WASTE NOT, WANT NOT

LESSON PACKET

Table of Contents

© 2025 American Farm Bureau Foundation for Agriculture

LESSON ONE

1 | BIOCHEMISTRY OF WASTE

2 HOUR

National Learning Standards:

HIGH SCHOOL

- CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
- CCSS.ELA-LITERACY.RST.11-12.5: Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

LEARNING OBJECTIVES:

1. Students will explore the impact of different combinations of enzymes and bacteria on the breakdown of waste products.
2. Students will be able to explain how limiting factors and environmental conditions affect the breakdown of waste products.
3. Students will design an experiment gathering data to verify and support a hypothesis about the ways in which limiting factors and/or environmental conditions impact chemical digestion of waste.

KEY TERMS:

Biochemistry   Enzyme   Bacteria   Chemical digestion   Molecules   Substrate
Active site   pH   Acidic, Basic, Neutral

Background Information:

- https://pdb101.rcsb.org/motm/57
- https://www.cpalms.org/Public/PreviewResourceLesson/Preview/131030
- http://brilliantbiologystudent.weebly.com/effect-of-temperature.html
- https://www.cpalms.org/Public/PreviewResourceLesson/Preview/129074

Materials:

- Safety goggles
- Potatoes (cut into small pieces)
- Scalpel (to cut potatoes)
- 3% hydrogen peroxide (H_2O_2)
- Test tubes (and rack)
- Hot water bath
- Ice water bath
- pH paper or test strip
- Ruler
- Marker, pen, or pencil
- Test tube clamps
- Hydrochloric acid (HCl)
- Sodium hydroxide (NaOH)
- Small pebble (e.g., aquarium gravel)

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

1 INTRODUCTION (ANTICIPATORY SET):

10 MIN

1. Students will complete a K-W-L chart for enzyme activity, using relevant vocabulary and activating prior knowledge.
    a. Students should complete the KWL chart "What Does an Enzyme Do"?
    b. Example chart:

What Does an Enzyme Do?		
K - What I know.	W - What I WANT to know.	L - What I have previously learned.

    c. Discuss the details of the activity. Be sure to review the procedure and safety concerns carefully.
    d. Discuss the following:
        - What are other types of enzymes?
        - How can this activity be applied to reducing food waste?
        - Are all enzymes impacted by limiting factors, such as pH and temperature?

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

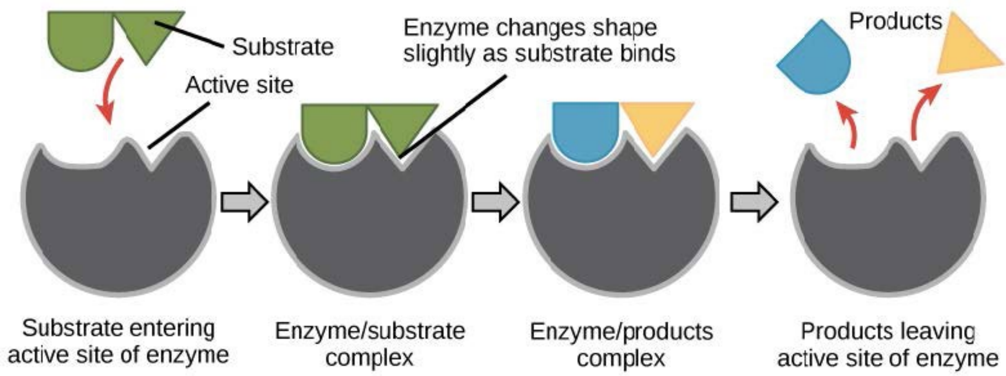
1 INPUT AND MODELING:

Catalysts are substances that speed up chemical reactions. Organic catalysts are called enzymes. Catalase is an enzyme typically found in many plant and animal tissues. Its purpose is to destroy toxic substances that are introduced into cells and to destroy cellular debris.

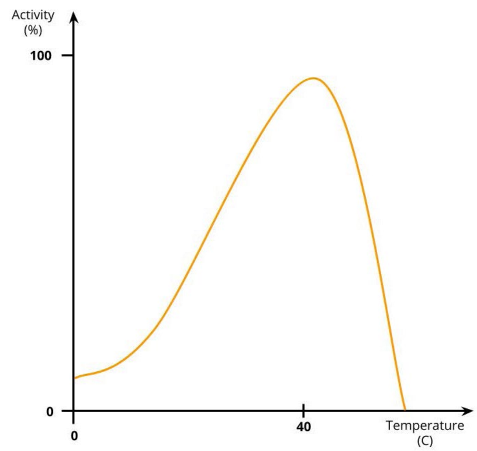
Catalase works using the following reaction:

$2H_2O_2$ (CATALASE) $\rightarrow$ $2H_2O + O_2$

Discuss the image below and its relation to the above reaction.



Discuss the graph.



Prompts include:

- What was being tested?
- What do the X and Y axes labels mean?
- What does the curve show?
- What conclusions could the researcher make?

Enzyme photo from: https://www.khanacademy.org/science/biology/energy-and-enzymes/introduction-toenzymes/a/enzymes-and-the-active-site

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

1 | INDEPENDENT PRACTICE:

2 HOUR

PART A - EXPLORING CATALASE ACTIVITY

1. Using four test tubes, set up the following:
    a. Tube A – 3 cm of H_2O_2 and pebble
    b. Tube B – 3 cm of H_2O_2 and small potato cube
    c. Tube C – 3 cm of H_2O_2 and chopped/mashed potato cube
    d. Tube D – 3 cm of water and chopped/mashed potato cube
2. Observe reactions for approximately five minutes. Bubbles emitted will be oxygen gas. Take numerical data (i.e., height of bubbles) and qualitative data (i.e., any observations about quality of bubbles) during the first minute and during the fifth minute.

PART B - EFFECT OF TEMPERATURE ON AN ENZYME

1. Using three test tubes, set up each tube with 3 cm of potato and five drops of water.
    a. Tube 1 – will be placed in a hot water bath for five minutes.
    b. Tube 2 – will be placed in an ice water bath for five minutes.
    c. Tube 3 – will be placed at room temperature for five minutes.
    d. After five minutes, add approximately 3 cm of H_2O_2 to each test tube.
    e. Wait five additional minutes and record the height of the bubbles in each tube.

PART C - EFFECT OF PH ON ENZYME

1. Using three test tubes, set up each tube with 3 cm of potato.
    a. Tube 1 – add 10 drops of HCl
    b. Tube 2 – add 10 drops of NaOH
    c. Tube 3 – add 10 drops of distilled water
2. Mix the contents of each tube by gently swirling. Test the pH of each tube using pH paper or a test strip. Record this information as acidic, basic, or neutral.
3. Wait two minutes, then add approximately 3 cm of H_2O_2 to each tube.
4. Wait five minutes, then measure and record the height of the bubbles.

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

1 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):

5 MIN

- Students will record three things they learned about how enzymes break down organic material and turn in their paper as they leave the classroom.
- Your ticket out the door today is to write down and turn in three things you learned from today's lesson.
- Have three people share and collect the papers as students walk out the door.

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

1 | ACTIVITY SHEET 1

What Does an Enzyme Do?		
K - What I know.	W - What I WANT to know.	L - What I have previously learned.

© 2025 American Farm Bureau Foundation for Agriculture

BIOCHEMISTRY OF WASTE

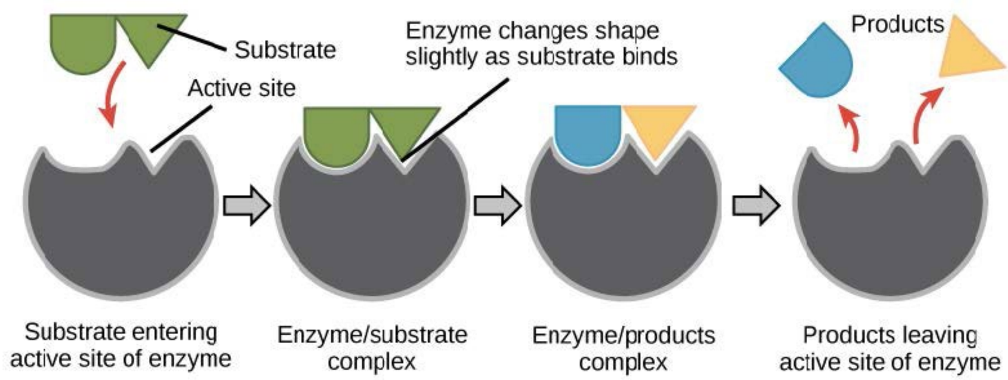
1 | ACTIVITY SHEET 2

CATALASE WORKS USING THE FOLLOWING REACTION:

$2H_2O_2$ (CATALASE) → $2H_2O + O_2$

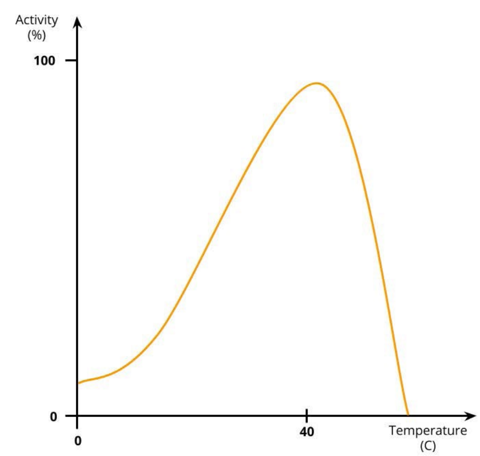
1. What are the reactants of the reaction?
2. What are the products of the reaction?
3. Explain how catalase works using the above reaction.

How does the image below relate to the above reaction?



USE THE GRAPH TO ANSWER THE QUESTIONS THAT FOLLOW:

- What was being tested?
- What do the X and Y axes labels mean?
- What does the curve show?
- What conclusions could the researcher make?
- What is optimum temperature
- (related to enzymes)?
- What is the optimum temperature the enzyme shown on the graph?



http://brilliantbiologystudent.weebly.com/effect-of-temperature.html

© 2025 American Farm Bureau Foundation for Agriculture

LESSON TWO

2 | UNDERSTANDING METHANE DIGESTION

1 HOUR

National Learning Standards:

HIGH SCHOOL

• CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

• CCSS.ELA-LITERACY.RST.11-12.5: Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

LEARNING OBJECTIVES:

1. Students will research the ways in which methane is digested.
2. Students will identify the various methods for methane collection in various settings (e.g., landfills, poop lagoons, wastewater treatment facilities, etc.).
3. Students will explore the creative ways collected methane is recycled and utilized based on location and product need.

KEY TERMS:

Methane digestion Anaerobic digestion Landfill Poop lagoon
Wastewater treatment facility Watt Digestate

Background Information:

The word anaerobic means "in the absence of oxygen." Anaerobic digestion is the process by which organic matter such as animal or food waste is broken down without oxygen by microorganisms. Anaerobic digestion can be used to manage waste or to produce fuels.

Materials:

• Computer with internet access

• Posterboard

• Coloring supplies (pens, markers, crayons, colored pencils)

• Access to a printer (if needed)

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | INTRODUCTION (ANTICIPATORY SET):

5 MIN

1. Show students the "Basic Anaerobic Digester System Flow" diagram.
2. Discuss the basics of anaerobic digestion.
   a. Prompts include:
      - What is anaerobic digestion?
      - What types of material can be digested (digester inputs)?
      - What products can be made from liquid digestate? Solid?
      - How can biogas be used locally or in industry?
      - Why is it necessary to remove H2O, H2S, and CO2 from digester inputs?

---

2 | INPUT AND MODELING:

10 MIN

1. Read about the "Sacramento Case Study."
2. Working in partners, students will write a brief summary.
3. Ask students to share their summary with another group to compare/contrast the information in the case study.

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | INDEPENDENT PRACTICE:

40 MIN

1. Assign students to small research groups to investigate the unique ways that waste products are being developed globally. There are three research groups: landfills, poo lagoons, and wastewater treatment facilities.
2. Students should take one of the locations listed and investigate the ways in which waste is creatively repurposed creatively (see Activity Sheet 3).
3. Students will be developing a poster to be shared with the class in the style of a gallery walk (i.e., students can go to each poster, read the information, and casually discuss with one another).
    a. Items to include on the poster include:
        - Type of facility (landfill, poo lagoon, or wastewater treatment).
        - What are three things that these locations had in common regarding waste repurposing?
        - What are three things that were different about each location's waste repurposing?
        - In general, what are the environmental benefits of waste repurposing at these facilities?
        - In general, what are the economic benefits of waste repurposing at these facilities?

---

2 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):

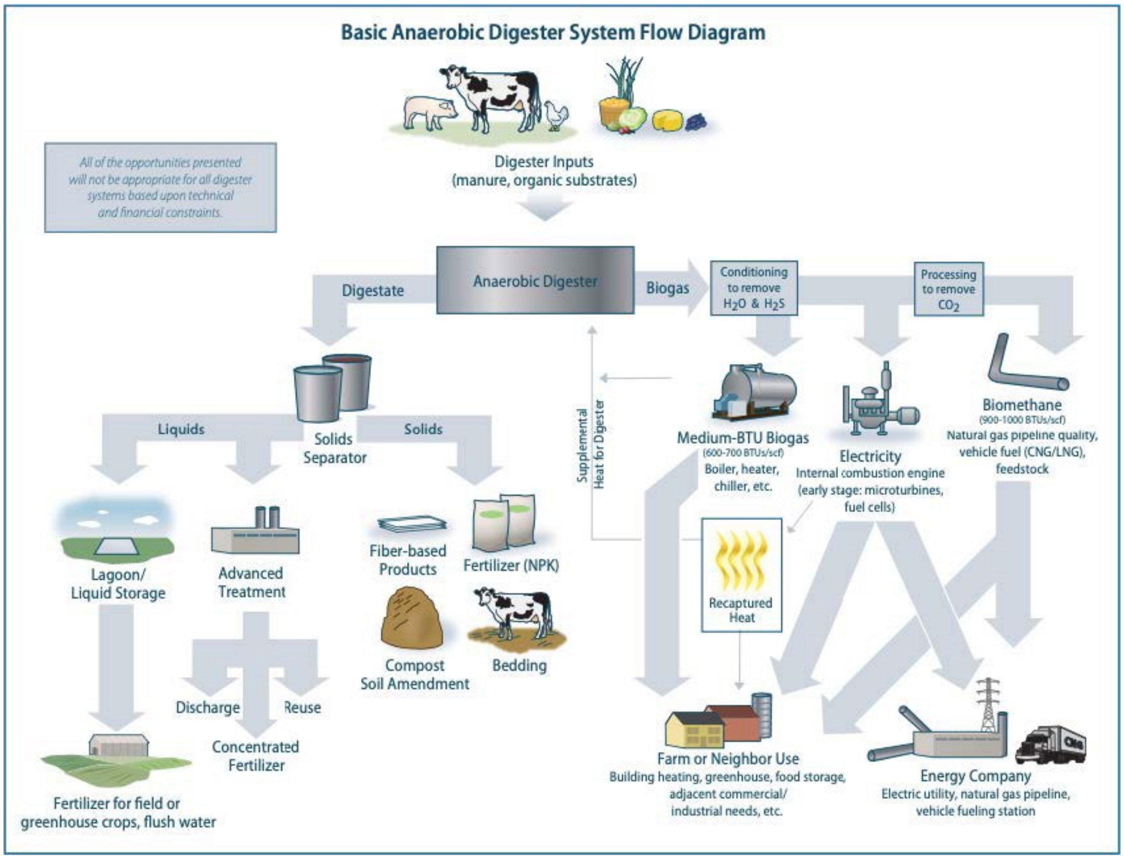
5 MIN

1. After the gallery walk, ask students to include one thing they found most interesting from each of the locations they did NOT research.
    a. What are two things you found most interesting? Please include one element from each of the locations that you did NOT participate in the research for.
2. Collect the papers as students walk out the door.

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | ACTIVITY SHEET 1



https://www.epa.gov/sites/production/files/2014-12/documents/recovering_value_from_waste.pdf

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | ACTIVITY SHEET 2

Case Example: Sacramento[5]

Hailed in 2013 as the largest anaerobic digestion system of its kind in North America, the Sacramento BioDigester started in 2012 with the capacity to process 10,000 tons of food waste per year and was expanded to four times that size in early 2015. The 40,000 ton input capacity includes food waste from area restaurants, food processors, hospitals, international airport, elementary schools and supermarkets.

The 730,000 gallons of biofuel produced annually are used at an onsite fueling station to fuel all of the natural gas trucks of the local trash and recycling collection fleet (24 of 55 trucks), as well as a portion of the city's and county's waste fleets, security cars, California State University Sacramento commuter buses (6 buses), two local catering companies and local school buses (exclusive contract with Sacramento School District's 6-12 buses, backup provider for Elk Grove's 6-12 buses). The waste gas (not clean enough to use for transportation fuel) is used to produce one million kilowatts of electricity which powers both the facility and the fueling station. The digestate is used to produce eight million gallons of organic soils and fertilizers for Sacramento area farms.

The project was undertaken as a partnership between CleanWorld and Atlas Disposal, and began as a proposal for repurposing an under-utilized waste transfer station owned by the county. CleanWorld and Atlas Disposal each received grants from the California Energy Commission and Recycled Market Development Zone loans from CalRecycle to help fund the digester and fueling station.

What is *Carbon Intensity?*

The term carbon intensity refers to the amount of carbon, by weight, emitted per unit of energy consumed.[2] For example, biomethane used as a transportation fuel for agency fleets or to generate electricity results in low carbon intensity because it emits less carbon on a life cycle basis.

Biomethane is also a component of California's Low Carbon Fuel Standard Program, which is intended to lower the greenhouse gas emissions from petroleum-based transportation fuels.[3] Within the Low Carbon Fuel Standard Program the carbon intensity of "High Solids Anaerobic Digestion" is considered negative,[4] meaning that it "displaces" more greenhouse gas emissions than it generates. Fuels such as this are referred to as "carbon negative" and can be produced or purchased by producers of petroleum-based fuels to reduce the overall carbon intensity of their products to levels required by the Low Carbon Fuel Standard.

https://www.ca-ilg.org/sites/main/files/file-attachments/ad_overview_final_draft_5.21.pdf

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | ACTIVITY SHEET 3

LANDFILLS				
Location	Waste product inputs at location?	How is this waste repurposed? What is it being used for?	Enviornmental Benefits	Economic Benefits
Cranberry Creek				
Mostoller				
Star Ridge				
Greentree				
Emerald Park				
North Landfill (Louisiana)				

Design an informational poster using the information obtained in your research to share with the class.

Your poster should include the following:

- Type of facility (i.e., landfill, poo lagoon, or wastewater treatment).
- What are three things that these locations had in common regarding waste repurposing?
- What are three things that were different about each location's waste repurposing?
- In general, what are the environmental benefits of waste repurposing at these facilities?
- In general, what are the economic benefits of waste repurposing at these facilities?

Be ready to share your poster with the class. Make sure all group members contribute to research and development of the final product.

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | ACTIVITY SHEET 3

POO LAGOON				
Location	Waste product inputs at location?	How is this waste repurposed? What is it being used for?	Enviornmental Benefits	Economic Benefits
Duke Energy (North Carolina)				
Toronto Zoo				
Smithfield Foods				
Reinford Farms				
Goodrich Family Farm and Middlebury College (Vermont)				
Amana Farms (Iowa)				

Design an informational poster using the information obtained in your research to share with the class.

Your poster should include the following:

- Type of facility (i.e., landfill, poo lagoon, or wastewater treatment).
- What are three things that these locations had in common regarding waste repurposing?
- What are three things that were different about each location's waste repurposing?
- In general, what are the environmental benefits of waste repurposing at these facilities?
- In general, what are the economic benefits of waste repurposing at these facilities?

Be ready to share your poster with the class. Make sure all group members contribute to research and development of the final product.

© 2025 American Farm Bureau Foundation for Agriculture

UNDERSTANDING METHANE DIGESTION

2 | ACTIVITY SHEET 3

WASTEWATER TREATMENT FACILITIES				
Location	Waste product inputs at location?	How is this waste repurposed? What is it being used for?	Enviornmental Benefits	Economic Benefits
Deer Island Treatment Plant				
Rich Earth Institute				
Xiangyang, China				
Marse-lisborg Wastewa-ter Treat-ment Plant (Denmark)				
Cam-bodian National Biodigester Program				
Metro Vancouver Canada				

Design an informational poster using the information obtained in your research to share with the class.

Your poster should include the following:

- Type of facility (i.e., landfill, poo lagoon, or wastewater treatment).
- What are three things that these locations had in common regarding waste repurposing?
- What are three things that were different about each location's waste repurposing?
- In general, what are the environmental benefits of waste repurposing at these facilities?
- In general, what are the economic benefits of waste repurposing at these facilities?

Be ready to share your poster with the class. Make sure all group members contribute to research and development of the final product.

© 2025 American Farm Bureau Foundation for Agriculture

2 | RESOURCES

Block, Dave. "Future of Disposal: Reducing Greenhouse Gases at Landfills." *BioCycle*, Apr. 2000, pp. 40–46.

Munthit, Ker. "Device Recycles Waste Into Energy." *Milwaukee Journal Sentinel*, 29 May 2019, p. 29A.

Nowak, Rachel. "Make Landfill History." *New Scientist*, 20 Oct. 2007.

Hillary, Rosner. "The Low-Hanging Fruit." *Popular Science*, July 2011.

United States, Congress, "Methane (Biogas) from Anaerobic Digesters." *Methane (Biogas) from Anaerobic Digesters*, Energy Savers, 2014.

https://www.nationalgeographic.com/culture/food/the-plate/2016/07/pig-waste-energy-northcarolina/

https://www.advanceddisposal.com/for-mother-earth/education-zone/landfill-gas-to-energy.aspx

https://www.ca-ilg.org/sites/main/files/file-attachments/ad_overview_final_draft_5.21.pdf

https://www.epa.gov/agstar/how-does-anaerobic-digestion-work

https://www.epa.gov/sites/production/files/2014-12/documents/recovering_value_from_waste.pdf

https://www.sciencedirect.com/science/article/pii/S0973082618302588

https://www.pri.org/stories/2015-04-27/torontos-zoo-plans-turn-its-animal-waste-electricity

https://www.reinfordfarms.com/

https://www.mynbc5.com/article/vermont-farm-turns-manure-into-renewable-energy-poweringmiddlebury-college/28764736

https://www.thegazette.com/2009/08/12/amana-farms-makes-electricity-frommanure#:~:targetText=An%20Amana%20Farms%20project%20to,Amana%20Farms%20anaerobic%20digester%20system.

© 2025 American Farm Bureau Foundation for Agriculture

LESSON THREE

3 | WASTE TRADE-OFFS

2 HOUR

National Learning Standards:

HIGH SCHOOL

• CCSS.ELA-LITERACY.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

• CCSS.ELA-LITERACY.RST.11-12.5: Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

LEARNING OBJECTIVES:

1. Students will explore the trade-offs at the global, national, and local levels of not reusing waste products.

2. Students will develop a mini-business plan comparing traditional MSW management costs/efficiencies and to those with a more unconventional model.

KEY TERMS:

Trade-off   Waste diversion   MSW management   Waste stream
Business plan

Background Information:

https://www.epa.gov/warm/policy-and-program-impact-estimator-materials-recoverygreenhouse-gas-ghg-calculator

Materials:

• Computer with internet access and Microsoft Excel

© 2025 American Farm Bureau Foundation for Agriculture

WASTE TRADE-OFFS

3 INTRODUCTION (ANTICIPATORY SET):

5 MIN

1. Students will record three things they know about MSW management practices in their local community.
    a. What are three things you know about the management practices of municipal solid waste (MSW) in your community?
2. Have three people share their thoughts and collect the papers from each student.

---

3 INPUT MODELING:

15 MIN

1. Direct students to the GHG Calculator for Communities.

    https://www.epa.gov/warm/policy-and-program-impact-estimator-materials-recoverygreenhouse-gas-ghg-calculator

2. Show them the features of the program and discuss what components and features are available.
    a. Be sure to discuss how to read results from the spreadsheet as data is entered.
    b. Be sure to discuss how to interpret results when values are changed.

© 2025 American Farm Bureau Foundation for Agriculture

WASTE TRADE-OFFS

3 | INDEPENDENT PRACTICE:

100 MIN

1. Students will develop a modified business plan to evaluate the trade-offs of using traditional MSW practices versus unconventional models for MSW management.
2. Business plan outlines should include the following:
   a. Business Description
      - Type of business
      - Location
      - Description of services
      - Cost and pricing strategies
   b. Market and Industry Analysis
      - Customer needs
      - Trends in market
      - Competition
      - Labor requirements
   c. Financials
      - Risks
      - Expenses
      - Capital requirements for startup
   d. Timeline of implementation
   e. Project drawings and prototypes
3. Use the GHG Calculator for Communities to provide data to support your MSW modifications included in your business plan.

---

3 | WRAP-UP (REVIEW, ASSESS, CHALLENGE):

10 MIN

1. Have students complete a graphical analysis using Activity Sheet 3.
2. Students will use the pie chart to determine areas that contribute most greatly to the waste stream of Wake County.
3. Based on their research, students should propose possible solutions to reducing waste in this area of concern.

© 2025 American Farm Bureau Foundation for Agriculture

WASTE TRADE-OFFS

3 | ACTIVITY SHEET 1

Business Plan Template

Develop a modified business plan to evaluate the trade-offs of using traditional MSW practices vs. unconventional models for MSW management.

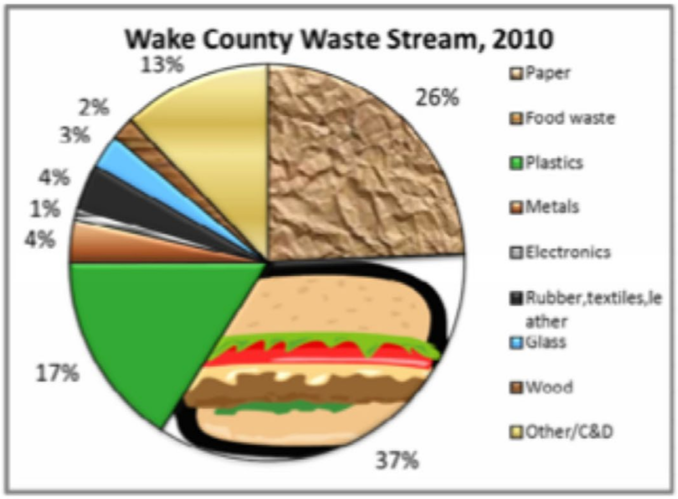
Your business plan should include the following:

A. Business Description
   i. Type of business
   ii. Location
   iii. Description of services
   iv. Cost and pricing strategies
B. Market and Industry Analysis
   i. Customer needs
   ii. Trends in market
   iii. Competition
   iv. Labor requirements
C. Financials
   i. Risks
   ii. Expenses
   iii. Capital requirements for startup
D. Timeline of Implementation
E. Project Drawings and Prototypes

© 2025 American Farm Bureau Foundation for Agriculture

WASTE TRADE-OFFS

3 | ACTIVITY SHEET 2



Source: SCS Engineers; 2011 Wake County Solid Waste Composition Study

Area that contributes to waste stream of Wake County?	Possible Solution for Waste Reduction

WASTE TRADE-OFFS

3 | RESOURCES

https://www.epa.gov/warm/policy-and-program-impact-estimator-materials-recoverygreenhouse-gas-ghg-calculator

https://www.tandfonline.com/doi/full/10.1080/14615517.2013.764633

https://www.waste360.com/collection-and-transfer/analyzing-trade-offs-when-implementingorganics-diversion-program

https://archive.epa.gov/wastes/conserve/tools/fca/web/pdf/fca-hanb.pdf

https://mhs.mcisd.net/ourpages/auto/2013/12/4/53811333/business_plan.pdf

http://compost.css.cornell.edu/MSWFactSheets/msw.fs3.html

https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overviewfacts-and-figures-materials

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935121/

© 2025 American Farm Bureau Foundation for Agriculture

THIS RESOURCE IS BROUGHT TO YOU BY

Purple Plow

American Farm Bureau Foundation for Agriculture®

THANKS TO GENEROUS SUPPORT FROM

Corteva™ agriscience