<u>SPECIAL NOTE:</u> The lecture video incorrectly states that 36 molecules of ATP are made per glucose by cellular aerobic respiration. The correct number is 32 ATP molecules per glucose.

Cell Respiration (chapters 3, 10, and 24) **Page 1**

Cellular aerobic respiration

A process by which cells obtain energy (to recharge their ATP) by using oxygen to break down glucose

• Most (but not all) steps of the cellular aerobic respiration occur in the mitochondria organelle

• Cells import O_2 and glucose from the blood

• The glucose is broken down into carbon dioxide and water using the O_2

$$\underset{\text{(glucose)}}{C_6H_{12}O_6} + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

• Breaking down glucose generates energy. The energy that is generated is used to recharge ATP

√ Each glucose molecule recharges 32 ATP

√ Fats and other molecules can also be broken down to recharge ATP

• The CO_2 and H_2O products are exported from the cell into the blood

• Cellular aerobic respiration occurs in 3 stages, at these locations:

1) Glycolysis (in the cytoplasm)

2) Citric acid cycle/Krebs cycle (in the mitochondria)

3) The electron transport system (in the mitochondria)

Figs 3.16, 10.12b, 24.2, 24.3, and 24.4

Glycolysis

The first stage of cellular aerobic respiration.

Glycolysis is a metabolic pathway that takes place in the cytoplasm. Each molecule of glucose that enters the glycolysis pathway is converted by a series of enzymes into 2 molecules of pyruvate (a three carbon molecule)

• Glycolysis produces 2 ATP per glucose

• No O_2 is required for the glycolysis stage

Figs 10.12b, 24.4, and 24.5

The citric acid cycle/Kreb's cycle and the electron transport system

The last two stages in cellular aerobic respiration

• These two stages both occur inside the mitochondria

• Together, these two stages produce 30 of the 32 ATP made by cellular aerobic respiration per glucose molecule

• O_2 is required for both of the citric acid cycle and the electron transport system

√ If O_2 is too low, these two stages halt

Fig 3.16, 10.12b, 24.4, 24.7, 24.8, and 24.9

Cellular anaerobic respiration (lactate fermentation)

A process by which cells can obtain energy (to recharge their ATP) by breaking down glucose **without using oxygen**

- Each glucose is broken down into two molecules of lactic acid

$C_6H_{12}O_6$	–>	$2C_3H_6O_3$
(glucose)		(lactic acid)

- Braking down glucose into lactic acid generates enough energy to recharge two ATPs per glucose molecule

- The metabolic pathway is the glycolysis pathway with one extra enzyme to convert the two pyruvate molecules into two lactic acid molecules

- Advantage: Cells can make ATP even when oxygen is too low for aerobic respiration

- Disadvantages:

  √ Only 2 ATP made per glucose molecule, so the glucose supplies are depleted very quickly

  √ Lactic acid causes muscle fatigue (temporary weakness and burning sensation)

Figs 10.12c and 24.6

Situations for cellular aerobic and anaerobic respiration:

- Cells use cellular aerobic respiration most of the time

    √ Resting, sitting, walking, and other non-strenuous activities

- Cellular anaerobic respiration is used only when oxygen levels in the body are too low for cellular aerobic respiration

    √ Example: Muscle cells use anaerobic respiration during short bursts of intense exercise when no increased breathing has occurred

- If the exercise is sustained, the body soon increases breathing rate for extra O_2 to increase aerobic respiration

    √ Aerobic exercise = Sustained exercise at increased breathing and heart rate

    √ During aerobic exercise muscle cells use both aerobic and anaerobic respiration to meet their ATP needs

The body's responses to insufficient blood glucose

If the glucose level in the blood is not sufficient for cells to make enough ATP, then (a) more glucose can be generated, and (b) cells can use molecules other than glucose as their cellular respiration fuel

Generating more glucose

- Glycogenolysis = Cells breaking down their stored glycogen into glucose molecules
  - √ Liver cells secrete the glucose from their glycogenolysis into the blood to help other cells meet their energy needs
  - √ Muscle cells keep the glucose from their glycogenolysis for their own energy needs
- Gluconeogenesis = Cells making glucose from non-carbohydrate molecules (such as fats, amino acids, and lactic acid)

Figs 24.3 and 24.10

Non-glucose fuel molecules for cellular respiration

- Cells can use fatty acids, amino acids, and ketone bodies as alternative fuel molecules for cellular respiration
  - √ Ketone bodies = Molecules made by the liver by partial break down of fatty acids

Figs 24.3, 24.13, 24.14, and 24.15