VCE PHYSICAL EDUCATION UNIT 3 AOS 2

CHARACTERISTICS OF THE THREE ENERGY SYSTEMS

Presented by Chris Hudd

Study design dot point:

- Characteristics of the three energy systems (ATP–CP, anaerobic glycolysis, aerobic system) for physical activity, including rate of ATP production, the yield of each energy system, fatigue/limiting factors and recovery rates associated with active and passive recoveries.

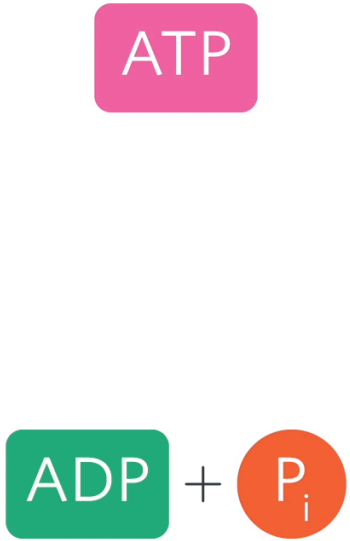
Overloaded cars and bikes

Source: Wikimedia Commons

The energy systems' role in energy production

Theory summary

The three energy systems work together to supply the energy required to resynthesise ATP. Their relative contribution is determined by the intensity and the duration of the exercise.



Recap:
The energy systems are responsible for providing the energy to resynthesise ATP from ADP and Pi.

The ATP-CP system

Theory summary

The ATP-CP system produces energy by breaking down the chemical fuel Creatine Phosphate. Energy is produced at an explosive rate due to the simple anaerobic chemical reactions that take place.

The system is limited by the amount of Creatine Phosphate stored in the muscles.

ATP

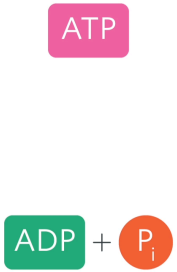
ADP + P_i

The ATP-CP system

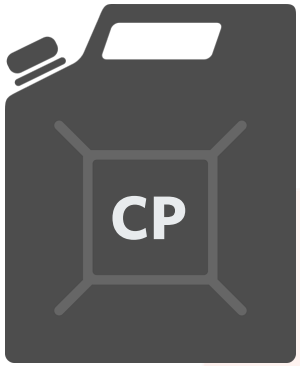
Theory summary

The following table displays some key characteristics of the ATP-CP System.

Characteristic	ATP-CP system
Exercise	The predominant system for all maximum intensity exercise up to 20 seconds in duration.
Fuel Source	Creatine Phosphate
Anaerobic/Aerobic	Anaerobic
Rate of energy for ATP resynthesis	Explosive/Instantaneous 3.6 mol/min
Intensity of activity	Maximal Intensity (95+% MHR)
Limiting Factor (Fatigue)	Limited fuel stores (CP Depletion)
Amount of energy produced	Limited yield 0.7 ATP for every CP molecule
Duration of activity	0-10 seconds
By-products	Creatine, Pi



The ATP-CP system in action



Source: Pixabay
Source: www.youtube.com/watch?v=tBozgYVgeDE

Anaerobic glycolysis

Theory summary

The anaerobic glycolysis energy system produces energy by partially breaking down Glucose anaerobically (no oxygen).

Energy is produced at a fast rate due to the simple anaerobic chemical reactions that take place.

When compared to the ATP-CP system, this process is more complex as it requires a greater number of steps.

The system is limited by the accumulation of hydrogen ions ($H+$) that are by-products of the process.

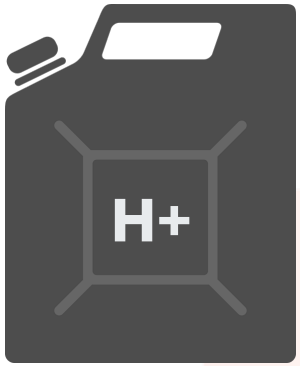
Anaerobic glycolysis

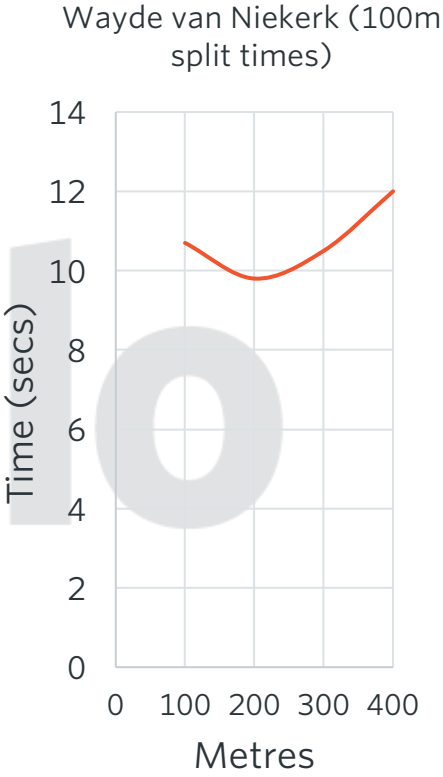
Theory summary

The following table displays some key characteristics of the anaerobic glycolysis system.

Characteristic	Anaerobic Glycolysis
Exercise	Predominant system for high intensity exercise up to 60 seconds in duration.
Fuel source	Glycogen
Anaerobic/Aerobic	Anaerobic
Rate of energy for ATP resynthesis	Fast, but not as fast as ATP-CP system $1.6\ \mathrm{mol/min}$
Intensity of activity	High intensity exercise $(85 - 95\%\ \mathrm{MHR})$
Limiting factor (fatigue)	Accumulation of metabolic by-product ($\mathrm{H}+$ ions)
Amount of energy produced	Small yield 2-3 ATP per glucose molecule
Duration of activity	10-75 seconds
By-products	Lactate, $\mathrm{H}+$ ions

The anaerobic glycolysis system in action





Source: Pixabay
Source: www.youtube.com/watch?v=xG91krXuxyw

The aerobic system

Theory summary

The aerobic system produces energy by breaking down glycogen or free fatty acids. Energy is produced at a slow rate due to the complex chemical reactions, however the system can continue to supply energy for many hours.

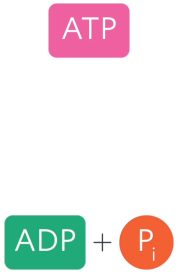
Stage 1

The aerobic system

Theory summary

The following table displays some key characteristics of the Aerobic system:

Characteristic	The aerobic system
Exercise	Predominant system for long duration, low/submaximal intensity exercise.
Fuel source	Glycogen and triglycerides
Anaerobic/Aerobic	Aerobic
Rate of energy for ATP resynthesis	Slow Glycogen $1.0\ \text{mol/min}$, triglycerides $< 1.0\ \text{mol/min}$
Intensity of activity	Submaximal intensity exercise $(70 - 85\%\ \text{MHR})$ Resting/low intensity exercise $(> 70\%\ \text{MHR})$
Limiting factor (fatigue)	Fuel depletion (glycogen) Thermoregulatory fatigue
Amount of energy produced	Large yield 38 ATP per glycogen molecule 441 ATP per triglyceride (147 per FFA)
Duration of activity	75+ seconds
By-products	CO_2, H_2O, heat



The aerobic system in action

Triathlon Leg	Split Time
1500m Swim	18:38 mins
40km Bike	1:00:54 hour
10km Run	31:23 mins
Final time	1:52:32 hour

Source: www.youtube.com/watch?v=xG91krXuxyw

Comparing the energy systems

Rate of energy production

ATP-CP

Anaerobic glycolysis

Aerobic glycolysis

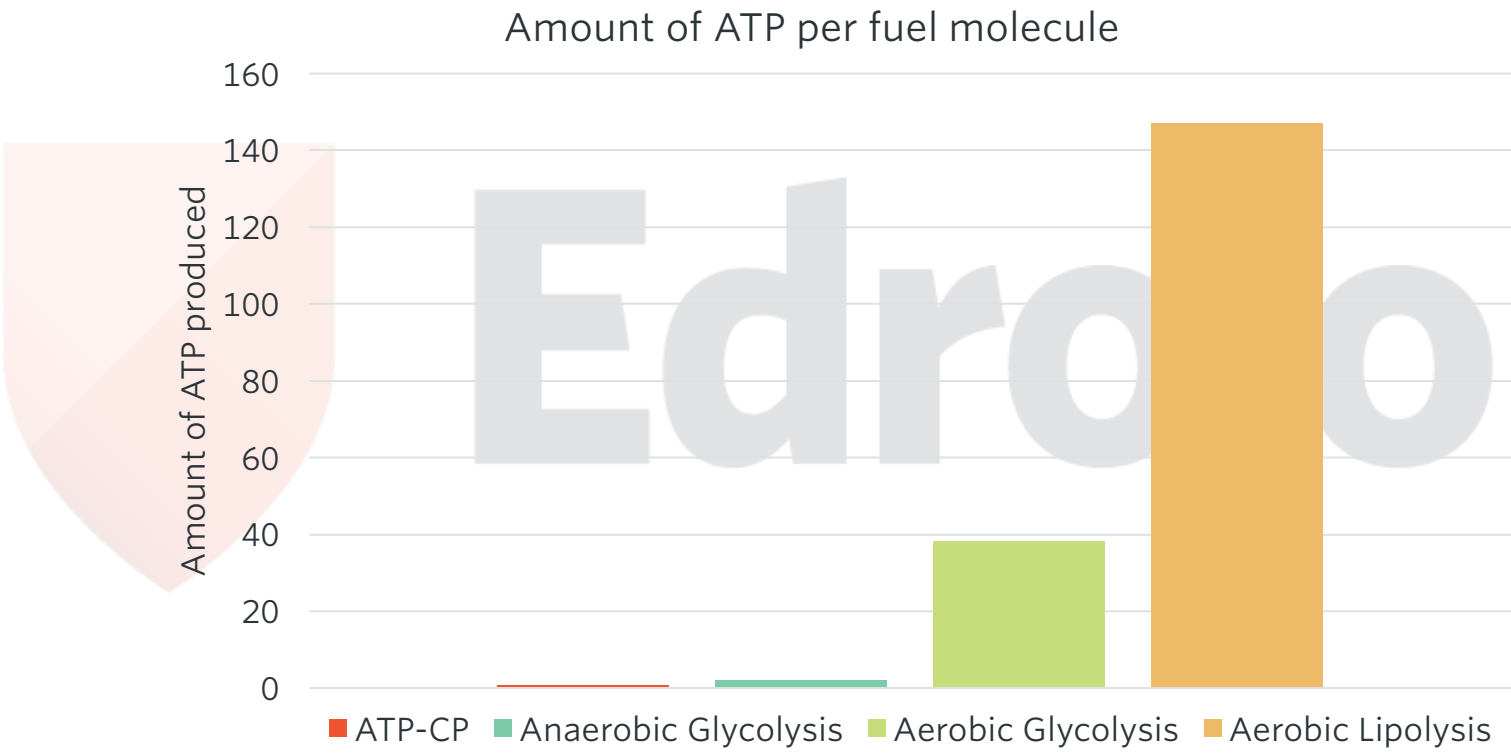
Aerobic lipolysis

Maximal **Rest**

Source: Pixabay

Comparing the energy systems

Yield of energy production



Advantages of each energy system

Energy system	Advantages	Examples of use
ATP-CP system	Simple, anaerobic energy pathway Provides energy at an explosive rate Allows for maximal intensity effort	
Anaerobic glycolysis	Also an anaerobic energy pathway Provides energy at a fast rate Allows for high intensity effort Provides energy in larger amounts than ATP-CP	
Aerobic glycolysis	Provides an “endless” amount of energy Allows sustained, long duration effort Produces non-toxic by-products Ability to oxidise lactic acid	

Disadvantages of each energy system

Energy system	Disadvantages
ATP-CP system	Limited intramuscular fuel stores (CP) Very limited amounts of energy produced Short duration of muscular effort
Anaerobic glycolysis	Relatively small amounts of energy produced By-product of H+ ions lead to fatigue
Aerobic glycolysis	Delay in aerobic responses at start of exercise Slow rate of energy production Submaximal intensity only allowed for muscular effort.

Multiple choice activity

The ATP-CP energy system produces energy at a:

A. slow rate with a low yield.

B. slow rate with a high yield.

C. fast rate with a low yield.

D. fast rate with a high yield.

E. I don't know.

(2013 VCAA Exam Section 1 Q11)

Multiple choice – Response

The ATP-CP energy system produces energy at a:

A. slow rate with a low yield.

B. slow rate with a high yield.

C. fast rate with a low yield. (86% correct)

D. fast rate with a high yield.

E. I don't know.

(2013 VCAA Exam Section 1 Q11)

Multiple choice activity

Most of the lactic acid produced during submaximal exercise is:

A. converted to protein.

B. excreted in urine and sweat.

C. used as a fuel for the aerobic system.

D. converted to glycogen in the muscles and liver.

E. I don't know.

(2014 VCAA Exam Section 1 Q8)

Multiple choice – Response

Most of the lactic acid produced during submaximal exercise is:

A. converted to protein.

B. excreted in urine and sweat.

C. used as a fuel for the aerobic system. (27% correct)

D. converted to glycogen in the muscles and liver.

E. I don't know.

(2014 VCAA Exam Section 1 Q8)

Multiple choice activity

Which one of the following is a by-product of aerobic respiration?

A. Lactic acid

B. Calcium ions

C. Hydrogen ions

D. Carbon dioxide

E. I don't know.

(2014 VCAA Exam Section 1 Q5)

Multiple choice – Response

Which one of the following is a by-product of aerobic respiration?

A. Lactic acid

B. Calcium ions

C. Hydrogen ions

D. Carbon dioxide (81% correct)

E. I don't know.

(2014 VCAA Exam Section 1 Q5)

Multiple choice activity

Teacher's tip

Get in the habit of ruling out incorrect responses to help you narrow the options in multiple choice.

Which of the following characteristics is associated with energy production in the anaerobic glycolysis system?

A. Energy production is limited by the amount of chemical fuel stored in the muscles

B. Maximum ATP production is 0.7 moles

C. ATP production occurs in the mitochondria

D. Peak power during maximal efforts occurs in 5 -15 seconds

E. I don't know.

(2007 VCAA Exam Section 1 Q12)

Multiple choice – Response

Teacher's tip

Get in the habit of ruling out incorrect responses to help you narrow the options in multiple choice.

Which of the following characteristics is associated with energy production in the anaerobic glycolysis system?

A. Energy production is limited by the amount of chemical fuel stored in the muscles

B. Maximum ATP production is 0.7 moles

C. ATP production occurs in the mitochondria

D. Peak power during maximal efforts occurs in 5 -15 seconds (48% correct)

E. I don't know.

(2007 VCAA Exam Section 1 Q12)

Multiple choice activity

Our body uses three energy systems to produce ATP – aerobic, anaerobic glycolysis and ATP-CP. They produce ATP at different rates and have different capacities as shown in the table below.

	Rate (maximal power output)	Capacity (kcal available)
Energy system X	16 kcal/min	14.5
Energy system Y	36 kcal/min	11.1
Energy system Z	10 kcal/min	> 100 000

Which of the following correctly identifies each of the three energy systems?

A. X = ATP-CP Y = anaerobic glycolysis Z = aerobic

B. X = anaerobic glycolysis Y = ATP-CP Z = aerobic

C. X = ATP-CP Y = aerobic Z = anaerobic glycolysis

D. X = anaerobic glycolysis Y = aerobic Z = ATP-CP

E. I don't know.

(2010 VCAA Exam Section 1 Q3)

Multiple choice – Response

Our body uses three energy systems to produce ATP – aerobic, anaerobic glycolysis and ATP-CP. They produce ATP at different rates and have different capacities as shown in the table below.

	Rate (maximal power output)	Capacity (kcal available)
Energy system X	16 kcal/min	14.5
Energy system Y	36 kcal/min	11.1
Energy system Z	10 kcal/min	> 100 000

Which of the following correctly identifies each of the three energy systems?

A. X = ATP-CP Y = anaerobic glycolysis Z = aerobic

B. X = anaerobic glycolysis Y = ATP-CP Z = aerobic (75% correct)

C. X = ATP-CP Y = aerobic Z = anaerobic glycolysis

D. X = anaerobic glycolysis Y = aerobic Z = ATP-CP

E. I don't know.

(2010 VCAA Exam Section 1 Q3)

We do our best to make these slides comprehensive and up-to-date, however there may be errors. We'd appreciate it if you pointed these out to us!