Module 4: Plant Growth, Management & Pest Control
Optional Extended Learning: Activity Worksheet

Metabolic Modeling for Root Microbiomes - Modeling Microbial Cooperation Simulation
Grouping: Pairs or small groups (3–4)
Time: 25-30 minutes

Materials:
- Printed microbial “trait cards” (see below)
- Activity worksheet with consortium design template
- Markers or colored pencils
- Access to lesson notes or optional slides on KBase and metabolic modeling
- Chart paper or digital drawing tool (e.g., Jamboard, Lucidchart, Canva)

Objective:
To simulate the process of designing a beneficial root microbiome that outcompetes a pathogen using basic metabolic modeling concepts. Students will apply systems thinking to balance nutrient needs, cooperation, and defense traits in a simplified root ecosystem.

Your Task:
Design a theoretical root microbiome “dream team” of 3–4 microbes that support plant growth and suppress disease. You will:
- Analyze trait cards showing what each microbe consumes, produces, and defends against
- Select microbes that cooperate well together (e.g., sharing amino acids or vitamins)
- Avoid conflicts (e.g., microbes that compete for the same carbon source)
- Include at least one member with pathogen-blocking traits.
- Justify your design using evidence from the cards

Skills You’ll Use:
- Systems thinking
- Reading scientific data
- Design reasoning
- Collaboration and justification

Instructions:
- Cut out or examine the microbe trait cards below
- Use the template on the next page to draw your microbial network
- Label arrows to show who gives and receives what
- Complete the reflection questions

Microbe Trait Cards

Microbe Name	Takes In	Produces	Special Trait
Nitrofex	Ammonia	Nitrate, Vitamins	Boosts nitrogen availability
SideroShield	Iron	Siderophores (Microbial compounds that tightly bind and scavenge iron)	Starves fungal pathogens
AminoMate	Sugars	Amino acids	Feeds neighboring

			microbes
SporeBlock	Glucose, Oxygen	Antifungal compounds	Protects roots from fungal disease
CarbonCraver	Glucose, Fructose	Nothing shared	Aggressive competitor
BioBridge	CO2, Organic acids	B-vitamins, Enzymes	Enhances microbe communication
RootBuddy	Sucrose, Oxygen	Hormone precursors	Stimulates plant root growth
PathoStopper	Sugars, Iron	Antibiotics	Suppresses bacterial pathogens

Pathogen Card

Pathogen Name: RootRot Fungus	
Takes in: Sugars, Iron	Produces: Spores
Special Trait: Infects roots, reduces plant growth	

Design Template:

- Draw 3-4 microbe icons
- Use arrows to show nutrient / metabolite exchange
- Label what each arrow represents
- Circle any microbes competing for the same input
- Add a pathogen icon and revise the team layout as needed

Justify Your Design:

1. What roles do your chosen microbes play in plant defense or growth?

2. How do they cooperate?

3. What did you do to avoid harmful competition?

4. How did you revise your team to suppress or block the pathogen?

Reflection Prompt:

- What was your biggest challenge in balancing cooperation vs. competition?
- Which microbe would you say was most essential, and why?
- How might designing microbial communities like this help farmers reduce pesticide use?

Grading Rubric
Use the following expectations rubric to evaluate short-response, short-essay, and design-based responses:

Criteria	Exemplary (4 pts)	Proficient (2 pts)	Developing (2 pts)	Beginner (1 pt)
Microbial Selection & Accuracy (Microbe choices match task requirements; avoidance of direct competition; inclusion of pathogen-suppressor)	Selected 3–4 microbes with strong reasoning; no resource conflict; clear inclusion of pathogen-suppressor; biologically sound choices.	3–4 microbes selected; some reasoning present; minor overlap in traits or unclear logic.	Fewer than 3 microbes or flawed selection; competition or redundancy not addressed.	Microbes chosen with no rationale; major misunderstandings of traits or roles.
Metabolic Interaction Diagram (Nutrient exchange arrows, labeling, logic)	Diagram is clear, labeled, and shows appropriate exchanges; all arrows and functions correctly represented.	Diagram present and mostly labeled; nutrient exchange mostly logical.	Diagram lacks clarity or missing arrows/labels; exchange logic weak or unclear.	Diagram missing or incoherent; no meaningful interactions shown.
Design Justification & Systems Thinking (Explanation of roles, cooperation, and trade-offs)	Thoughtful justification of each microbe; demonstrates understanding of metabolic cooperation and trade-offs; strong systems perspective.	General explanation of microbe functions and teamwork; some systems-level thinking.	Vague explanation or unclear reasoning; minimal discussion of cooperation or trade-offs.	Justification missing or completely off-topic; no evidence of systems thinking.
Reflection & Real-World Connection (Response to prompts about pesticide reduction and design choices)	Reflection shows deep insight into how microbiomes reduce pesticide use; clearly connects design to real-world challenges.	Reflection responds to prompts with general understanding of microbial benefits.	Response is superficial or incomplete; limited understanding of real-world relevance.	Reflection missing or shows little to no understanding.
Communication & Effort (Clarity, organization, creativity, completeness)	Work is neat, highly organized, and shows creativity and care; all sections	Work is organized and mostly complete; some creativity or	Work is somewhat disorganized or incomplete; little effort to visualize	Work is sloppy, missing sections, or very difficult to interpret.

	completed.	visual effort shown.	or explain.	