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Energy Metabolism

A single muscle cell is known as a muscle fibre. Each muscle is a number of muscle fibres bounded together by connective tissue. The muscle fibre transforms chemical energy to mechanical energy to contract and perform external work.

ATP or Adenosine Tri Phosphate is the only source of energy for muscle contraction. In general terms energy is stored in a molecule when bonds are formed and consequently the energy stored in a bond is released when the bond is broken.

Energy is stored in the reaction

ADP + P + Energy ⟶ ATP

and similarly released in the reaction

ATP ⟶ ADP + P + Energy

As ATP in muscle fibres is limited, ATP must be resynthesised as rapidly as it is broken down if muscle contraction is to continue.

There are three sources of ATP resynthesis:-

(1) Creatine Phosphate
(2) Anaerobic glycolysis
(3) Aerobic metabolism of carbohydrates, fats and proteins.

The anaerobic processes provide rapid resynthesis of ATP at the beginning of exercise or during a short burst of intense exercise due to oxygen deficit. If exercise is prolonged more than a few minutes, most of the energy needed to maintain ATP concentration is provided by the aerobic processes which include aerobic glycolysis and aerobic metabolism of fatty acids and amino acids.

During severe exercise anaerobic glycolysis can produce a large amount of ATP rapidly to meet ATP requirements, but this cannot be sustained for very long and therefore the intensity of exercise must be reduced if the exercise is to continue.
Anaerobic glycolysis can not keep the muscles working very long so if exercise is to continue for more than 60 - 100 secs , oxygen must be supplied to the working muscles by the blood for aerobic ATP production in the mitochondria of those muscles.

Carbohydrates are broken down and stored as glycogen in the muscles and liver. Glycogen molecules are clusters of glucose molecules.
Glucose is available through diffusion into muscle cells from the blood and the breakdown of glycogen stored in muscle cells.

The breakdown of glucose or glycogen is the result of a series of complex chemical reactions occurring in the sarcoplasm and mitochondria of the muscle cell. The energy released by aerobic glycolysis is sufficient to produce 38 molecules of ATP from one molecule of glycogen.

One of the physiological adaptations that occurs when an athlete trains for long distance running, cycling or skiing is that fats tend to be preferentially used for ATP production during sub - maximal exercise while carbohydrate is spared.

Fatty acids are split from stored triglycerides and transported to the muscles by the blood.
In the presence of oxygen the metabolism of fats produces 30% more ATP than carbohydrate. Fats however require more oxygen per ATP mole resynthesised. In situations where maximum performance is limited by oxygen supply, it is important to utilise the carbohydrate supply. Although carbohydrate is a more efficient fuel in terms of ATP produced per molecule of oxygen consumed, athletes engaged in long duration activity must also rely on fat in order to conserve the limited body reserves of carbohydrates.

Read the above information and ;

1. **Comment on the role of ATP in the production of energy for muscle contraction.**

2. **What is the source of ATP during exercise for extended durations ?**
   Discuss the role of carbohydrates and fats in the provision of energy for prolonged muscle contraction.

Energy for physical activity is released when adenosine tri-phosphate (a high energy compound) is broken down. Electrical impulses sent to the muscles stimulate the breakdown of ATP into adenosine di-phosphate and phosphate.

ATP -> ADP + Pi

To enable muscle contraction to continue ATP must be resynthesised (re built) via one of three energy pathways :

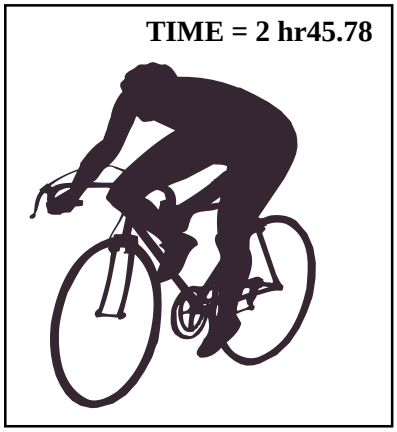
- *** ATP - PC System**
- *** Anaerobic Glycolysis System**
- *** Aerobic System.**

The pathway that is utilised is determined by the intensity and duration of exercise and a person's aerobic fitness.

Each pathway requires different amounts of oxygen, uses varying fuel sources, produces different amounts of energy and in some cases produces fatiguing by-products.

1. Think about the following athletes :

Soccer goalie
200 metre runner
Road cyclist



Identify which energy pathway is predominantly used in each activity and discuss the major characteristics of the pathway and why it is suited to the activity.

2. The soccer goalie has a different role to other members of his team.
Explain how in a game of soccer, different players will rely differently on the three energy pathways.

3. Identify periods in a soccer game that allow for full or partial replenishment of energy stores which will allow repeated use of energy pathways throughout the game.
Discuss how the duration of these periods and what the players do during this time influences the recovery of the energy stores and how this influences the repeated use of particular energy pathways.

4. Discuss the by product of energy production affecting a 200 metre runner and how this impacts on performance.

5. What is the preferred food source of energy production for an endurance cyclist and why ? Discuss.

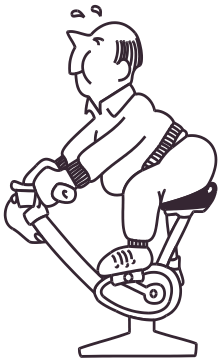
6. During physical activity all three energy pathways will be in use but one may be the dominant supplier of energy. Explain the factors that determine which pathway is predominantly in use and why ?

Three subjects were administered different diets and performed a maximal test on a bicycle ergometer.

Subject A

Normal diet.
Continued for 90 seconds before exhaustion.

Subject B



Diet consisted of high protein and high fat intake.
Exhausted after 57 minutes.

Subject C

High carbohydrate diet and continued for 167 minutes before exhaustion.

D i s c u s s i o n :

1. **What was the predominant energy pathway used by each subject.**
2. **What was the major fuel source(s) for each subject.**
3. **Outline the reasons why subject C was able to exercise longer than subject B**
4. **Why did subject A have to stop after 90 seconds.**
5. **Subject A's diet is described as normal.**
   Identify the contribution of the major food groups in a normal diet.
6. **Outline the modifications to a normal diet you would suggest for an aerobic athlete.**
7. **Describe a special dietary procedure which could have further increased subject C's glycogen stores.**
8. **Outline possible long term effects of subject B's diet.**

C o n c l u s i o n :

Explain how energy is produced using the three energy pathways.

To understand sports participation and design training programs it is necessary to analyse movement patterns and skill execution via games analysis.
This information can then be used to determine the energy pathway involvement and the physiological requirements of the sport.

Conduct a games analysis using a video or observation of a practical session in order investigate energy pathway involvement in a sport.

E q u i p m e n t : **- stop watches**
- movement pattern grid (diagram of field or court)

P r o c e d u r e :

1. MOVEMENT PATTERN :
- observe the game and plot the movement of a designated player on the movement grid for 10 minutes.
- use symbols that indicate distances and intensities of each movement.

2. INTENSITY :
- allocate movements and skills into categories of intensity - LOW / MEDIUM / HIGH.
- record the movement intensities of a designated player for 10 minutes below :

INTENSITY	TIME (seconds)																			
	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300
LOW																				
MEDIUM																				
HIGH																				

3. WORK - REST RATIO :
- observe a designated player for 10 minutes and record the time spent "working".
- calculate the work : rest ratio.

TIME SPENT WORKING	TIME SPENT RESTING (10 min - work time)	WORK : REST RATIO

R e s u l t s :

MOVEMENT PATTERNS :

Tabulate the results and complete the movement pattern table below :

	NO. OF BOUTS PER DIST. COVERED										
MOVEMENT	**0-5m**	**6-10m**	**11-15**	**16-20**	**21-25**	**26-30**	**30+**	**TOTAL**	**AV. DIST.**	**TOT.DIST.**	**% OF TOT.**
WALK											
RUN											
SPRINT											
TOTAL											

INTENSITY :

Graph the intensities from your games analysis.

D i s c u s s i o n :

1. (a) Identify the movements that utilised the ATP - PC pathway.

(b) Refer to the work : rest ratio and intensity chart.
Is there opportunity for the replenishment of the ATP - PC pathway ?
What implications do your results have for the repeated use of this pathway during the game ? Discuss.

2. (a) Identify the times when the ANAEROBIC GLYCOLYSIS pathway would be predominant.

(b) In terms of energy production and the fuels required, when and why is this pathway brought into play ?

3. (a) Identify the movements that would utilise the AEROBIC energy pathway.

(b) How important is this pathway in relation to the recovery between bouts of exercise in this sport ? Discuss.

C o n c l u s i o n :

1. Discuss the importance of each energy pathway and the interplay of the energy pathways as they relate to this sport.

2. With specific reference to your results, design a fitness training program for this sport.
Consider carefully the intensity and duration of movements, the work : rest ratio and the involvement of each energy pathway.

I n t r o d u c t i o n:

The energy used in the performance of day to day activities is provided from the breakdown of fuels such as carbohydrates and fats. Which of the fuels is used depends on a number of factors including the supply of oxygen, duration of activity, intensity of activity and reserves of fuel.

A i m:

To identify the conversion of food to energy in a range of daily activities.

P r o c e d u r e:

• Record the various activities you complete in a typical day - 24 hours.
Include sleeping, resting, household, school related, leisure and sporting pursuits etc.....

• For each activity record : duration
the intensity (high, medium, low)
energy pathway used
fuel sources drawn upon.

R e s u l t s: **See table over.**

D i s c u s s i o n:

1. **Which energy pathway was utilised the most during the day?**

2. **Based on this data, what fuel source provided the most energy?**

3. **Do you think any fuel stores would have been depleted during the day? Explain.**

4. **Discuss the relationship between the intensity of an activity and the fuel source utilised.**
Why does the body use different sources of fuel for certain activities?

5. **In terms of the depletion of fuel stores, do you think your diet during the day was adequate to replace used stores?**
What type of diet best suits your energy needs?

C o n c l u s i o n:

Discuss the percentage contribution of carbohydrates and fats in the following situations:-

(i) rest.
(ii) short duration intense exercise (e.g. running 400m).
(iii) prolonged sub-maximal exercise (e.g. jogging 10km).

Results:

ACTIVITY	DURATION (MINS)	INTENSITY (H / M / L)	ENERGY PATHWAY	FUEL SOURCE

I n t r o d u c t i o n:

The energy for physical activity and sport is released from the breakdown of adenosine tri-phosphate (ATP).
For muscle contractions to continue ATP must be resynthesised from energy derived from three pathways or energy systems :
*** ATP - PC**
*** Anaerobic Glycolysis**
*** Aerobic**

The involvement of each energy pathway in the resynthesis of ATP depends on the duration and intensity of exercise.

A i m: **To determine the energy pathways used during physical activity of varying duration and intensity.**

E q u i p m e n t : **- running track**
- stop watches

P r o c e d u r e:
1. Subjects perform three different runs :
- 50 metre sprint (maximum intensity)
- 200 metre sprint (maximum intensity)
- 1 km jog (sub maximal intensity)

2. Record :
- time taken for each run.
- heart rate at completion of each run.
- respiratory rate at completion of each run.

R e s u l t s:

50 metre		SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	AVERAGE
	TIME					
	HR - bpm.					
	RR - per min.					

200 metre		SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	AVERAGE
	TIME					
	HR - bpm.					
	RR - per min.					

1 km.		SUBJECT 1	SUBJECT 2	SUBJECT 3	SUBJECT 4	AVERAGE
	TIME					
	HR - bpm.					
	RR - per min.					

D i s c u s s i o n:

50 METRE SPRINT ;

1. **Graph the results and averages for time, heart rate and respiratory rate.**

2. **Based on the results and observations of time and intensity, which energy pathway is predominant ?**

3. **Briefly explain the operation of this energy pathway as it relates to the 50 metre sprint.**

4. **Explain why the heart rates and respiratory rates are elevated in an activity that is predominantly anaerobic.**

200 METRE SPRINT :

5. **Graph the results and averages for time, heart rate and respiratory rate.**

6. **What was the major energy pathway in use during the 200 metre sprint.**
   What is the major fuel source used ? Where and in what form is it stored.

7. **Briefly explain the operation of this energy pathway as it relates to the 200 metre sprint.**

8. **Did you (or did you notice others) struggle to maintain your intensity of effort towards the finish of the run ?**
   Why / why not ?

1 KM JOG :

9. **Graph the results and averages for time, heart rate and respiratory rate.**

10. **In a run of this type (conducted at a jogging pace or low intensity), which energy pathway is in use ?**
    What is the major fuel source and what happens if, after prolonged running, that fuel source is depleted ?

11. **Did the heart rates rise to the same levels as the sprints ? Explain observed differences.**

12. **Based on your knowledge of activity patterns of the subjects (type and frequency of activity), rate each subject for perceived aerobic fitness. Did the respiratory rates of the "fitter" subjects rise to the same levels as the others ?**
    Why or why not ?

C o n c l u s i o n:

Describe the process of replenishment and recovery from each activity.

Ie : Explain the body's recovery process for each energy pathway and what can be done by athletes to assist this.

Introduction :

The "Beep Test" or "20 metre Multistage Fitness Test" is a commonly used fitness test to estimate aerobic fitness. It is a test of the athlete's ability to produce energy continuously and the scores can be used to estimate a person's VO2 max or aerobic capacity.

Aim : **To predict students' VO2 max or aerobic fitness.**

Equipment : **- Cones** **- Tape measure.** **- Beep test CD** **- CD player**

Procedure :

Students run continuously between the cones set 20 metres apart with the aim of keeping up with the beeps indicated by the CD.
The beeps get progressively closer together indicating that the speed of running must increase progressively as well.
Students continue to run until they fail to get to the 20 metre line on 2 consecutive occasions.

Results :

Record your results and use the tables provided to calculate your "rating" and " estimated VO2 max"

MY SCORE		**MY RATING**		**MY VO2 MAX**	

Record the male and female averages for estimated VO2 max.

MALE AVERAGE		**FEMALE AVERAGE**	

Discussion :

1. **What was the predominant energy pathway used in the early stages of the test ?**
2. **What was the major fuel source(s) used during the early stages of the test and what foods provide the fuel(s) ?**
3. **As the pace got faster and faster, which energy pathway became the predominant one and what is the fuel for this energy pathway ?**
4. **Why did you fatigue and eventually have to stop running ?**
5. **What does you VO2 max and rating indicate about your ability to produce energy aerobically ? Discuss your suitability for endurance events or sports.**
6. **Did the male average for VO2 max exceed that of the female average ? Why or why not is this the case ?**

Discussion :

During the beep test, all three energy pathways will be in use but one may be the dominant supplier of energy. Explain the factors that determine which pathway is predominantly in use at any time and why ?

BEEP TEST NORMS:

MALES	
> 13	EXCELLENT
11 - 13	VERY GOOD
9 - 11	GOOD
7 - 9	AVERAGE
5 - 7	POOR
< 5	VERY POOR

BEEP TEST NORMS:

FEMALES	
> 12	EXCELLENT
10 - 12	VERY GOOD
8 - 10	GOOD
6 - 8	AVERAGE
4 - 6	POOR
< 4	VERY POOR

VO2 MAX CALCULATOR:

LEVEL	VO2 MAX
4.2	26.8
4.4	27.6
4.6	28.3
4.9	29.5

LEVEL	VO2 MAX
5.2	30.2
5.4	31.0
5.6	31.8
5.9	32.9

LEVEL	VO2 MAX
6.2	33.6
6.4	34.3
6.6	35.0
6.8	35.7
6.10	36.4

LEVEL	VO2 MAX
7.2	37.1
7.4	37.8
7.6	38.5
7.8	39.2
7.10	39.9

LEVEL	VO2 MAX
8.2	40.5
8.4	41.1
8.6	41.8
8.8	42.4
8.11	43.3

LEVEL	VO2 MAX
9.2	43.9
9.4	44.5
9.6	45.2
9.8	45.8
8.11	46.8

LEVEL	VO2 MAX
10.2	47.4
10.4	48.0
10.6	48.7
10.8	49.3
10.11	50.2

LEVEL	VO2 MAX
11.2	50.8
11.4	51.4
11.6	51.9
11.8	52.5
11.10	53.1
11.12	53.7

LEVEL	VO2 MAX
12.2	54.3
12.4	54.8
12.6	55.4
12.8	56.0
12.10	56.5
12.12	57.1

LEVEL	VO2 MAX
13.2	57.6
13.4	58.2
13.6	58.7
13.8	59.3
13.10	59.8
13.13	60.6

LEVEL	VO2 MAX
14.2	61.1
14.4	61.7
14.6	62.2
14.8	62.7
14.10	63.2
14.13	64.0

LEVEL	VO2 MAX
15.2	64.6
15.4	65.1
15.6	65.6
15.8	66.2
15.10	66.7
15.13	67.5

(Norms and VO2 max calculations - www.topendsports.com/testing/tests/20mshuttle)

The energy for physical activity can be provided by three energy pathways :
*** ATP - PC System * Anaerobic Glycolysis System * Aerobic System**

The involvement of each energy pathway in the resynthesis of ATP depends on the duration and intensity of exercise.

Participate in a team sport that allows players the chance to play in a variety of positions :
(eg; netball - goaler vs centre / basketball - centre vs guard / footy - key position vs follower / soccer - midfield vs sweeper or goalie / etc.)
Students will thereby experience a variety of actions that will bring into play all three energy pathways.

I n t r o d u c t i o n :

1. Describe the intensity, duration and fuel source for each of the energy pathways :

SYSTEM	INTENSITY	DURATION	FUEL
ATP - PC			
ANAEROBIC GLYCOLYSIS			
AEROBIC			

2. Briefly explain the functioning of each of the energy pathways.

ATP - PC :_____

_____

_____

_____

_____

ANAEROBIC GLYCOLYSIS : :_____

_____

_____

_____

_____

AEROBIC :_____

_____

_____

_____

_____

D i s c u s s i o n :

1. List the playing positions you experienced during the practical session.

_____

_____

2. List the movements you performed that utilised each of the following energy pathways :

ATP - PC :_____

_____

ANAEROBIC GLYCOLYSIS :_____

_____

AEROBIC :_____

_____

_____

3. Think about the playing positions you experienced - ie: set position / semi - mobile / mobile.
Complete the table below to highlight the approximate percentage contributions of each of the energy pathways.

POSITION	ATP - PC	ANAEROBIC GLYCOLYSIS	AEROBIC

4. Which of the energy pathways do you believe you relied most heavily on and why ?

_____

_____

_____

5. Which of the energy pathways did you rely least on and why ?

_____

_____

_____

6. In which position did you experience the most fatigue ?
With specific reference to the energy pathway involved in playing this position, explain why ?

_____

_____

_____

1. **Name the three energy pathways.**

2. **Are there any alternate names to those listed above ? Name them.**

3. **What is the actual proper name of the chemical compound known as ATP ?**

4. **What are the body's sources of ATP and where is ATP stored.**

5. **What is the role of ATP in energy production ?**

6. **What is PC ? What does it do ? Where is it stored. How long can its contribution to energy production last ? What happens when the supply of PC runs out ?**

7. **(a) Name the three sources of fuel or energy we get from the food we eat.**
(b) Give three examples of foods we can get each fuel from.
(c) Where in the body and in what form is each stored as ?
(d) What fuel source does each of the energy pathways rely upon ?
(ie: ATP-PC / Anaerobic Glycolysis / Aerobic)
(e) Which fuel source can provide ATP the easiest during aerobic activity and why ?
(f) Which fuel source can provide the most ATP during aerobic activity and why ?

8. **What do the terms "ANAEROBIC" and "AEROBIC" refer to ?**

8. **Using appropriate diagrams or maps, demonstrate how energy is produced using each energy pathway.**

9. **What determines which energy systems will be in use in any given physical activity ?**

10. **Explain the difference between slow and fast twitch muscle fibres.**

11.. **Which energy pathway and muscle fibre type will be predominantly in use during each of these activities and why ?**
(a) rest
(b) shot put
(c) 200 m sprint
(d) 5000 m run

12. **Explain the predominant energy pathway and muscle fibre type used by these two soccer players and why ?**
(a) goalie
(b) midfielder

13. **Which energy pathway and muscle fibre type would be relied upon most in the following sports ?**
(a) Diving
(b) Hockey
(c) Distance swimming
(d) Gymnastics vaulting

14. **Discuss the statement " Not only one energy system is used in most physical activities - there is generally an interplay between the three energy pathways".**

1. What determines which energy pathway (s) will be used in any given physical activity ?

_____

_____ **/2**

2. Describe the TYPE and DURATION of activity that each of the energy pathways is used for :

(a) ATP / PC : _____

_____

(b) ANAEROBIC GLYCOLYSIS : _____

_____

(c) AEROBIC : _____

_____ **/6**

3. Give two examples of activities that predominantly use each energy pathway :

(a) ATP / PC : _____

_____

(b) ANAEROBIC GLYCOLYSIS : _____

_____

(c) AEROBIC : _____

_____ **/6**

4. (a) When the body is at rest, which energy pathway provides the majority of energy ?

_____ **/1**

(b) What is the major fuel source at rest and give two examples of foods from where this can be obtained ?

_____ **/3**

5. Fill in the table below :

ENERGY SYSTEM	FUEL	OXYGEN REQUIRED ?	SPEED OF ATP PRODUCTION	QUANTITY OF ATP PRODUCED
ATP / PC				
ANAEROB. GLYC.				
AEROBIC				

/6

6. Fill out the table below :

FOOD FUEL	STORED AS	STORED IN
CARBOHYDRATE		
FATS		
PROTEIN		

/6

7. Explain how energy is produced using each of the energy pathways :

(a) ATP / PC : _____

_____

_____

_____

_____

_____

_____ **/5**

(b) ANAEROBIC GLYCOLYSIS : _____

_____

_____

_____

_____

_____

_____ **/5**

(c) AEROBIC : _____

_____

_____

_____

_____

_____

_____ **/5**

8. What is the "lactate inflection point" ?

_____

_____ **/2**

9. (a) During aerobic exercise, which food fuel would the body prefer to use and why ?

_____

_____

_____

_____ **/2**

(b) What happens when this food fuel is depleted ? Explain.

_____

_____

_____ **/2**

10. For training purposes, why is it important to understand the energy pathway contribution of your sport ?

_____

_____

_____ **/2**

11. Explain how it may be possible for two players participating in the same sport to rely more heavily on different energy pathways for their energy production ?

_____

_____

_____

_____

_____ **/2**

12. Explain the interplay between the three energy pathways during physical activity.

_____

_____

_____

_____

_____

_____

_____ **/5**

TOTAL = /60

1. **Energy System used is determined by duration and intensity of exercise (and person's aerobic capacity).**

2. **(a) ATP / PC - very high intensity physical activity for very short duration - up to about 10 seconds**
(b) ANAEROBIC GLYCOLYSIS - high intensity physical activity for short duration - 10 seconds to 1/2 minutes
(c) AEROBIC - sub maximal physical activity for long periods of time - 3 minutes plus.

3. **(a) ATP / PC - shot put / 50 m sprint / long jump / gym vault / goalie save**
(b) ANAEROBIC GLYCOLYSIS - 200 m sprint / gym floor routine / 50 m swim
(c) AEROBIC - marathon / triathlon / 1500 m swim

4. **AT REST** **(a) aerobic system in use**
(b) food fuel = fats eg; dairy / oils / margarines / non-lean meat.

5.

ENERGY SYSTEM	FUEL	OXYGEN REQUIRED ?	SPEED OF ATP PRODUCTION	QUANTITY OF ATP PRODUCED
ATP / PC	PC	NO	VERY FAST	VERY LIMITED
ANAEROB. GLYC.	CARBOS	NO	FAST	LIMITED
AEROBIC	CARB/FAT/PROT	YES	SLOW	UNLIMITED

6.

FOOD FUEL	STORED AS	STORED IN
CARBOHYDRATE	GLUCOSE GLYCOGEN EXCESS AS FAT	BLOOD MUSCLES / LIVER FAT CELLS AROUND BODY
FATS	FATTY ACIDS TRIGLYCERIDES EXCESS AS FAT	BLOOD MUSCLES / LIVER FAT CELLS AROUND BODY
PROTEIN	MUSCLE / AMINO ACIDS	MUSCLES

7. **(a) ATP / PC - energy is produced by the breakdown of ATP to ADP + P. Phosphocreatine resynthesises the ADP & P back into ATP but this can only be done for about 10 seconds as the PC is depleted. This is done during very high intensity exercise and therefore is done without oxygen as there is insufficient time for oxygen to be involved.**

(b) ANAEROBIC GLYCOLYSIS - for high intensity physical activity for short durations anaerobic glycolysis produces ATP by breaking down carbohydrates (glucose stored as glycogen). This system will usually be predominant for between 10 to 120 seconds. A by product of this system is Lactate.

(c) AEROBIC - sub maximal physical activity for long periods of time where oxygen demands can be met will produce ATP via aerobic glycolysis. The preferred fuel is carbohydrates but fat and protein may be used. Fats will be used once carbo stores are depleted but this requires more oxygen to produce the same amounts of ATP. Protein will only be used in extreme exercise or in the case of starvation for example.

8. **LACTATE INFLECTION POINT - the exercise intensity at which the rate of lactate production is greater than that of lactate removal and therefore there is an accumulation of lactates in the muscle(s).**

9. **(a) During AEROBIC exercise the preferred fuel is carbohydrates as it is easier for the body to break down and produce the required ATP.**

(b) Once the stored carbohydrates are depleted, fats become the source of fuel. This however, requires more oxygen to produce the same amount of ATP as carbos and therefore puts more strain on the body's systems.

10. **Understanding the energy contribution of your sport will allow training loads to match competitive demands and therefore the appropriate energy systems can be trained and improved.**

11. **Two players participating in the same sport can rely more heavily on different energy pathways for their energy production because they may play different positions. A full forward in aussie rules or a goaler in netball will require short intense bursts and therefore rely more heavily on the ATP - PC system. A rover or netball centre who is constantly on the move will use the aerobic system more heavily.**

12. **There is an interplay between the 3 energy pathways as many physical activities will require a contribution from all 3 pathways. The ATP - PC will be used at the start of activities and then a contribution will be made by the ANAEROBIC GLYCOLYSIS system as the athlete moves through to the point where the oxygen demands can be met by the body and the aerobic system will become predominant.**