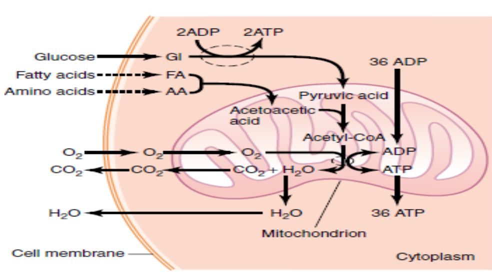
UNIT-2 ATP, CREATINE PHOSPHATE, Basal Metabolic Rate

1.ATP

- **ATP** is a nucleotide composed of (1) the nitrogenous base *adenine*, (2) the pentose sugar *ribose*, and (3) three *phosphate radicals.*
- *Under the physical and chemical conditions of the body*, each of these high energy bonds contains about 12,000 calories of energy per mole of ATP, which is many times greater than the energy stored in the average chemical bond, thus giving rise to the term *high-energy bond.*
- The high-energy phosphate bond is very labile so that it can be split instantly on demand whenever energy is required to promote other intracellular reactions.
- When ATP releases its energy, a phosphoric acid radical is split away and *adenosine diphosphate* (ADP) is formed.
- This released energy is used to energize virtually many of the cell's other functions, such as synthesis of substances and muscular contraction.
- To reconstitute the cellular ATP as it is used up, energy derived from the cellular nutrients causes ADP and phosphoric acid to recombine to form new ATP, and the entire process repeats over and over again.
- For these reasons, ATP has been called the energy currency of the cell because it can be spent and remade continually, having a turnover time of only a few minutes.



- The initial event is removal of an electron from the hydrogen atom, thus converting it to a hydrogen ion.
- The terminal event is combination of hydrogen ions with oxygen to form water plus the release of tremendous amounts of energy to large globular proteins, called *ATP synthetase*, that protrude like knobs from the membranes of the mitochondrial shelves.
- Finally, the enzyme ATP synthetase uses the energy from the hydrogen ions to cause the conversion of ADP to ATP.
- The newly formed ATP is transported out of the mitochondria into all parts of the cell cytoplasm and nucleoplasm, where its energy is used to energize multiple cell functions.

Uses of ATP for Cellular Function:

- Energy from ATP is used to promote three major categories of cellular functions:
- transport of substances through multiple membranes in the cell,
- synthesis of chemical compounds throughout the cell, and
- mechanical work.
- To supply energy for the transport of sodium through the cell membrane,
- To promote protein synthesis by the ribosomes,
- To supply the energy needed during muscle contraction.
- In addition to membrane transport of sodium, energy from ATP is required for membrane transport of potassium ions, calcium ions, magnesium ions, phosphate ions, chloride ions, urate ions, hydrogen ions, and many other ions and various organic substances. Membrane transport is so important to cell function that some cells—the renal tubular cells, for instance—use as much as 80 percent of the ATP that they form for this purpose alone.
- In addition to synthesizing proteins, cells make phospholipids, cholesterol, purines, pyrimidines, and a host of other substances. Synthesis of almost any chemical compound requires energy.
- For instance, a single protein molecule might be composed of as many as several thousand amino acids attached to one another by peptide linkages; the formation of each of these linkages requires energy derived from the breakdown of four high-energy bonds;

thus, many thousand ATP molecules must release their energy as each protein molecule is formed. Indeed, some cells use as much as 75 percent of all the ATP formed in the cell simply to synthesize new chemical compounds, especially protein molecules; this is particularly true during the growth phase of cells.

- The final major use of ATP is to supply energy for special cells to perform mechanical work. Each contraction of a muscle fiber requires expenditure of tremendous quantities of ATP energy.
- Other cells perform mechanical work in other ways, especially by *ciliary* and *ameboid motion*. The source of energy for all these types of mechanical work is ATP.

2.CREATINE PHOSPHATE

- **Phosphocreatine**, also known as **creatine phosphate** (**CP**) or **PCr** (**Pcr**), is a phosphorylated creatine molecule that serves as a rapidly mobilizable reserve of high-energy phosphates in skeletal muscle, myocardium and the brain to recycle adenosine triphosphate, the energy currency of the cell.
- In the kidneys, the enzyme AGAT catalyzes the conversion of two amino acids — arginine and glycine — into guanidinoacetate (also called glycocyamine or GAA), which is then transported in the blood to the liver. A methyl group is added to GAA from the amino acid methionine by the enzyme GAMT, forming non-phosphorylated creatine.
- This is then released into the blood by the liver where it travels mainly to the muscle cells (95% of the body's creatine is in muscles), and to a lesser extent the brain, heart, and pancreas.
- Once inside the cells it is transformed into phosphocreatine by the enzyme complex creatine kinase, which makes it able to donate its phosphate group to convert adenosine diphosphate (ADP) into adenosine triphosphate (ATP).
- This process is an important component of all vertebrates' bioenergetic systems. For instance, while the human body only produces 250 g of ATP daily, it recycles its entire body weight in ATP each day through creatine phosphate.
- Creatine phosphate can be broken down into creatinine, which is then excreted in the urine. A 70 kg man contains around 120 g of creatine, with 40% being the unphosphorylated form and 60% as creatine phosphate. Of that amount, 1–2% is broken down and excreted each day as creatinine.

- Phosphocreatine can anaerobically donate a phosphate group to ADP to form ATP during the first two to seven seconds following an intense muscular or neuronal effort.
- Conversely, excess ATP can be used during a period of low effort to convert creatine to phosphocreatine. The reversible phosphorylation of creatine (i.e., both the forward and backward reaction) is catalyzed by several creatine kinases.
- The presence of creatine kinase (CK-MB, MB for muscle/brain) in blood plasma is indicative of tissue damage and is used in the diagnosis of myocardial infarction.
- The cell's ability to generate phosphocreatine from excess ATP during rest, as well as its use of phosphocreatine for quick regeneration of ATP during intense activity, provides a spatial and temporal buffer of ATP concentration.
- In other words, phosphocreatine acts as high-energy reserve in a coupled reaction; the energy given off from donating the phosphate group is used to regenerate the other compound - in this case, ATP.
- Phosphocreatine plays a particularly important role in tissues that have high, fluctuating energy demands such as muscle and brain.

3.BMR

The Basal Metabolic Rate (BMR) is the energy required by an awake individual during physical, emotional and digestive rest. It is the minimum amount of energy required to maintain life or sustain vital functions like the working of the heart, circulation, brain function, respiration, etc. The metabolic rate during sleep is less than BMR.

Basal metabolic energy required to support the basic processes of life, including circulation, respiration, temperature maintenance, etc. It excludes digestion and voluntary activities.

BMR constitutes the largest proportion (2/3) of a person’s daily expenditure.

FACTORS THAT AFFECT BMR

- Age – BMR higher in youth. Lean body mass declines with age; physical activity can offset this effect.
- Height – tall people have larger surface area.
- Growth – children & pregnant women have higher BMR’s
- Body composition – more lean tissue, higher BMR

- Fever – raises BMR
- Stress
- Environmental temperature
- Fasting/starvation, lowers BMR
- Malnutrition, lowers BMR
- Thyroxine – regulates BMR

Normal Value for BMR

Since BMR is affected by body surface area, it is usually expressed in kilocalories per hour/square meter of body surface. Body surface area is calculated using the formula

A = $\mathbf{W}^{0.425} \times \mathbf{H}^{0.725} \times \mathbf{71.84}$

A = area in sq cm,

H = height in centimeters and W = weight in kilograms.

The BMR is then calculated from the values of oxygen consumption, calorific value and surface area.

NORMAL VALUE FOR BMR

For adult men normal value for BMR is 34-37 kcal/square meter/hour, and

For adult women, 30-35 kcal/Sq.m./hour.

For easier calculations, BMR for an adult is fixed as 24 kcal/ kg body weight/day.