ENERGY

- Humans need energy for vital functions like respiration, digestion, etc
- Unlike plants, we cannot synthesize energy from sunlight
- Hence, it has to be provided by the food, specifically energy yielding nutrients- CHO, proteins, fat.

WHAT IS ENERGY?

It can be explained as "**The ability or capacity to do work**".
It can be grouped into

1. **Potential energy**- Stored energy/energy of position eg, gravity, chemical energy- energy in the bonds between atoms in a molecule, nuclear energy- the energy stored in the nucleus of an atom and that holds the atom together.
2. **Kinetic energy**- It is the energy of motion. Eg, sound energy-released by vibrating objects, radiation energy- energy that travels in transverse waves e.g., solar energy, thermal energy-energy because of vibration of the atorns present, etc. It is the motion of waves, electrons, atoms, molecules, substances and objects.

According to the First Law of Thermodynamics ``Energy can neither be created nor be destroyed, however energy can be converted from one form to another form. Eg, the human body converts chemical energy from food by metabolizing it to produce thermal energy (body temperature), mechanical (body movement, contraction of muscles), electrical energy (brain, nerve activities).

UNIT OF ENERGY

Energy is measured in joules in International System of Units It can be defined as "**energy expended used when 1 kg is moved through a distance, of 1 meter by force of I newton**"

- Energy is also measured in calories
- Calorie is defined as the amount of heat required to raise the temperature of gram of water by 1 degree celsius from 14.5-15.5 degree C
- 1 Calorie = 4.184 Joules
- 1000 Calories 1 kilocalorie (kcal)
- 1000 Joules kilojoule (Kj)
- Because the human body utilizes a considerable amount of energy and humans consume large amounts of energy, generally kilojoule kilocalorie is used.

PHYSIOLOGICAL FUEL VALUE

Physiological fuel value is the difference between the number of kilocalories measured with calorimetry and the number of kilocalories that the human body derives from a food.
When undergoing complete oxidation in the bomb calorimeter the foodstuffs yield the following average heats of combustion:

- Carbohydrates - 4.1 Calories per gram.
- Fats - 9.45 Calories per gram.
- Proteins - 5.65 Calories per gram.

In the body carbohydrates and fats are oxidized to the same products as in the calorimeter and so yield the same amounts of heat.
Protein, however, which burns in the bomb to carbon dioxide, water, and nitrogen, yields in the body no free nitrogen, but urea and other organic nitrogen compounds which are eliminated as end products.

These organic nitrogenous end products are combustible; they represent a less complete oxidation of protein in the body than takes place in the bomb.

Hence, when the body burns material which it has previously absorbed, it obtains:

- From carbohydrates - 4.1 Calories per gram.
- From fats - 9.45 Calories per gram.
- From protein (5.65-1.30=) - 4.35 Calories per gram..

In calculating the fuel value of the food, however, allowance must be made for the fact that a part of each of the materials is lost in digestion.

The approximate averages on a mixed diet are:

Fats - 9.45 x 95% = 9 kilo calorie per gram

Proteins - 4.35 x 92% = 4 kilo calorie per gram

ENERGY REQUIREMENTS

- For most nutrients requirements of healthy individuals at a given age/ life stage is set up.
- However certain nutrients can be disposed of by the body if taken in excess.
- But this is not the case for energy-body does not have the ability to get rid of excess energy as it is converted to fat and person gains weight.
- Hence there should be a balance between intake and energy expenditure.
- Energy requirement is the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long term good health.
- This includes the energy needed for optimal growth and development of children, for deposition of tissues during pregnancy, and for the secretion of milk during lactation consistent with the good health of mother and child (FAO,2004).
- Hence, requirements are estimated from measures of energy expenditure + additional energy needs for growth, pregnancy and lactation. Dietary intake must satisfy these requirements for the attainment & maintenance of optimal health, physiological function and well being. The latter depends not only on health, but also on the ability to satisfy the demands imposed by the society, as well as the other energy-demanding activities that fulfill individual needs.
- Hence, if a person is overweight/obese, intake should be less than expenditure.
- If a person is undernourished/ underweight, intake should be more than expenditure.
- Since, the requirements depend on expenditure, there is a lot of variation as energy expenditure depends on a number of factors. Eg, Sex males have more lean muss, hence requirements are more than females of same age and stature.
- For infants/children/adolescents/pregnancy/lactation, Intake - expenditure + for growth/development/maturation (tissue deposition/growth of fetus/ milk secretion/ increased BMR) consistent with health yet not result in overweight or obesity.
- Thus, with growth, energy requirements increase, generally higher for boys weight gain.
- Energy requirement's level off and decline after adulthood. By 75 yr of age, there is a 30% decrease in energy requirements due to loss of cells, muscle mass and lower BMR.

ENERGY EXPENDITURE

Energy expenditure is the amount of energy required for "TEE" Total Energy Expenditure i.e., total energy spent in 24 hours by an individual.

It may not be the same everyday, because activity patterns may vary each day.

Predominantly there are 3 components of energy expenditure:

- Basal Metabolic Rate (BMR)- (50-60% Of total energy)
- Diet Induced Thermogenesis (DIT) Or Thermic Effect of Food (TEF) (10%)

- Physical Activity (PAL) (20-30%- very variable)

BASAL METABOLISM

- Involves minimum energy required for vital metabolic activities necessary to sustain life.
- It includes cellular functions, turnover of cells, synthesis, secretion and transport of molecules and cardiac and brain functions. Involuntary functions by brain, liver, GI tract, heart, kidneys (maintenance activities).
- These are the functions which occur during sleep/ rest and in fasting state.
- Energy for these activities must be met before anything else.
- It is 50-60% of total energy requirements.
- It is estimated in supine position, standard conditions of fisting and resting stage (physically/emotionally/physiologically)(neither hot nor cold temperature). In this situation, oxygen consumption is lowest and heat generated by cells through metabolism is also lowest.
- Usually in the morning, after 12 hours fasting, 8 hrs of rest and are awake.
- It is calculated as kcal per minute per hour/ per 24 hr.
- It varies among individuals, but usually constant.
- The total amount of energy used in basal metabolism is called the basal metabolic rate. It is the rate at which the body invests energy in these maintenance activities.
- However, measurement of BMR requires stringent conditions, which is difficult to attain-
- Hence Resting Metabolic Rate (RMR) is measured- where such stringent conditions are not required. Even if one of the conditions for measuring BMR is not met, the measurement is termed as RMR.
- RMR is 10-20% higher than BMR.

FACTORS AFFECTING BMR

1. **Genetics**: Some individuals are born with a higher metabolism, while others have a lower metabolism.
2. **Body surface area/ body size**: Body surface is related to heat production. Larger body size means higher BMR. However BMR is not influenced by body surface but not with weight. Two people with the same weight may differ in height, one being short, the other tall. Taller person will have a greater skin surface, from which heat is lost by radiation. Thus, more heat is generated by tall/thin people.
3. **Body composition:** Lean body mass (LBM) means muscle tissue that is metabolically active tissue. It influences BMR- higher the LBM, higher is the BMR. Adipose tissue is not as active as active/lean mass/muscle. Thus, overweight people have low BMR.
4. **Sex**: Women have more adipose tissues, hence have 5-10% lower BMR than men. Hence, the energy requirement of women is lower than men. Men have more muscle mass, hence higher BMR & energy requirement RMR of adolescent girls/women fluctuates during menses, where TEE may increase approx. by 150 kcal/day.
5. **Age**: Infants, children and adolescents have high BMR because there is multiplication. of cells and cellular processes. This raises BMR by 15-20%, thus raising energy requirements. Once growth stops after 20 years, there is a 2% decrease in BMR per decade in women, and 3% in men due to reduction of LBM with age. Also activity levels reduce with age, hence reducing energy expenditure and requirement.
6. **Pregnancy**: Growth of fetus & maternal tissues requires energy. Also the woman needs to put more effort into physical activity. There is an increase in BMR by 20-25% (350 kcal extra) due to accelerated tissue synthesis, active tissue mass, increased cardiac/ respiratory work.
7. **Lactation**: Mother requires extra energy for milk secretion Mother's milk provides 65 kcal/ 100 ml, thus there is increased caloric requirement of lactating mother.
8. **Physical Activity**: Greater is the body movement, greater is the energy requirement, hence there is an increase in BMR.

9. **Climate**: In cold climates, the body attempts to produce more heat to counteract the effect of the cold environment to maintain body temperature. Thus metabolism increases. However, clothing and insulation provided by body fat affects RMR. Persons living in tropical areas have lower BMR. Exercise in temperature above 86 degree F increases metabolic load by 5% due to sweating.
10. **Sleep**: Rate of physiological function is reduced during sleep (muscular and emotional), hence BMR is lowered by 10-15%.
11. **Body temperature:** Heat acts as a catalyst for all the biological reactions in the body. Hence, BMR increases.
12. **Nutritional Status:** In case of fasting, BMR is reduced- adaptive response to preserve the body's stores. Also in undernutrition or starvation, LBM is lost resulting in low BMR - upto 20% depending on duration of under nutrition. In overweight also there is reduction in BMR due to more adipose tissue. High calorie restriction also lowers BMR.
13. **Hormonal influence:** Thyroid gland regulates metabolism through hormone thyroxine. When activity of this gland reduces, there is a decrease in BMR- as much as 30%. Hence, a hypothyroid person requires less energy as compared to a normal person. In Case of hyperthyroidism, BMR increases by 50-75%.
14. **Stress:** Disease condition is a stressful condition, hence there can be an increase in BMR. A rise in 1 degree F leads to a 7% increase in BMR. Sometimes it can increase as much as 15%.

THERMIC EFFECT OF FOOD

- Energy is required to digest, absorb, transport and store nutrients. This is called Thermic Effect of Foods (TEF) or Diet Induced Thermogenesis (DIT), previously known as Specific Dynamic Action (SDA) of food.
- When food is eaten, there is movement of muscles to chew it, then movement through the digestive system, synthesis of enzymes, hormones and other substances required for digestion, absorption and transport of the nutrients.
- Thermogenesis reaches a maximum within one hour after a meal.
- Energy expended is app 7-13% of a person's energy intake. It is proportional to the amount of food (larger the meals, more is thermogenesis) and calories consumed.
- However, it depends on the individual, food, food composition(protein is more thermogenic as compared to fat/ carbs) & body's capacity to process the food.
- TEF of:
    1. Carbohydrate-5 to 10% (increment above baseline)
    2. Fat-0 to 5% (increment above baseline)
    3. Protein- 20 to 30% (increment above baseline)
- High fiber meal has been found to reduce TF (due to slow absorption of glucose and blunted insulin response, which can reduce energy required for insulin mediated glucose disposal).

PHYSICAL ACTIVITY

Physical activity involves use of muscles for bodily movement to contract and do work.
Hence, the more physical activity, the more energy expenditure.
It accounts for approx 30% of total energy requirements.
Also called exercise **thermogenesis.**

There are two types of activities:

1. **Obligatory activities**: ones which cannot be avoided, are linked to one's occupation, roles and responsibilities at home. These are daily activities performed, depending upon the life stage, socio economic and cultural environment.
2. **Discretionary activities**: Activities that are optional, performed by choice. This can include exercise and sports, gardening, social and community activities. These activities are undertaken voluntarily &

individually for various purposes like personal enjoyment, social interaction, social service, etc Overall these activities are important for well-being and quality of life. It's the most variable component because of the differences in the activity pattern, intensity of the activity (demand on muscles) and its duration (amount of time spent). frequency (how often the activity is performed), type of activity (how many muscles are being used), level of fitness (body weight, muscle mass. It can be 15 to 40% of TEE.

Depending upon intensity and energy spent on an activity, different activities are grouped as:

1. **Sedentary workers**: Those persons involved in more desk jobs and use less muscular movements are referred to as sedentary workers. Eg, executives, teachers, clerks, studio housewives. People who use energy saving devices and equipment and keep domestic help. They spend half of the day in very light activities like TV watching, internet surfing, and playing games.
2. **Moderate workers:** The people who use a considerable amount of muscle movements and spend more time on moderate to vigorous physical activities like regular exercise, playing outdoor sports, long distance walking, using stairs, running, cycling, dancing, floor cleaning pottery, gardening, etc.
3. **Heavy worker:** The persons regularly performing strenuous work for several hours such as construction and mine workers, swimmers, agricultural laborers, rickshaw pullers, coolies, etc. It also includes sportsmen and athletes who practice or play for long hours.

Physical activity is also affected by the following factors:

1. **Biological**: Heredity, sex, adiposity, nutritional status, health status, sexual maturity, proficiency in motor skills, physical fitness.
2. **Psychological**: Self efficacy, self-concept of activity, perception of barriers to activity, perception of physical competence, attitude about activity, belief.
3. **Social**: Attitude and behavior of the parents, peer groups, socioeconomic status, time spent on computer games, cultural values.
4. **Physical environment**: Area of residence, availability of facilities, safety, day of the week, season and climate.

CARBOHYDRATES

Carbohydrates as a nutrient are abundant and relatively less expensive source of energy for people. Carbohydrates as a nutrient are the main source of energy for people. CHO provides about ½ to ¾ of energy intake across the globe. Chemically carbohydrates contain 3 elements- **carbon, hydrogen and oxygen.** Hydrogen and oxygen are present in proportion as in water i.e. H2O- ratio of **2: 1**. Hence it is called carbo- hydrates. Carbohydrates are also known as saccharides - Greek word 'sakcharon' meaning sugar. **General formula**- Cn(H2O)
Energy value of **1g of CHO----4 kcal**

CLASSIFICATION (based on number of carbohydrate units present)

A. **Monosaccharides** - Compounds with one carbohydrate unit or one molecule. These compounds are the simplest form of carbohydrates and cannot be hydrolysed (broken down) further to simpler compounds. Monosaccharides are further classified according to number of carbon atoms -
3 carbon atoms-known as trioses- $C_3H_6O_3$
4 carbon atoms- known as tetroses- $C_4H_8O_4$
5 carbon atoms-known as pentoses- $C_5H_{10}O_5$
6 carbon atoms- known as hexoses- $C_6H_{12}O_6$, glucose, fructose, galactose
7 carbon atoms- known as heptoses- $C_7H_{14}O_7$

- They are relatively small molecules, have low molecular weight and soluble in water
- Commonly found in daily diet
- Add varying degree of sweetness to foods
- Major source of energy and required for the biosynthesis of many molecules
- Glucose is the most important monosaccharide.
- The level of glucose in blood is used to indicate the blood sugar level.
- Easy absorption of mono and disaccharides, therefore rapid raise in the blood sugars
- Recommendation: not more than 10% of dietary energy should come from simple sugars.

Glucose - Present in human blood also. Also known as dextrose, grape sugar. Found in fruits like grapes, oranges, carrots and honey. Cell utilizes glucose for energy, the Central nervous system or brain can use only glucose as energy source. Extra glucose is stored in the liver and muscles in the form of glycogen.

Fructose - or fruit sugar. Found in ripe fruits and honey. It is sweetest of all sugars Found with glucose in sucrose.

Galactose - Not found in free state, found in combination with glucose in lactose.

B. **Disaccharides -** Compounds with two carbohydrate units ie. two monosaccharides either same or different joined to form disaccharides. The two monosaccharide units are joined by a linkage known as glycosidic linkage.
The three important disaccharides in our diet are:---
Maltose = glucose + glucose (Formed in cereals during germination.)
Lactose = glucose + galactose (Milk sugar- Found only in milk.)
Sucrose = glucose + fructose (Cane sugar- Found in sugarcane and common table sugar)

C. **Oligosaccharides -** Compounds with three to nine monosaccharide units eg, raffinose, stachyose.
Found in plant foods such as legumes, soybean and dairy products such as yogurt.
Inulin, a chicory root extract, is also an oligosaccharide.
They are fermented by the gut microflora and often produce flatus (gas) which gives rise to the feeling of bloating (often experienced after eating whole pulses).

D. **Polysaccharides** - Compounds with more than ten monosaccharide units. They are complex molecules. They may have straight or branched structure e.g. starch, dextrins, glycogen, cellulose, gums. They are complex molecules/complex carbohydrates.
Starch - it is the storage form of CHO in plants. It is made up of glucose. Sources are roots, cereals, pulses, tubers.
Glycogen - known as animal starch. Storage form of CHO in animal tissues especially liver and muscles.

FUNCTIONS OF CHO

1. **To supply energy -** Main function. 1 gm of CHO when oxidized in body gives 4 keals. About 60- 70% of total energy should come from CHO. Even though fats give twice the amount of energy (9 kcals), the amount of CHO in our diet is much more. Brain or nervous system cannot utilize any source of energy other than glucose. It is indispensable. Any failure to supply glucose can damage the brain.
2. **Protein sparing action -** CHO has protein sparing action. Body preferably uses CHO as a source of energy if present in adequate amounts in diet. If not sufficient, proteins are used for energy rather than body building This leads to protein breakdown. Thus adequate amounts of carbohydrates spare proteins for its primary function of body building and repairing body tissues.
3. **Formation of adipose tissue -** Excess CHO is converted to fats and stored in the adipose tissue.
4. **Role in intestinal tract -** Carbohydrates, especially lactose, stay in the intestine for a long time and promote growth of certain desirable bacteria which are useful in synthesis of B-complex vitamins. Also lactose creates a mildly acidic environment in the intestine which helps in absorption of calcium and iron.
5. **Detoxification in liver**
6. **Health benefits**
7. **Source of Carbon -** CHO supplies carbon for the synthesis of DNA/RNA. Ribose is a 5C unit present in the DNA

REQUIREMENTS OF CHO

- All over the world there is wide variation in CHO intake.
- In India, mostly our diets contain 65-70% of carbohydrates i.e. 65-70% of energy intake comes from carbohydrates.
- Related to the total energy requirement.
- Under normal conditions the CHO should provide 55-65% of daily caloric intake.
- Out of this only 10-15% should come from simple sugars and the rest should be from complex CHO
- A minimum of 30% calorics should come from CHO or about 100-130g CHO should be consumed to prevent exhaustion and ketosis.

DIETARY FIBER

Dietary fiber is defined as that portion of food derived from plant cells which is resistant to digestion by human digestive enzymes.
They are classified as Soluble and Insoluble Fiber.
Both are indigestible. Soluble fiber is soluble in water and insoluble fiber is not soluble in water.
Soluble fiber examples- gums, pectin
Insoluble fiber examples- cellulose, hemicellulose.
Soluble fiber is helpful in diabetes, heart disease and insoluble fiber is helpful in constipation.
Recommendation - 25-30 grams per day.
Insoluble:Soluble = 2:1