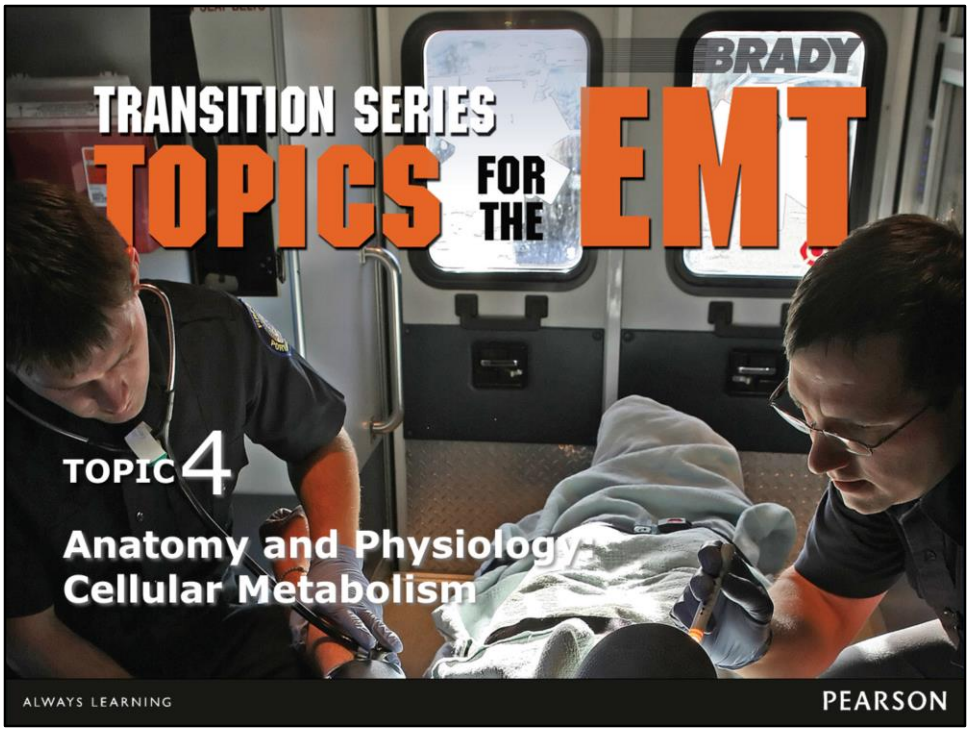
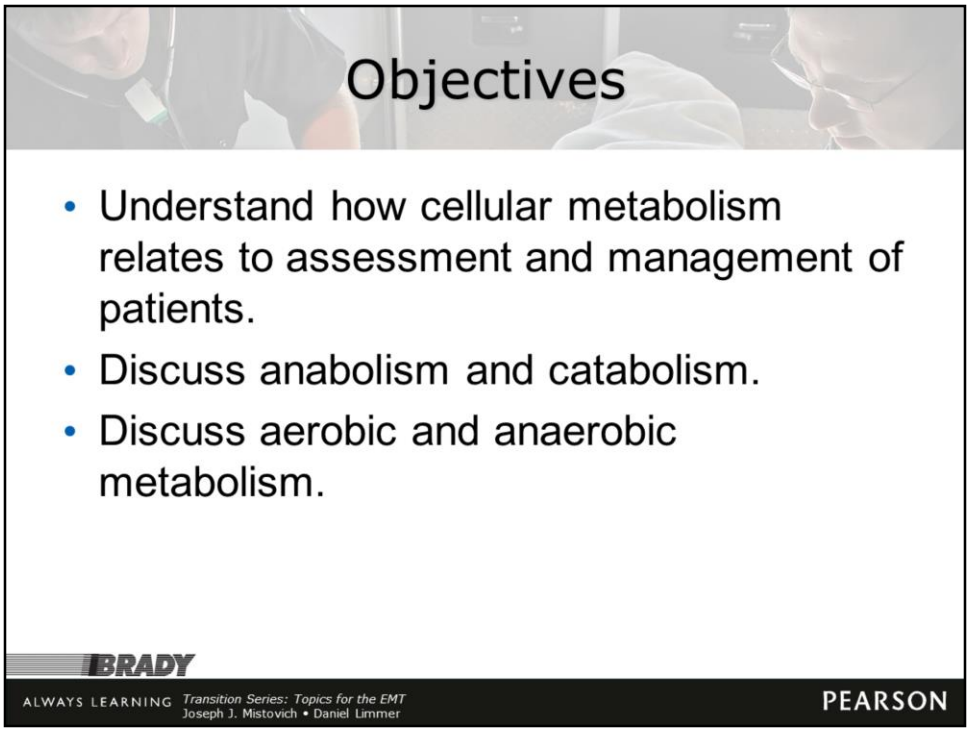
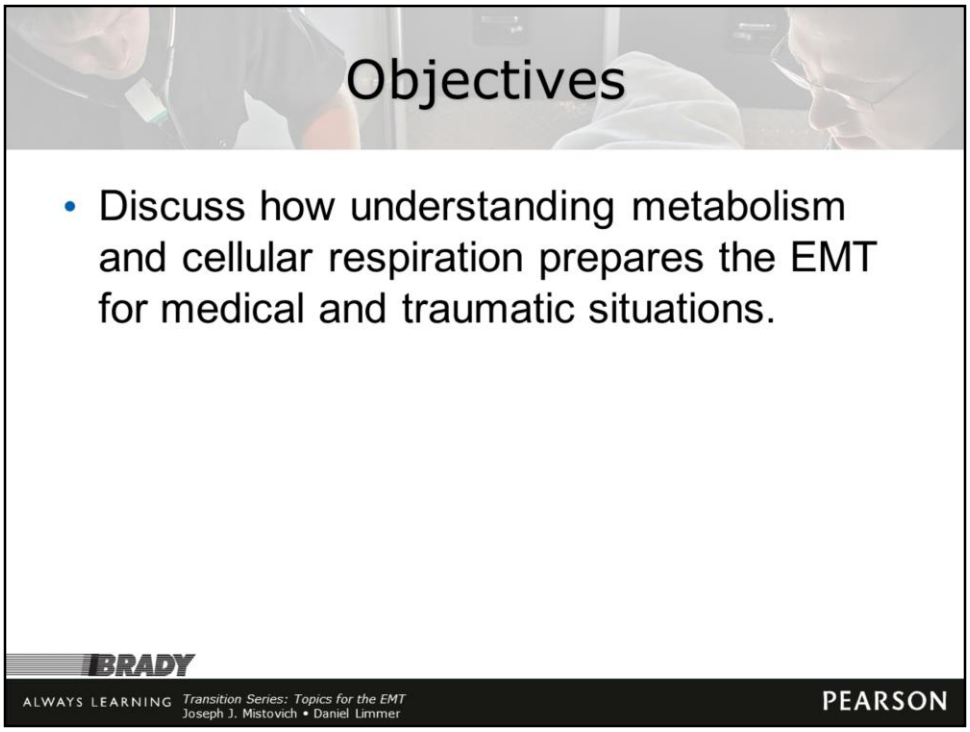

BRADY
TRANSITION SERIES
TOPICS FOR THE EMT
TOPIC 4
Anatomy and Physiology:
Cellular Metabolism
ALWAYS LEARNING
PEARSON



Discuss objectives as listed.



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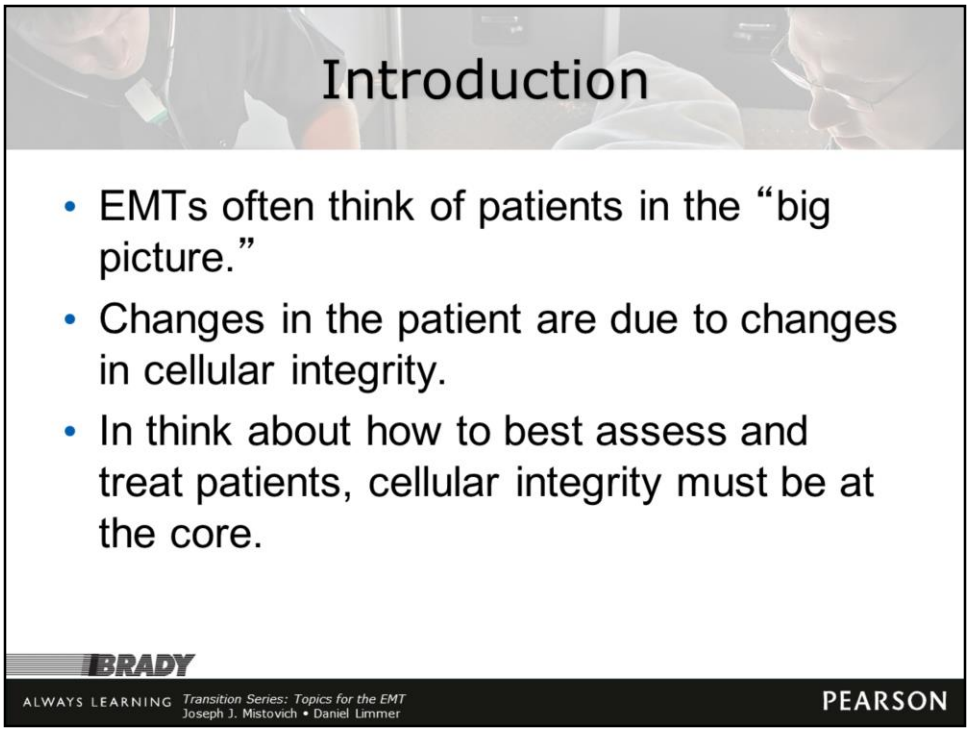
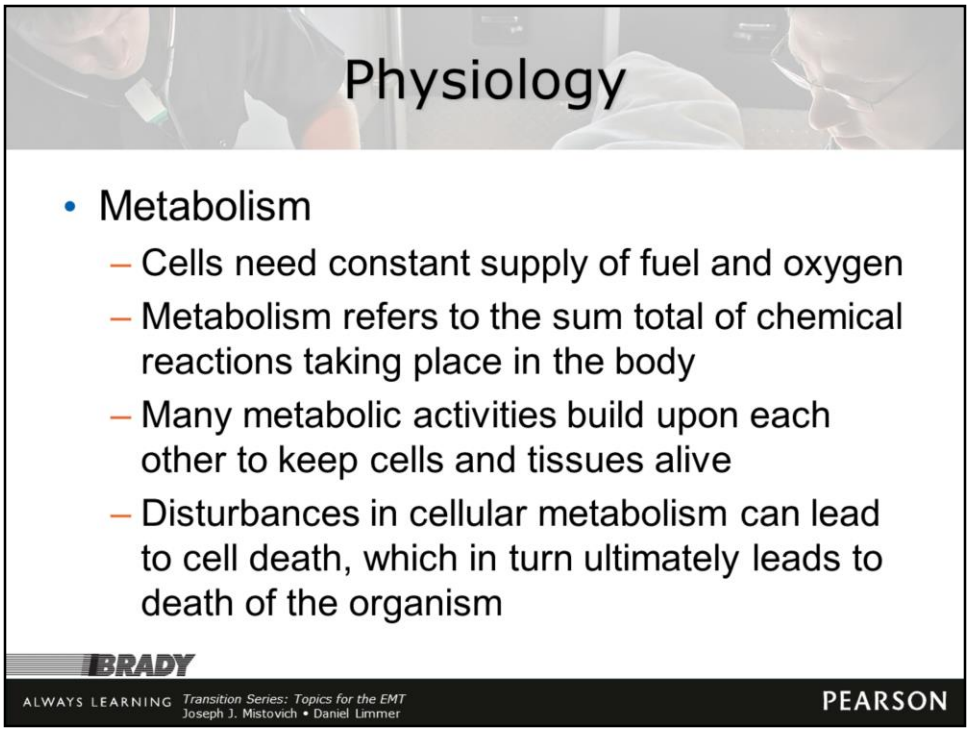


Emergency medical service personnel, regardless of their level of certification, have always been taught that the most important aspect of any emergency care provided in the prehospital environment is:
•To establish and maintain an airway
•Ventilation
•Oxygenation
•Circulation

To keep the patient alive, it is necessary to keep the cells alive. Most EMS providers do not think of prehospital care in this manner, but almost every aspect of emergency care provided is geared to keeping cells alive.

Most think of the care in a much bigger patient picture such as:
•Keeping the patient conscious
•Relieving chest discomfort
•Reducing respiratory distress
•Increasing blood pressure
These are all potential indicators of continued or improved cellular function.

This topic is designed to provide the EMT with a basic understanding of normal cellular metabolism and a deviation from the "normal" state as it relates to assessment and emergency medical care.



The cell is the basic functional unit of life.

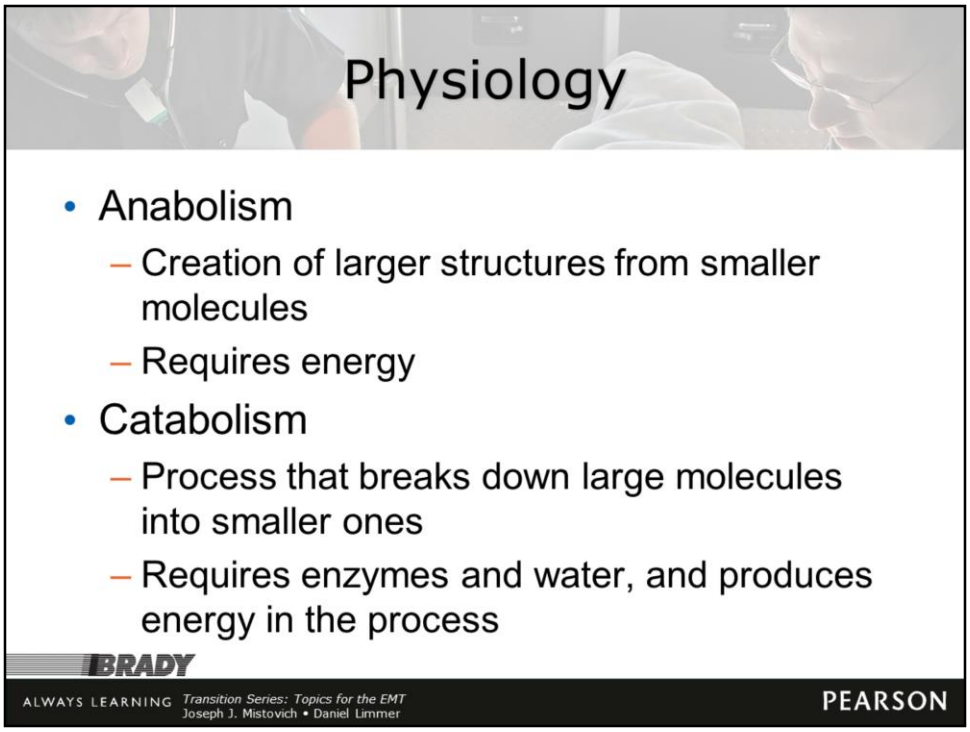
Every person who dies does so at a cellular level, regardless of the presenting injury or illness.

For a cell to stay alive, it must maintain its metabolism, which requires a constant supply of fuel and oxygen and a normal cellular environment (milieu).

Thousands of chemical reactions take place every second in the body and are essential to life.

Metabolism is described as the sum total of the chemical reactions.
Many of these reactions are linked, where the product of one metabolic reaction is the impetus to start another set of reactions.
Enzymes are special proteins that control these reactions.

If cell death occurs, it can lead to tissue death which in turn contributes to organ death and system failure, which ultimately causes organism death.



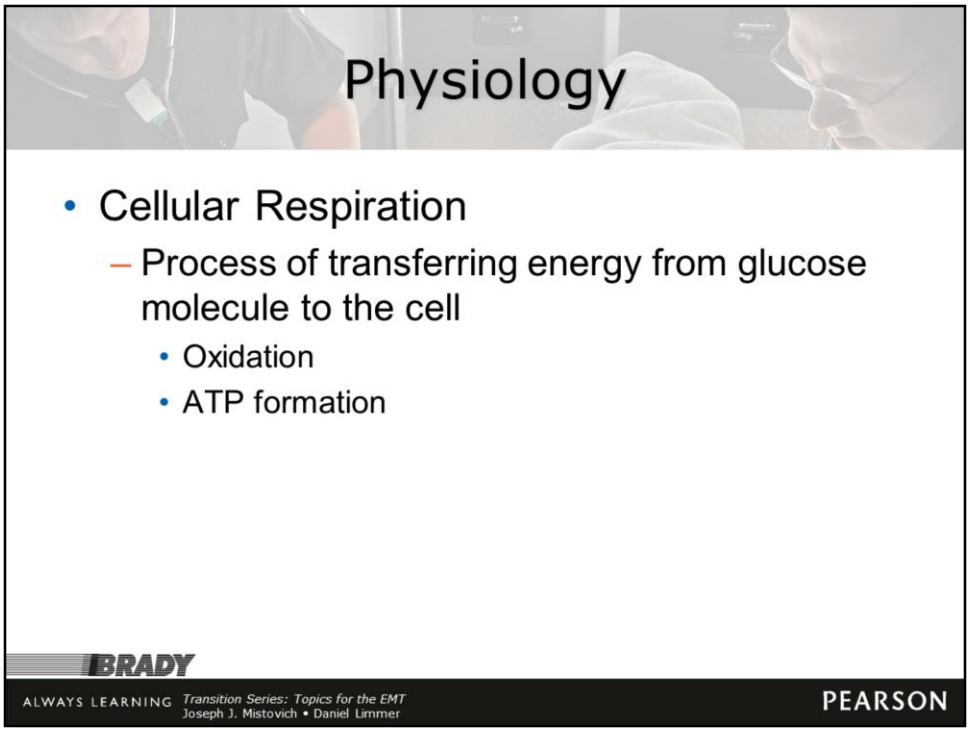
The two types of metabolic processes:
•Anabolism
•Catabolism

Anabolism is the process in which larger molecules are made from smaller ones, whereas *catabolism* is the process that breaks down large molecules into smaller ones.

Anabolism uses energy and forms water in the process. The material provided is needed for continuous cellular growth and repair. An example of anabolism would be the formation of glycogen from glucose molecules; glycogen is then stored in the liver and other organs for return to the body for later use.

Catabolism requires specific enzymes to break down large molecules into smaller ones. The enzymes use water to split the molecules, and energy is released during the process. Thus, dehydration can impact the effectiveness of catabolism.

The rate of catabolism must occur similar to the rate of anabolism. If disturbance occurs in which the rate of catabolism does not meet the rate of anabolism, cell damage or death will result.



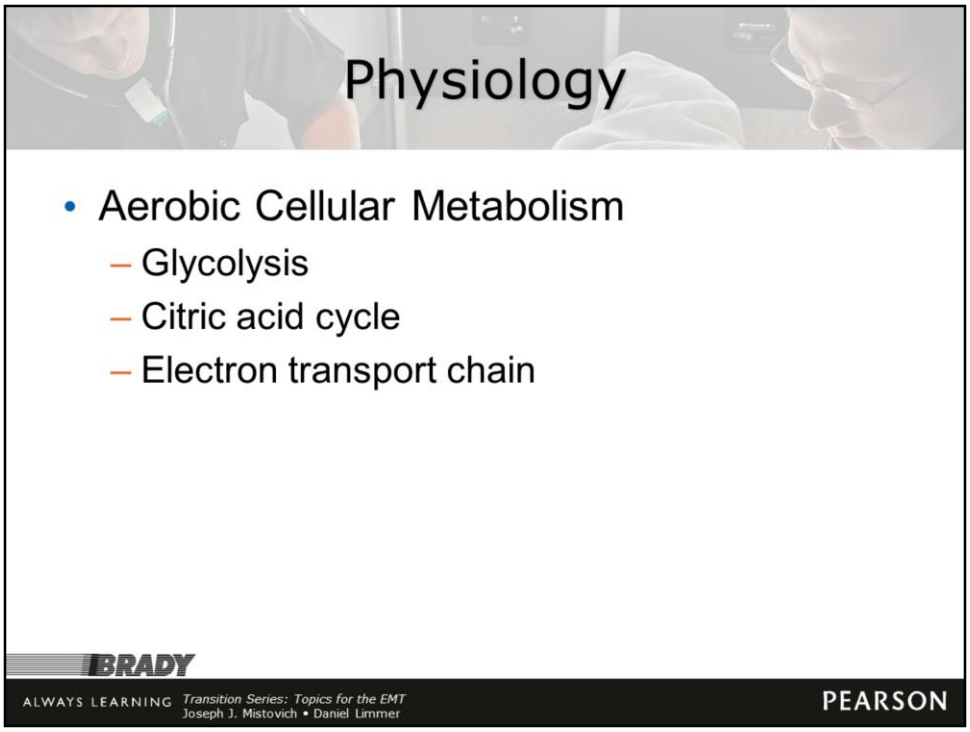
Cellular respiration is the process in which energy is transferred from a glucose molecule and made available for use within the cell.

Oxidation is the process of breaking down the glucose molecules in the cell.
This reaction releases:
•Energy
•Heat
The energy that is formed is carried as adenosine triphosphate (ATP) molecules that can be used by the cell.
ATP is the primary energy-carrying molecule.

Without enough ATP, cells will quickly die.

Thus, a constant source of energy in the form of ATP is necessary for normal cellular function.

In addition, the breakdown of glucose (oxidation) is necessary to maintain body heat. Without an adequate rate of oxidation of glucose molecules in the cells, the body temperature will decrease, eventually leading to hypothermia.

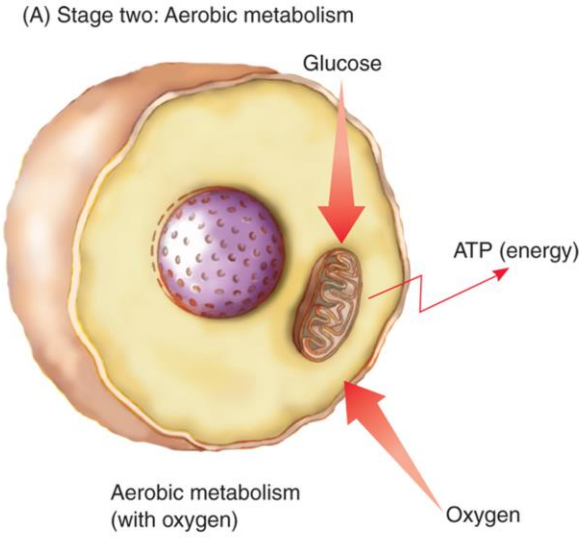


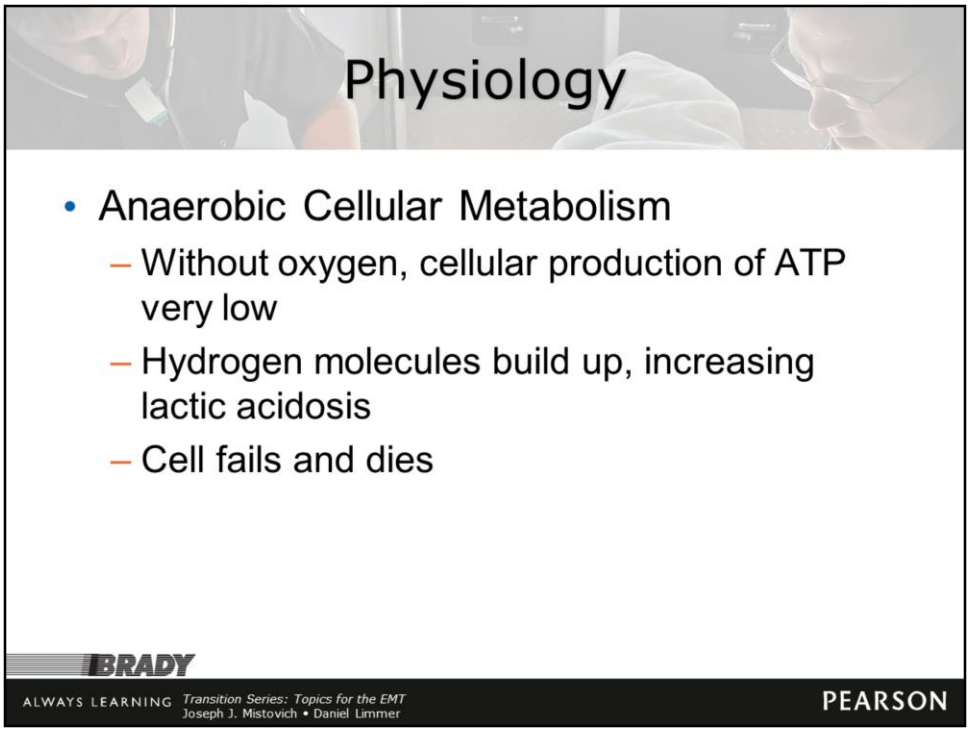
The creation of sufficient cellular energy (ATP) is dependent upon three reactions:

- Glycolysis is the first process in cellular respiration, which takes a glucose molecule that crosses the cell membrane and breaks it down into two pyruvic acid molecules. During this process two ATP (energy) molecules are released, along with high-energy electrons. This process is *anaerobic* —it does not require oxygen to be present.
- The citric acid cycle, also known as the *Krebs cycle*, occurs in the mitochondria of the cell. The pyruvic acid that was produced during glycolysis enters the mitochondria, where carbon dioxide, more high-energy electrons, and more ATP are produced.
- The electron transport chain; the high-energy electrons are passed along the chain and energy is transferred to form even more ATP. The final electron carrier is oxygen. With oxygen available, the final byproduct of aerobic cellular metabolism is:
    - Water (H_2O)
    - Carbon dioxide (CO_2)
    - A large amount of energy (32 to 34 moles of ATP)
    - Heat

The ATP, water, and heat are necessary for normal cell function; the carbon dioxide is passed to the blood and transported to the lungs, where it is eliminated during exhalation.

Figure 4-1 Aerobic metabolism. Glucose broken down in the presence of oxygen produces a large amount of energy (ATP).





Anaerobic metabolism means without oxygen (e.g., if a patient was breathing inadequately).

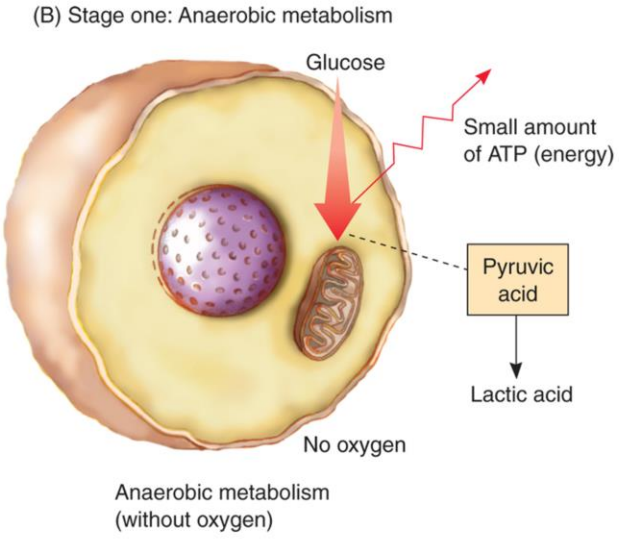
Without oxygen available in the mitochondria for the next reaction to occur, hydrogen molecules and the electrons are given back to the pyruvic acid, which then forms lactic acid.

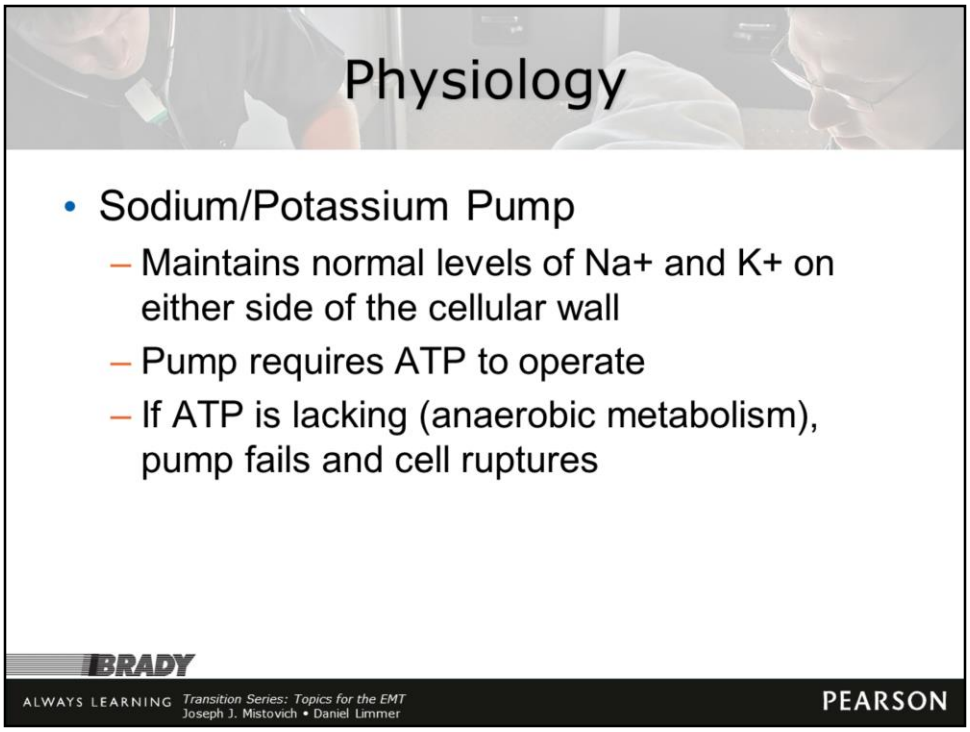
Lactic acid builds up within the cell that is now lacking adequate ATP levels for normal function, and the environment becomes acidotic.

The acid inactivates enzymes necessary to control the metabolic reactions and disrupts the cell membrane.
If the integrity of the cell membrane is lost, the cell will die.

The lactic acid will also diffuse out of the cell and enter the blood, making it acidotic as well.

Figure 4-2 Anaerobic metabolism. Glucose broken down without the presence of oxygen produces pyruvic acid, which converts to lactic acid and only a small amount of energy (ATP).





Sodium is normally found outside the cell and potassium is found inside the cell.

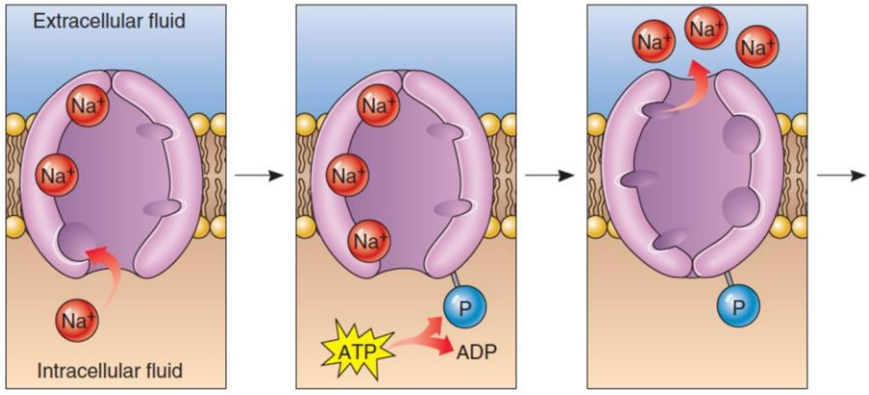
The Na+/K+ pump keeps levels on either side normal.

If pump fails, Na+ accumulates in cell which draws water towards it.

The cell then swells, ruptures, and dies.

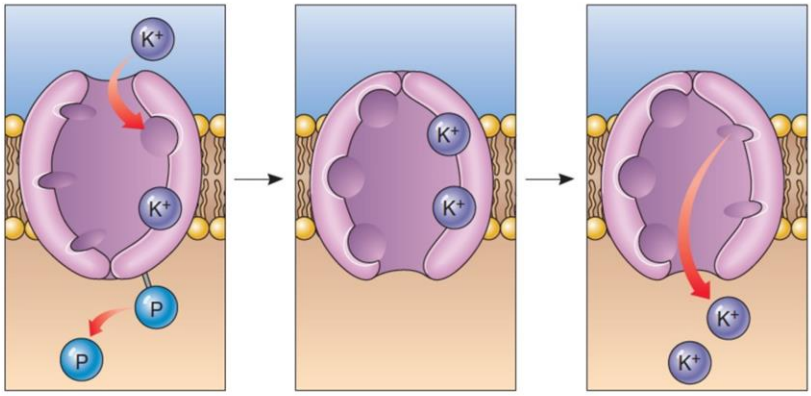
The exchanges of three sodium molecules from inside the cell for two potassium molecules located outside the cell.
This exchange maintains a normal balance of sodium and potassium and prevents the cell from swelling and rupturing.

Figure 4-3 The sodium/potassium pump. Energy (ATP) is required to pump sodium (Na+) molecules out of the cell against the concentration gradient. Potassium (K+) then moves with the gradient to flow into the cell. Sodium and potassium are exchanged in a continuous cycle, which is necessary for proper cell function. The cycle continues as long as the cells produce energy through aerobic metabolism. When insufficient energy is produced through anaerobic metabolism, the sodium/potassium pump will fail and cells will die.

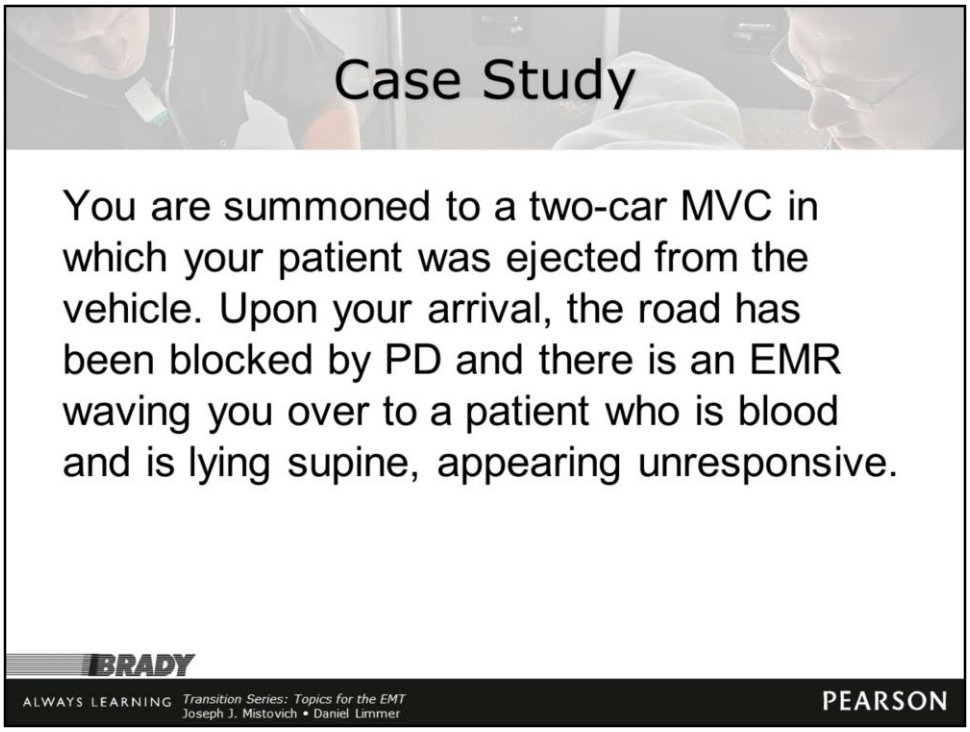


(a) (b) (c)

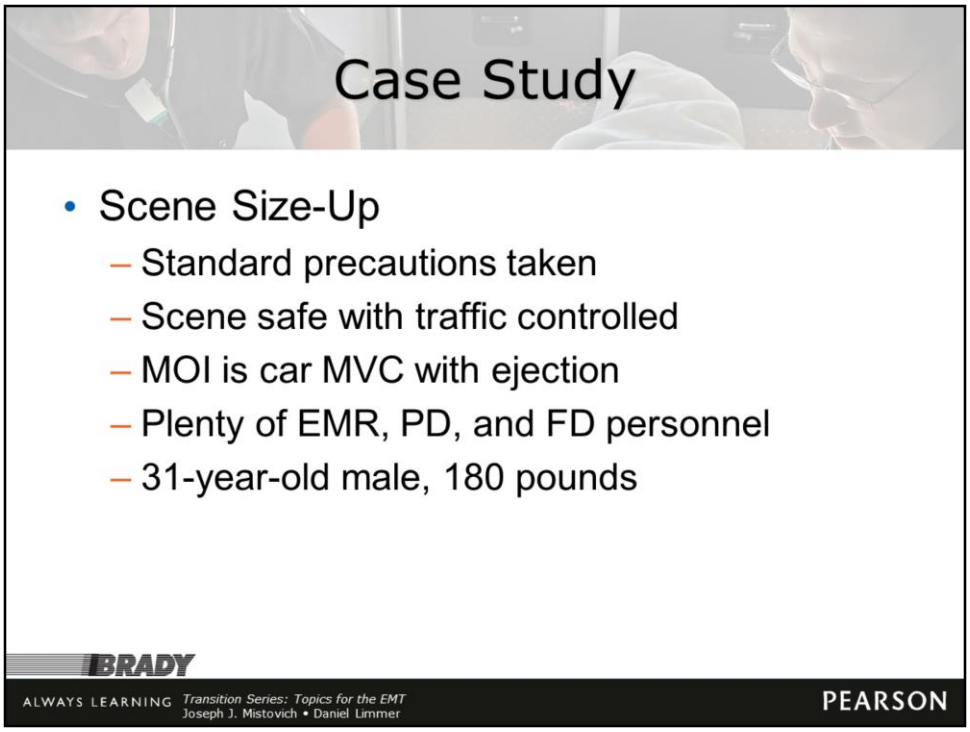
Figure 4-3 (continued) The sodium/potassium pump. Energy (ATP) is required to pump sodium (Na+) molecules out of the cell against the concentration gradient. Potassium (K+) then moves with the gradient to flow into the cell. Sodium and potassium are exchanged in a continuous cycle, which is necessary for proper cell function. The cycle continues as long as the cells produce energy through aerobic metabolism. When insufficient energy is produced through anaerobic metabolism, the sodium/potassium pump will fail and cells will die.



(d) (e) (f)



Discuss case presentation.



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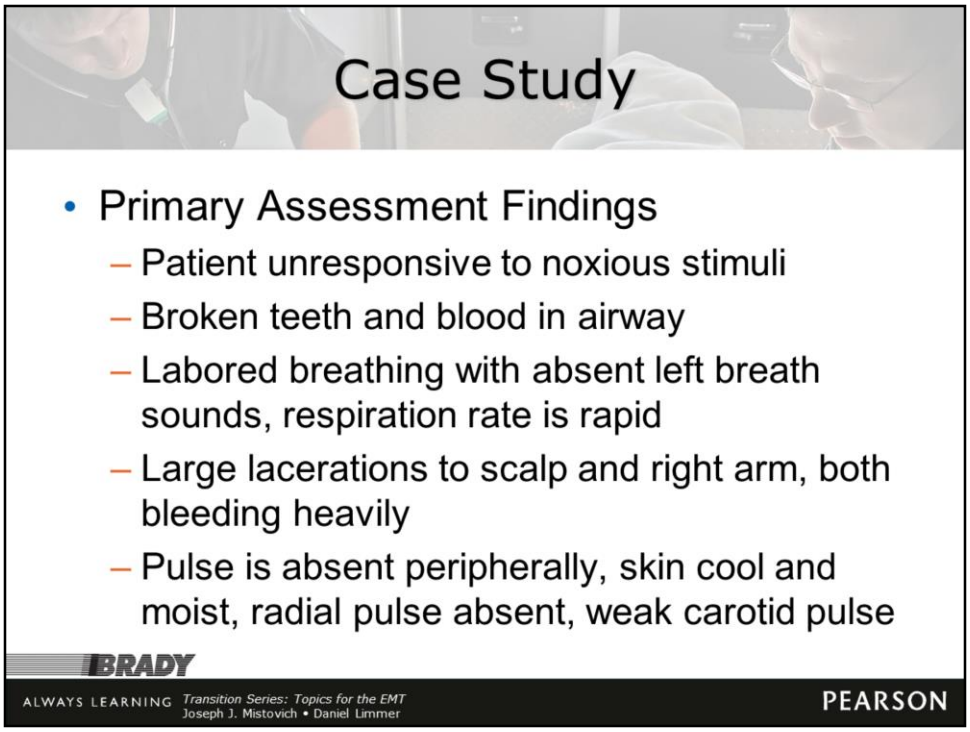
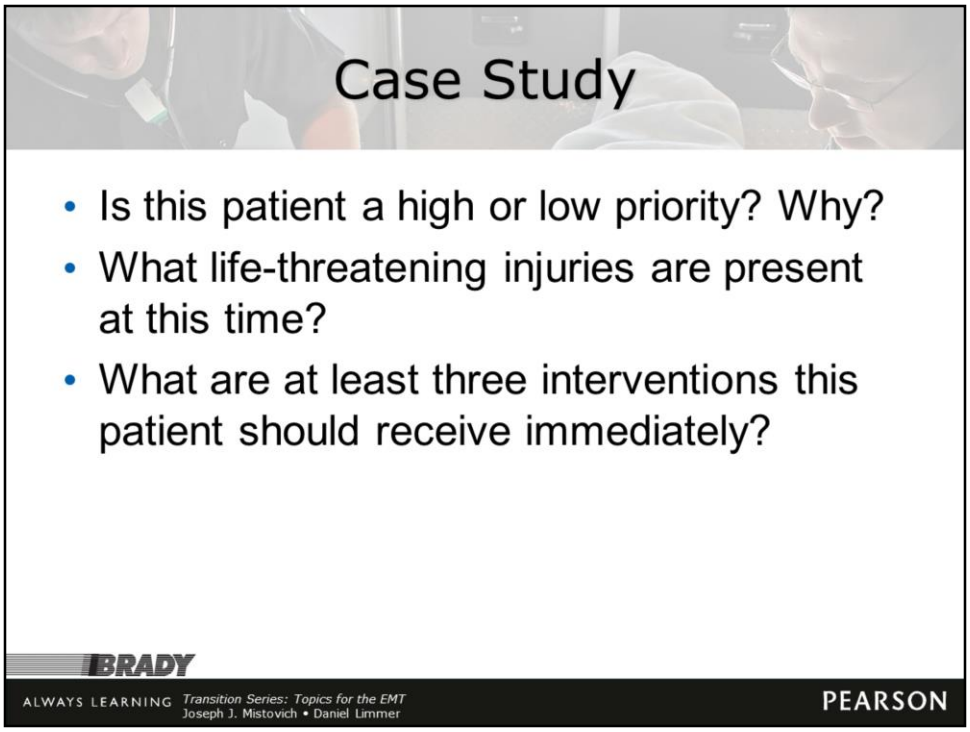


Discuss as needed.



Patient is a high priority due to:

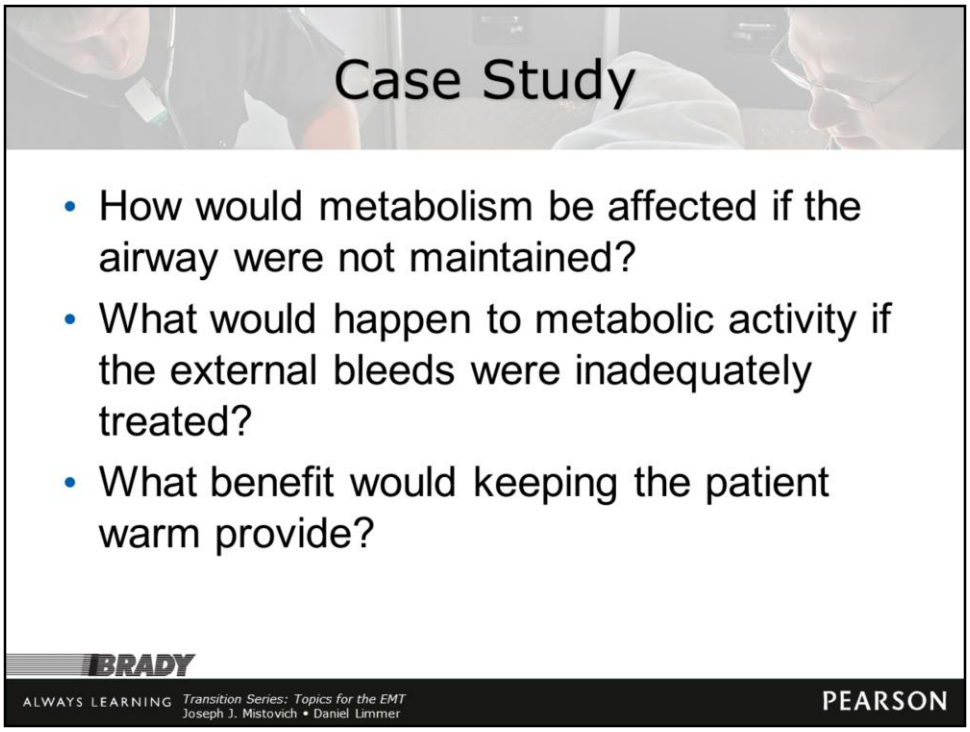
- Mental status
- Airway occlusion
- Breathing inadequacy
- Major bleed

Life threats include:

- Occluded or partially occluded airway from blood/teeth
- Inadequate minute ventilation due to chest trauma
- Poor peripheral perfusion secondary to blood loss from two lacerations

Although there are multiple interventions that need completed, the treatment the patient should receive as soon as possible should include:

- Manual stabilization of the cervical spine
- Suctioning of the airway with probable use of a mechanical adjunct to maintain airway
- Provision of PPV with supplemental oxygen
- Direct pressure on the bleeds to stop them



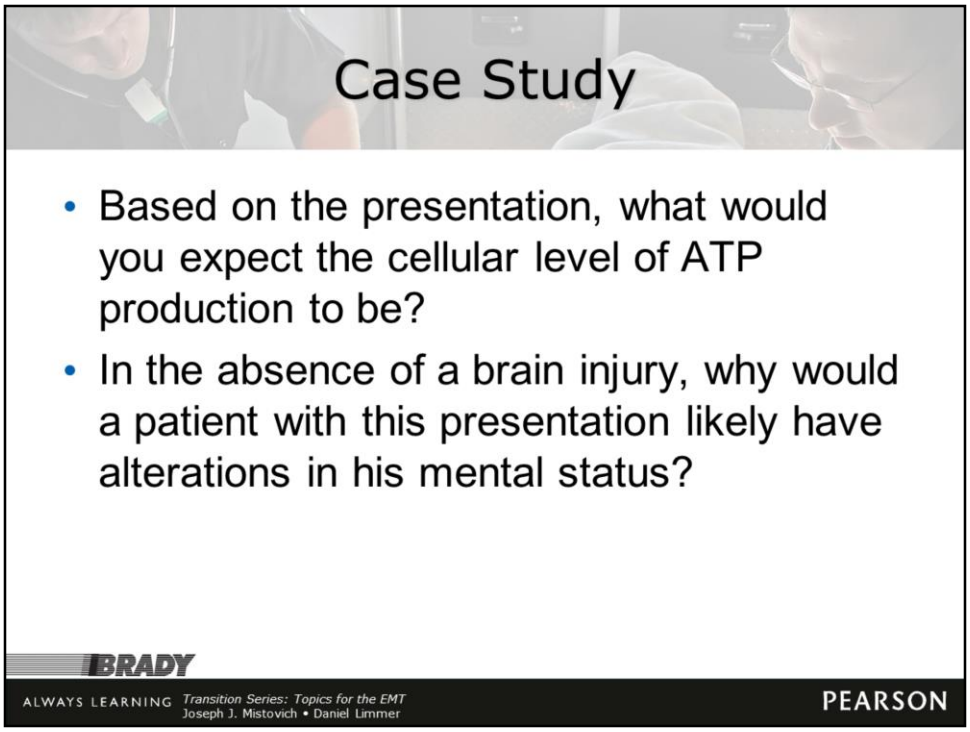
If the airway was not maintained, then the patient would be unable to adequately bring in oxygen and eliminate carbon dioxide.

This in turn would cause cellular hypoxia which can lead to anaerobic metabolism with inadequate ATP production and overwhelming acidosis to occur.

Metabolic activity would worsen as the inadequate delivery of metabolic substances and oxygen further causes a shift to anaerobic metabolism with ultimate failure of the sodium/potassium pump which also causes cellular death and rupture.

A patient who is bleeding out will start to become hypothermic partially because of poor distribution of warm blood through the body and partially due to a slowing of the metabolic rate as cells die.

In either instance, hypothermia actually accelerates cellular death which in turn causes:
•More widespread tissue damage
•Organ dysfunction
•System failure
•Organism death



Cellular production of ATP would start to decline as the levels of available oxygen would diminish due in part to the airway occlusion and poor tissue perfusion. This impacts:

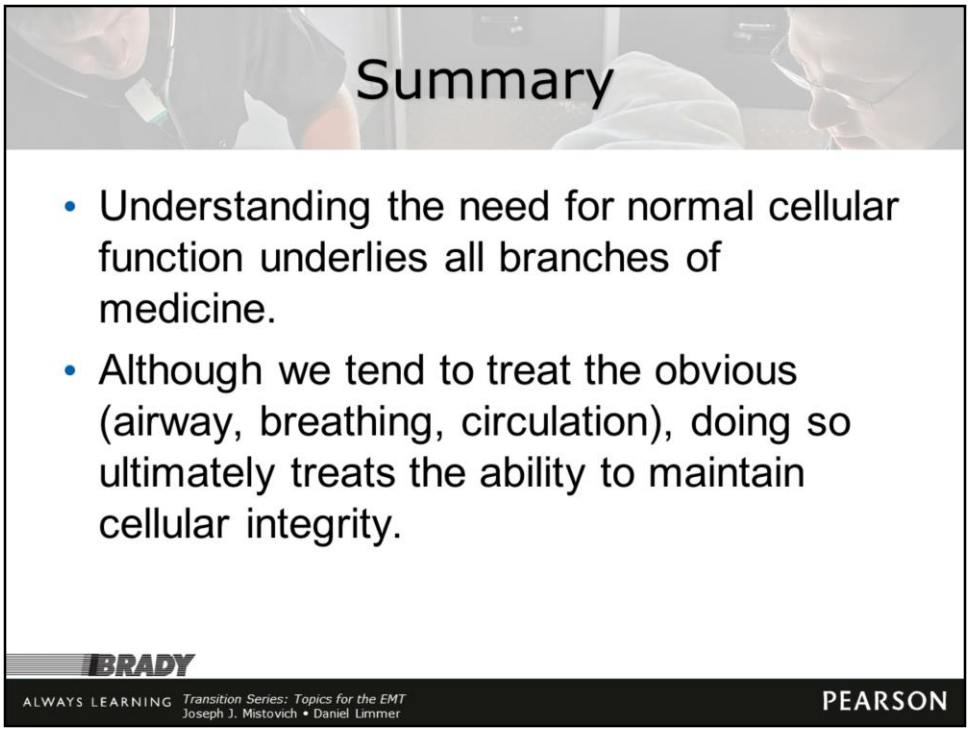
- Cellular functioning
- Chemical reactions
- Na+/K+ pump activity in a negative way

The alteration in the mental status is likely due to:

- A lack of cellular oxygen
- Cellular metabolic substrates

The brain is incapable of storing either of these, thus any change in oxygen levels or perfusion pressures will have an immediate and negative effect of brain function.

This is almost always characterized by initial anxiety, followed with lethargy and apathy, progressing to unresponsiveness and ultimately death.



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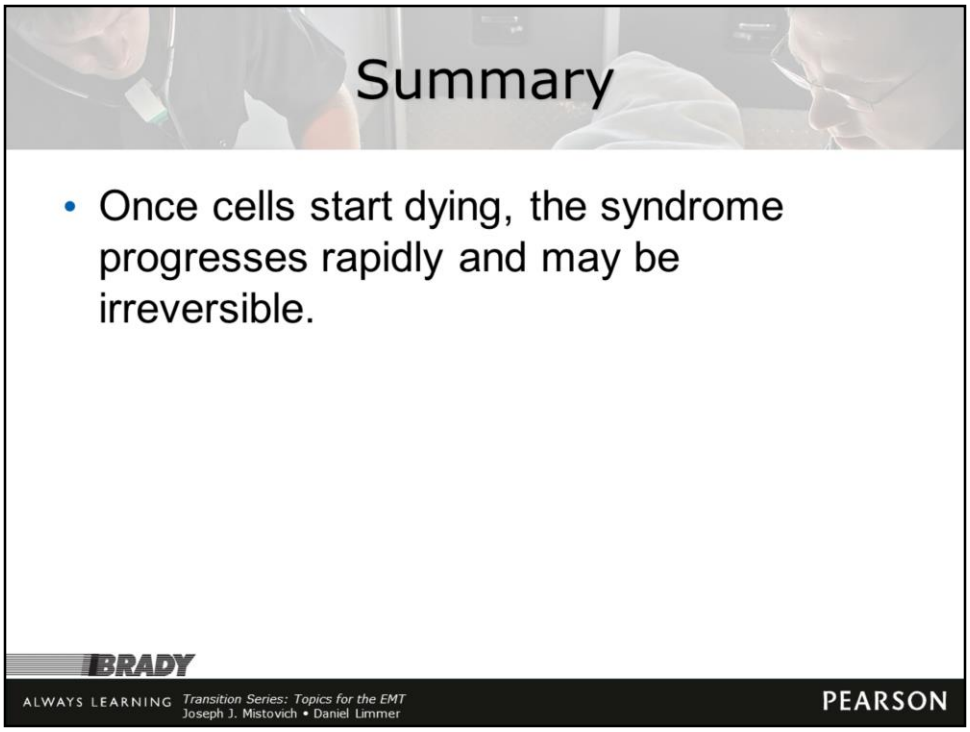

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