Energy Systems

3 Body Energy Systems

- Phosphagen
- Anaerobic Glycolysis
- Aerobic

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There are 3 energy systems within the body that provide energy to the working muscles. These are:

- **ATP-PC**
- **Anaerobic Glycolysis**
- **Aerobic**

- The **ATP-PC** system breaks down Phosphocreatine (PC) to rebuild ATP.

- The anaerobic glycolysis system only breaks down **carbohydrates** to rebuild ATP.

- The aerobic system can break a range of fuels to rebuild ATP: **fats, carbohydrates and proteins** if required.
• **Adenosine Triphosphate (ATP)**

• Provides energy for every function that occurs in the human body
• Is constantly being broken down to release chemical energy that is then transformed into mechanical energy used for movement.
• Individuals have **limited supply of ATP**, in fact, we only have sufficient supply to produce energy for **approx. 2 seconds** unless resynthesis of this molecule occurs.

• **ATP** can be **resynthesised** or rebuilt by;
  - The breakdown of PC
  - The break down of any of the three food fuels, being Carbohydrates, Fats & proteins.
The body will use different **food fuels** and **energy systems** depending on **intensity and duration** of the activity, as well as the availability and restoration of fuels.

- **At rest:** The body uses more fats than carbohydrates

- **Maximal efforts:** Carbohydrates are used almost exclusively

- **Prolonged activities:** Carbohydrates are again preferred.
The **three systems** do not function independently or one at a time, but work together via the process of **interplay** to supply energy and rebuild ATP.

- All three energy systems are activated at the start of exercise and their relative contribution is essentially **determined by the intensity** and **duration** of the exercise.
- Factors affecting which energy system operates during exercise depends upon:
  - **Duration**
  - **Intensity**
  - **Whether or not oxygen is present**
  - **The depletion of chemical and food fuels during exercise**

- *So, at any one time during activity, one system will be providing more ATP than the other two energy systems i.e. dominant*
Energy system *interplay* refers to all 3 energy systems *co-contributing to ATP production* with one producing the bulk of ATP = *dominant/predominant system.*
The following diagram shows the **dominant** energy systems used for activities of varying **duration** and **intensity**.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Total event duration</th>
<th>Dominant energy system</th>
<th>Food and/or chemical fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>n/a</td>
<td>Aerobic</td>
<td>Glucose and FFAs</td>
</tr>
<tr>
<td>Submaximal</td>
<td>30 seconds</td>
<td>Aerobic</td>
<td>Glucose and FFAs</td>
</tr>
<tr>
<td>Submaximal</td>
<td>30 minutes</td>
<td>Aerobic</td>
<td>CHO</td>
</tr>
<tr>
<td>Submaximal</td>
<td>3+ hours</td>
<td>Aerobic</td>
<td>FFAs</td>
</tr>
<tr>
<td>Maximal</td>
<td>1–3 seconds</td>
<td>ATP–PC</td>
<td>Stored ATP</td>
</tr>
<tr>
<td>Maximal</td>
<td>5 seconds</td>
<td>ATP–PC</td>
<td>Remaining stored ATP–PC</td>
</tr>
<tr>
<td>Maximal</td>
<td>30 seconds</td>
<td>Anaerobic glycolysis</td>
<td>CHO</td>
</tr>
<tr>
<td>Maximal</td>
<td>75 seconds</td>
<td>50% ATP–PC and lactic acid, 50% aerobic</td>
<td>CHO</td>
</tr>
</tbody>
</table>
ATP-PC System

Is an **anaerobic energy system**; that is, it does not depend on oxygen being transported to working muscles to release energy.

*Provides the most rapidly available source of ATP* for energy
- depends on simple, short chemical reactions and the ready availability of PC in muscles.

*Is limited by the amount of PC stored in the muscles*
- The more intense the activity, the more quickly PC is utilised to produce ATP.

*Uses stored PC which lasts for up to 15 seconds* at maximal intensity, with larger muscles capable of storing slightly more than smaller muscles (12 to 14 seconds).
- When the PC stores are **40 to 50%** depleted (*after about 5 seconds at maximal intensity*), the anaerobic glycolysis system becomes the major producer of ATP.

*Can only be replenished* through the aerobic pathway *during recovery*, once the activity has stopped.
**Anaerobic Glycolysis System**

*Supplies ATP at a slower rate than the ATP–PC system* because it requires longer and more complicated chemical reactions.

*Produces lactic acid* which can be broken down (without oxygen) to glycogen to provide energy (ATP). Hence it is called the anaerobic glycolysis or lactic acid system.

*Supplies energy from the start of intense exercise.*
- Peaks *between 5 and 15 seconds*
- Continues to contribute to ATP production until it fatigues, after *2 to 3 minutes*.

*Provides twice as much energy for ATP resynthesis as the PC system.*
- Increases its ATP contribution when *intensity* exceeds the lactate inflection point.
- During *maximal exercise*, the rate of glycolysis may increase to 100 times the rate at rest.

*Provides energy for longer during submaximal activities when PC is depleted* and lactic acid accumulation is slower.
The anaerobic glycolysis system & aerobic system comparison when considering carbohydrates (CHO) as a fuel source

Aerobic glycolysis:
- Glycogen → Glucose → ATP → Pyruvic acid → Sufficient oxygen → CO₂ + H₂O + ATP

Anaerobic glycolysis:
- Glycogen → Glucose → ATP → Pyruvic acid → Insufficient oxygen → Lactic acid = lactate + H⁺ then more ATP released

Same process up until the availability/unavailability of oxygen.

Lactic acid (C₃H₆O₃) → Lactate (C₃H₅O₃⁻)
The Aerobic System

*Produce ATP at the slowest rate compared to the anaerobic systems.* It involves more complex chemical reactions than the ATP–PC and anaerobic glycolysis systems.

- **Provides 30 to 50 times as much ATP as both anaerobic energy systems combined**
- **Requires oxygen**, which can be provided (90% VO2max) within 60 seconds.
- **Preferentially breaks down carbohydrates** rather than fats to release energy.
- **Can produce more ATP by using fats compared to carbohydrates**, but they require more oxygen to produce an equivalent amount of ATP.
- **Does not release toxic or fatiguing by-products** and can be used indefinitely.
- **Is also activated at the start of intense exercise.** Peak power from this system is usually reached between 1 and 2 minutes and will continue to be the major ATP contributor as the anaerobic glycolysis system decreases its contribution.
**Energy Systems**

<table>
<thead>
<tr>
<th>Energy system</th>
<th>Fuel used</th>
<th>Rate of ATP (energy) production</th>
<th>Total amount of ATP (energy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATP-PC system</td>
<td>Phosphocreatine (PC) or creatine phosphate (CP)</td>
<td>Fastest</td>
<td>0.7–1.0</td>
</tr>
<tr>
<td>Anaerobic glycolysis or lactic acid (LA) system</td>
<td>Glucose</td>
<td>Fast</td>
<td>2–3</td>
</tr>
<tr>
<td>Aerobic system</td>
<td>Aerobic glycolysis</td>
<td>Moderate</td>
<td>36–38</td>
</tr>
<tr>
<td></td>
<td>Aerobic lipolysis</td>
<td>Slowest</td>
<td>147</td>
</tr>
</tbody>
</table>

The **rate** of an energy system refers to how fast it produces ATP.

The **capacity** of an energy system refers to how much ATP it can produce — referred to as amount or yield.
The following charts show an AFL player’s energy system contribution at the 5 and 20 second stage of a passage of play consisting of high intensity efforts such as sprints.

Energy system contribution to a 5 second maximal effort in AFL

- Aerobic: 2%
- Stored ATP: 15%
- Anaerobic Glycolysis: 29%
- PC: 54%

Energy system contribution to a 20 second maximal passage of play in AFL

- Aerobic: 2%
- Stored ATP: 21%
- PC: 31%
- Anaerobic Glycolysis: 46%

Notice the change in energy system contribution as the effort continues!
• The *interchange system* is being used increasingly by coaches to “*rest*” players and enable them to rebuild/resynthesize PC before taking to the field for more high intensity efforts.

• *Gary Ablett* often rates amongst the highest possession getters in the AFL and is regularly rested on the bench for short periods of time.