# Biology 12 Respiratory System

Biology 12

Day 2

# Nuggets from Last Day

- On your desk, draw and label the various parts of the respiratory system

# Nuggets from Last Day

- What are the various receptors that monitor your breathing? List them all, where they are, and what they do.

# Nuggets from Last Day

- What is the equation that shows how carbon dioxide will impact blood pH?

# Into Thin Air

- Respiratory System case study

## *"Into Thin Air"*

### A Case Study in Physiology

by
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**Part I - Mt. Denali, Alaska, 17,660 Feet**

The winded climbers slowly ascended the icy cliff in the near darkness of 4 a.m., carefully avoiding the steep crevasses that fell off sharply to either side. Several times each hour, Tom Benman, lead climber and expedition frontman, would call out "Everyone okay?" They had stopped replying long ago, too exhausted by the supreme effort of simply placing each foot in the proper direction. Three hours into a 12+ hour climbing day, the silence was permeated only by labored breathing and the crunch of ice under crampons.

Emily Norman, a Registered Nurse and the only woman on the six-person expedition team, was third in line, following her friend Mark McKinley, the least experienced climber of the group. For the last couple of days, Mark had been coughing heavily, and all morning had been slowing up, causing a backlog behind them and prompting several "everyone okay"'s from Tom. Knowing Mark's competitive spirit, Emily was hesitant to urge him to pick up the pace, and when he pulled up to rest on a protected ledge, Emily motioned to the other climbers to pass on by. Her head was pounding anyway, and she rationalized she could use the break.

"You okay?" Emily asked.

"Yeah....I just....can't seem to....catch my breath," gasped Mark.

"Just rest a minute. There's no rush, Mark. Take your time....slow, deep breaths."

Tom appeared from the upper trail. "What's up?"

"Mark's having a little trouble catching his breath." Emily was getting worried.

Tom looked sharply at her. "How much trouble?"

"Quite a bit, I think." Emily looked over at Mark, whose breathing didn't appear eased by the rest stop, and then back at Tom. "I think we should get him down to a lower altitude. Quickly."

Tom nodded. "I'll get the others."

# Read Part 1: Mt. Denali, Alaska

1. What types of physiological problems do humans encounter at high altitudes?

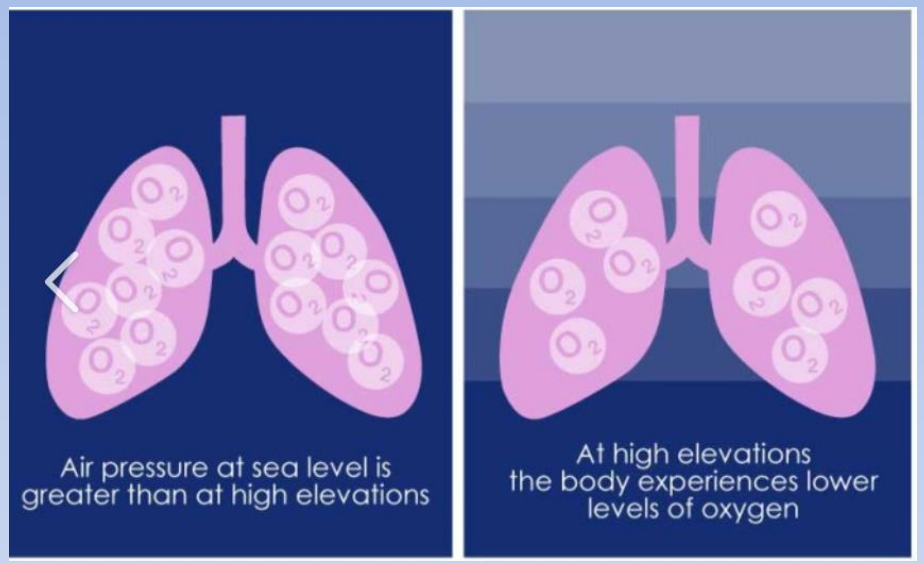
2. What symptoms did the climbers exhibit that might be related to altitude?

3. Compare the air at 18,000ft (280mmHg) to air at sea level (760mmHg). How will this impact the respiratory system?

# Read Part 1: Mt. Denali, Alaska

***Altitude Sickness Symptoms***

- Shortness of breath
- Fatigue
- Vomiting
- Rapid heart rate
- Insomnia
- Nausea
- Headache




***Serious symptoms may include:***

- Skin discoloration-blue, pale or grey
- Shortness of breath at rest
- Confusion
- Decreased consciousness
- Not being able to walk in a straight line
- Chest tightness
- Coughs with bloody mucus

# Read Part 2: Gasping for Air

Why does someone “altitude train”? What does it do?

What are some advantages of altitude training?

## hypoxia

Generalised hypoxia occurs in healthy people when they ascend to high altitude, where it causes altitude sickness, and the potentially fatal complications of altitude sickness,

Altitude training uses mild hypoxia to increase the concentration of red blood cells in the body for increased athletic performance

The body adapts to the relative lack of oxygen by increasing the concentration of red blood cells and haemoglobin

# Read Part 3: Airlift

How would oxygen and Gammow (hyperbaric) bag help Mark?


Once Mark reaches the hospital, what type of tests would you want to run?

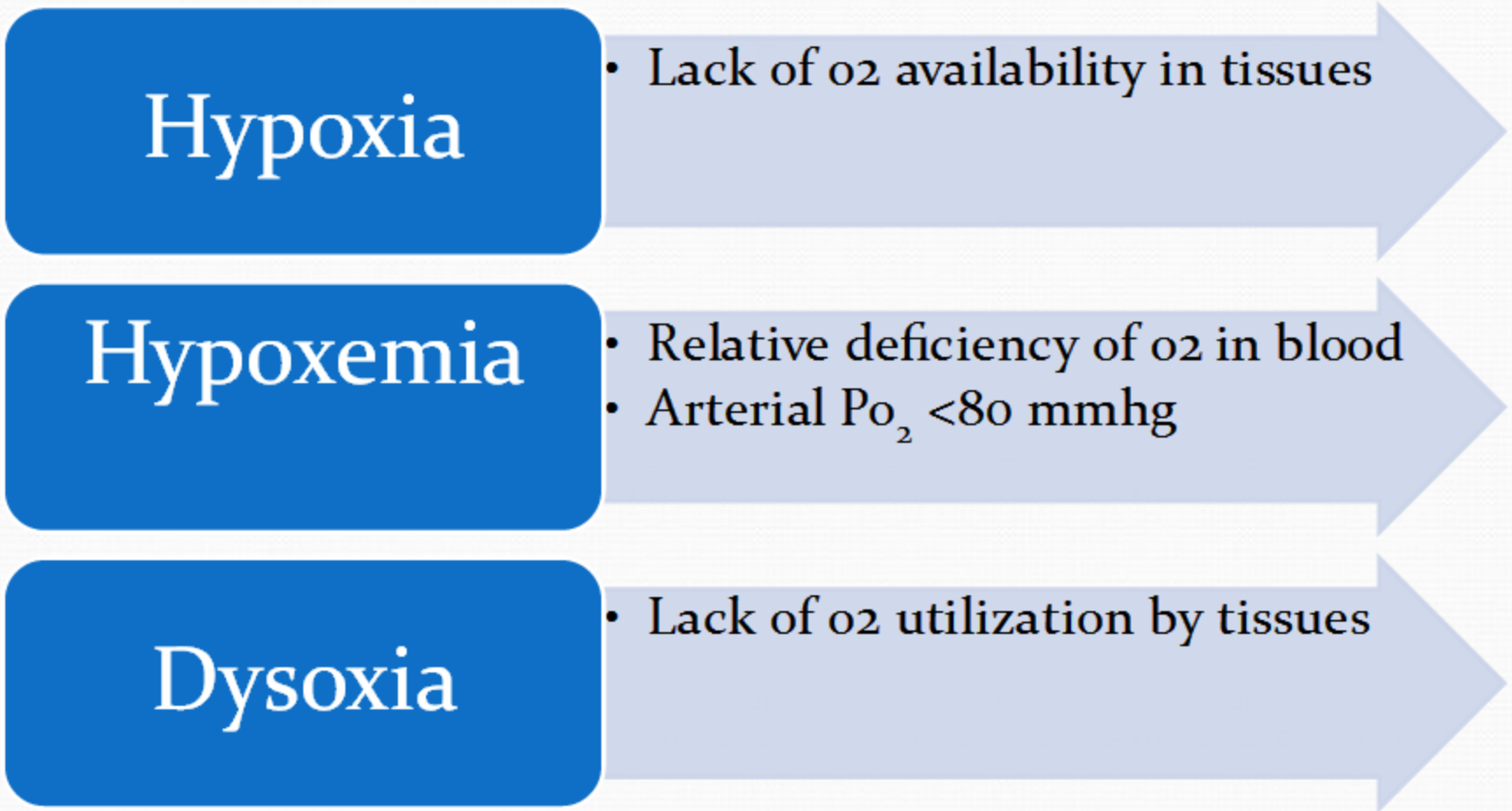
# Read Part 4: Mark's Medical Data

**Which results are abnormal? What does this mean?**

Use your phone or ipad for research

**BLOOD LEVELS**

| | MARK'S | NORMAL |
|---|---|---|
| Arterial Oxygen | 52 Torr | 80-100 Torr |
| Arterial Carbon Dioxide | 30 Torr | 35-45 Torr |
| Arterial pH | 7.23 | 7.38-7.44 |
| Hematocrit | 58% | 42-52% |
| Arterial glucose | 102 mg/100ml | 60-110 mg/100ml |
| Urea Nitrogen (BUN) | 12 M | 7-14 M |
| Creatinine | 1.1 mg/100ml | 1-1.5 mg/100ml |
| Potassium | 4.0 meq/L | 3.5-5.0 meq/L |
| Sodium | 145 meq/L | 136-145 meq/L |
| Bicarbonate | 18 meq/L | 20-24 meq/L |
| Chloride | 100 meq/L | 98-106 meq/L |


Hypoxia
• Lack of o2 availability in tissues
Hypoxemia
• Relative deficiency of o2 in blood
• Arterial $Po_2$ <80 mmhg
Dysoxia
• Lack of o2 utilization by tissues
#PULMONOLOGY_CAPSULE

# Read Part 4: Mark's Medical Data

**Which results are abnormal? What does this mean?**

Use your phone or ipad for research

**PULMONARY FUNCTION TESTS**

| | | |
|---|---|---|
| Inspired Oxygen Tension | 147 Torr | 150 Torr |
| Vapor Pressure | 45 Torr | 47 Torr |
| Alveolar Oxygen | 110 Torr | 98-104 Torr |
| RQ | 0.66 | 0.78-0.82 Torr |
| Tidal Volume | 0.4 L | 0.5 L |

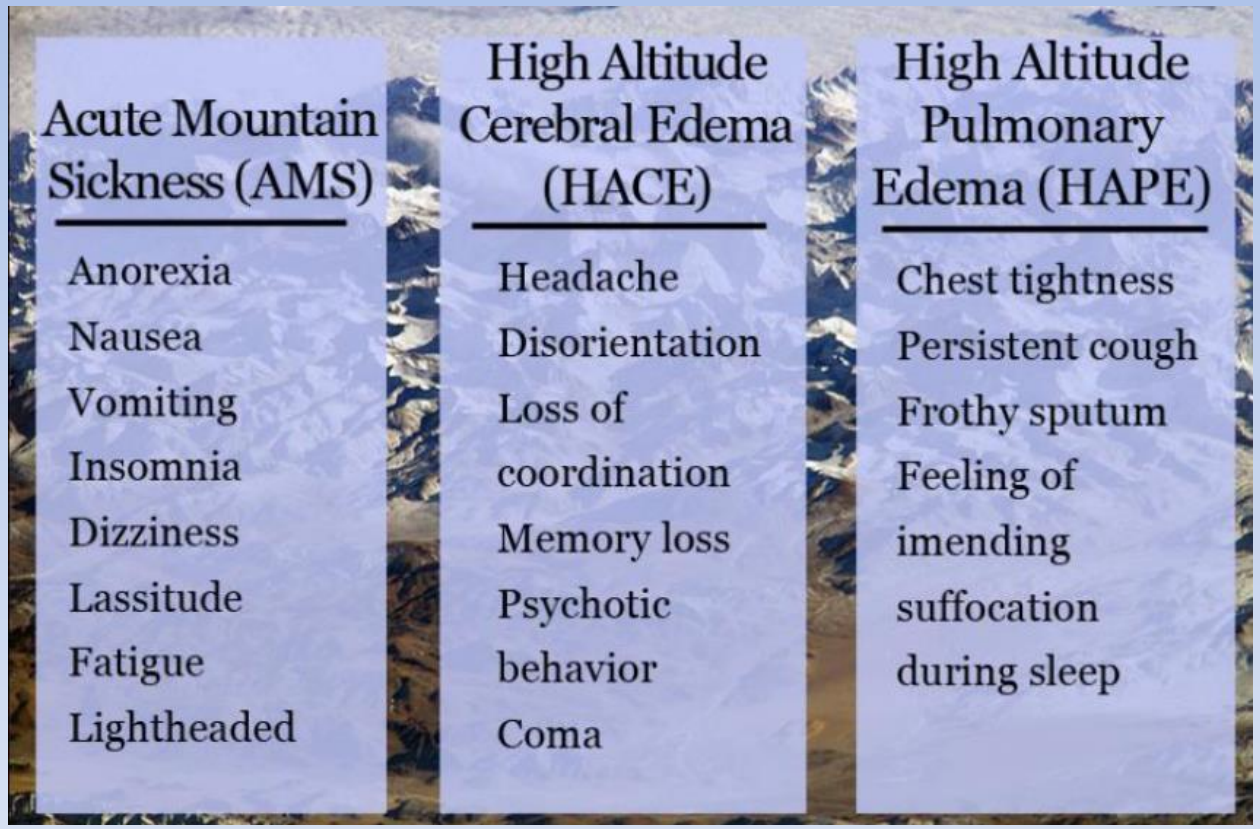
**HEART RATE**: 88 bpm (normal: 60-90 bpm)

**BLOOD PRESSURE**: 105/60 (normal: 110-120/60-80 mm Hg)

# Read Part 5: Mark This…

**AMS can occur greater than 2,500m**

**Rockies (4,200m)**
**Coquihalla (1,800m)**

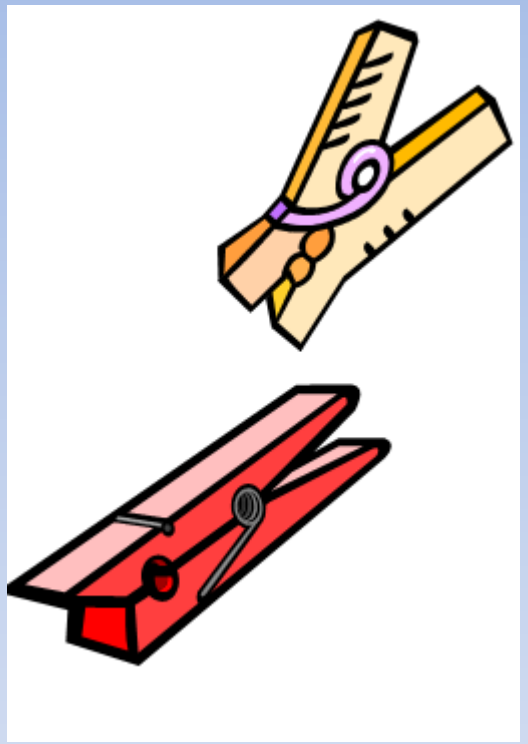


# Cellular Respiration

**How does our body make out ATP?**

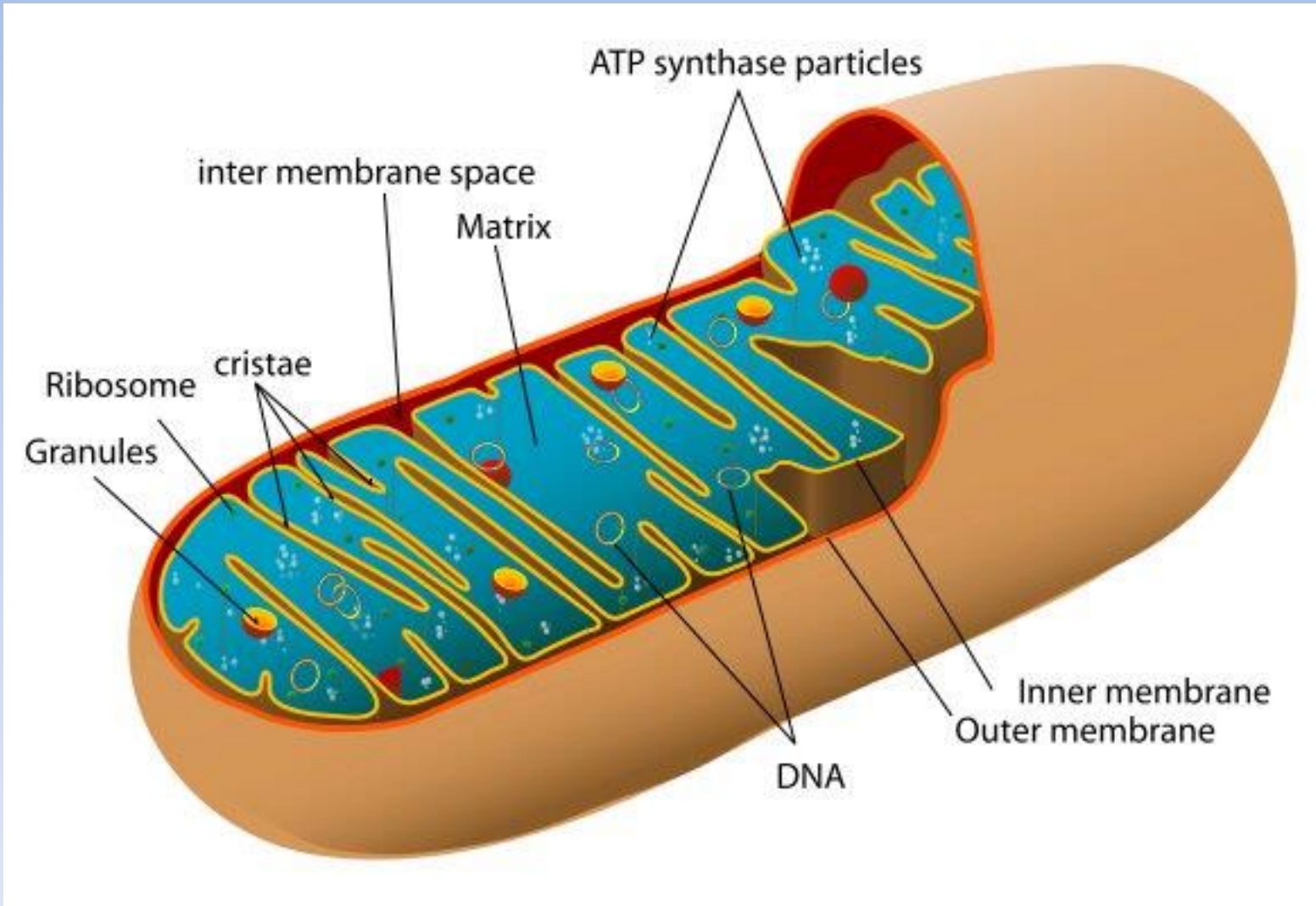
# I'm so strong!

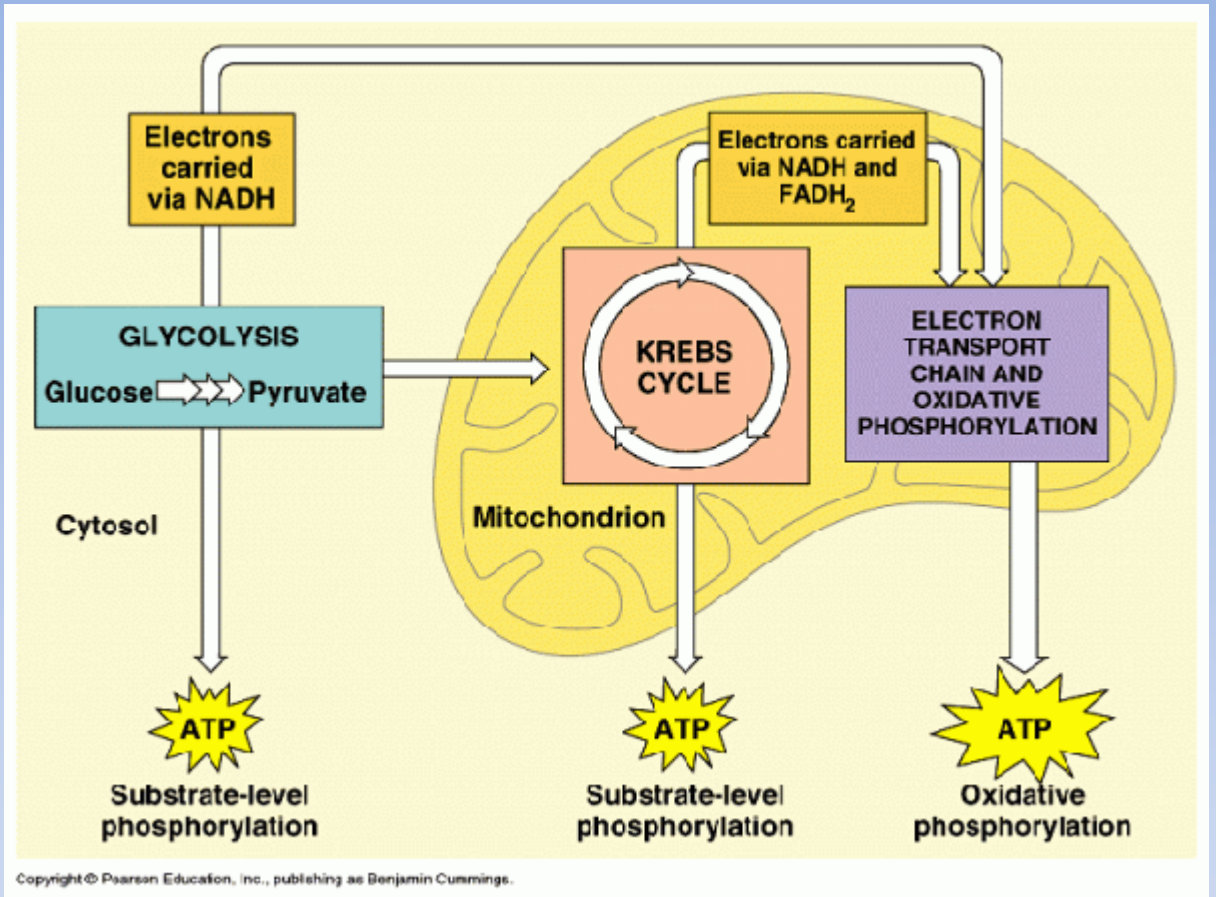
Show your muscle strength by opening and closing the clip as many times as possible.



- Record how many times you open in 1  minute
- Let's do this 5 times
- **What do you notice?**
- **Why is this happening?**

# Mitochondria Structures

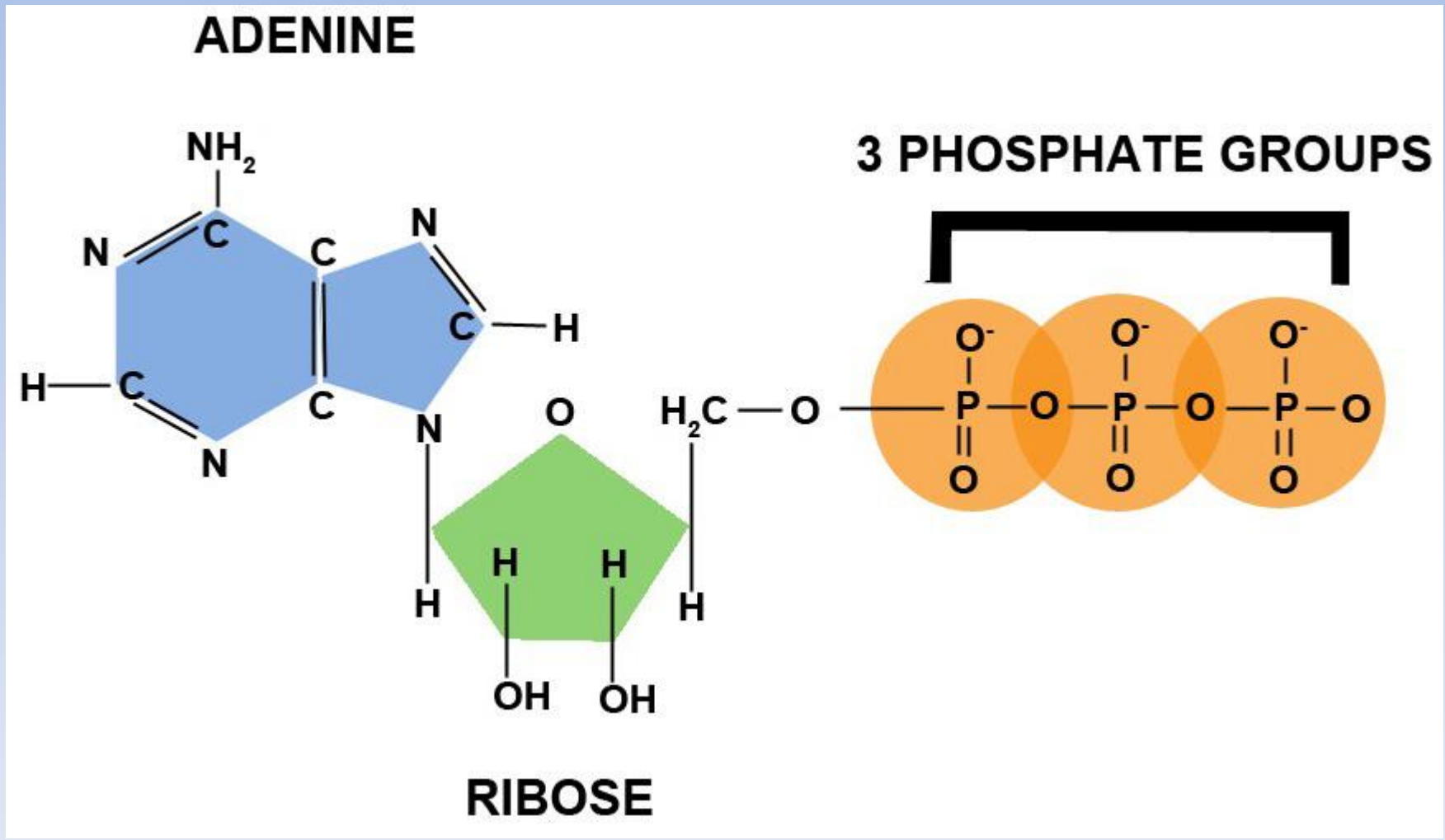




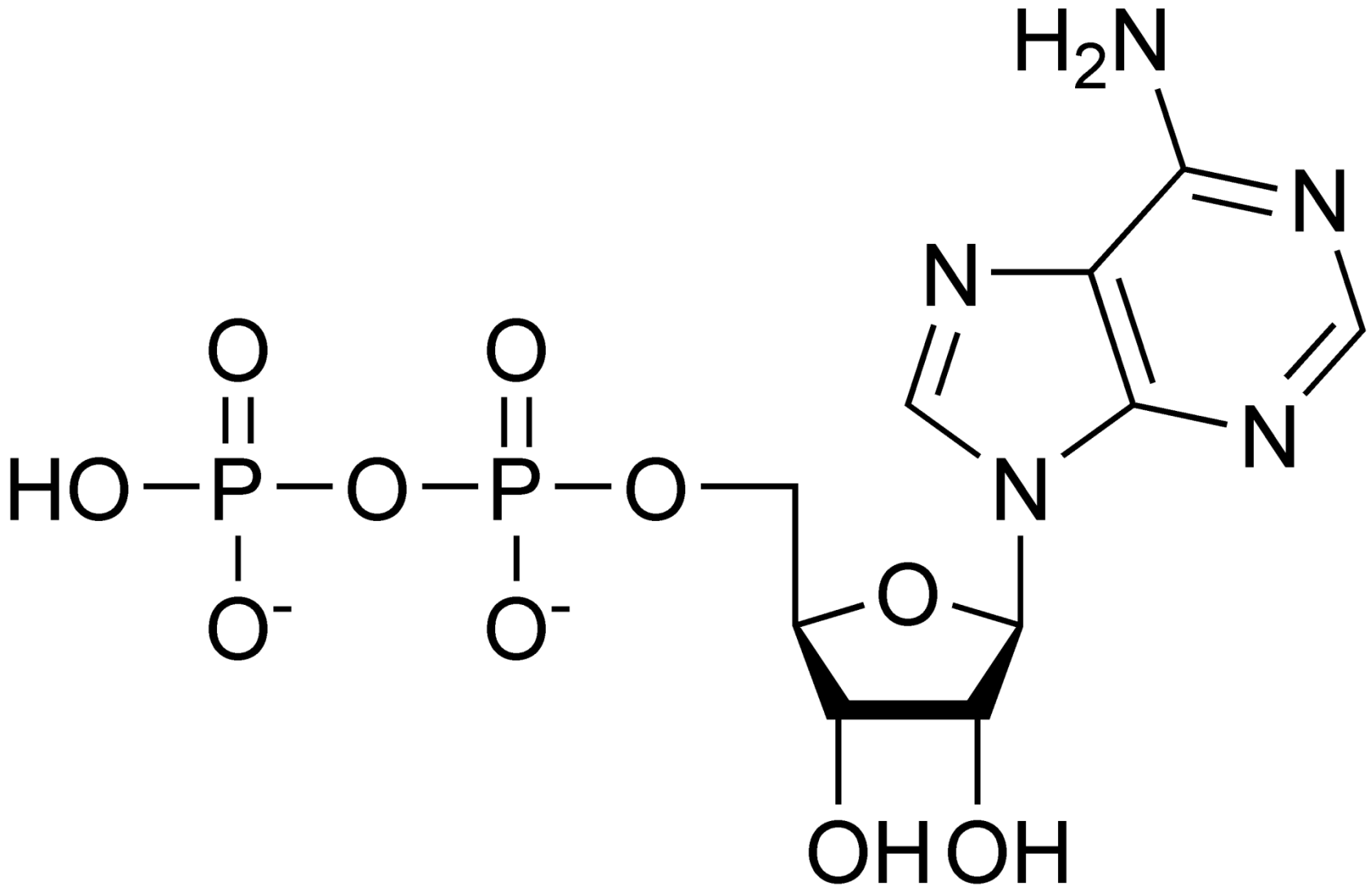

## 3 steps

1. Glycolysis (in cytoplasm of cell)
2. Kreb's Cycle (in matrix of mitochondria)
3. Electron Transport Chain (inner membrane cristae of mitochondria)

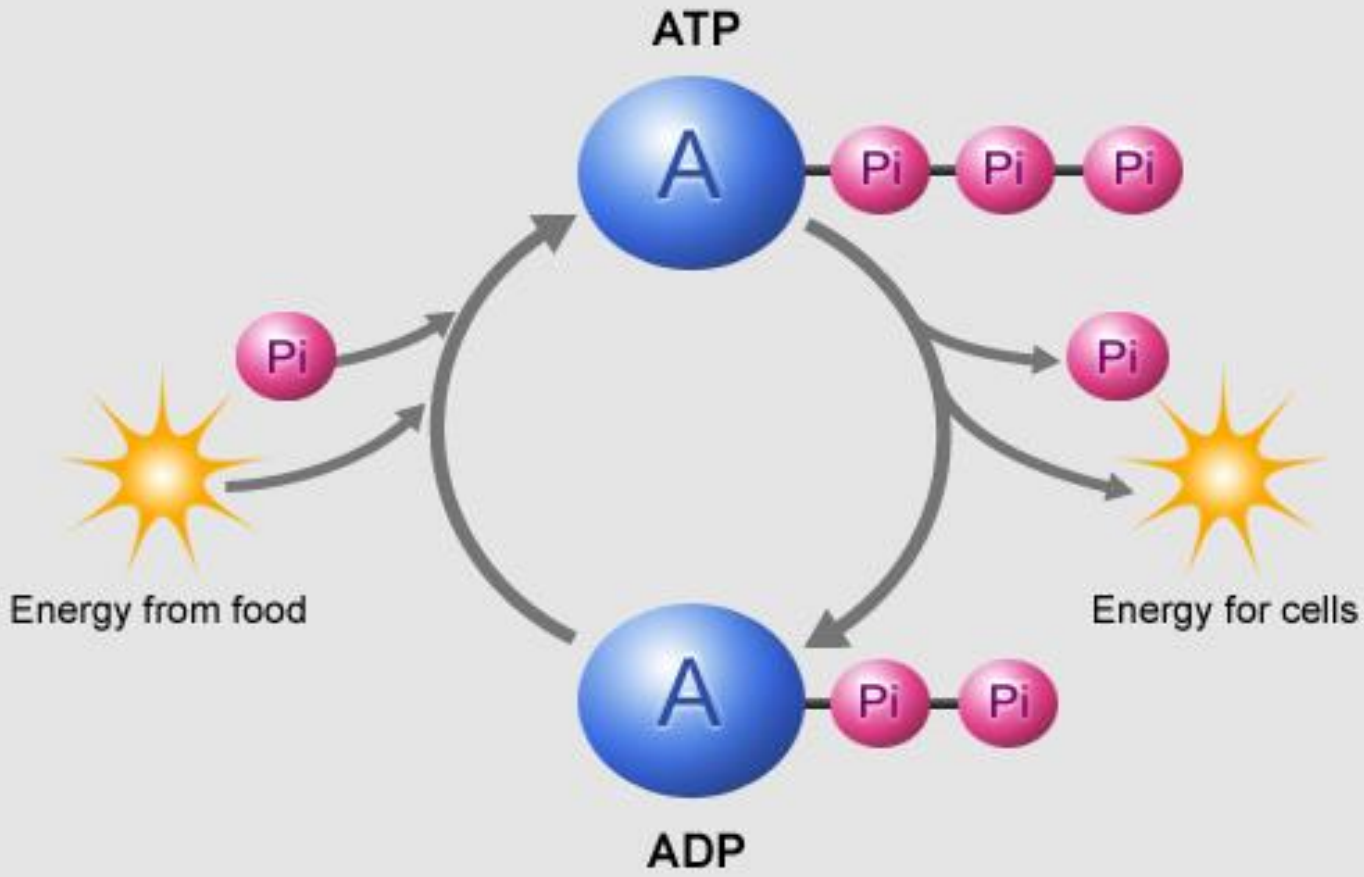
# Structure of ATP



# Structure of ADP

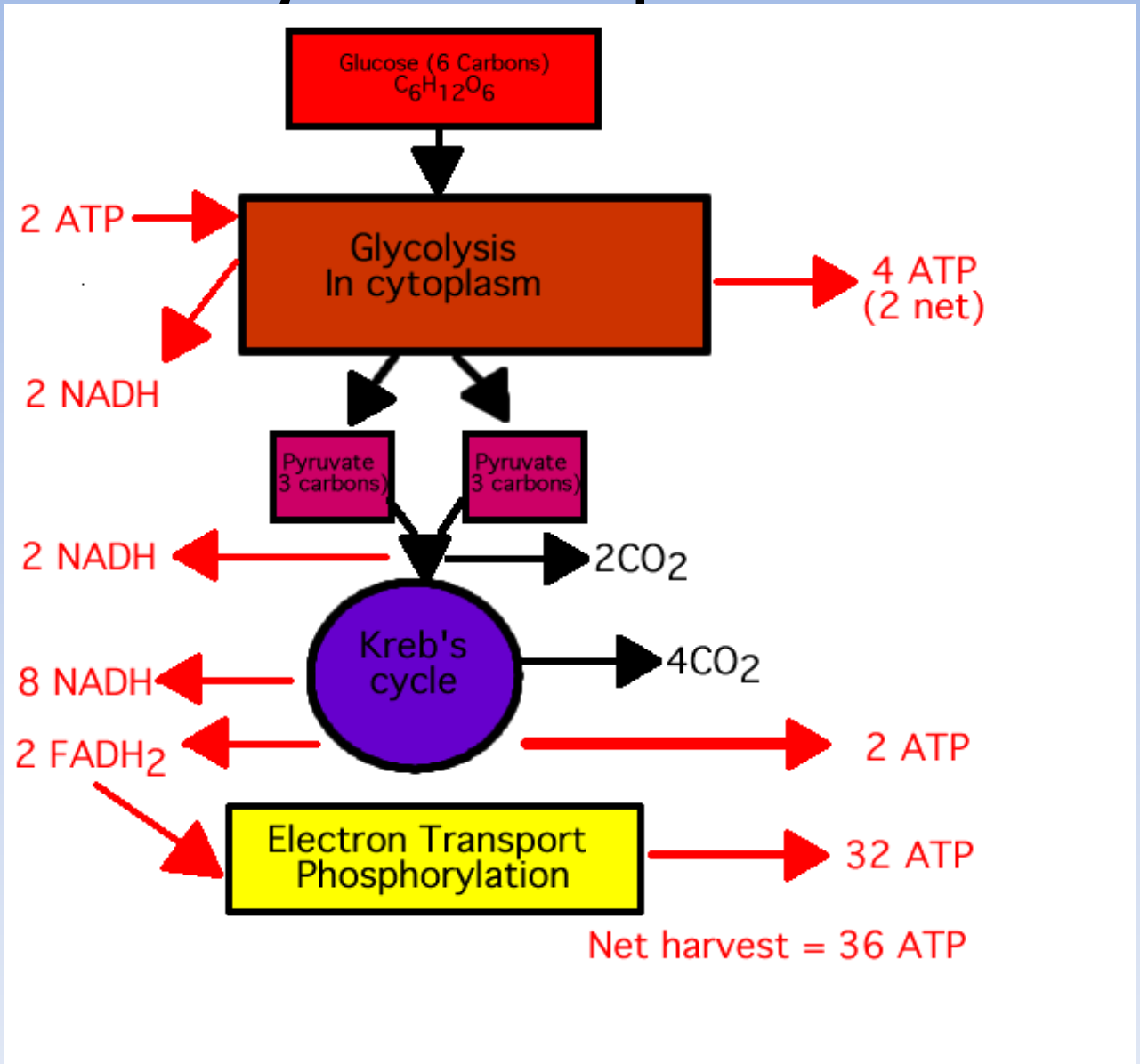


## ATP - 100% renewable energy



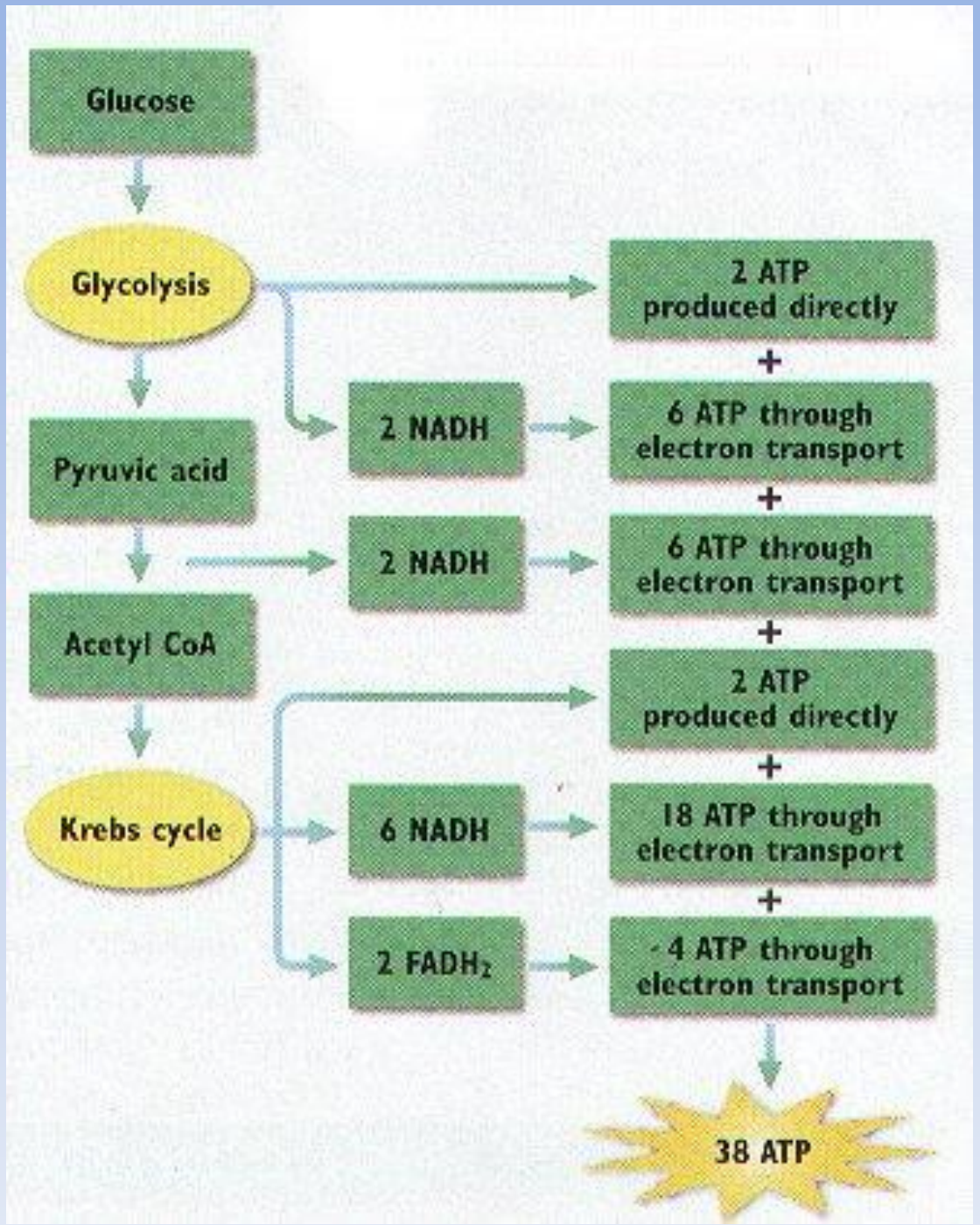

All living cells rely on one source of energy to do everything from building molecules to flexing muscles - ATP (adenosine triphosphate). Breaking down ATP releases energy, and cells constantly replace their ATP by wacking a spare phosphate onto ADP (adenosine diphosphate). The energy for that comes from food we eat (in animals) or make (in plants). Enzymes control the breaking and making of ATP.

# Summary of ATP production

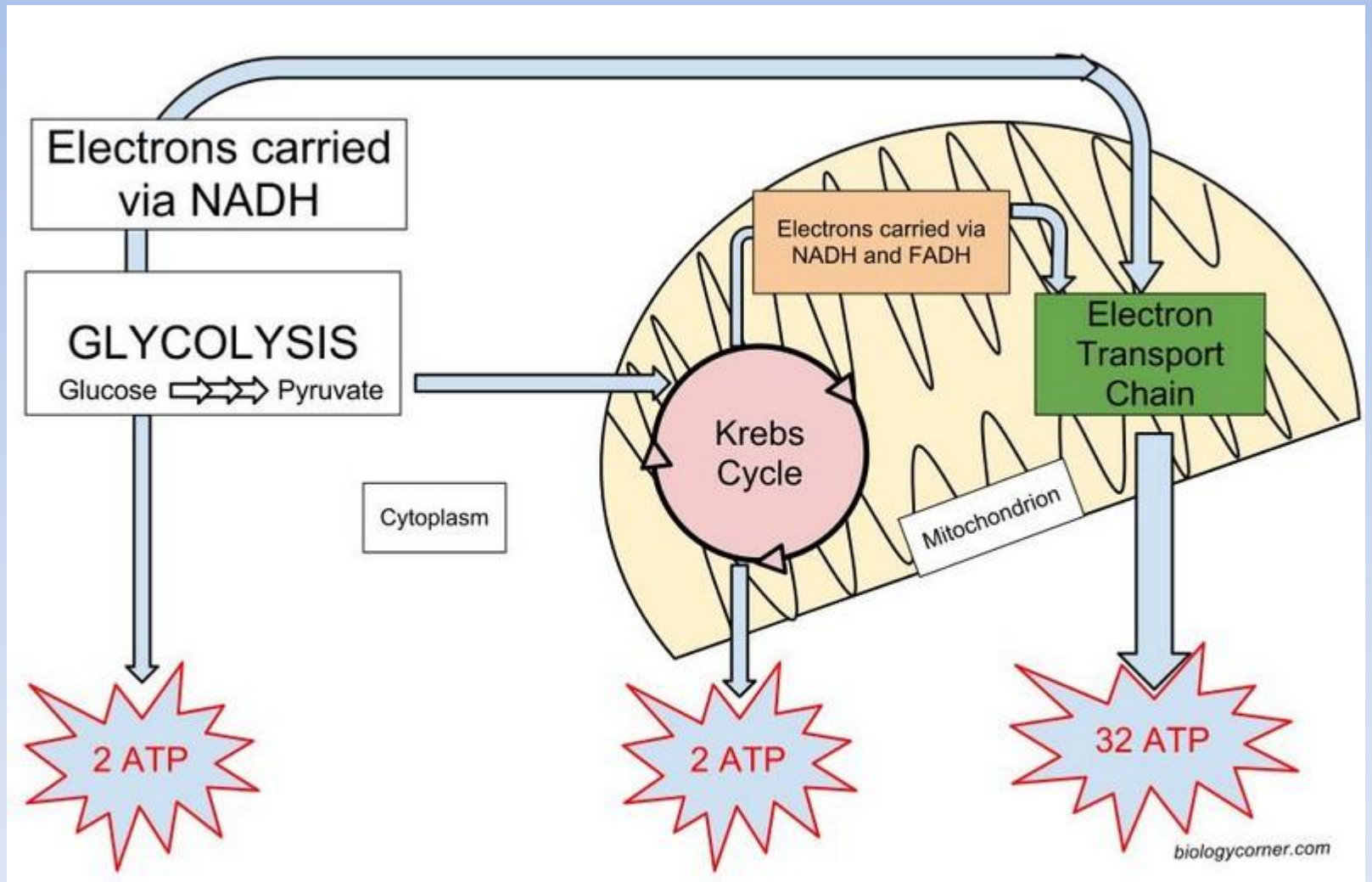


# What makes ATP?

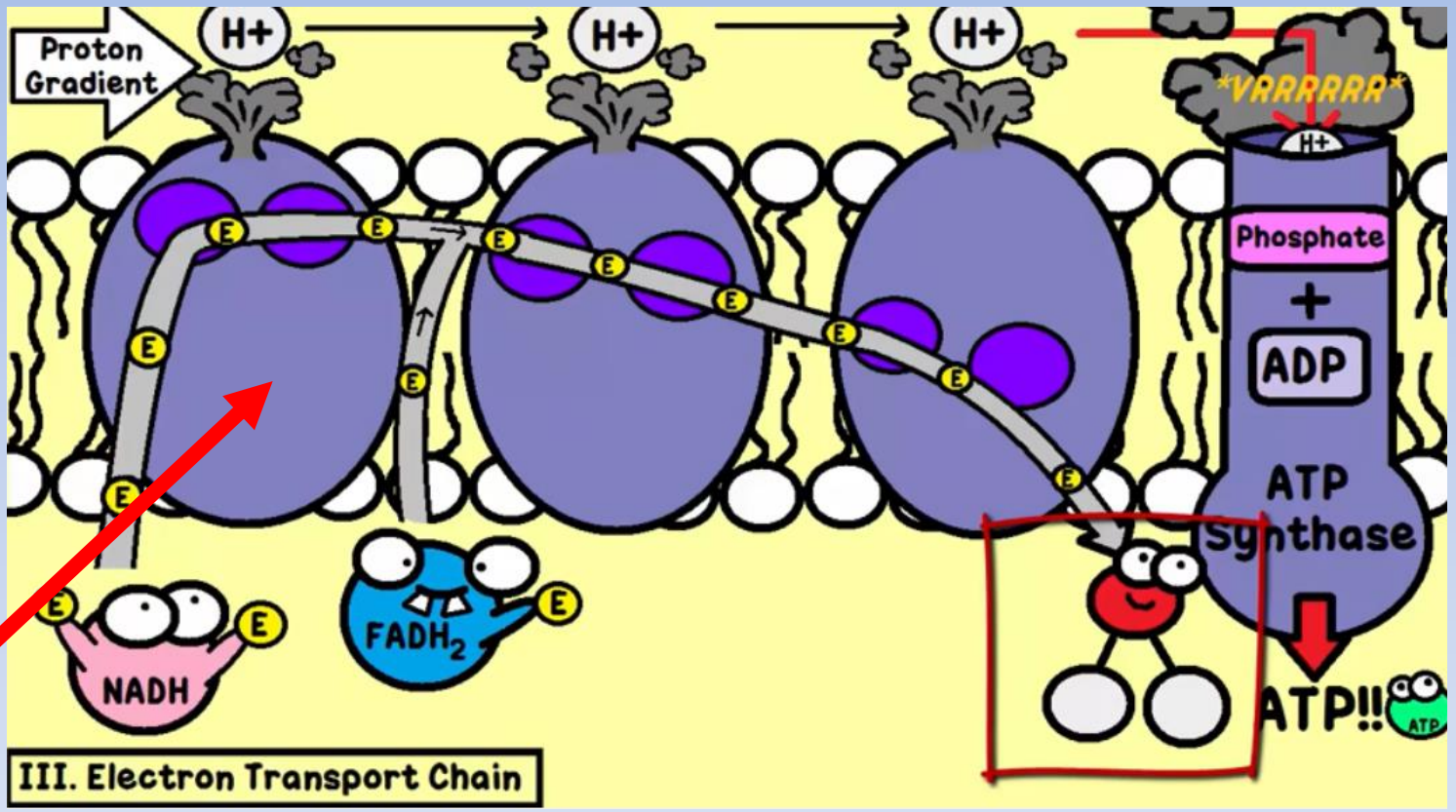

- **Glycolysis**
  - 2 ATP directly
  - 2 NADH → ETC → 6 ATP
- **Krebs Cycle**
  - Prior to KC, 2 NADH → ETC → 6 ATP
  - 2 ATP directly
  - 6 NADH → ETC → 18 ATP
  - 2 $FADH_2$ → ETC → 4 ATP


Glucose
Glycolysis
Pyruvic acid
Acetyl CoA
Krebs cycle
2 ATP produced directly
+
2 NADH
6 ATP through electron transport
+
2 NADH
6 ATP through electron transport
+
2 ATP produced directly
+
6 NADH
18 ATP through electron transport
+
2 FADH2
4 ATP through electron transport
38 ATP

# Summary of ATP production



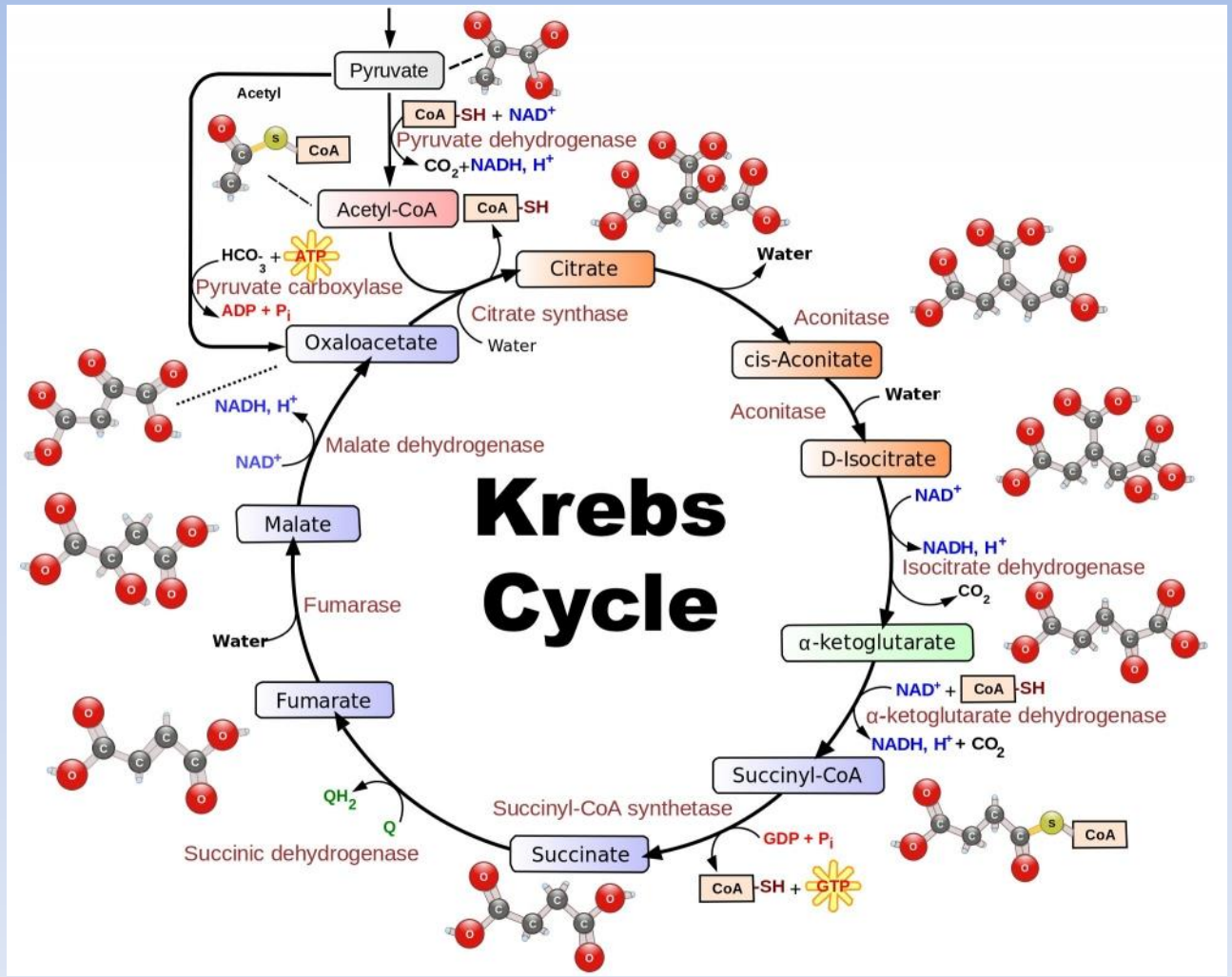
# Watch and take 5 notes of new learning for you…



# Let's Walk Through the Process Again!

- **What are the three parts to cellular respiration?**
- **What happens first? What is made? Where does it go?**
- **What happens next? What is made, where does it go?**
- **What happens lastly? Where does this go? How is it used?**

# What is the WASTE of Krebs?



# Partner Practice

- Use Whiteboards and Pens to draw either on board or on window

1. Process of Cellular respiration
   - **Molecules to include:** glucose, pyruvate, Acetyl CoA
   - **Products to Include:** ATP, NADH, FADH2
   - **Locations to include:** cytoplasm, mitochondria cytosol, matrix
   - **Steps to include:** glycolysis, Krebs Cycle, Electron Transport Chain

# The Mystery of the Seven Deaths

A study of cellular respiration

## The Mystery of the Seven Deaths: A Case Study in Cellular Respiration

*by*
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### Part I – The Symptoms

Imagine that you work at the medical examiner's office for a major metropolitan city. As Chief Medical Officer, you investigate suspicious deaths and provide toxicology services for the county. Unfortunately, it's been a busy week. In the past five days, seven people have died, all with similar symptoms. It is your job to examine the data and determine the cause of death for these victims.

The first was a 12-year-old girl. Her parents said that she was awake in the middle of the night complaining of a stuffy nose and sore throat. They gave her an extra strength Tylenol and sent her back to bed. At 7am the next morning, the parents discovered that the girl had collapsed on the bathroom floor. An ambulance rushed the girl to a nearby hospital, where she was pronounced dead.

That same day, paramedics found the second victim unconscious on his kitchen floor after what they thought was an apparent heart attack. Sadly, the victim's brother and fiancée also collapsed later that night while the family gathered to mourn his passing. Both had taken Tylenol to help them cope with their loss shortly before collapsing; neither survived.

In the next four days, four other similar deaths were reported, all in the same neighborhood and all with similar symptoms.

Are these seven deaths related? What is causing these people to die? It is your job to answer these questions before more deaths are reported.

Symptoms exhibited by most patients:

- Dizziness
- Confusion
- Headache
- Shortness of breath/rapid breathing
- Vomiting

Most deaths were very rapid, occurring within a few hours of symptoms.

*Questions*

1. Are there any similarities or connections between these seven individuals? What questions would you want to ask the families to answer these questions?
2. In your opinion, are these seven deaths connected? Why or why not?

# Read Part 1: The Symptoms

**1. Are there any similarities or connections between these seven individuals? What questions would you want to ask the families to answer these questions?**

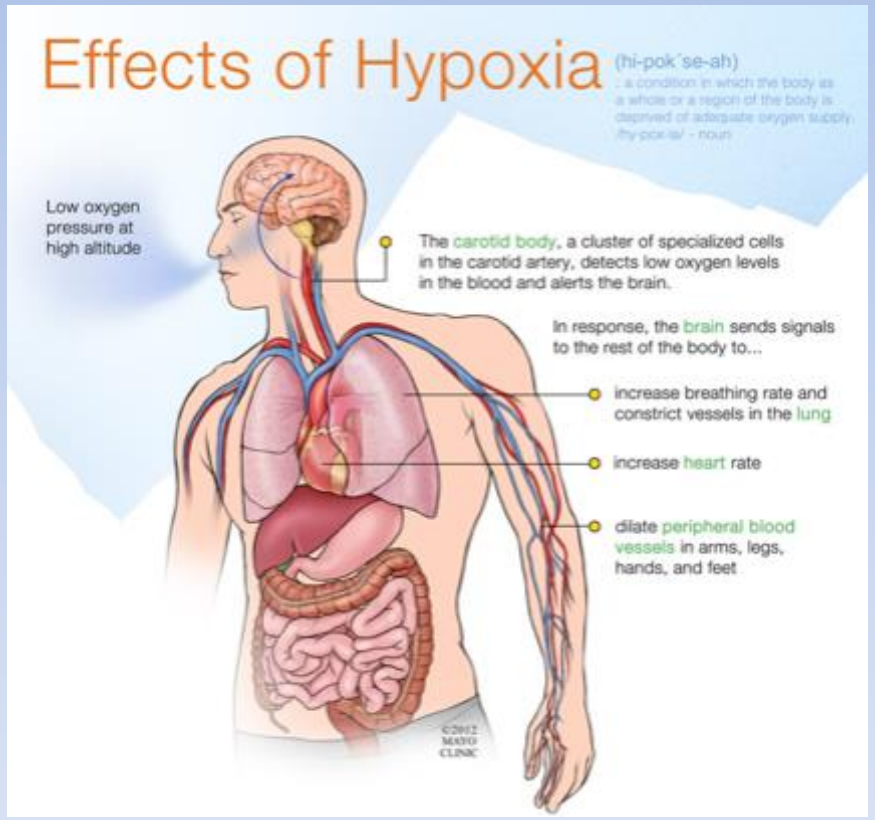
**2. In your opinion, are these seven deaths connected? Why or why not?**

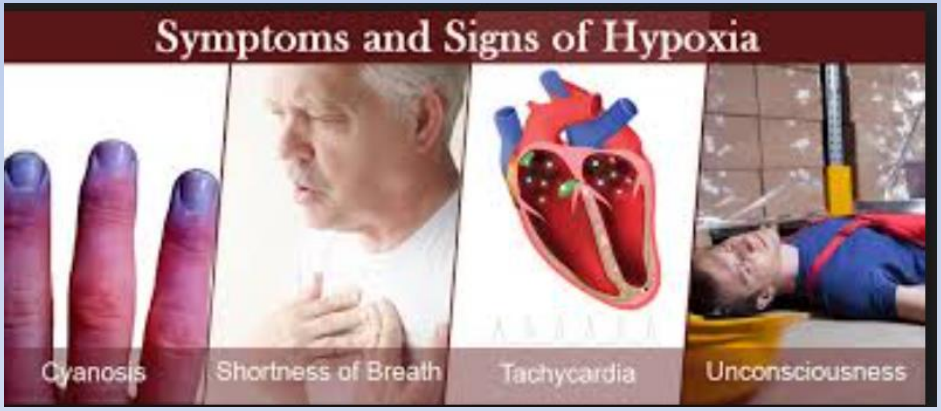
# Read Part 2: Autopsy Report

**Answer the following questions (Use your device or ipad to do some research)**

1. **What are the symptoms of hypoxia? What are some issues that can cause it? Do you think those are at play here?**
2. **Recalling your knowledge of the function of organelles, what function of the cells was interrupted in these patients? Could this loss of function lead to the death of these individuals? Why or why not?**
3. **Given the data in the autopsy, were there any reports that seemed inconsistent with the immediate cause of death?**

# Hypoxia


Effects of Hypoxia
(hi-pok´se-ah)
Low oxygen pressure at high altitude
The carotid body, a cluster of specialized cells in the carotid artery, detects low oxygen levels in the blood and alerts the brain.
In response, the brain sends signals to the rest of the body to...
increase breathing rate and constrict vessels in the lung
increase heart rate
dilate peripheral blood vessels in arms, legs, hands, and feet

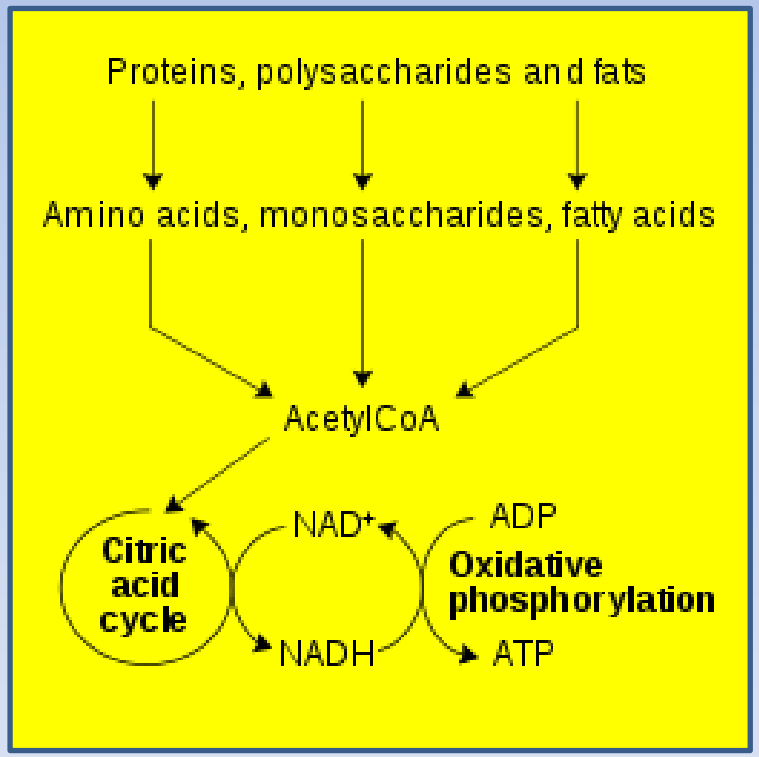

Symptoms and Signs of Hypoxia
Cyanosis
Shortness of Breath
Tachycardia
Unconsciousness

# Read Part 3: Subcellular Metabolite Analysis

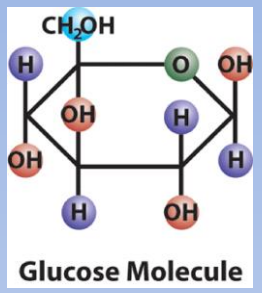
Average Metabolite Levels

| *Metabolite* | *Average Patient Levels* | *Normal Levels* |
|---|---|---|
| Glucose | 99 µM | 100 µM |
| Pyruvate | 27 µM | 25 µM |
| NAD+ | 10 µM | 75 µM |
| NADH | 400 µM | 50 µM |

**1. What do each of the above molecules do in the body?**

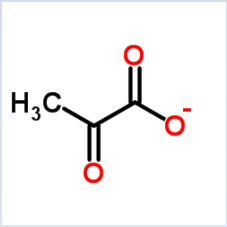


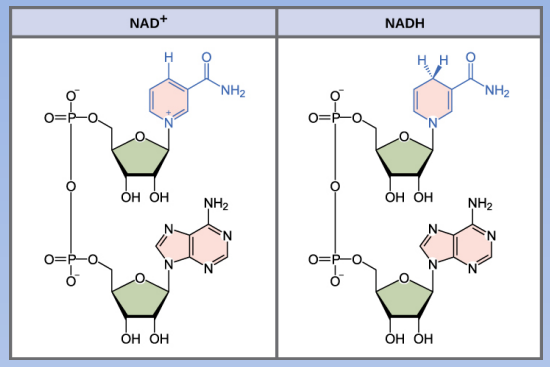
# Biomolecules




- **Glucose -** a monosaccharide that functions as the main energy source for the body. It is the substrate that enters glycolysis, where it is broken down into pyruvate, forming 2 NADH and a net yield of 2 ATP molecules.

- **Pyruvat**e - a 3 carbon sugar that is formed as a product of glycolysis. It is a substrate of the preparatory reaction, where it is converted into a two carbon Acetyl CoA molecule, releasing a molecule of carbon dioxide and producing a molecule of NADH. Acetyl CoA then functions as a substrate of the citric acid cycle.

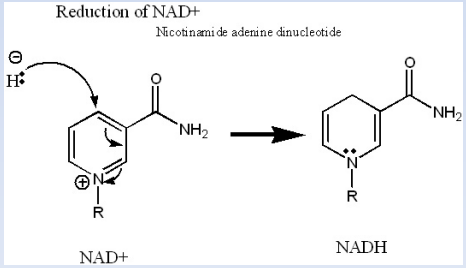





# Biomolecules

- **NAD+**—This is an electron acceptor. It functions as a substrate in glycolysis and the citric acid cycle, where it picks up electrons (is reduced) to form NADH.

- **NADH**—This is an electron donor. It is a product of glycolysis and the citric acid cycle; it is the reduced form of NAD+. NADH functions to bring electrons from glycolysis and the citric acid cycle and donate them to the electron transport chain (NADH is oxidized back to NAD+).

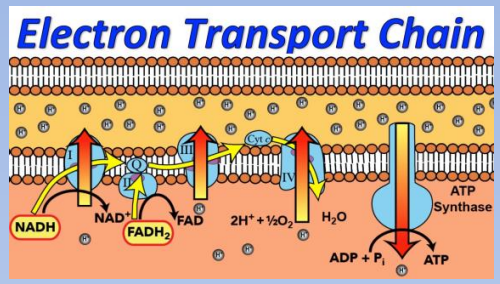


# What Could Be Wrong?

1. Are there any abnormalities in the levels of these metabolites in the victims? Develop a hypothesis about which pathway may be affected based on these abnormalities.

2. Explain your reasoning for your hypothesis.

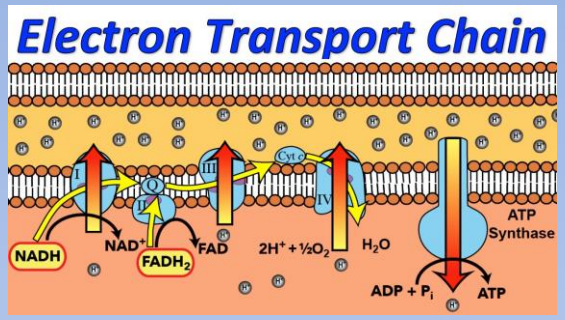
# Hypothesis




***Hypothesis - electron transport chain is no longer working.***

- If this is the case, then there would be no removal of electrons from the NADH carrier.

- NADH levels would increase as it was continually made by the glycolysis and citric acid cycle pathways, resulting in the increased levels observed in the patients.




# Hypothesis

- NAD+ is regenerated from NADH after it donates its electrons to the ETC.
- Because NADH is unable to transfer electrons, NAD+ is unable to be regenerated.
- NAD+ is being used up during glycolysis and the citric acid cycle, but no more is being produced, resulting in the low levels seen in the patients.

# Part 4: Cyanide

1. What affect would cyanide have on the electron transport chain and the production of ATP? Explain your answer.

2. Given what you now know about the action of cyanide on cellular respiration, explain why the patients died of lack of oxygen while their blood oxygen levels were normal?

3. Would artificial respiration or oxygenation have saved these people? Why or why not?

4. Looking back at the information you have about the people before they got sick, can you suggest a possible source of the cyanide poisoning? How should public health officials and police respond to this tragedy

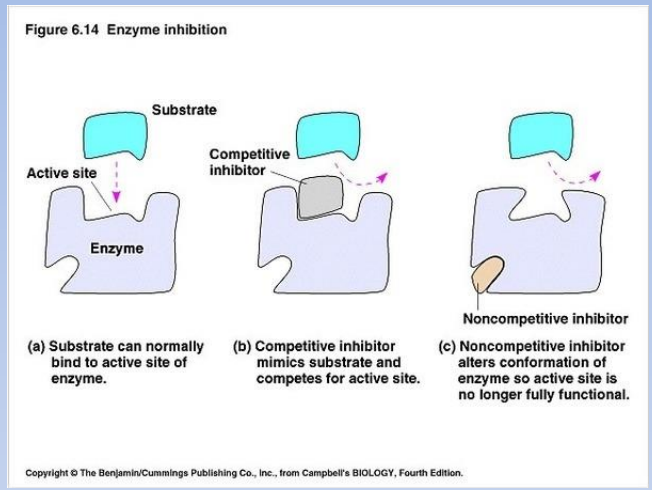
# What does cyanide do?

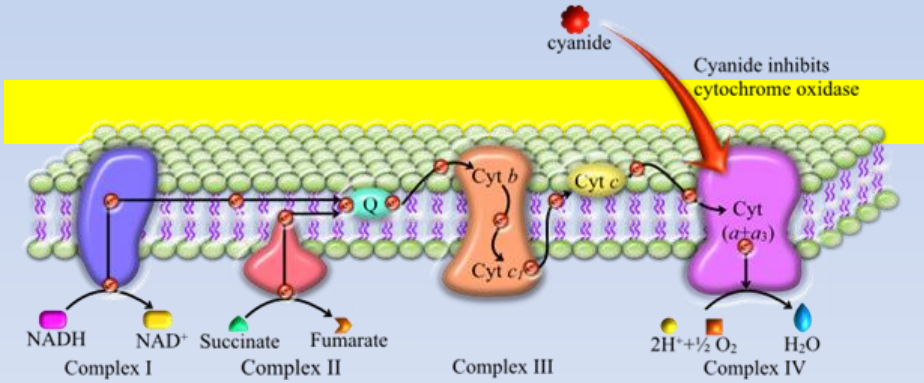
**Cyanide is a non-competitive inhibitor of cytochrome C enzyme in ETC**

**Prevents NADH from giving electron to ETC and becoming NAD+**

**Ultimately prevents ATP production**

**Carbon Monoxide can also work this way**



# Would oxygen save these peoples lives?

**Why?**

# Connection between deaths?

# Real Story

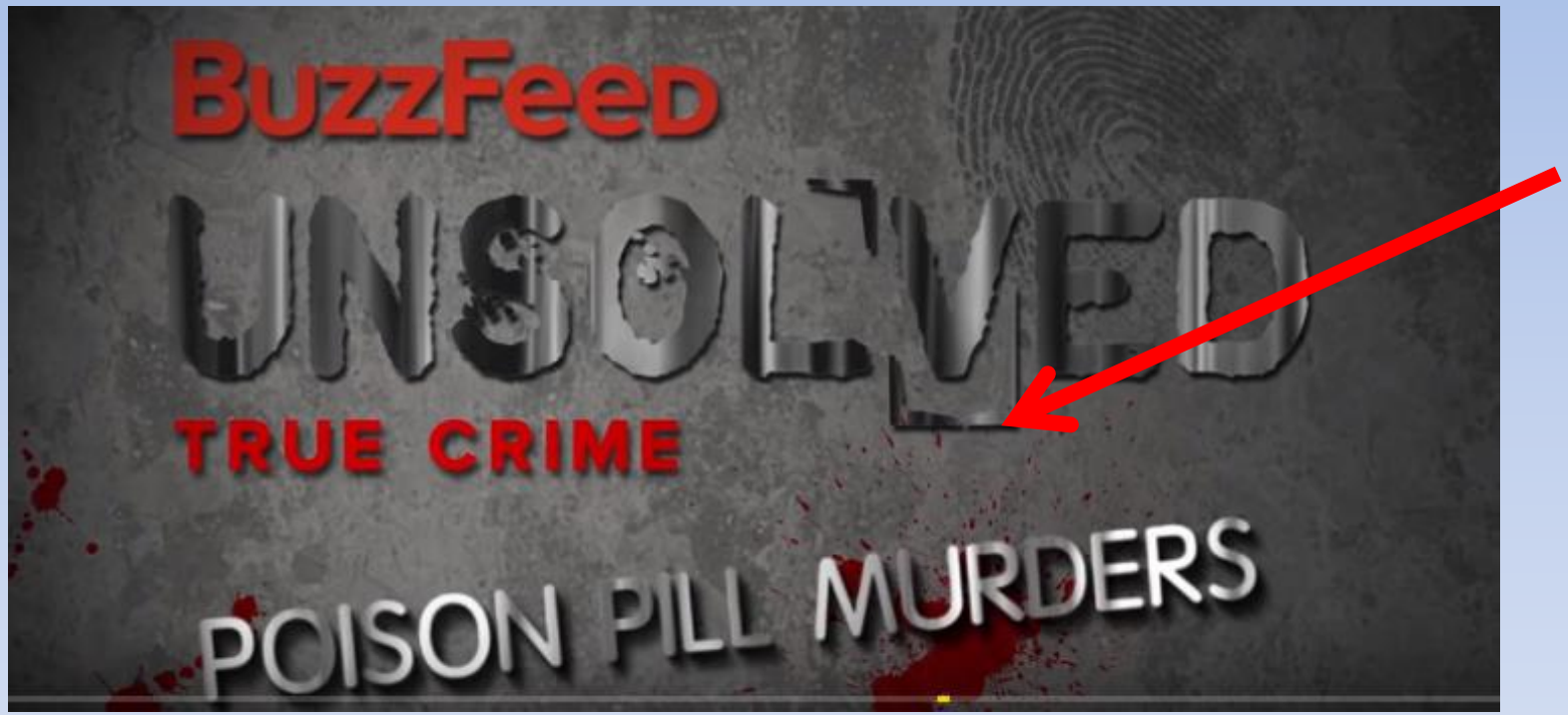

- These seven deaths occurred in autumn 1982 in the Chicago area.
- The victims had all taken Tylenol capsules laced with **potassium cyanide**.
- The laced capsules were found in different bottles from different production sites and thus the contamination did not occur during production but afterwards, when the bottles were on the shelves. It is believed that the Tylenol killer removed the bottles, laced the capsules, and then placed the bottles back on the shelf.

# Real Story

- The **Tylenol killer was never caught** although they did arrest and convict James W. Lewis who sent a note to Johnson and Johnson demanding 1 million dollars to stop the attacks.

- He was convicted of extortion, but police could never link him to the actual murders. The $100,000 reward offered by Johnson and Johnson has never been claimed.

# Unsolved Mysteries – The Tylenol Killer



# Breakout Box Competition

- As a team, figure out the clues to open the various locks and find out your prize in the tool box