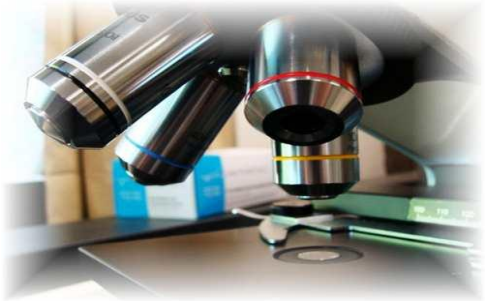

About Science Prof Online PowerPoint Resources

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• The SPO Virtual Classrooms offer many educational resources, including practice test questions, review questions, lecture PowerPoints, video tutorials, sample assignments and course syllabi. New materials are continually being developed, so check back frequently, or follow us on Facebook (Science Prof Online) or Twitter (ScienceProfSPO) for updates.

• Many SPO PowerPoints are available in a variety of formats, such as fully editable PowerPoint files, as well as uneditable versions in smaller file sizes, such as PowerPoint Shows and Portable Document Format (.pdf), for ease of printing.

• Images used on this resource, and on the SPO website are, wherever possible, credited and linked to their source. Any words underlined and appearing in blue are links that can be clicked on for more information. PowerPoints must be viewed in *slide show mode* to use the hyperlinks directly.

• Several helpful links to fun and interactive learning tools are included throughout the PPT and on the Smart Links slide, near the end of each presentation. You must be in *slide show mode* to utilize hyperlinks and animations.

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Image: Compound microscope objectives, T. Port

Microbial Metabolism

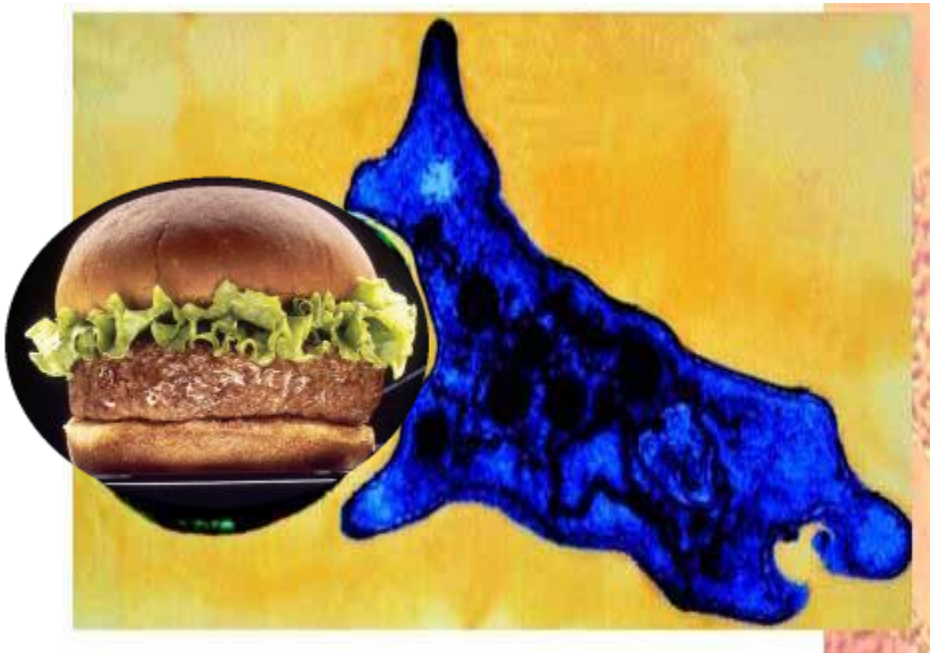
From the Virtual Microbiology Classroom on ScienceProfOnline.com

Images: MacConkey's media with Salmonella growing on left plate and E. coli on right; API20E test strip, T. Port

Metabolism

The Transformation of Energy

- Cells either get their energy either by _____ or _____ _____.
- But a cell can't just use sunlight or nutrients to run cellular reactions.
- ***Q**: What type of fuel is needed to run a cell?*
- So food, needs to be turned into ATP, because that's what actually runs your body.



Cells Can't Eat Hamburgers

Image: Hamburger, Wiki

ATP

Energy storing nucleotide.

The mother of all rechargeable batteries.

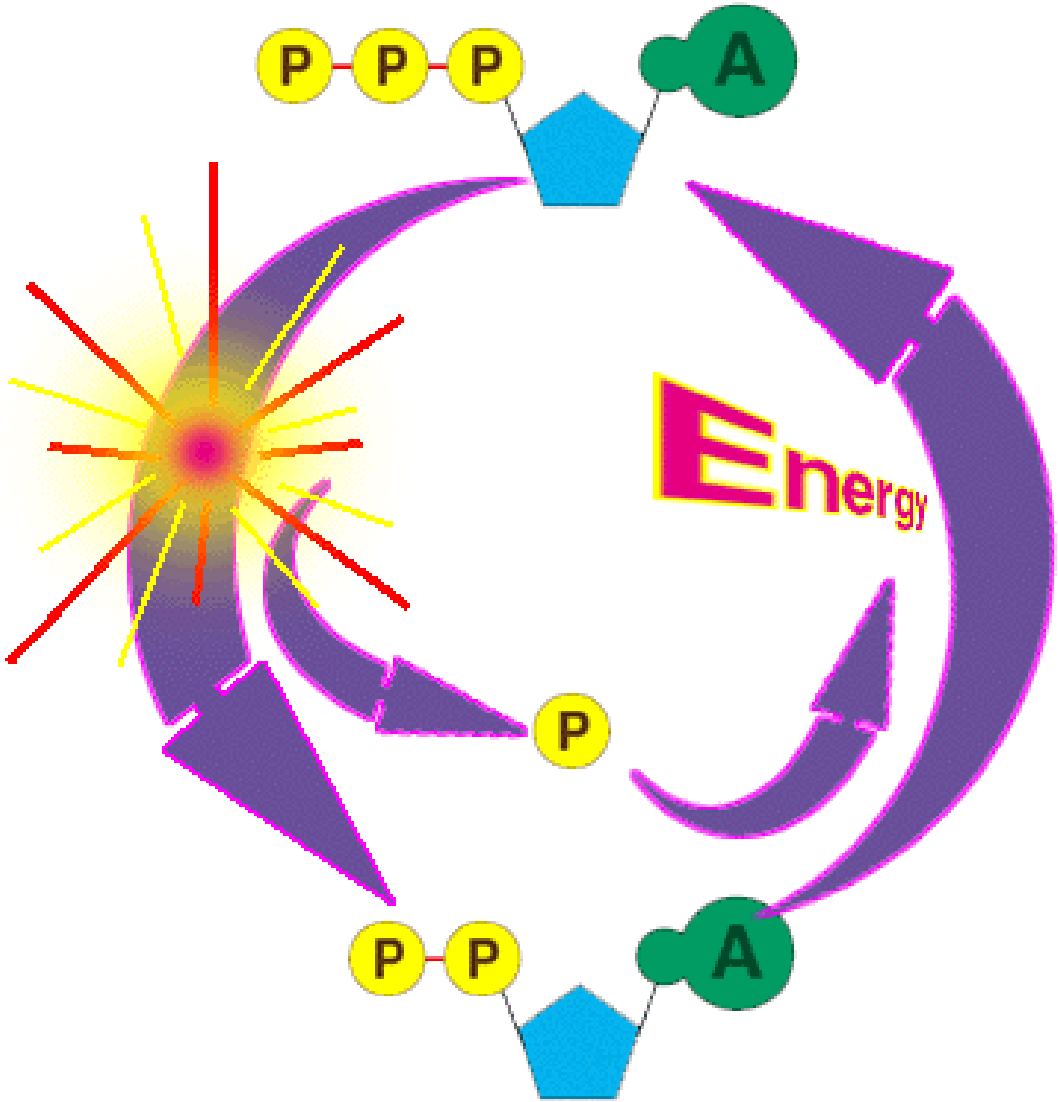


Image: ATP-ADP Cycle, CUNY

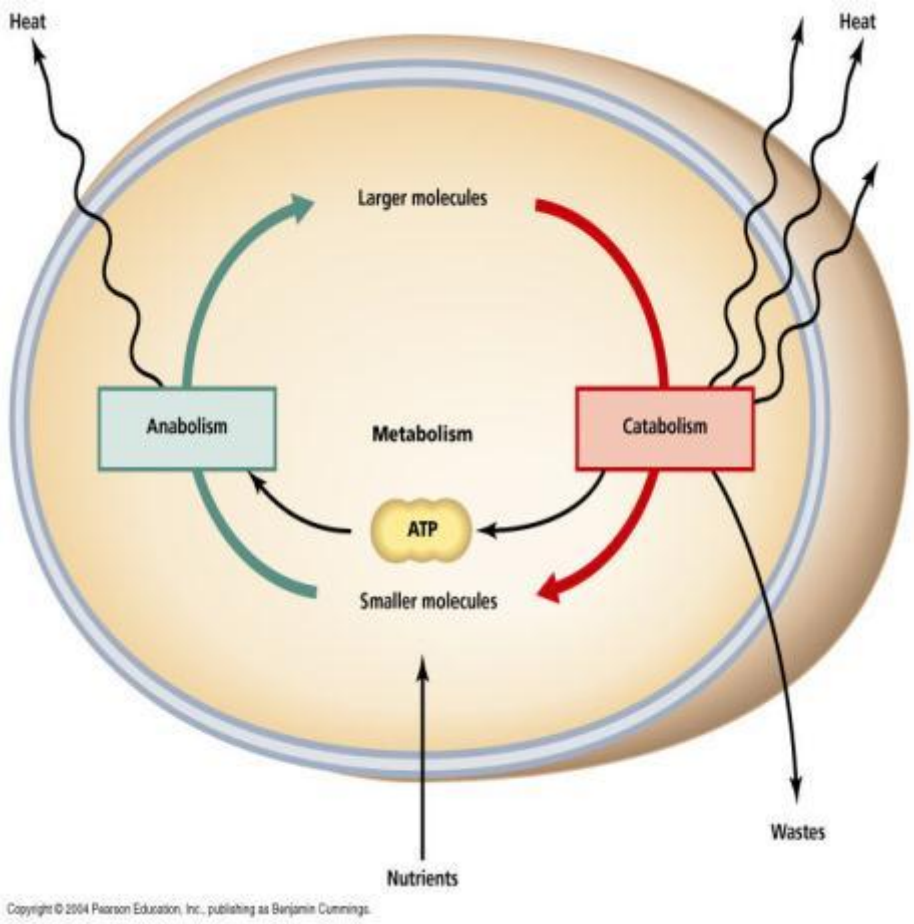
Basic Metabolic Reactions

Anabolic Reaction
(anabolism)

The phase of metabolism in which simple substances are _____ into the complex materials of living tissue.

Catabolic Reaction
(catabolism)

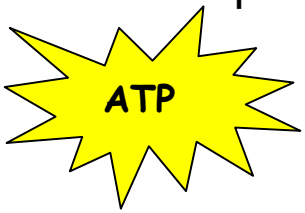
The metabolic _____ _____ of complex molecules into simpler ones, often resulting in a release of energy.



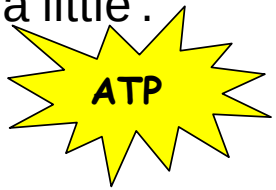
Carbohydrate Catabolism

- Organisms catabolize carbohydrates as the primary energy source for anabolic reactions.
- ***Q:*** *What sugar is most commonly broken down in cellular respiration?*

  - **Aerobic cellular respiration** → Results in complete breakdown of glucose to carbon dioxide, water and a lot of



  - **Anaerobic respiration & Fermentation** → Only partially breaks down glucose, into pyruvic acid and organic waste products and a little .

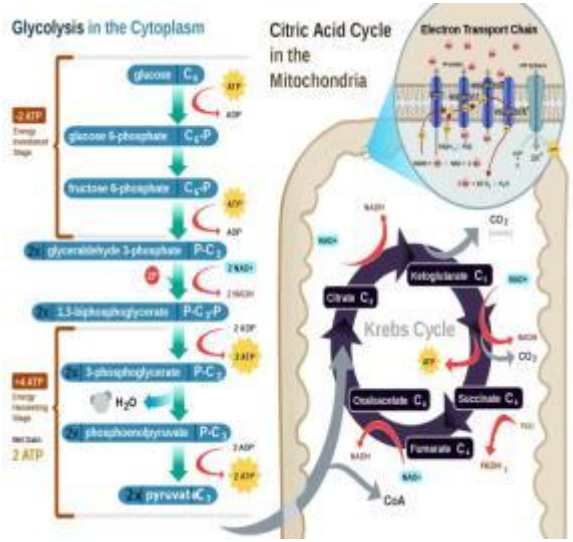


Aerobic cellular respiration →

The steps that a cell must go through to turn other forms of energy into ATP.

The 4 subpathways of cellular respiration are …

1. glycolysis
2. synthesis of acetyl-CoA
3. Krebs cycle
4. electron transport chain



…which result in complete breakdown of glucose to carbon dioxide, water and ATP

***Q:** What is required for respiration to be **aerobic**?*

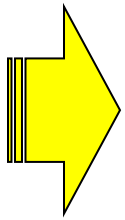
Images: Cellular Respiration, Regis Frey

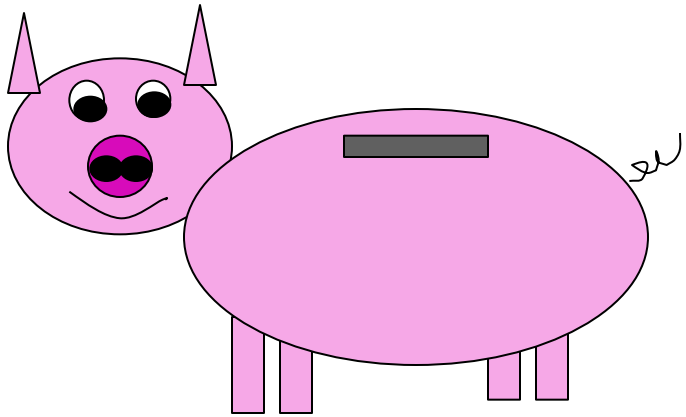
From the Virtual Microbiology Classroom on ScienceProfOnline.com

Aerobic Cellular Respiration

Subpathway	Molecule In	Molecule Out	Energy Obtained
1. glycolysis			
2. synth acetyl-CoA			
3. Krebs cycle			
4. ETC			

Let's put the energy extracted from glucose into our energy piggy bank.

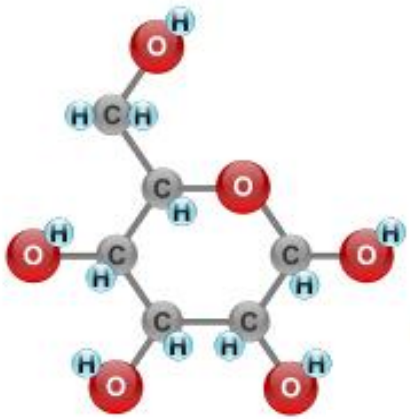




Aerobic cellular respiration →

1. _____

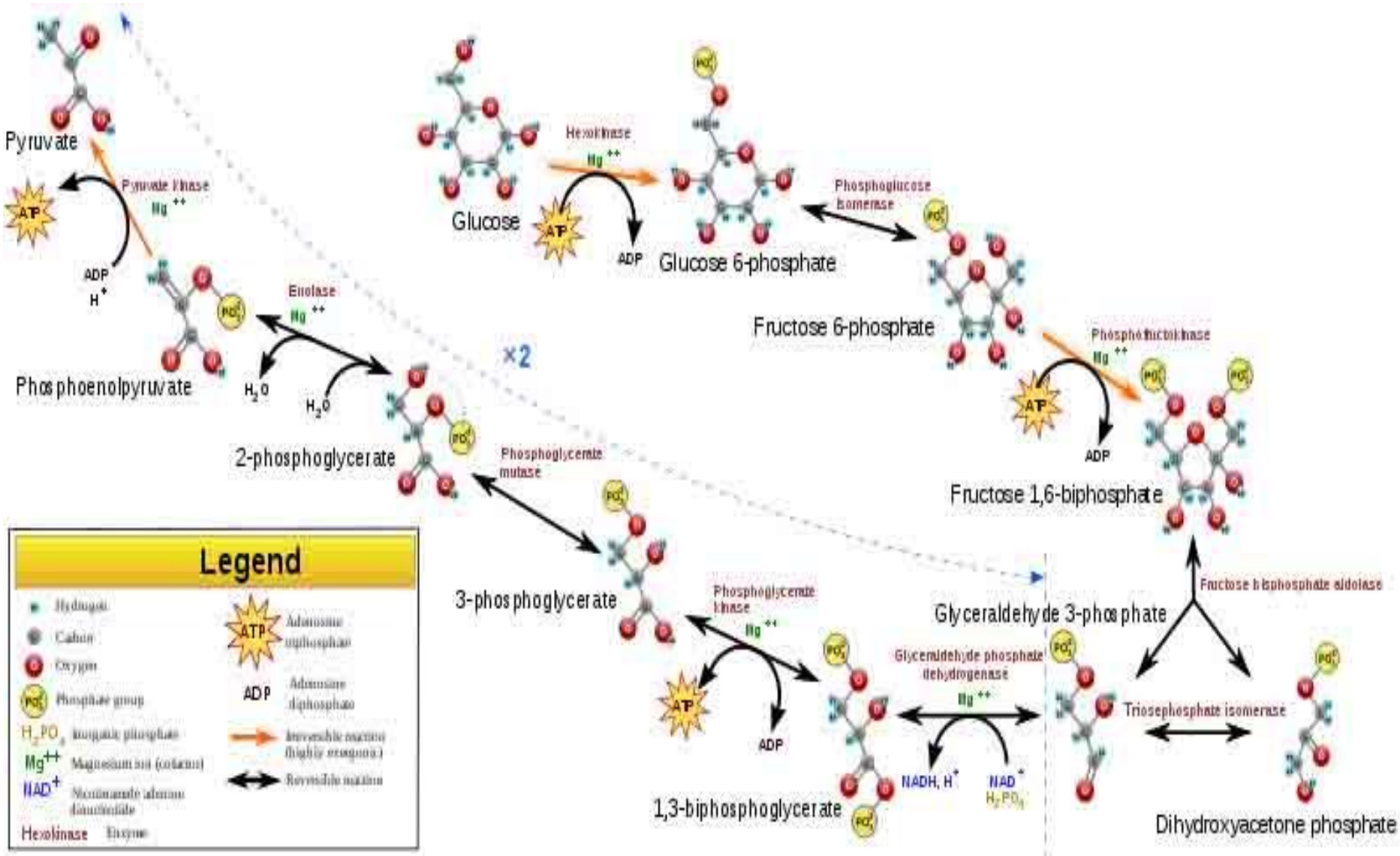
- Occurs in the **cytoplasm** of most cells.
- Involves splitting of a six-carbon glucose into two three-carbon _____ molecules.
- Results in:
  - a net gain of 2 ATP
  - 2 NADH



Glucose

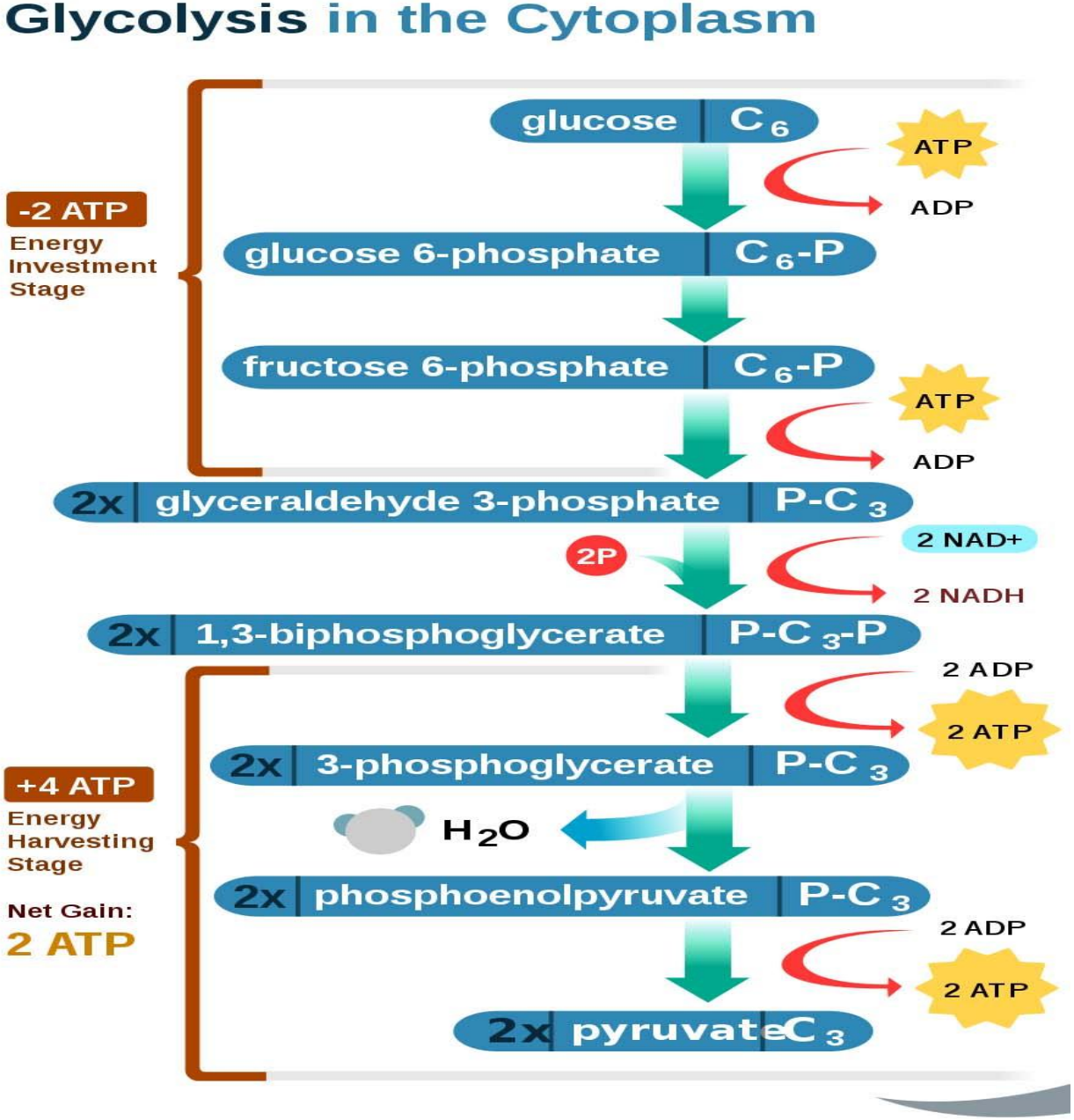
Image: Glucose molecule, YassineMrabet

Glycolysis



From the Virtual Microbiology Classroom on ScienceProfOnline.com

Image: Glycolusis, YassineMrabet


Glycolysis in the Cytoplasm
-2 ATP
Energy Investment Stage
glucose C6
ATP
ADP
glucose 6-phosphate C6-P
fructose 6-phosphate C6-P
ATP
ADP
2x glyceraldehyde 3-phosphate P-C3
2P
2 NAD+
2 NADH
2x 1,3-biphosphoglycerate P-C3-P
2 ADP
2 ATP
+4 ATP
Energy Harvesting Stage
Net Gain:
2 ATP
2x 3-phosphoglycerate P-C3
H2O
2x phosphoenolpyruvate P-C3
2 ADP
2 ATP
2x pyruvate C3

Q: *What is NADH?*

- Cells use special molecules to carry electrons *(often in H atoms).*

- This is potential energy, another way to transport energy.

- Two important _____ _____
  - Nicotinamide adenine dinucleotide (NAD^+) → **add electrons & hydrogen → NADH**
  - Flavine adenine dinucleotide (FAD) → **add electrons and hydrogen → $FADH_2$**

- Think of these energy carriers as rechargeable batteries. (When they have the electrons and hydrogens they are charged up, when they don't, they need charging.)

Electron Carriers & Oxidation-Reduction Reactions

- Or **Redox** reaction = chemical reactions in which electrons are gained, lost or shared in a chemical reaction.

- _____ describes the loss of electrons by a molecule, atom or ion.

- _____ describes the gain of electrons by a molecule, atom or ion.

Q: *When NAD+ and FADH are turned into NADH and $FADH_2$, are they being oxidized or reduced?*

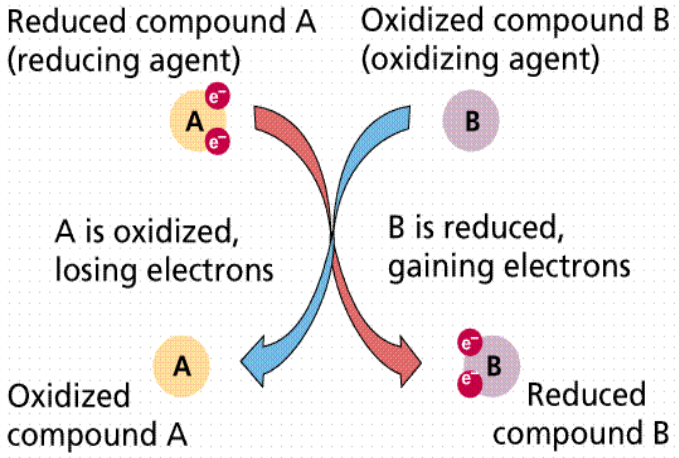
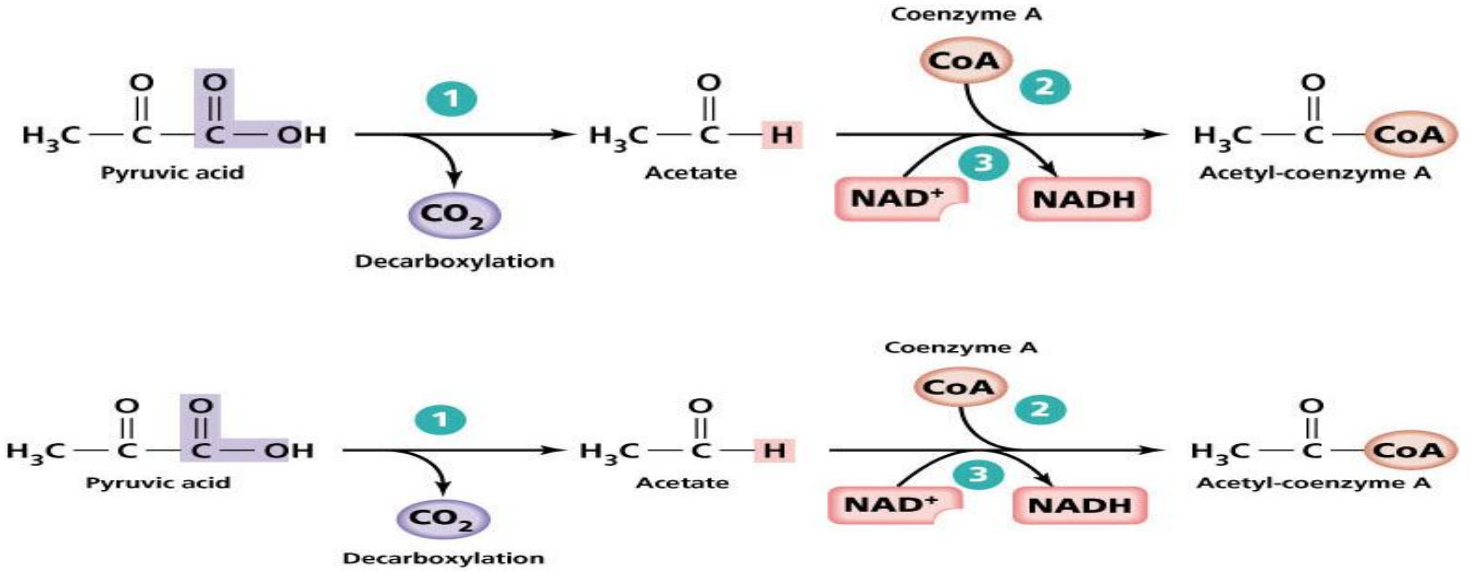


Image: Oil Rig Platform, NASA

From the Virtual Microbiology Classroom on ScienceProfOnline.com

2. _____ _____ _____

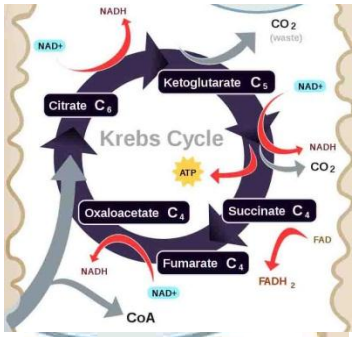


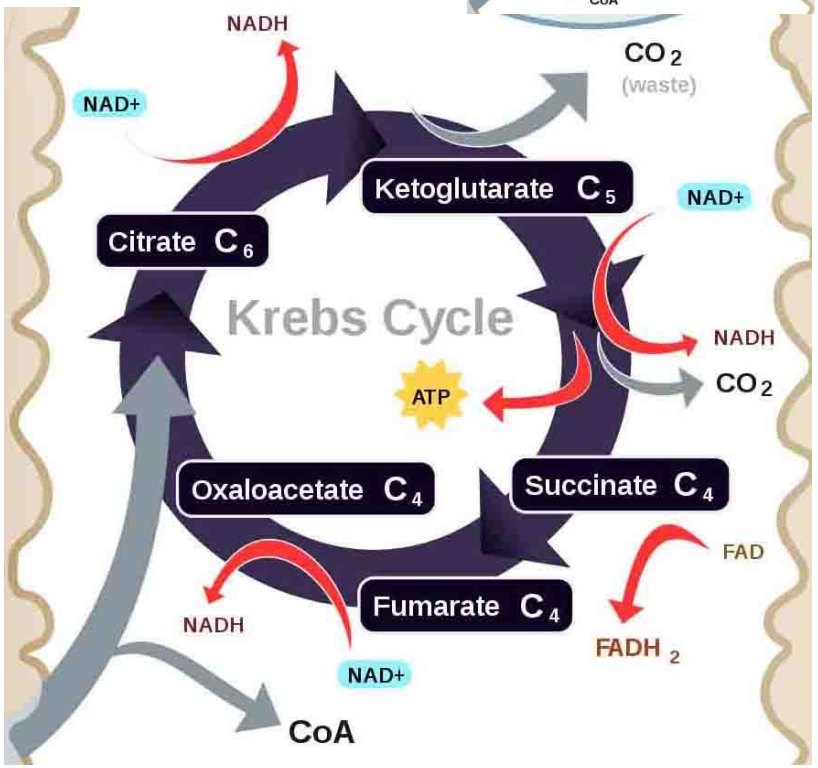
The two molecules of pyruvate (pyruvic acid above) **result in:**

- Two molecules of _____ _____
- Two molecules of _____ (This is what generates carbon dioxide that you breathe out.)
- Two molecules of _____ (electron carrier)

3. _____ _____ (a.k.a Citric Acid Cycle)

- Great amount of energy remains in bonds of acetyl-CoA.
- The Krebs cycle transfers much of this energy to electron carriers NAD^+ & FAD.
- Occurs in cytoplasm of prokaryotes and in matrix of mitochondria in eukaryotes.





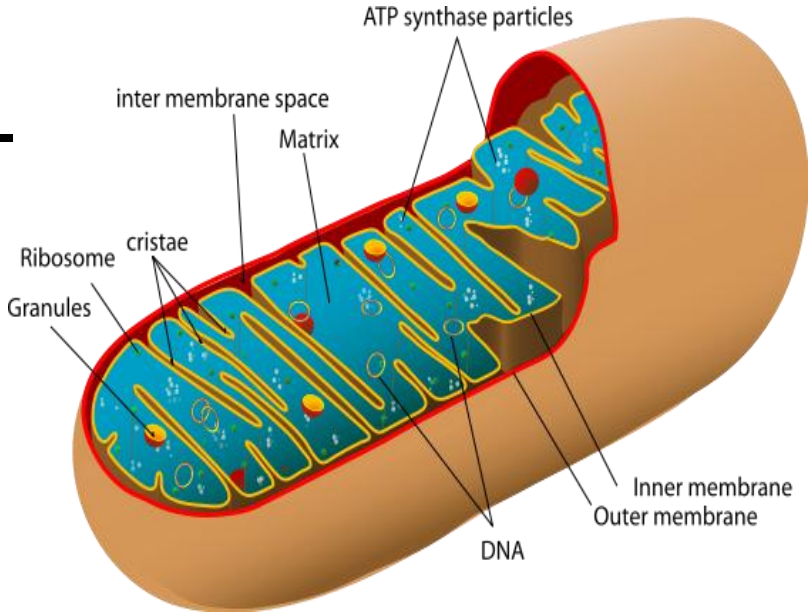
The two molecules of Acetyl Co-A result in:

- Two molecules of 

- Two molecules of _____ (electron carrier)
- Six molecules of _____ (electron carrier)
- Four molecules of _____ (This is what generates carbon dioxide that you breathe out.)

Images: Krebs Cycle of Cellular Respiration, Regis Frey

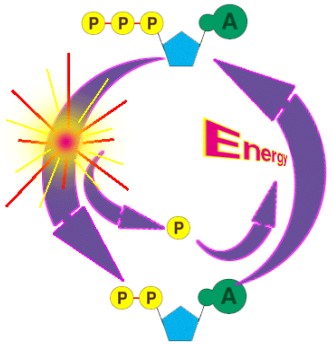
4. _____ _____



- Most of the ATP made in cellular respiration comes from the stepwise release of energy through a series of redox reactions between molecules known as the **electron transport chain** (ETC).

- Must occur in a membrane. The ETC is located in cristae of _____ in eukaryotes.

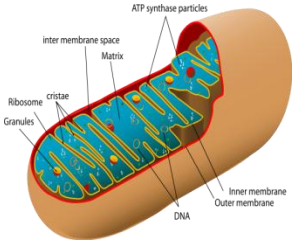
- ***Q**: Where would the ETC of prokaryotes be located?*



Three main events important in the ETCs generation of ATP:

1. _____
2. _____
3. _____

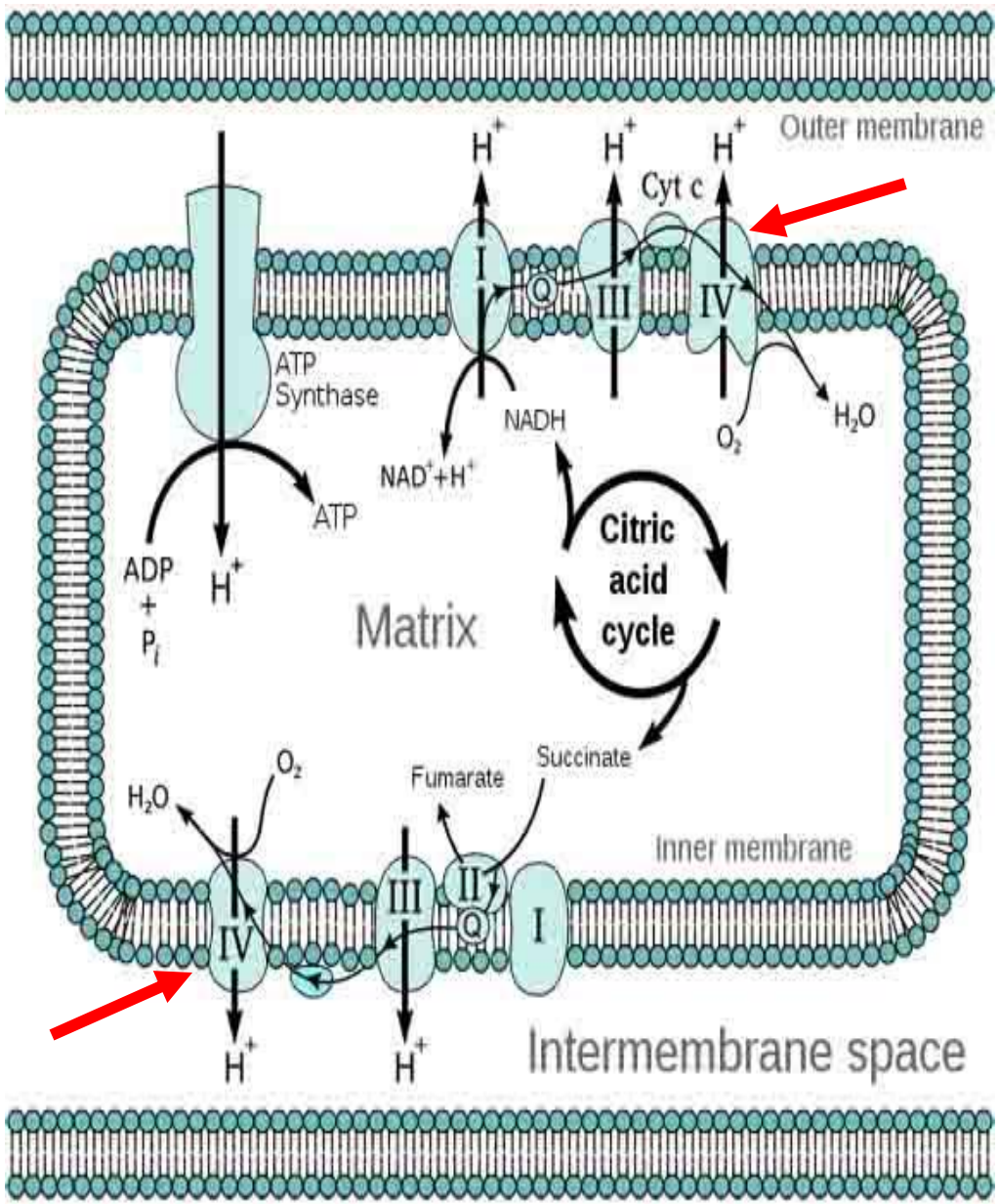
Images: Mitochondrion diagram M. Rui; ATP-ADP Cycle, CUNY z



Electron Transport

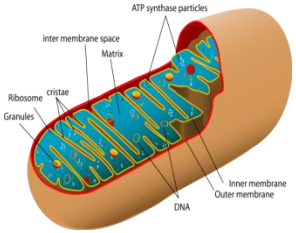
1. _____

- The electron carriers (NADH and FADH2) bring electrons and protons (H+) to the ETC.
- Carrier molecules in the membrane of the mitochondria pass electrons from one to another and ultimately to final electron acceptor.



From the Virtual Microbiology Classroom on ScienceProfOnline.com

Images: Mitochondrion diagram M. Ruiz
Electron transport chain Tim Vickers

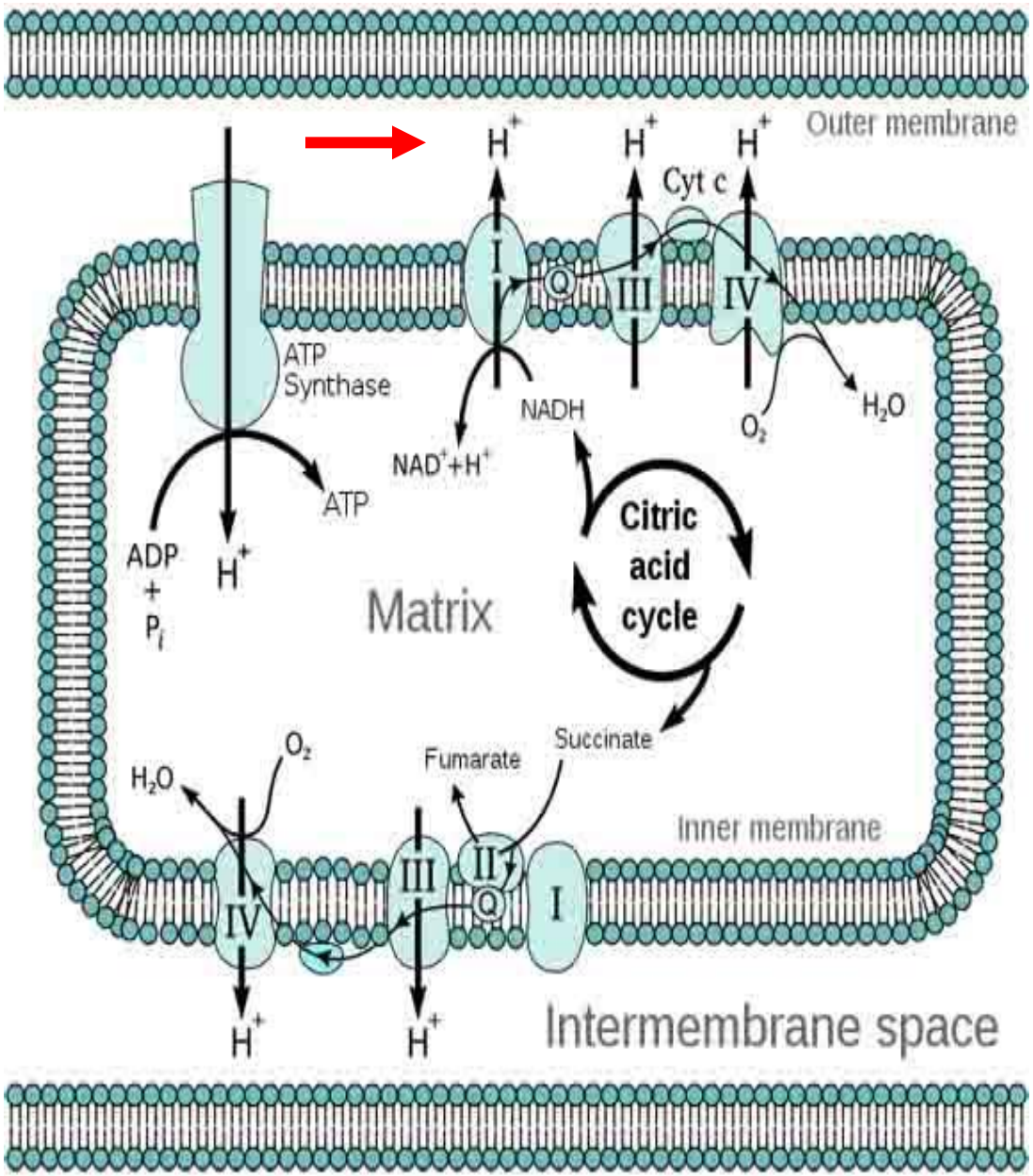


Electron Transport

2. _____

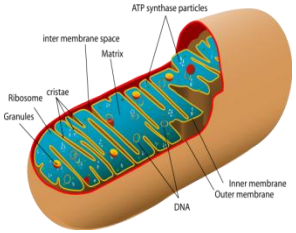
- Energy from each electron being passed down the chain is used to pump protons (H+) from one side of the membrane to the other.

- Proton gradient = type of _____ (difference in ion concentration on either side of a membrane) … potential energy available for work in cell.



From the Virtual Microbiology Classroom on ScienceProfOnline.com

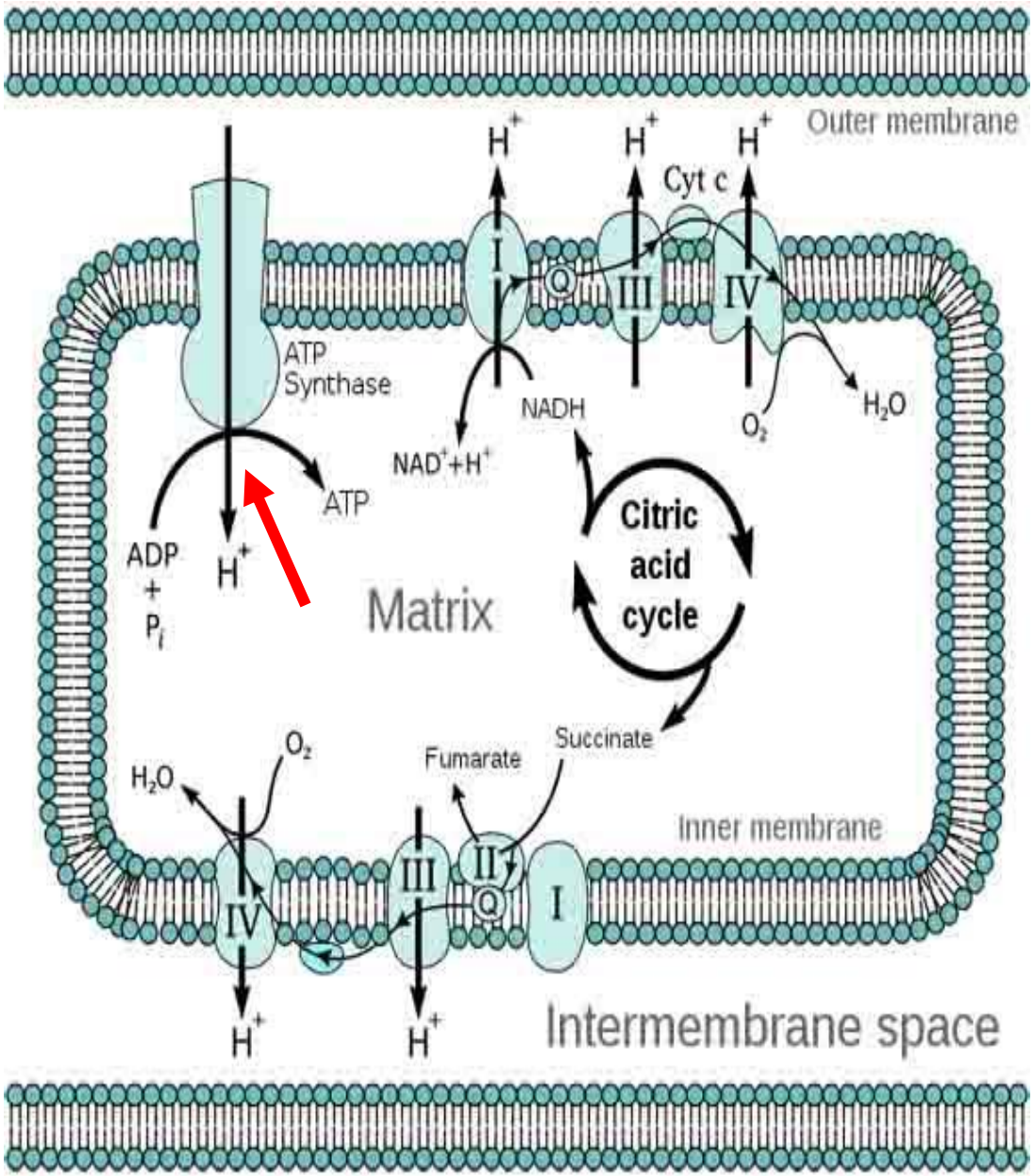
Images: Mitochondrion diagram M. Ruiz
Electron transport chain, Tim Vickers



Electron Transport

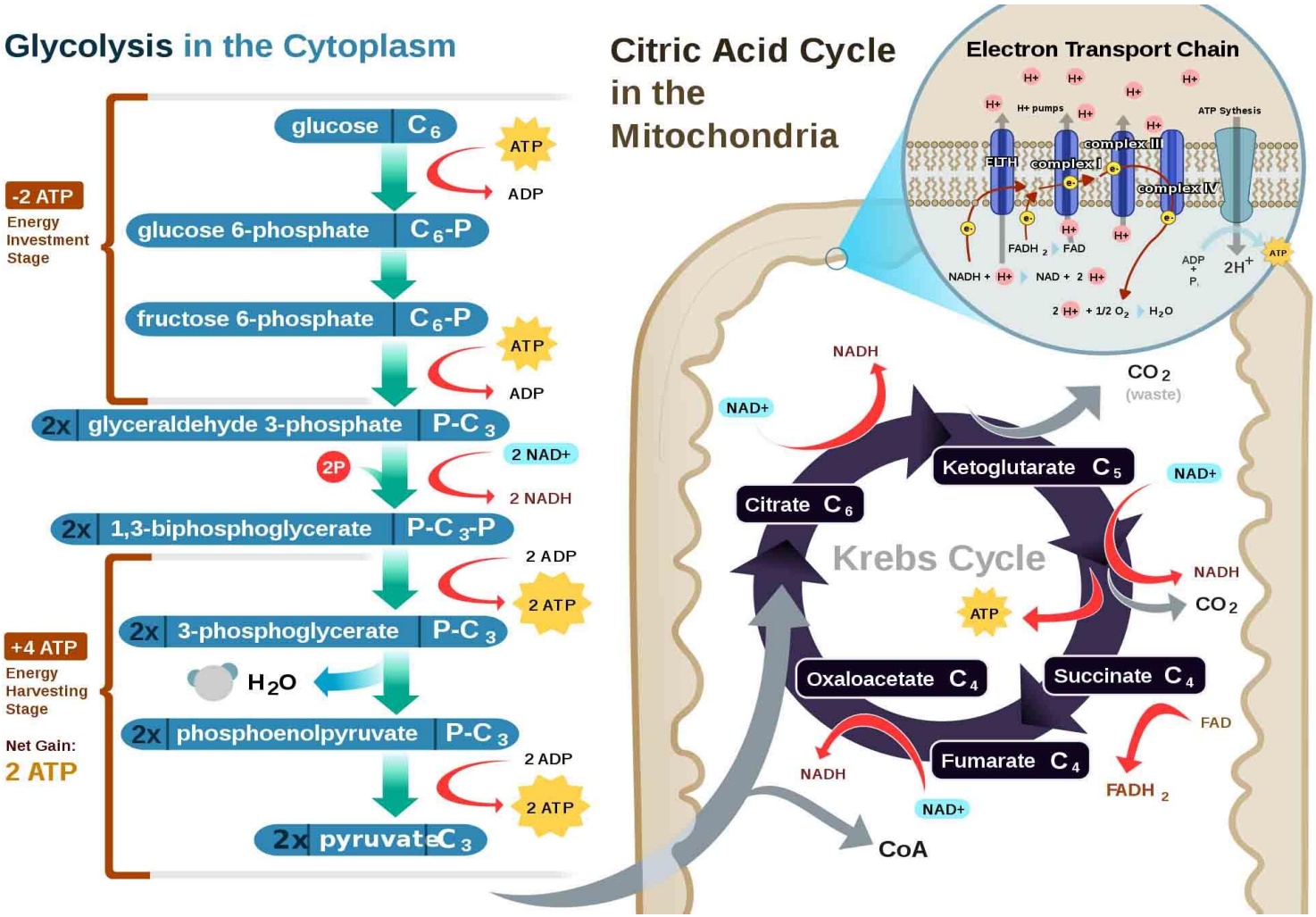
3. _____

H^+ ions flow down proton gradient through the enzyme ATP synthase that phosphorylates ADP to make ATP.



Images: Mitochondrion diagram M. Ruiz
Electron transport chain, Tim Vickers

Aerobic Cellular Respiration



From the Virtual Microbiology Classroom on ScienceProfOnline.com

Images: Cellular Respiration, Regis Frey

Aerobic cellular respiration →

Utilizes glycolysis, synthesis of acetyl-CoA, Krebs cycle, and electron transport chain; results in complete breakdown of _____ to carbon dioxide, water & 

The ultimate objective is to make 

molecules to do cellular work.

Each NADH results in 3 ATP, Each FADH2 results in 2 ATP.

A total of 38 molecules of ATP are formed from one molecule of glucose.

Lets figure out how we got 38 ATP by the end of aerobic respiration.

Using oxygen (1/2 O_2) in metabolism creates toxic waste.

Microbes that are able to use aerobic respiration produce enzymes to detoxify oxygen:

Catalase: H_2O_2 -------→ H_20 and 0_2
Superoxide dismutase (SOD): oxygen radical -----→ H_20 and O_2

Microbes that don't make these enzymes cannot exist in the presence of oxygen.

Q: *How do cells get energy if there is no O_2 available to them, or if they can't use O_2?*

- Cells that don't have access to oxygen, or that are obligate anaerobes can make ATP by using something other than oxygen as an electron acceptor *(nitrate, sulfate & carbon dioxide).*

- In anaerobic respiration, not all the ETC is used, so less ATP is produced.

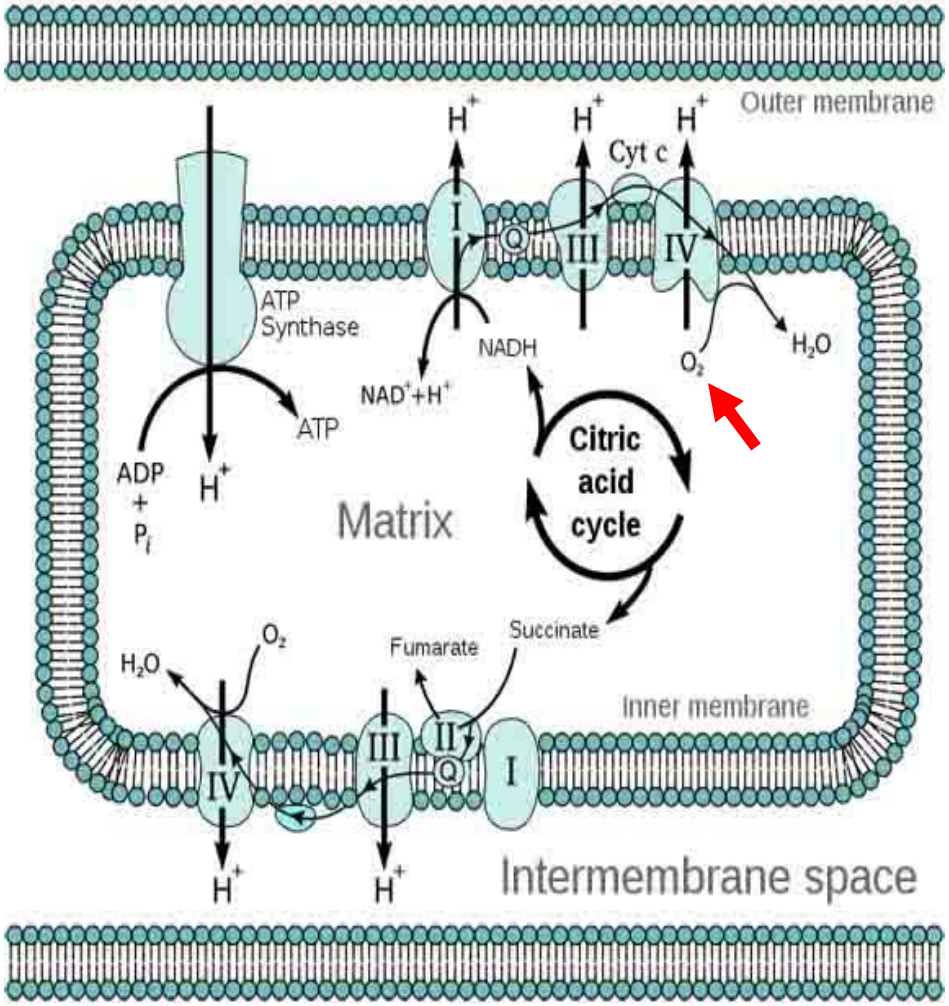
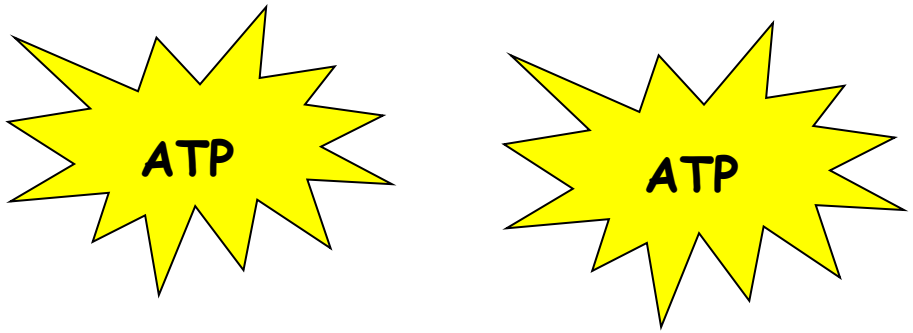
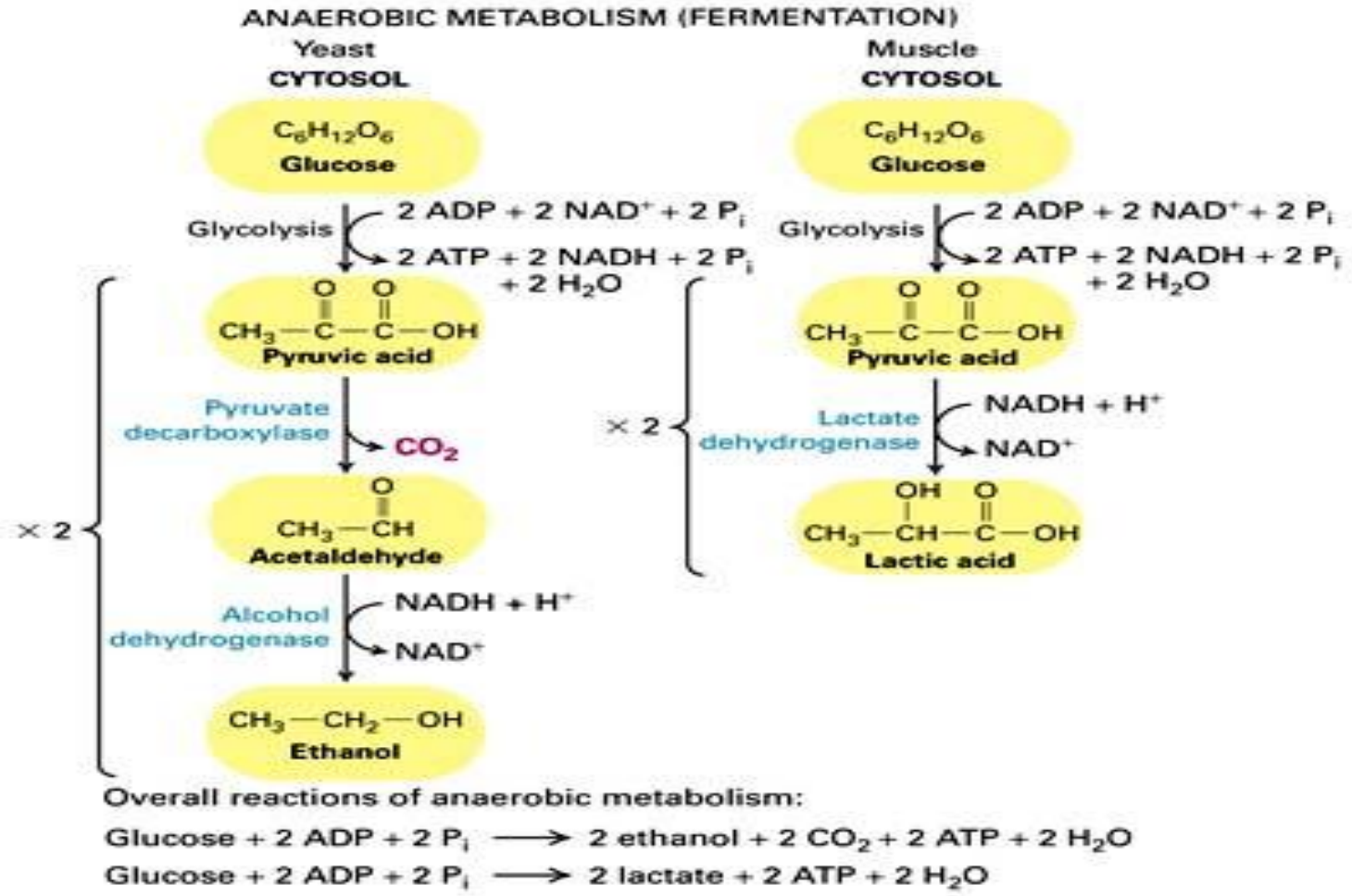


Image:Electron transport chain, Tim Vickers

- When there is no final _____ _____ for the ETC, the electron transport can't happen.
- Fermentation is an alternative system that allows glycolysis to continue without the other steps of respiration.
- Not as energetically efficient as respiration.
- Produces only 2 ATP.



Fermentation



Metabolism & Identification of Microbes

Some of the specialized media that we have worked with in lab is both **selective** and **differential**.

The **differential** properties give us information about bacteria based on its metabolism.

Qs: *What is the medium in top picture?*

- *Is selective …Why? What does it grow?*
- *Is differential …Why?*
- *What does the differential property reveal about the bacteria growing there?*

Qs: *What is the medium in bottom picture?*

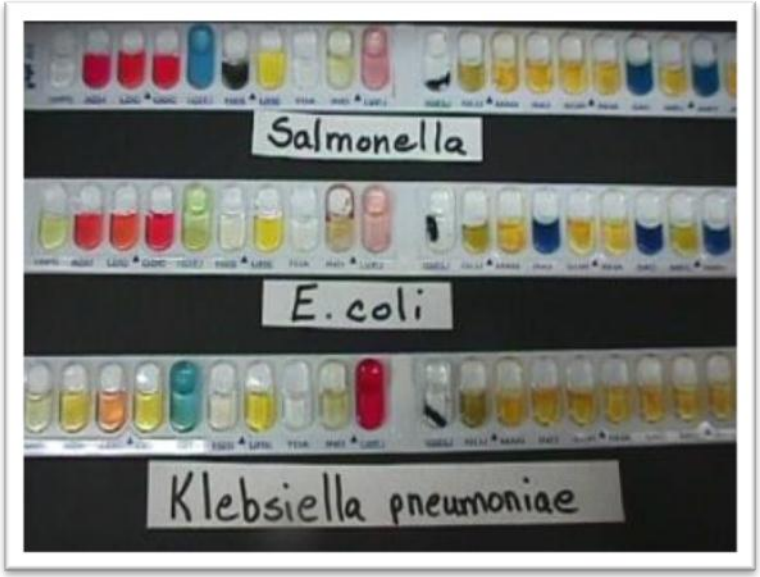
- *Is selective …Why? What does it grow?*
- *Is differential …Why?*
- *What does the differential property reveal about the bacteria growing there?*

Images: MacConkey's Agar (MAC) & Mannitol Salt Agar (MSA), T. Port

Metabolism & Identification of Microbes

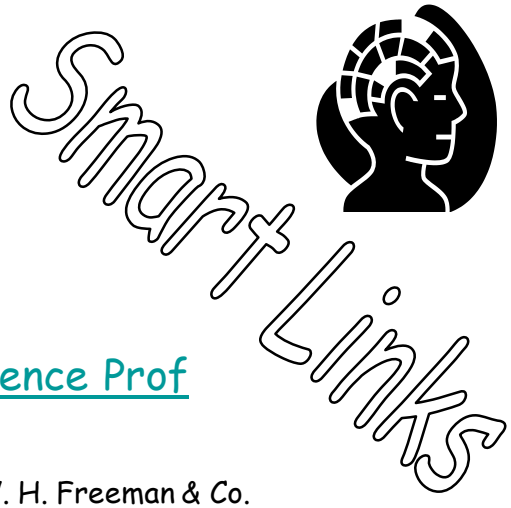
API-20E

- The API-20E test is used to ID Gram-negative enteric bacilli-shaped bacteria from the family.
- System of 20 individual, miniaturized tests used to determine the _____ _____ of the organism.
- Some microbes can metabolize certain molecules while others can't.
- When molecules are metabolized, specific waste products are created.
- From identification of metabolic capabilities, we can zero in on identification of genus and species.



Images: API-20E with results sheet, T. Port; API-20E results for different species of bacteria, Dr. Charles Gerba, University of Arizona

Confused?



Here are links to fun resources that further explain cellular respiration:

- Microbial Metabolism Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- Cellular Respiration animation by Jay Phelan, "What is Life? A Guide to Biology", W. H. Freeman & Co.
- Anaerobic Respiration Page by Timothy Paustain, University of Wisconsin, Madison.
- Alcohol and Lactate Fermentation by Central Michigan University.
- "The Body Machine" music video by School House Rock.
- How NAD+ Works animation and quiz from McGraw-Hill.
- Glycolysis animation and quiz from McGraw-Hill.
- Krebs Cycle Animation & Quiz 1 from McGraw-Hill.
- Krebs Cycle Animation & Quiz 2 from McGraw-Hill.
- Electron Transport Chain animation from Molecular & Cellular Biology Learning Center.
- Electron Transport Chain click through animation by Graham Kent Bio231 Cell Biology Laboratory.
- Electron Transport System & Formation of ATP (Quiz 1) by McGraw-Hill
- Electron Transport System & ATP Synthesis (Quiz 2) by McGraw-Hill
- Food Molecules video from HowStuffWorks, a Discovery company.
- "The Energy" song by Audiovent.

(You must be in PPT slideshow view to click on links.)

Homework Assignment

See the ScienceProfOnline Virtual Microbiology Classroom **Microbial Metabolism** lecture for a printable Word .doc of this assignment.

- At the end of some lectures, I will give you some type of homework to evaluate your understanding of that day's material.
- This homework will always be open-book.
- Today you will be given an *activity* on the topic of **Microbial Metabolism & Selective Media**.
- If assigned, this homework is due at the at the start of class, next time we meet for lecture.

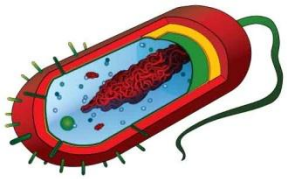
Images: Osmosis animation

Are microbes intimidating you?

Do yourself a favor. Use the…

Virtual Microbiology Classroom *(VMC)* !

The VMC is full of resources to help you succeed, including:



- practice test questions
- review questions
- study guides and learning objectives

You can access the VMC by going to the Science Prof Online website
www.ScienceProfOnline.com

Images:, *Staphylococcus,* Giant Microbes; Prokaryotic cell, Mariana Ruiz