITY	ADDITIONAL RESOURCES
11. Test Cycle I	Streaking Isolated Colonies	Slides, Set Up, Homework
Students compare bottom-up and top-down design processes, then grow four bioengineered bacterial strains.		
12. Test Cycle II	Growing Overnight Cultures, Making Solutions	Slides
Students use bioinformatics to consider sequence variations, and follow abbreviated Batch Record to prepare solutions.		
13. Test Cycle III	Enzyme Assay	Slides, Set-Up, Quiz Review, Optional Activity
Students are introduced to consensus sequences and measure enzyme activity in four strains.		
14. Quiz II	Assessment	Slides, Answer Key
Students analyze the protocol and data for 10 strains that are variations of the four tested.		
15. Test Cycle IV	Growing Overnight Cultures, Making Solutions	Slides
Students learn basic statistical analysis of data, standardization of DNA parts, and grow triplicate overnight for one bioproduction strain.		
16 & 17. Lab Practical II	Assessment	Slides, Rubric
Over two lab periods, students perform triplicate measurements of enzyme activity, calculation, analysis, and submit lab notebook for evaluation.		
18. Redesign I	Pouring Plates	Slides, Homework
Students consider the engineering approach to reliable performance, then pour YPD petri dishes.		
19. Redesign II	Isolating Yeast Colonies	Slides, Set-Up
Students look at yeast as a model organism, and then streak yeast cells for single colonies.		
20. Redesign III	Reisolating Yeast Colony	Slides, Homework
Students learn about yeast re-engineered to produce Vitamin A, then streak engineered yeast for single colonies.		
21. Lab Practical III	Assessment	Slides, Answer Key
Students develop a PCR protocol for a new gene of interest, and predict the size of the PCR product.		
22. Redesign IV	Yeast Transformation	Slides
Students explore the concept of codon shuffling, then transform white yeast with a codon shuffled copy of a gene.		
23. Quiz III	Assessment	Slides, Answer Key
Students illustrate their understanding of genetic complementation and positive and negative controls.		



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LESSON	CONTENT	ADDITIONAL RESOURCES
24. Biodesign I	Students analyze their yeast transformation experiment and present their data with a slide.	Slides
25. Biodesign II	Students evaluate current synthetic biology products, and consider their role in shaping the development and use of new technologies.	Slides, Role-Playing Activity
26. Biodesign III	Students brainstorm new biotechnology ideas for various topics.	Slides, Collaboration Document
27. Biodesign IV	Students consider historical debates surrounding the ethical application of biotechnology.	Slides, Video Transcript
28. Final Project	Students present their biotechnology ideas using abstraction from systems to devices then parts.	Slides