Lectures 8 -11: Metabolism

I. The breakdown of glucose to pyruvate

A. Glycolysis ( )

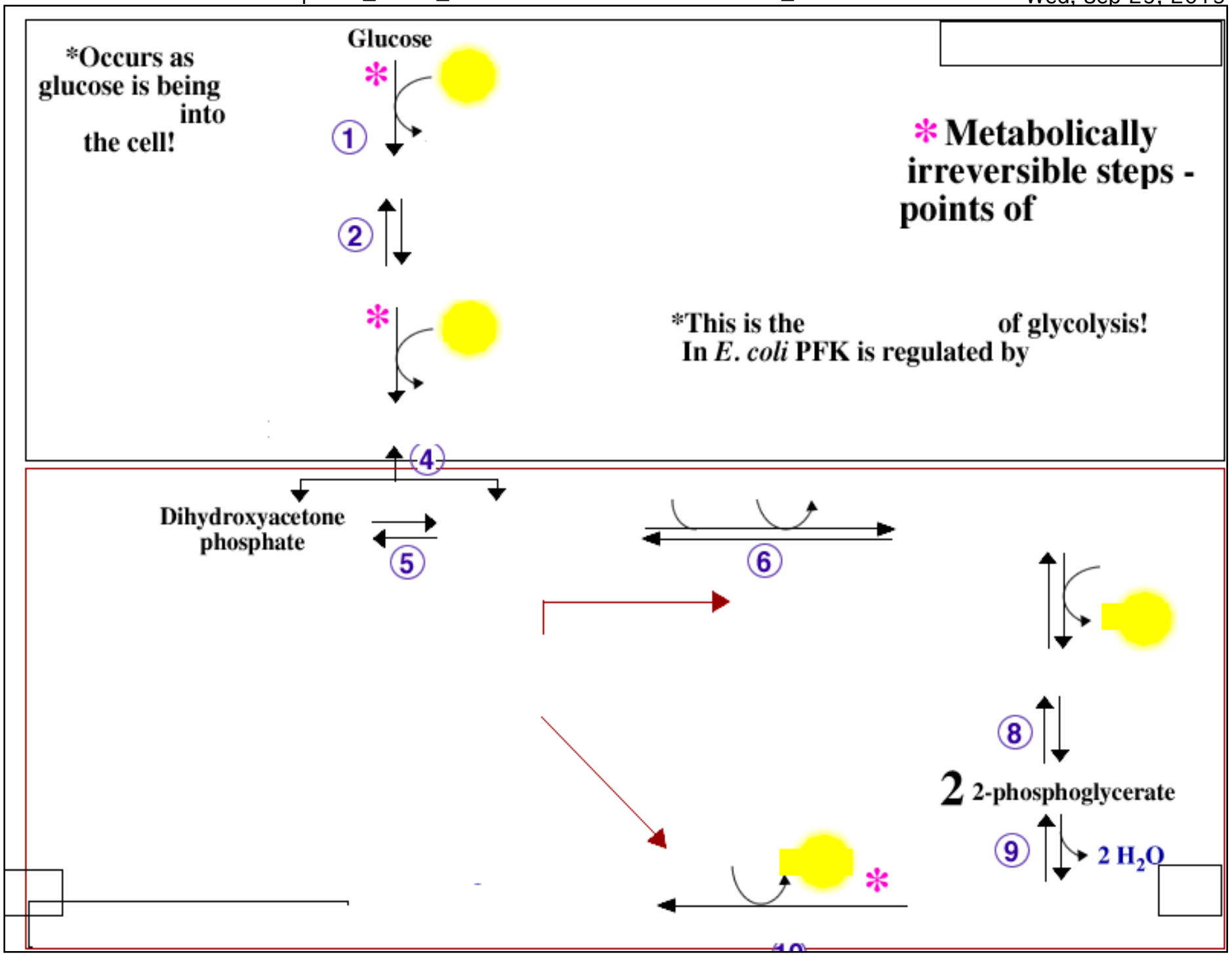
1. Facts

a. Glycolysis is a pathway that occurs in the of both prokaryotic and eukaryotic cells.

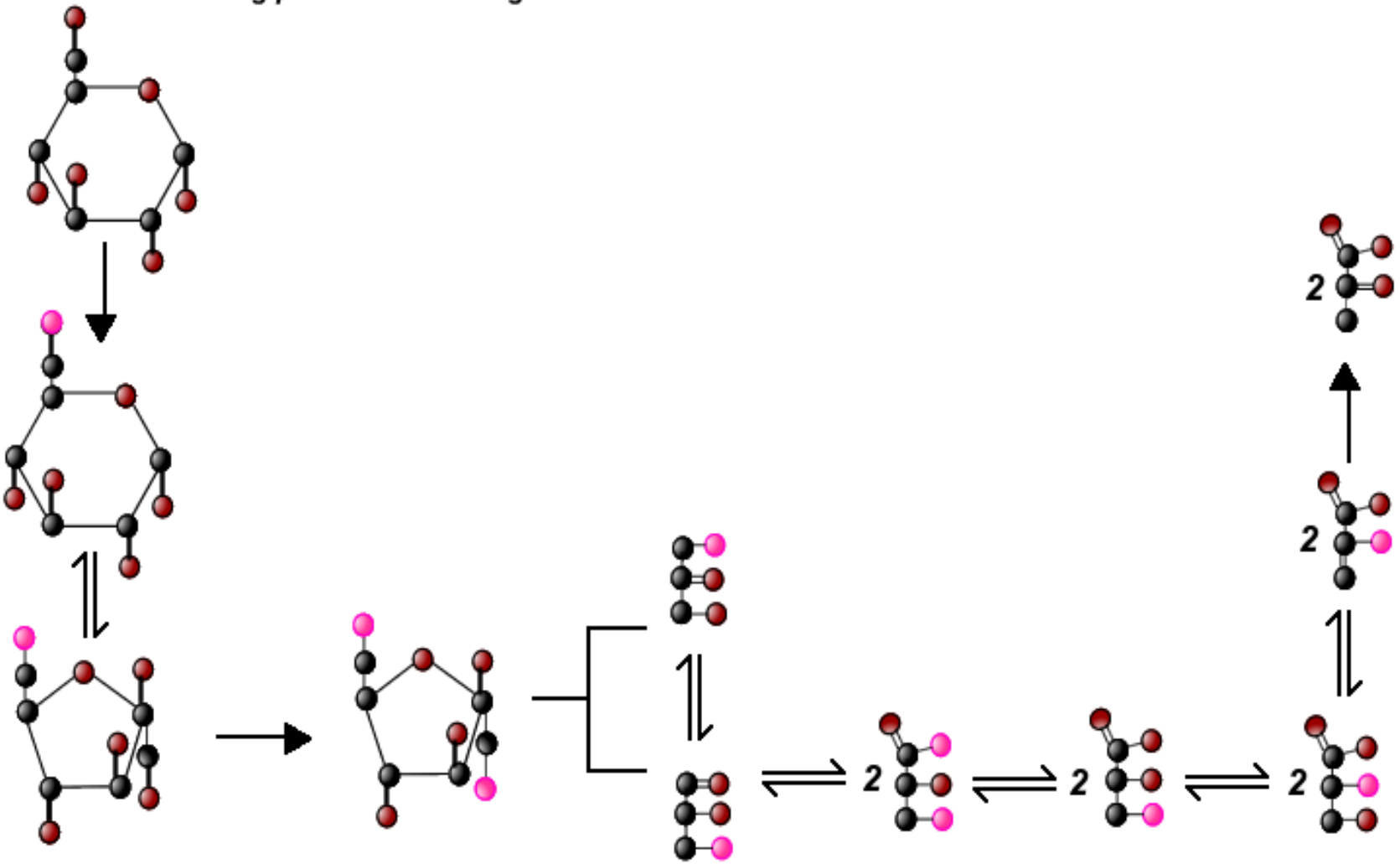
b. Glycolysis can occur under conditions.

c. Glycolysis is an pathway.

2. Reactions


*Occurs as glucose is being into the cell!
Glucose
1
2
* Metabolically irreversible steps - points of
*This is the of glycolysis!
In E. coli PFK is regulated by
4
Dihydroxyacetone phosphate
5
6
8
2 2-phosphoglycerate
9
2 H2O

Practice labeling the structures and the stages of glycolysis. Also practice labeling the ATP and reducing power consumed/generated.



If 3.34×10^{21} molecules of glucose are oxidized by a culture of bacteria living on a GSA plate, how many net ATP molecules are harvested via substrate level phosphorylation in the Embden-Meyerhof Pathway? How much reducing power is created (# of reduced NADH molecules)?

B. The Pentose Phosphate Pathway

1. Functions

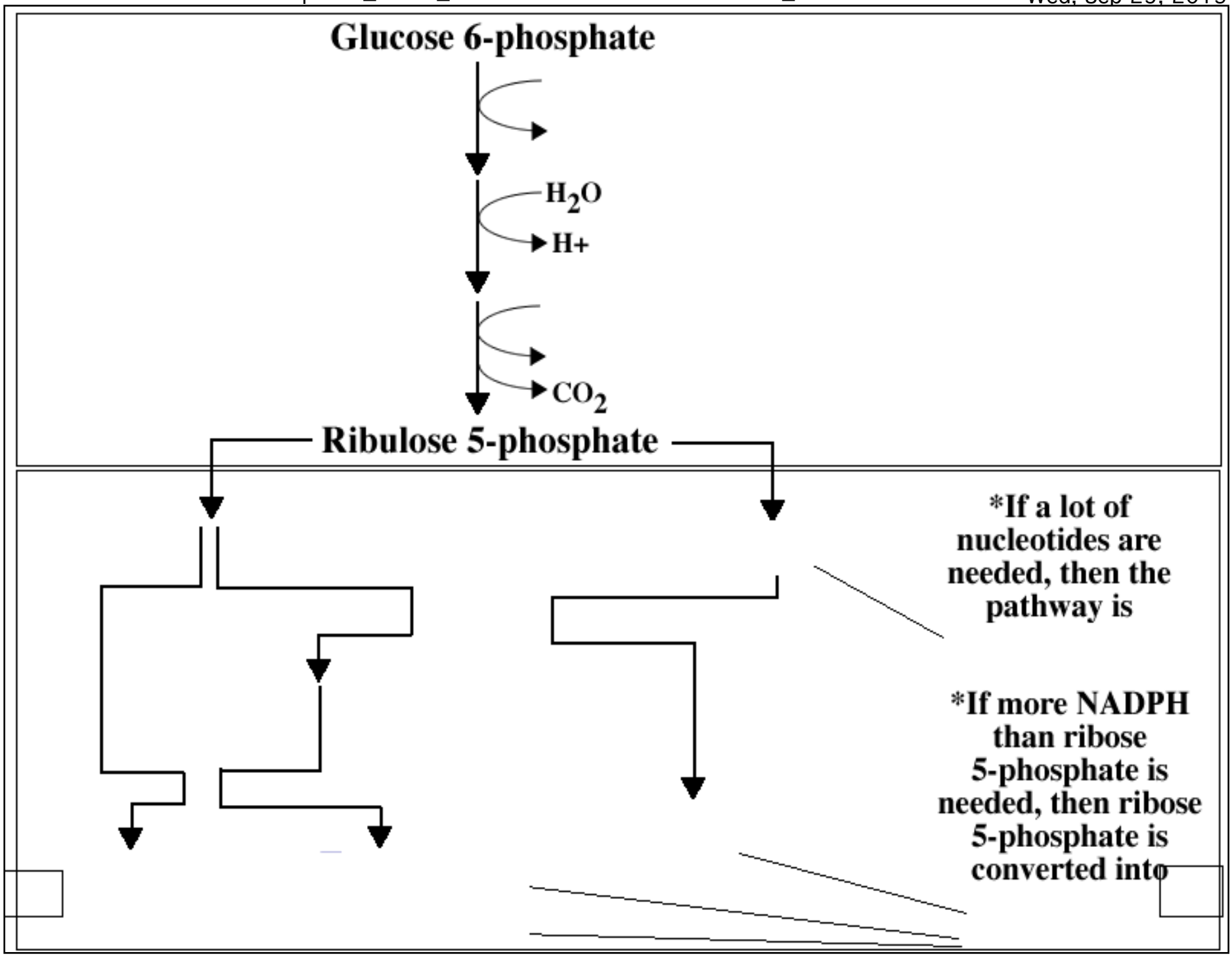
a. to form ribose 5-phosphate which is needed for the

b. to form , whose electrons are needed in reductive biosynthesis (e.g. the synthesis of fats).

2. Occurs in the of prokarytic and eukaryotic cells.

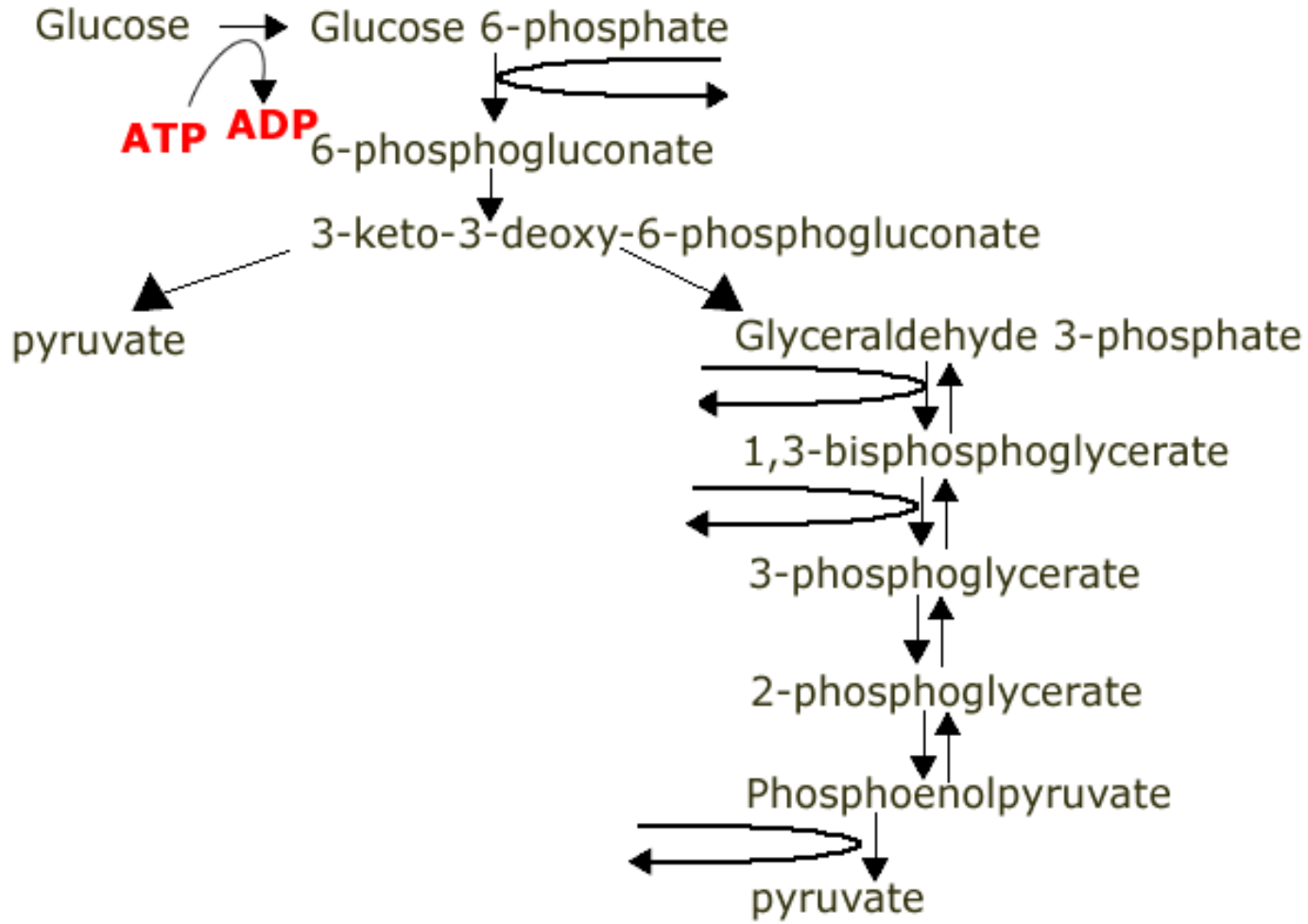
3. Can operate at the as the Embden-Meyerhof Pathway.

4. Can operate


Glucose 6-phosphate
H_2O
H+
CO_2
Ribulose 5-phosphate
*If a lot of nucleotides are needed, then the pathway is
*If more NADPH than ribose 5-phosphate is needed, then ribose 5-phosphate is converted into

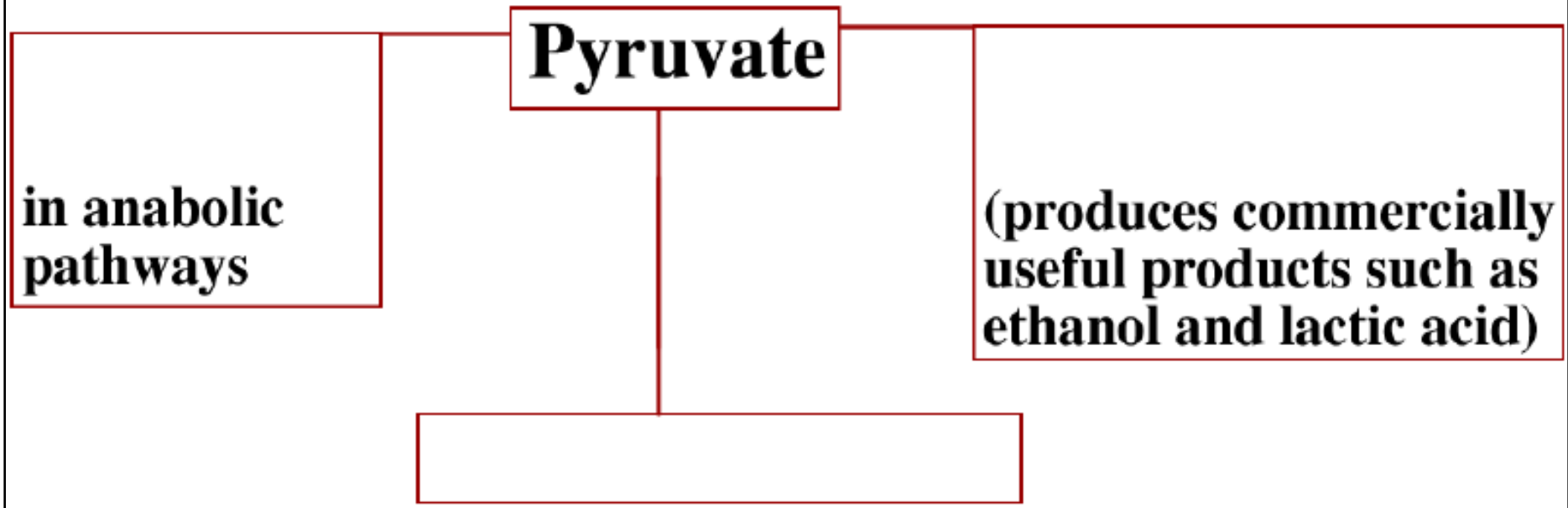
C. The Pathway

1. An alternative pathway that converts hexose sugars to pyruvate. It is primarily observed in (e.g. *Pseudomonas*, *Rhizobium*, *Azotobacter* and *Agrobacterium*).
2. The steps of the triose stage are the same as those in (Embden-Meyerhof pathway)
3. The steps of the hexose stage are similar to those in the pathway

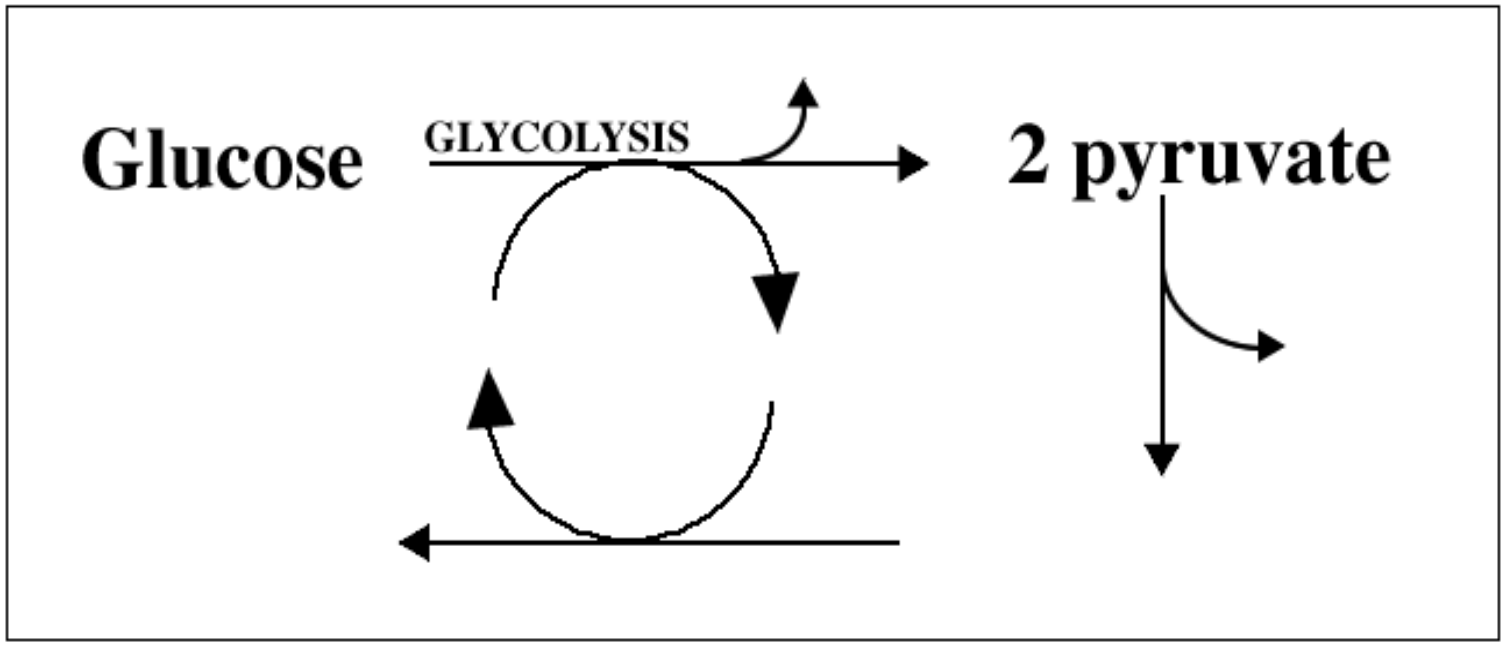


4. The Net Yield is and per glucose metabolized.

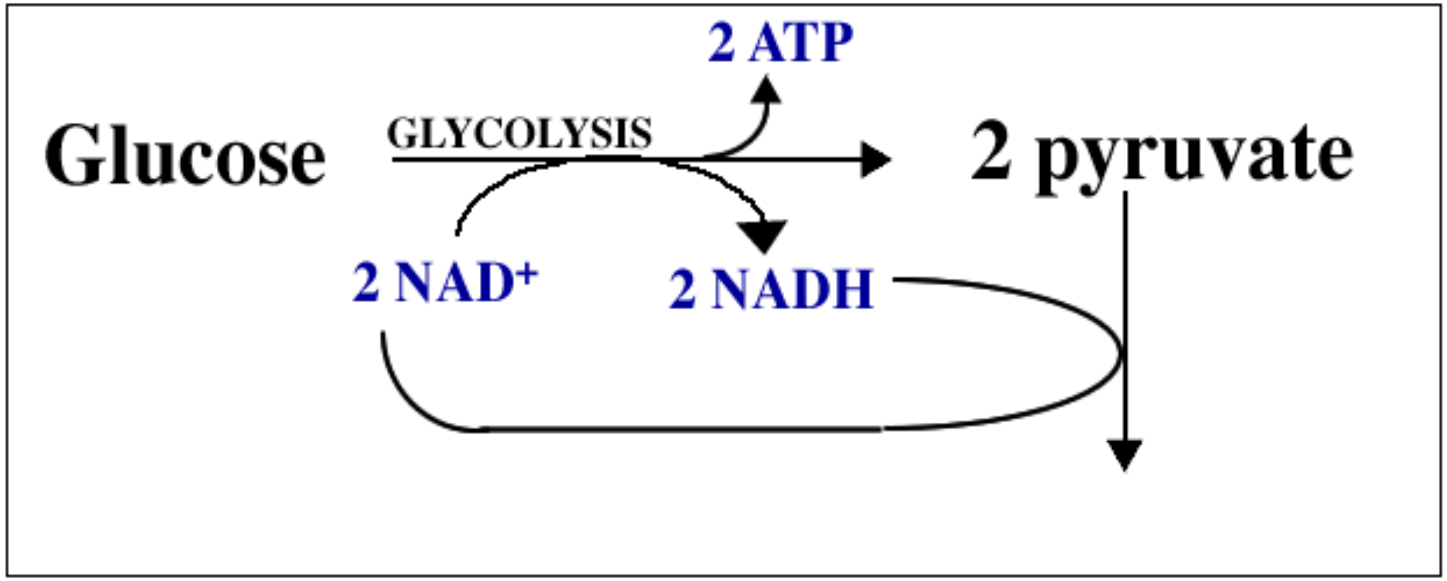
II. Fermentation - A potential fate of pyruvate



A. Alcoholic fermentation - Used by many fungi, some bacteria and protists



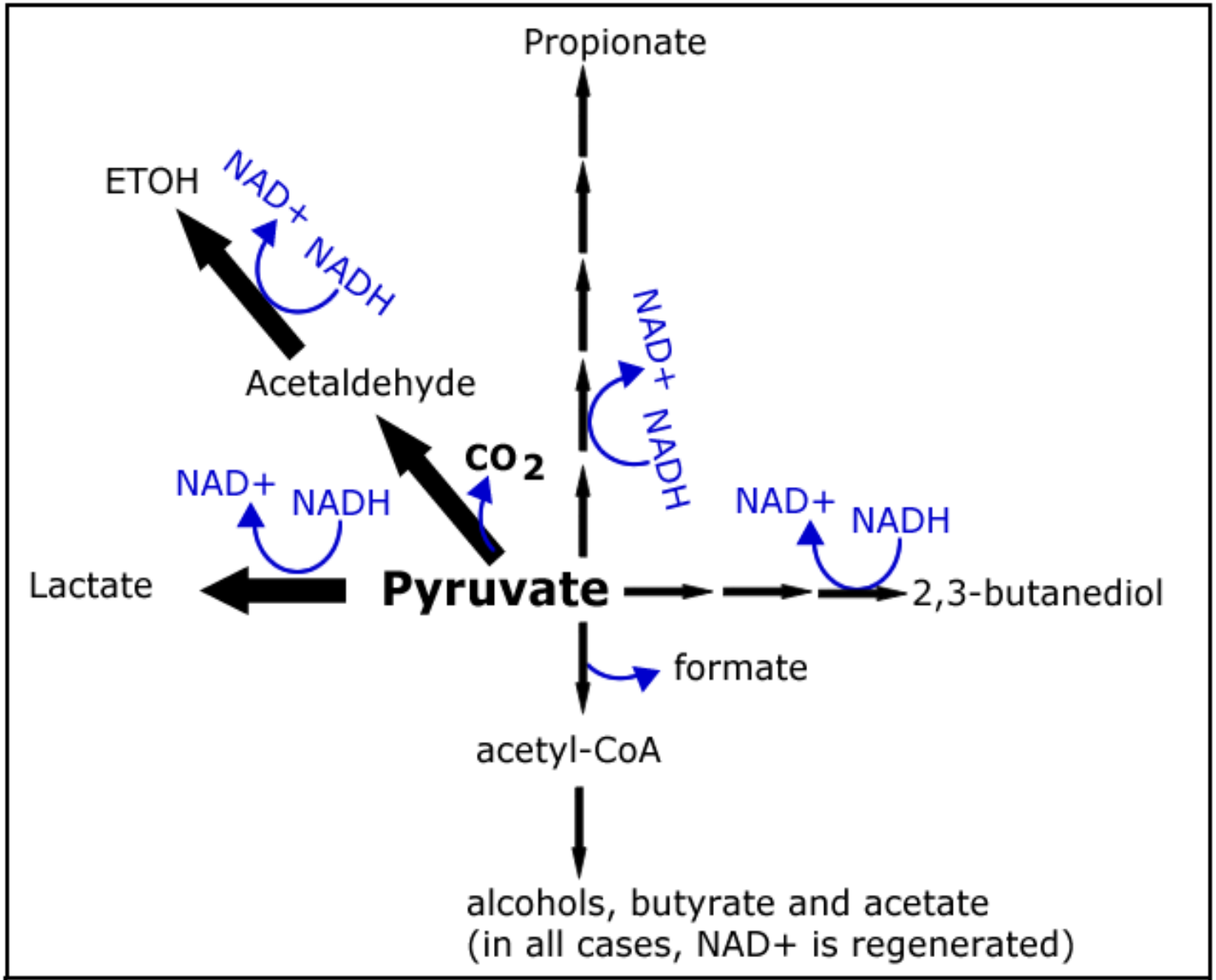
B. Lactic acid fermentation - Used by bacteria (the lactic acid bacteria / *Bacillus*), and some protists



*Some bacteria produce only lactic acid as a product of fermentation ( ) whereas others produce ethanol and CO_2 in addition to lactic acid ( ).

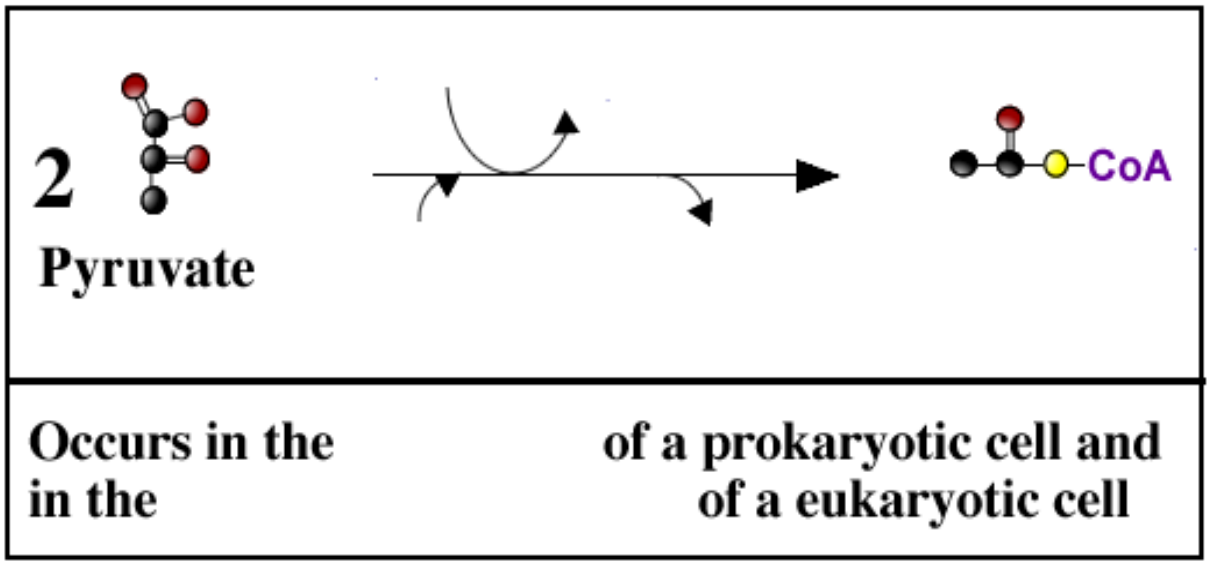
*The purpose of fermentation is to reduced during glycolysis. This allows glycolysis to continue to run and ATP to continue to be generated

(e.g. O_2)!



A Simplified Overview of Pyruvate Fermentations

III. The Transition Step (FATE = FURTHER OXIDATION)



IV. The TCA Cycle (citric acid cycle or Krebs cycle)

A. The facts

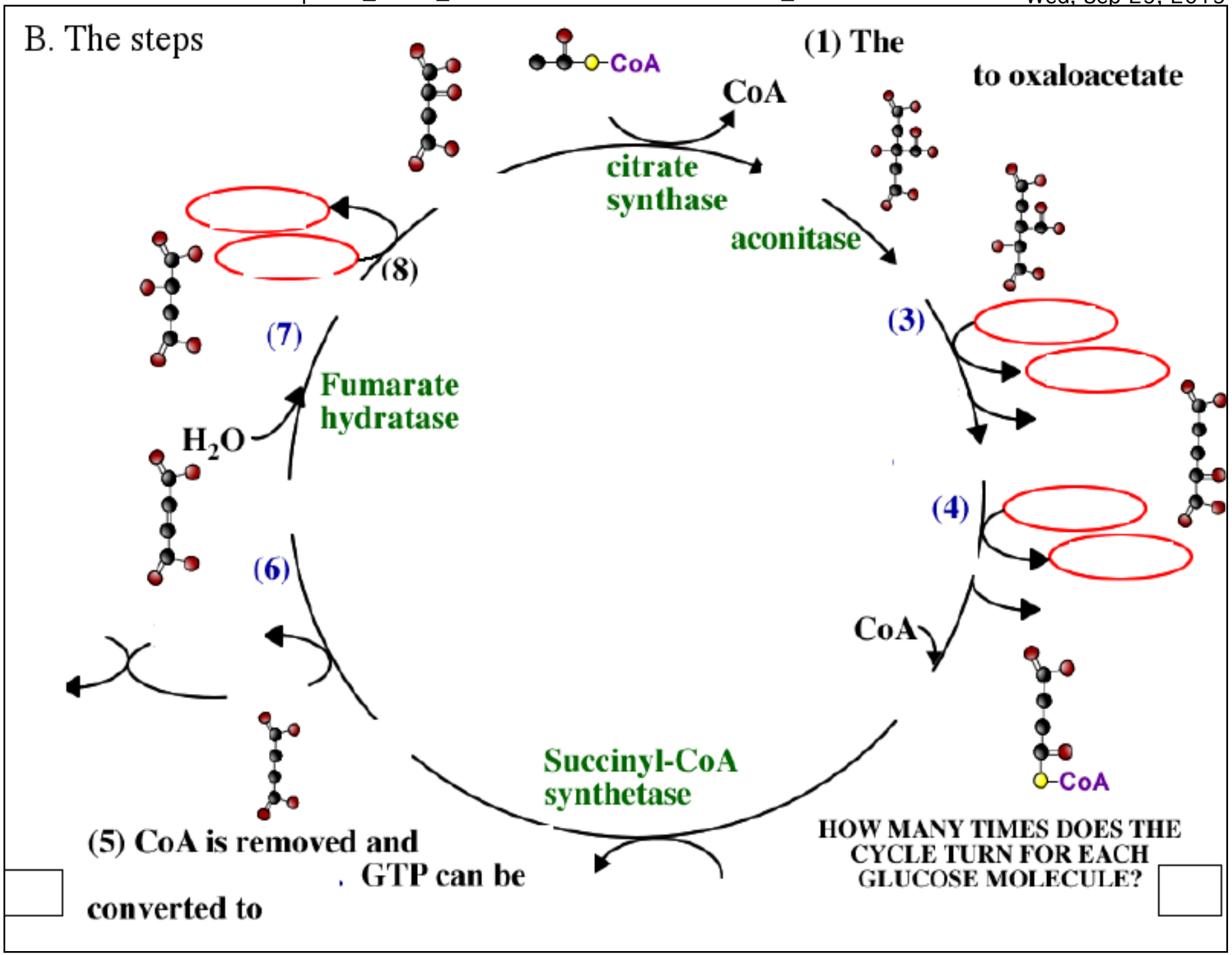
1. Occurs in the cytoplasm of prokaryotic cells and in the of eukaryotic cells.

2. Appears to be functional in many aerobic bacteria, many protists and most fungi.

3. Is an pathway.

B. The Goal

of the 2-carbon acetyl group. To these ends, how many completely oxidized (thoroughly worn out, totally used up) CO_2 molecules will be lost in 1 turn of the cycle?


B. The steps
(1) The
to oxaloacetate
CoA
CoA
citrate
synthase
aconitase
(3)
(4)
CoA
CoA
(5) CoA is removed and
. GTP can be
converted to
Succinyl-CoA
synthetase
(6)
Fumarate
hydratase
H_2O
(7)
(8)
HOW MANY TIMES DOES THE
CYCLE TURN FOR EACH
GLUCOSE MOLECULE?

C. The net yield of the TCA cycle

1. ATP

ATP/acetyl or ATP/glucose in step 5

2. Reducing power

NADH/acetyl or NADH/glucose in steps 3,4 and 8

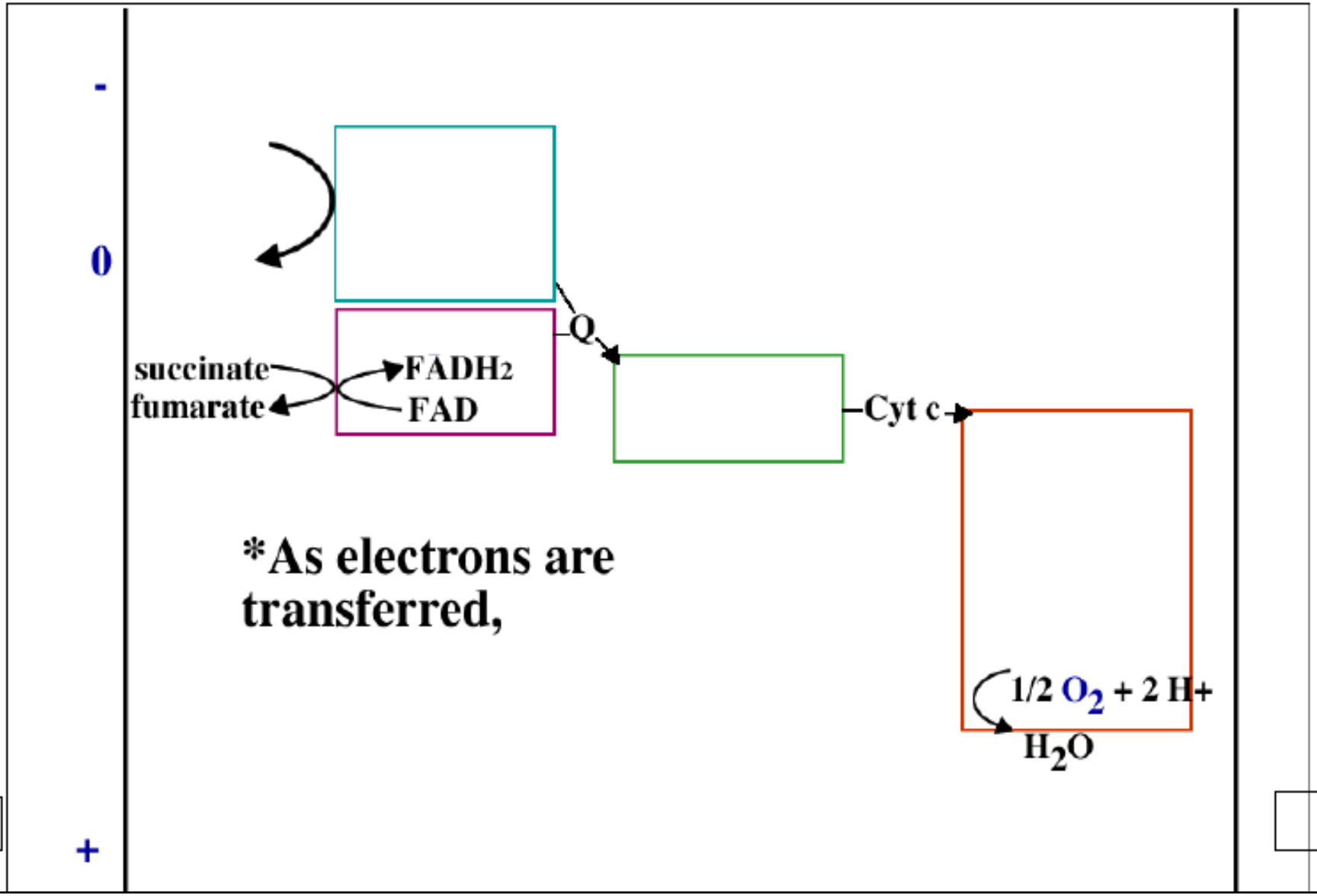
$FADH_2$ (QH_2)/acetyl or $FADH_2$ (QH_2)/glucose and in step 6

3. Precursor metabolites
(α-ketoglutarate, succinyl-CoA and Oxaloacetate are common building blocks in biosynthetic reactions)

If 1.2×10^{18} molecules of glucose are catabolized, how many ATP molecules are net via substrate-level phosphorylation during glycolysis and the TCA cycle?

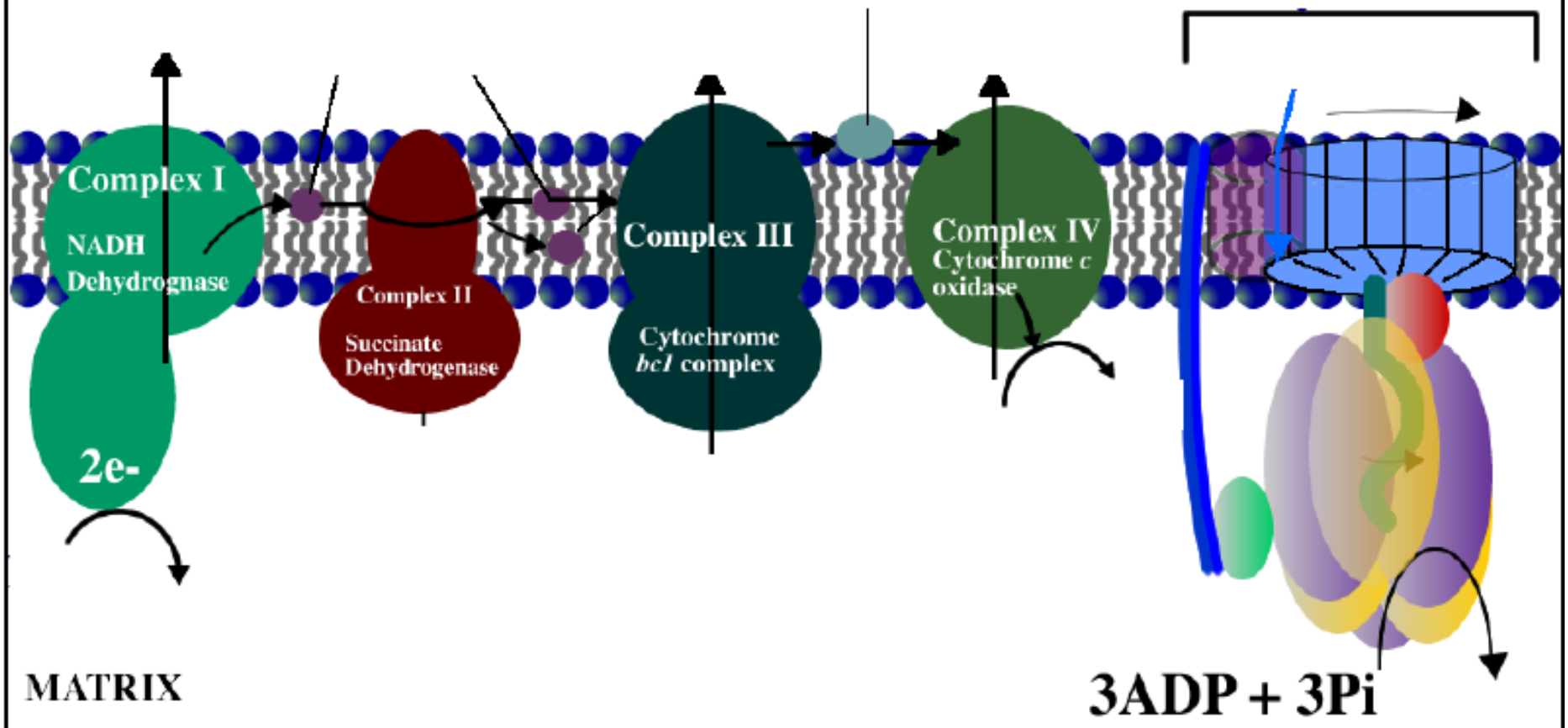
V. The Electron Transport Chain and Oxidative Phosphorylation

A. Electrons are transferred from NADH or from the oxidation of succinate to one of the membrane-embedded carriers. They are then transferred along the entire electron transport chain.



B. ATP Synthase and the Chemiosmotic Hypothesis

The Electron Transport Chain of Mitochondria



How many protons are pumped upon the complete oxidation of NADH? $FADH_2$?

A proton concentration gradient (PMF) serves as an E reservoir for driving

C. The components of the electron transport chains of prokaryotes

- *Pseudomonas* and *Neisseria* have
  (Activity of this complex can be used to help
  members of these genera.)
  - *E. coli* has two different
    . However, *E. coli* also has several
    alternative complexes allowing it to use a of energy
    sources and (Fig. 10.12 (8th)
    and 11.13 (9th))

Theoretical ATP yield from aerobic respiration of glucose in eukaryotes:

Conversion factors

For each pair of electrons delivered to the ETC by NADH, are formed via oxidative phosphorylation.

For each pair of electrons delivered to the ETC by $FADH_2/QH_2$, are formed via oxidative phosphorylation.

Metabolic process	# of ATP via substrate-level phosphorylation	# of ATP via oxidative phosphorylation	Total
Glycolysis			
The Transition Step			
The TCA Cycle			
Total			

***Depending on how the electrons from NADH enter the mitochondrion, thus affecting the overall total.**

Just as the composition of bacterial ETCs varies, so to does the

VI. Anaerobic respiration

Organisms capable of anaerobic respiration can use as the terminal electron acceptor.

A. Some facultative anaerobes, like *E. coli* use as the final electron acceptor:

B. Some anaerobes called sulfate-reducers use as the terminal electron acceptor.

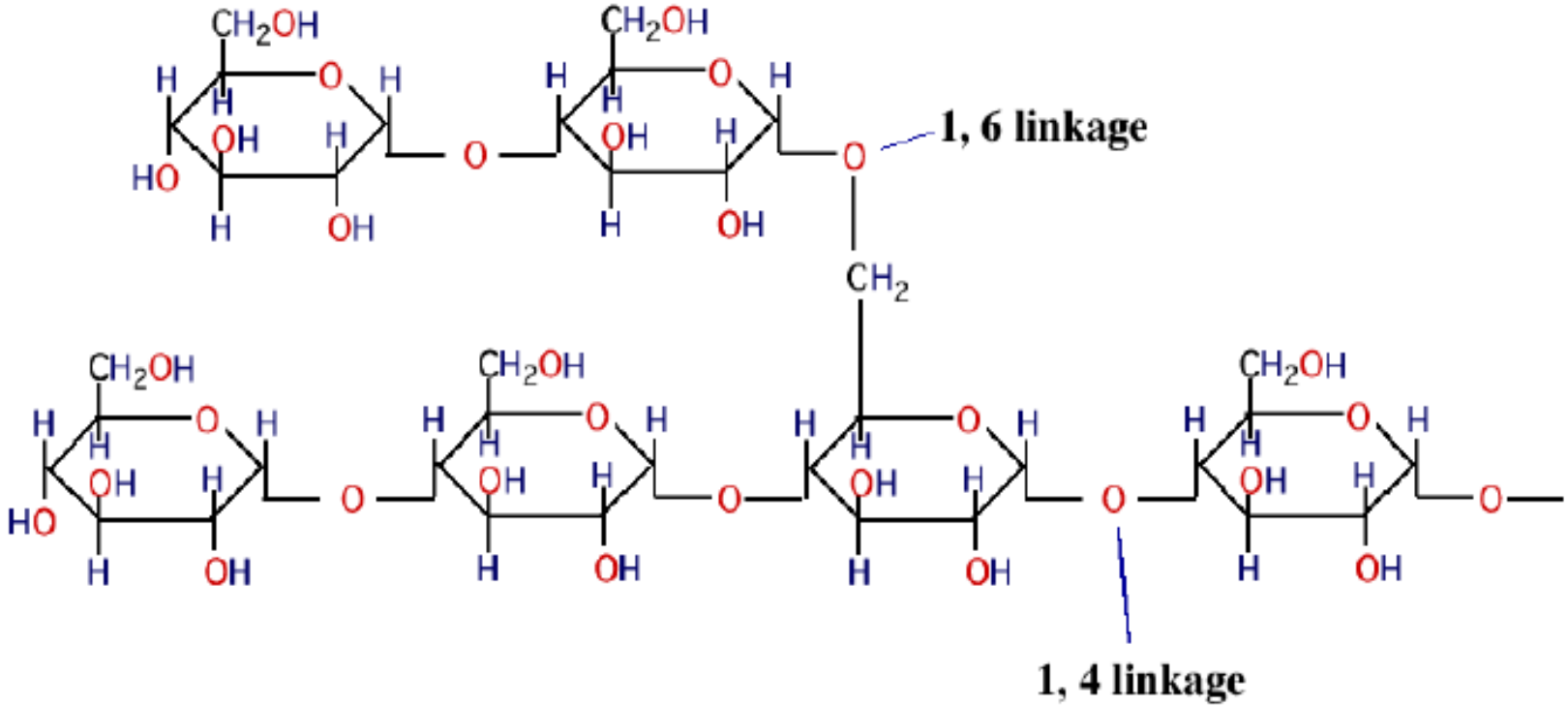
C. Other anaerobes, such as the methanogens, use as their terminal electron acceptor.

D. Anaerobic respiration produces than aerobic respiration.

VII. Catabolism of carbohydrates, triacylglycerols and proteins

A. Carbohydrates

1. Monosaccharides besides glucose ( ) can enter the glycolytic pathway (Fig 10.20 (8th) or 11.21 (9th)).
2. Common can be cleaved to monosaccharides which can then enter the glycolytic pathway.
3. Starches are digested by



4. Cellulose is digested by enzymes called . Only a few microorganisms such as and some produce these enzymes.

-The glucose subunits released when polysaccharides are digested enter the .

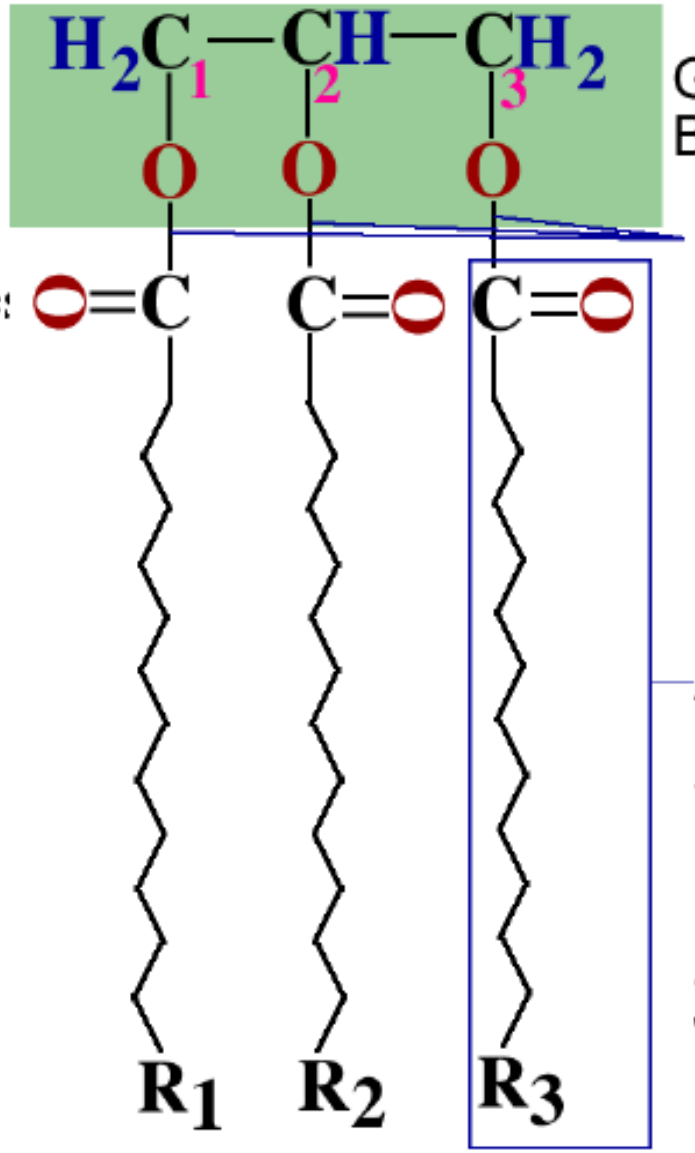
5. Some bacteria even produce enzymes that degrade pesticides and other pollutants ( ), transforming these compounds into normal metabolic intermediates

B. Lipids

1. Fats (triglycerides) are hydrolyzed by secretory enzymes called .

2. The glycerol backbone is converted into

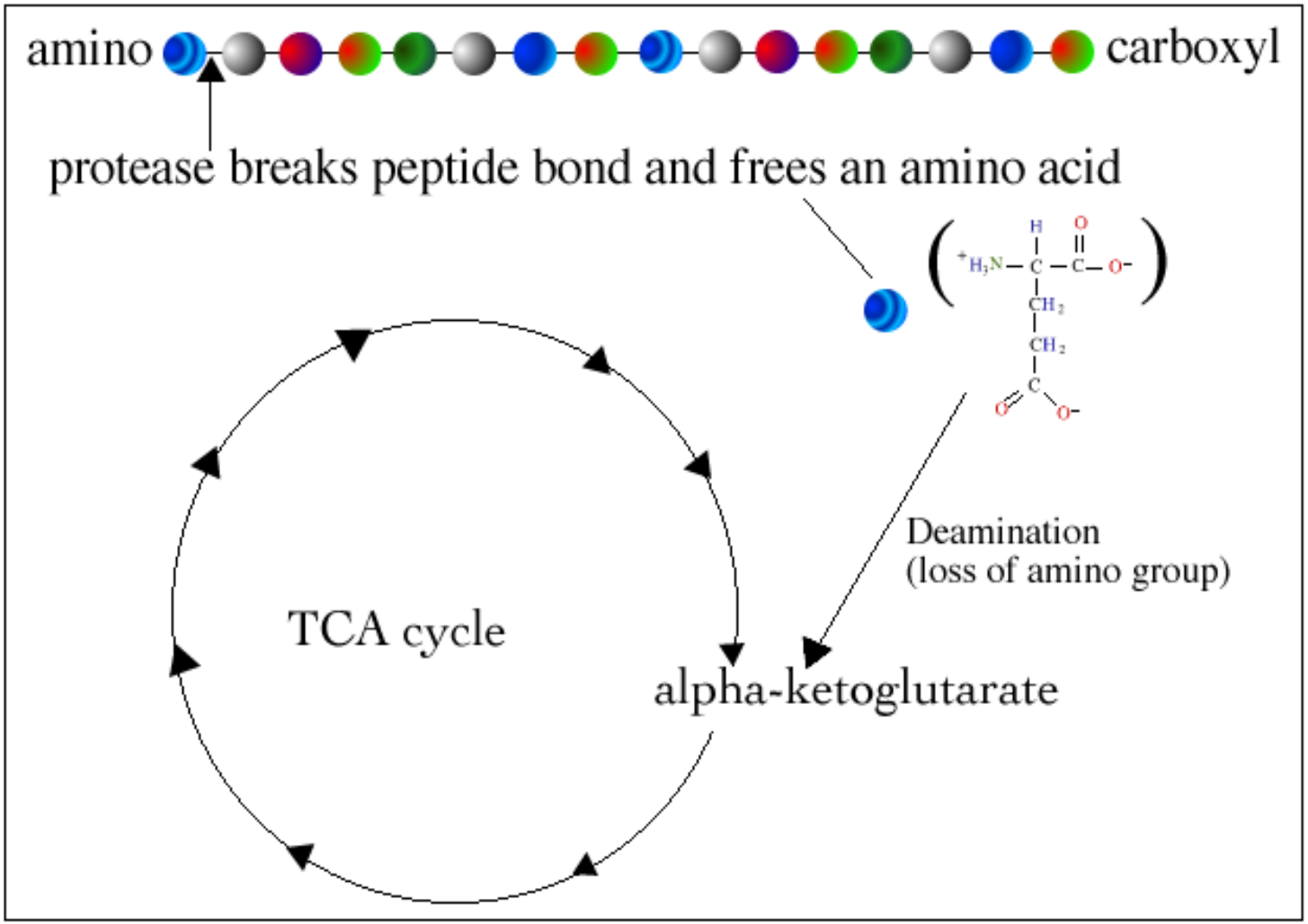
3. The fatty acids are degraded 2 carbons at at time to form



C. Proteins

1. Enzymes called break the peptide linkages.

2. A deamination reaction leaves just the carbon skeleton which can enter the



VII. Chemoautotrophs (chemolithotrophs)

A. Prokaryotes are alone in their ability to use

as an energy source.

Many of these inorganic compounds are byproducts of

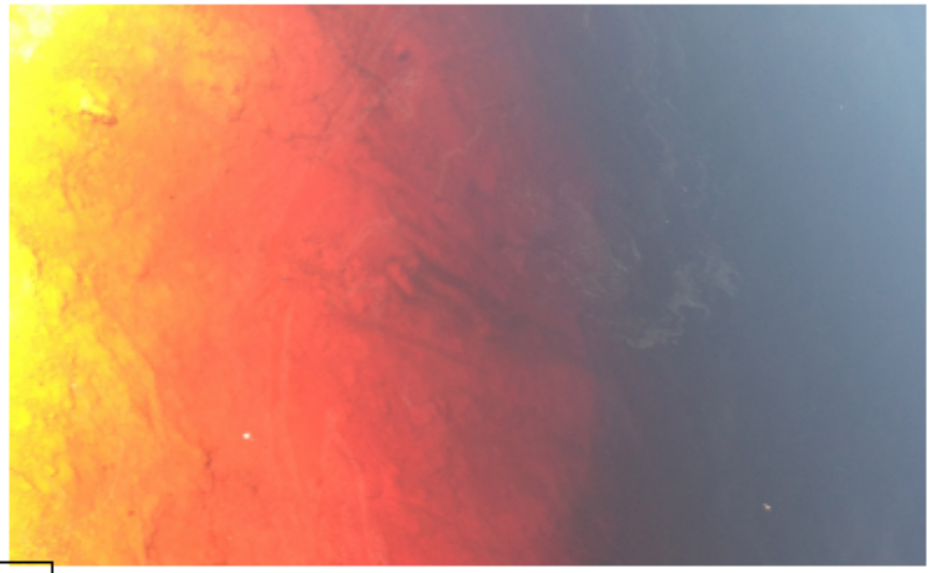
.

Type of chemoautotroph	Identity of chemical oxidized for energy
bacteria	hydrogen ( ) gas
bacteria	hydrogen sulfide ( )
bacteria	reduced forms of iron ( )
bacteria type 1 type 2	(NO_2^-) ammonia (NH_3)
*electrons extracted during the oxidation of these chemicals are carried to an Generally serves as the terminal electron acceptor.	

B. Chemoautotrophs often thrive in where

are often found.

Table 10.4 (8th) or 11.5 (9th)



Acid mine drainage

Photos taken by Rachel near her hometown of Leadville