

## Chapter 8 Microbial Metabolism: The Chemical Crossroads of Life

### Building Your Knowledge

1) What are the two branches of metabolism?

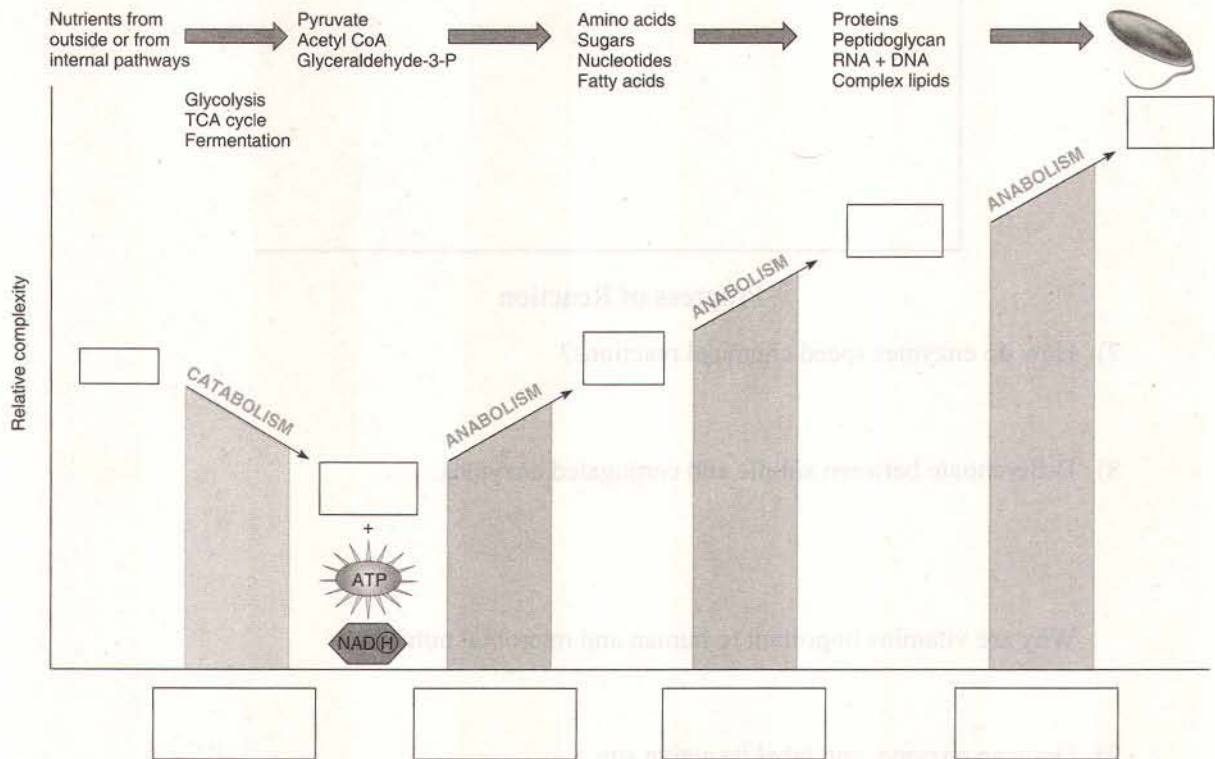
a. \_\_\_\_\_

b. \_\_\_\_\_

Which branch synthesizes large molecules from small subunits? \_\_\_\_\_

Which breaks down large molecules into small subunits? \_\_\_\_\_

2) Fill in the boxes on the following table, using figure 8.1 as a reference.



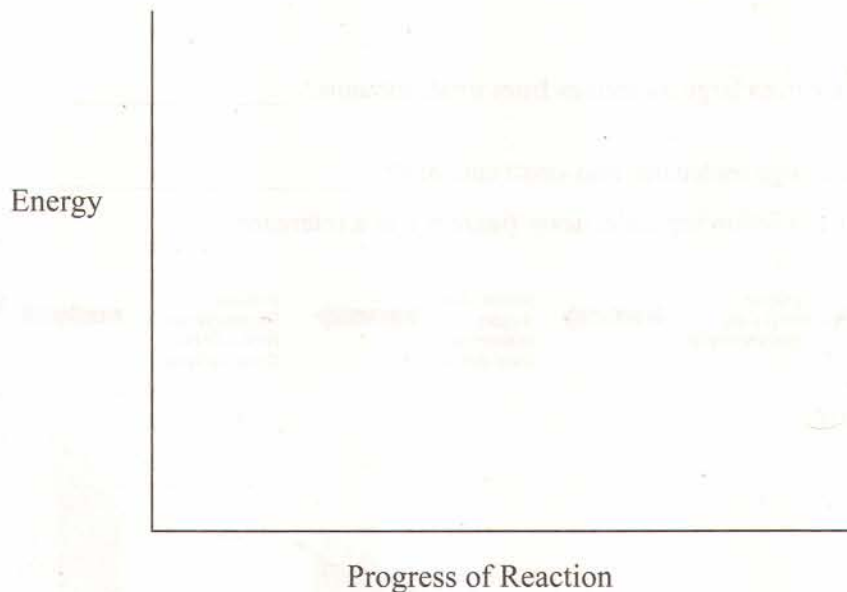
3) What do catalysts do in a chemical reaction?

4) Do enzymes add energy to chemical reactions?

Are they changed by the reaction?

Do they interact with several substrate molecules or one molecule per enzyme (then the enzyme goes away)?

- 5) What are enzymes made up of—proteins, lipids, or sugars? \_\_\_\_\_
- 6) Draw a simple reaction on the following graph. Label the products, reactants, and energy of activation ( $E_a$ ).



- 7) How do enzymes speed chemical reactions?
- 8) Differentiate between simple and conjugated enzymes.

Why are vitamins important to human and microbial nutrition?

- 9) Draw an enzyme, and label its active site.
- 10) Endoenzymes work inside the cell. What are enzymes that work outside a cell called? \_\_\_\_\_
- 11) Enzymes that are present all the time are called \_\_\_\_\_.

Induced enzymes are activated or produced only when \_\_\_\_\_ is present.

12) How are oxidation and reduction related?

If a molecule is reduced, does it gain or lose electrons? \_\_\_\_\_

If a molecule is oxidized, does it gain or lose electrons? \_\_\_\_\_

13) How do enzymes contribute to the disease process caused by *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, and *Clostridium perfringens*?

Organism	Enzyme	Disease
<i>Streptococcus pyogenes</i> ,		
<i>Pseudomonas aeruginosa</i>		
<i>Clostridium perfringens</i>		

14) Differentiate between competitive and noncompetitive inhibition of enzyme activity.

15) What is energy?

Describe 3 forms of energy.

Which forms of energy are most commonly used in cells?

16) How do endergonic and exergonic reactions differ?

Which are typically anabolic? \_\_\_\_\_

Which are typically catabolic? \_\_\_\_\_

17) What is ATP and why is it called “metabolic money”?

18) What are the three coupled pathways of catabolism?

19) Which yields more energy, anaerobic respiration or aerobic respiration?

Which requires oxygen?

20) What is the basic equation for aerobic respiration in microbes?

For every glucose molecule burned, the cell needs \_\_\_\_\_ oxygen molecules, and produces \_\_\_\_\_ molecules of carbon dioxide and \_\_\_\_\_ molecules of water.

21) What is the final electron acceptor in aerobic respiration? \_\_\_\_\_

22) Does the TCA cycle reduce or oxidize glucose? \_\_\_\_\_

23) Glycolysis starts with \_\_\_\_\_ and ends with \_\_\_\_\_.

How many ATP molecules are generated in glycolysis for each molecule of glucose consumed?

24) How many carbons are in a glucose molecule? \_\_\_\_\_

How many carbons are in a pyruvic acid molecule? \_\_\_\_\_

How many pyruvic acid molecules are produced for every glucose molecule metabolized? \_\_\_\_\_

25) The TCA cycle produces \_\_\_\_\_ and \_\_\_\_\_.

Where do NADH molecules go with their electrons?

26) Which stage of glucose metabolism requires a membrane?

Why?

27) How does ATP synthase generate ATP?

28) Draw an ATP synthase molecule, a membrane, the  $H^+$  gradient, the flow of  $H^+$  ions and the formation of ATP from ADP and P.

29) Where and how is water formed during aerobic respiration?

30) Why do we consider pyruvic acid a central part of metabolism?

What can pyruvate be converted to anaerobically?

31) Which form of glucose metabolism yields more energy—anaerobic or aerobic?

Where is most ATP generated?

32) How do fermentation and anaerobic respiration differ?

Which yields more energy per glucose molecule? \_\_\_\_\_

33) How do alcoholic and acidic fermentation differ?

Which fermentation do you want if you are making bread or beer?

Which process sours milk?

Which process do you want if you are making yogurt?

What happens when you work out to the point when your muscles are deprived of oxygen?



34) Amino acids are made up of carbon and nitrogen. Where can cells get the carbon?

What do amino acids combine to form?

35) How are carbohydrates produced?

Where are carbohydrates used in a bacterial cell?

36) How are lipids (fats) made?

What are they used for in a procaryotic cell?

37) Many metabolic pathways are amphibolic. What does this mean?

38) Do precursor molecules (amino acids, sugars, lipids) come from the electron transport chain (Yes or No)?

Where may they come from?

39) If we labeled a glucose molecule's carbon atoms radioactively, so they could be traced, where would the carbons exit the metabolic pathway?

## Organizing Your Knowledge

Part of Aerobic Respiration	Location	Starting Molecules	End Products
glycolysis			
TCA cycle			
Electron transport chain			

Metabolic Mechanism	Pathways Included	Final Electron Acceptor	Products	Microbes Using This
Aerobic respiration				
Anaerobic fermentation				
Anaerobic respiration				

# Microbial Metabolism

PWKUEJYCWDTYZTZFQXAMEQROKRRGRNQ  
LDOKGYXTPSIGITYTGVI AOMMBBNKAA  
RQZUMBWWLKPITNCWCQYSANXFQWNABI  
CZNBNEFZWQJZLGZSDCYMXRKKXKUJDQL  
ZOYSCRVS LGDYPTRDUZKGEUKWEOYLHX  
PWHZDCWGLYCOLYSISBXCCTFHISBEBF  
MOLENACONSTITUTIVESMXNAPKQQDOH  
RTKJOHMF XF WALOZKHLUT AUPBEHKWUL  
VLDWC GTDRKCB CUYFEOZERUEOORAHE  
BKHQTGEJEI VPATCKNDMERADNXLYNAC  
FXXRMYFPWRIDTDXXJADFWETR JYI ZZH  
AQZKJKPWKDAMDJEWYGYQKXDEFNTSUZ  
HJEPQMECOMPETITIVEINHIBITIONMW  
ZYWOUHNTIJHBAMEVEMKLFIZGNEPKEA  
ZODPOEEABCTEVJOZSVNWESNRCAPFVW  
BVZRQKR BGLAFCEBVBSKSRQC DAGCCWA  
MQHIOZGWTWUKQFKFSTTFMOSKUYNQQK  
ULUSVLYLFVYDDBDVYORTIEOJDICXROD  
JCPGHNYOFZPJEDISENTXNCQOZEWHX  
YSBNT RFSWEJB JVS PGXJFTBHP C PC DRO  
CUNRC PWHIVUWTGTQAFYKABAJQADTNW  
ANABOLISMSYLPOLUMDWXTRRATOIWK F  
LYTCACYC LEHJKOLEYRVBIJXAENZ YME  
GADWXQHMFYPI DFP EZJVHOQB AFILCVD  
GV BXLNXISWNWYTDRFLCZNOVVSUKHXN  
UJGIWOCCLANAMPHIBOLICLC OFACTORS  
VXAZLDHHSREDUCTIONFIRSENV OEBAS  
SIOHLEEEWNOMVYEGWDSQOENOEKOTFT  
SNXENDERGONICZTOOMPL LWYFOGPFLO  
O OULOSNZQBQVP I VFLFTOZJKMGJLPGS

- ( ) Energy currency of a cell
- ( ) Cycle that takes in pyruvic acid and converts it to CO<sub>2</sub> and provides NADH for the electron transport chain
- ( ) Metabolic pathways that can be used for anabolism and catabolism
- ( ) Synthesis of large molecules from small ones
- ( ) Breakdown of large molecules into small ones
- ( ) Metallic ions associated with enzymes that are critical to enzyme function
- ( ) Process by which a substance binds to the active site of an enzyme and stops it from binding to its substrate
- ( ) Enzyme that is present in constant concentrations, independent of substrate concentration
- ( ) Chemical reaction that requires the addition of energy
- ( ) The ability to do work
- ( ) Protein catalyst that speeds reactions by lowering the energy of activation
- ( ) Anaerobic process that leads to the production of gases, acids and/or alcohol
- ( ) Pathway that converts glucose to pyruvic acid
- ( ) The addition of water to break bonds
- ( ) Enzyme that is found in higher concentrations when its substrate is present
- ( ) Molecules that are chemically unstable are called
- ( ) Sum of all chemical and physical activities - converting energy to usable forms AND using energy to do work
- ( ) The gaining of electrons
- ( ) Product of *Streptococcus pyogenes* that dissolves blood clots
- ( ) Molecule that enzymes interact with to produce products



## Practicing Your Knowledge

- Enzymes \_\_\_\_\_.
  - add energy to chemical reactions
  - increase the rate of chemical reactions
  - are changed by the chemical reactions they catalyze
  - work on all chemical reactions the same way
- What is the final electron acceptor in aerobic respiration?
  - oxygen
  - carbon dioxide
  - sulfur
  - NADH
- Which of the following factors will change enzyme function?
  - temperature
  - pH
  - substrate concentration
  - all of the above
- An enzyme inhibitor that binds to the site normally used by a substrate and blocks enzyme function is called a \_\_\_\_\_.
  - positive feedback inhibitor
  - competitive inhibitor
  - allosteric inhibitor
  - enzyme inducer
- The energy of activation of a chemical reaction \_\_\_\_\_.
  - increases when enzymes are present
  - decreases when enzymes are present
  - is not changed by enzymes
- Beta-galactosidase is not produced by a cell unless its substrate, lactose, is present. It metabolizes lactose inside the cell. We would describe this as a \_\_\_\_\_.
  - constitutive endoenzyme
  - induced endoenzyme
  - induced exoenzyme
  - constitutive exoenzyme
- Enzyme cofactors are \_\_\_\_\_.
  - generally vitamins and used to support enzyme function
  - generally apoenzymes and work alone
  - generally metallic and activate enzymes
  - not used in bacterial cells; procaryotes have simple enzymes
- If you labeled the carbons of glucose and sent them through aerobic respiration, where and how would the carbons be released?
  - in glycolysis as carbon dioxide
  - in glycolysis as water
  - in the TCA cycle as water
  - in the TCA cycle as carbon dioxide
- Which portion of aerobic respiration requires a membrane to generate energy?
  - glycolysis
  - TCA cycle
  - electron transport chain
  - fermentation
- Which part of central metabolism does NOT contribute precursor molecules to anabolic pathways?
  - TCA cycle
  - electron transport chain
  - glycolysis
  - pyruvic acid
- The loss of electrons is a(n) \_\_\_\_\_.
  - reduction
  - oxidization
  - condensation
  - induction
- The addition of water to chemical bonds \_\_\_\_\_ them and is a \_\_\_\_\_ reaction.
  - creates : anabolic
  - breaks : anabolic
  - creates : catabolic
  - breaks : catabolic

13. Anabolic reactions \_\_\_\_\_ energy and are used in a cell for \_\_\_\_\_ reactions.

- a. release : synthesis
- b. use : degradative
- c. release : degradative
- d. use : synthesis

14. \_\_\_\_\_ is the energy currency of cellular reactions.

- a. DNA
- b. phosphate
- c. ATP
- d. AMP

15. Where is most of the energy (ATP) generated during aerobic respiration?

- a. glycolysis
- b. TCA cycle
- c. fermentation
- d. electron transport chain