Lesson B
Grouping: Pairs or small groups (3–4)
Time: 25-30 minutes

Materials:
- One worksheet per student (or one per pair) — this page.
- ΔCO_2-eq quick reference (post on board or handout):
- Pens / markers; whiteboard or chart paper for class synthesis; sticky notes (optional).

Objective:
Students will learn to use ΔCO_2-eq values to compare waste-to-resource pathways. They will evaluate each option across five trade-off criteria (Energy Input, Cost/Complexity, Processing Time, Main Benefits, Key Limitations) and decide which pathway is best for a cafeteria-scale scenario. Students will justify their choice using both carbon math and one practical criterion.

Instructions:
1. Assign pathways: Each group member takes 1–2 pathways. Skim the ΔCO_2-eq quick reference and jot 2–3 quick notes.
2. Group synthesis: In groups of 3–4, combine notes to complete the full table (all five pathways, one row each). Keep notes short — 1–2 points per cell.
3. Decision: As a group, rank the pathways and choose the best option for the cafeteria.
4. Justification: Prepare a 1-minute defense citing:
    a. ΔCO_2-eq carbon math
    b. One practical criterion (cost, space, time, social acceptability).
5. Share out: Each group posts a sticky note with their top choice and a 2-line justification. The teacher compiles results and leads a short discussion.

Provided Data (Quick Reference)

Pathway	ΔCO_2-eq (g/kg)	Key Process Gas	Conversion Factor (to CO_2e)	Notes
Landfill	+500	CH_4 release	$1 \text{ g } CH_4 = 28 \text{ g } CO_2e$	High emissions from methane
Composting	−100	$CO_2 + N_2O$	$1 \text{ g } N_2O = 265 \text{ g } CO_2e$	Low-tech, soil benefits
Bokashi/Digester	−200	Captured CH_4	Avoided 28 g CO_2e per g CH_4	Produces biogas
Biochar Pyrolysis	−450	Carbon storage	Long-term sequestration	Requires high heat
Insect Bioconversion	−300	Avoided feed emissions	—	Produces animal feed

Your Task:

Your task is to compare, rank, and justify. Work together to complete the table below, then decide on the single best option for the cafeteria.

Step 1: Assign Pathways

Each group member takes 1–2 pathways. Use the quick reference to jot short notes (inputs, outputs, ΔCO_2-eq, one strength, one limitation).

Pathway	Energy Input / ΔCO_2-eq	Cost / Complexity	Time (processing)	Main Benefits	Key Limitations
Landfill	**+500 g/kg** (highest emissions)	Very low (waste hauling included)	Immediate removal	Fast, easy disposal; no setup needed	Highest climate cost (methane); no resource recovery
Composting	**−100 g/kg** (modest benefit)	Low (bins, turning, training)	2–4 months	Returns nutrients to soil; simple setup	Needs space and labor; slower process
Bokashi / Digester	**−200 g/kg** (moderate benefit)	Low–medium (sealed bins or digester pumps)	2–6 weeks	Works indoors; handles diverse waste; produces soil amendment or biogas	Requires airtight containers/equipment; some odors
Biochar Pyrolysis	**−450 g/kg** (highest benefit here)	Moderate–high (specialized unit, skilled operation)	Continuous if steady feedstock	Locks carbon long-term; creates soil-enhancing char + syngas energy	High setup cost; limited to dry biomass
Insect Bioconversion	**−300 g/kg** (strong benefit)	Medium (larvae production, climate control optional)	Days to weeks	Produces protein-rich animal feed + frass fertilizer	Needs consistent monitoring; not all wastes are suitable

Step 2: Rank and Decide

As a group, rank all 5 pathways (1 = best, 5 = worst).

1. ___Biochar Pyrolysis_____   2. ___Insect Bioconversion_____

3. ___Bokashi / Digester_____   4. ___Composting_____

5. ___Landfill_____

Step 3: Justification

Justify your top choice with carbon math evidence and one practical factor. (

CO_2-e = Mass of waste (kg) × emission factor (kg CO_2-e/kg waste) Note: Make up a feasible mass of waste (kg) for a week.

1. Carbon math evidence (ΔCO$_2$-eq) per week:
Biochar avoids about −450 g CO₂-eq per kg of food waste. For a cafeteria generating 50 kg/day, that equals 22.5 kg CO₂-eq saved daily, compared to +25 kg/day from landfilling.

2. One practical factor (cost, space, time, etc.):
Although setup cost is high, biochar creates a long-term carbon vault and soil improvement, making it the most sustainable pathway if infrastructure is available.

Reflection:
1. Based on your calculations, which pathway gave the largest climate benefit? Why might this pathway not always be the best choice in a real cafeteria?
The pathway that gave the largest climate benefit was biochar, which avoided about −22.5 kg CO₂-eq per day for 50 kg of waste. However, this pathway might not always be the best choice in a real cafeteria because biochar production requires specialized kilns, high heat, and technical expertise. The setup and operating costs are significant, so while the climate math looks strongest, the financial and logistical barriers make it less practical in a school setting.

2. If the school wanted to use two pathways in combination, which pair would you recommend and why? Consider trade-offs such as cost, space, time, and social acceptance.
If the school wanted to use two pathways together, a strong recommendation would be Bokashi plus insect bioconversion. Bokashi is versatile and can handle diverse food scraps such as meat and dairy, while insect bioconversion transforms waste into valuable protein feed and fertilizer. This combination spreads the benefits: Bokashi manages waste efficiently while insects create usable products. Another good combination would be composting with biochar, since compost provides immediate nutrients to plants and biochar offers long-term carbon storage and soil health benefits.

3. Which trade-off (carbon benefit, cost, processing time, or social acceptability) was the hardest to balance in your group's decision? Why?
The hardest trade-off to balance was between social acceptability and the climate math. For example, insect bioconversion scored well in terms of carbon math, but many students thought the idea of using insects to process cafeteria scraps was unappealing or "gross." Similarly, biochar scored highest for carbon reduction but was unrealistic in terms of cost and equipment requirements. These tensions forced groups to weigh technical feasibility and cultural acceptance against environmental benefits.

Skills You'll Use:
- Systems thinking (balancing multiple criteria)
- Reading scientific data (using ΔCO₂-eq values)
- Design & evaluation reasoning (choosing solutions under constraints)
- Collaboration & justification (explaining choices with evidence)

Carbon-math worked example:
Use this example in class to show how to use the ΔCO₂-eq numbers.
- Scenario: school cafeteria generates 50 kg of food waste per day.
- Landfill: +500 g CO₂-eq/kg → 50 kg × 500 g = 25,000 g = 25 kg CO₂-eq per day

- Compost: −100 g CO_2-eq/kg → 50 kg × (−100 g) = −5,000 g = −5 kg CO_2-eq per day
- Anaerobic digester (optimistic −200 g/kg): 50 kg × (−200 g) = −10,000 g = −10 kg CO_2-eq per day