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VEPACHEDU EDUCATIONAL FOUNDATION

The Telangana Science Journal

Health and Nutrition

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METABOLISM, DIET AND EXERCISE

METABOLISM

The term “metabolism⁽²⁾” is used to describe all chemical reactions involved in maintaining the living state of the cells in an organism and the organism. Metabolism is how the body converts or uses energy for activities such as digestion, building muscle, storing fat, producing glucose, storing glucose, breathing, circulating blood, reproduction etc. required for sustaining life.

Metabolism can be divided into two categories:

Catabolism is the breakdown of molecules to obtain energy, *e.g.*, Glucose to carbon dioxide, water and energy. **Anabolism** is the synthesis of all compounds needed by the cells, *e.g.*, photosynthesis of glucose from carbon dioxide, water and energy.

There are two kinds of metabolic rates.

Basal metabolic rate (BMR) is the amount of energy expended while at rest in a neutrally temperate environment, in the post-absorptive state when the digestive system is inactive, which requires about twelve hours of fasting. BMR or sleeping metabolic rate (SMR) is the largest component of total energy expenditure (EE). The BMR for a person weighing 170 pounds and 6 ft is: 1873 cal/day for a male at age 25, 1614 cal/day for a female at age 25, 1704 cal/day for a male at 50, 1497 cal/day for a female at 50 (3). Total calories for a sedentary man of 154 pounds and 5 feet 10 inches is 1,800 (26 years) and 1,600 (50 years)⁽³⁾.

Resting metabolic rate (RMR)^(3a) is the rate at which calories are burned by the resting body and is different from "basal metabolic rate (BMR)." RMR calculation is a bit complicated requiring the use of fat-free mass for calculations, five or more different equations, and averaging it out⁽⁴⁾. RMR decreases with the loss of muscle, which happens most often in crash diets. Several things affect the metabolism and RMR, such as age, genetics, body type, muscularity, height and weight, the weather, diet, pregnancy, crash-dieting, supplements etc. However, there is a low variance in RMR between individuals who have the same values for the key variables, such as fat-free mass, height, and sex. The BMR is on average 10% lower in Indians than in North Europeans^(3b).

FUEL STORAGE AND USAGE

After the diet is consumed, liver cells convert the extra glucose from the blood to its storable form glycogen. When blood glucose levels in the blood fall below a certain level, glucose is released into the blood from the stored glycogen, ensuring that cells have a continual supply of glucose to support life.

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When more carbohydrates, fats or proteins than the body's daily requirement are consumed, the body stores them as glycogen and fats. Carbohydrates, fats and proteins are first broken down to their monomers and excess is converted into a storable form, either glycogen or fat. Carbohydrates and proteins are converted to glucose. Glucose conversion to glycogen is limited to a specific amount. When glucose is available in excess more than that can be stored as glycogen, all that extra glucose is converted to fat and deposited into fat cells.

CARBOHYDRATE DIGESTION AND METABOLISM^(4a)

Carbohydrates can be complex or simple. Simple carbohydrates consist of monosaccharides and disaccharides, where as complex carbohydrates are oligomers or polymers.

During digestion disaccharide and polysaccharide carbohydrates are cleaved into monosaccharides such as glucose by enzymes called glycoside hydrolases such as amylase. Carbohydrate digestion begins in the mouth. Food mixed with salivary amylase and other salivary juices is called chyme, which is further treated with acid in stomach and then with pancreatic amylase in the duodenum. Amylase breaks the polysaccharides down into a disaccharides. The small intestine then produces enzymes called lactase, sucrase and maltase, which break down the disaccharides into monosaccharides such as glucose, the fuel. Glucose can also be synthesized from noncarbohydrate precursors by reactions referred to as gluconeogenesis. Glycogen is synthesized by glycogenesis when glucose levels are high and degraded by glycogenolysis when glucose is in short supply.

Glycolysis aka the Embden-Meyerhof-Parnas pathway is the energy-capturing reaction pathway that converts glucose into pyruvate. Glycolysis is believed to be among the oldest of all the biochemical pathways, occurring in almost every living cell.

FAT DIGESTION AND METABOLISM^(4b)

Most of the fat in the human diet is in the form of triacylglycerol (TAG), which consists of three fatty acids linked to glycerol. In the digestive tract, TAG is hydrolyzed by the enzyme lipase, to release free fatty acids and monoglycerides. The free fatty acids and monoglycerides are absorbed in intestine. In general, fatty acids which have a chain length of less than 14 carbons enter directly into the portal vein system and are transported to the liver. Fatty acids with 14 or more carbons are re-esterified within the enterocytes of the small intestine and enter the circulation via the Iymphatic route as chylomicrons.

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lipoprotein particles. Lipoprotein lipase located on the interior walls of the capillary blood vessels hydrolyses the triacylglycerols, releasing fatty acids.

Long-chain fatty acids of 16 to 20 carbon length are stored as triglycerides and mobilized into the circulation when needed for energy. These natural fatty acids are chiefly oleic, linoleic and palmitic and are carried in the circulation bound to serum albumin.

Saturated fatty acids and monounsaturated fatty acids can be biosynthesized from carbohydrates and proteins. However, the essential fatty acids are those that must be supplied in the diet and they include members of both the n-6 and n-3 series. Unsaturated fatty acids in membrane lipids play an important role in maintaining fluidity. In the skin, linoleic acid plays a specific role where it is linked to some very long chain fatty acids (C30-C34) in the acyl ceramides, and form an intercellular matrix to maintain the epidermal permeability barrier.

An organism subsisting on a mixed diet will preferentially use carbohydrate, and that administration of carbohydrate inhibits both the mobilization of fatty acids from depots into the blood (thus lowering the amount of these acids in the blood) and the oxidation of fatty acids by the peripheral tissues.

PROTEIN DIGESTION AND METABOLISM^(4c)

Dietary proteins are digested to individual amino acids by enzymes and hydrochloric acid present in the gastro-intestinal tract. Protein digestion begins in the stomach with the action of an enzyme called pepsin in the stomach, breaking down the bonds that hold the protein molecule together, called peptide bonds, to produce polypeptides. These polypeptides then move into your small intestine, where additional enzymes such as trypsin, chymotrypsin, and carboxypeptidase produce smaller units called peptides of two or more amino acids linked together and finally into monomeric amino acids to be absorbed into the blood.

The body's protein mass not only provides architectural support for cells but also serves vital roles in maintaining their function and survival through enzymes to catalyze metabolic reactions, signaling intermediates within and between cells, and fuel to allow survival. The whole body protein pool, as well as that of individual tissues, is determined by the balance between the processes of protein synthesis and degradation. These in turn are regulated by interactions among hormonal, nutritional, neural, inflammatory, and other influences. Protein synthesis and degradation are closely regulated in vivo, and each is affected by physiological and pathophysiological conditions, such as fasting, feeding, exercise, disease, and aging.

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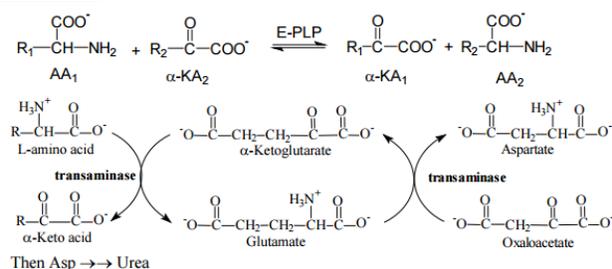
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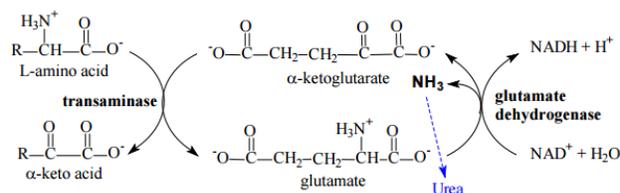
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The synthesis of a new protein requires the presence of all necessary amino acids. Amino acids have the same general structure with unique side chains determining the identity and function of each. There are eight essential amino acids that can only be obtained from the diet. The quality of a protein is determined by its amino acid makeup and the bioavailability of those amino acids. A quality score is calculated by comparing the amino acids in the protein to human needs. The amino acid in shortest supply is considered

Transamination



Oxidative deamination



the limiting amino acid. Digestibility of a protein is also a major factor affecting quality. Plant proteins can be as complete as meat, providing all required essential amino acids.

Each individual amino acid is catabolized by its own path way^(4a). However, the catabolic path of the amino acid carbon skeletons involves simple 1-step aminotransferase reactions that directly produce net quantities of a TriCarboxylicAcid (TCA) cycle intermediate, which follows the gluconeogenic pathway to glucose. A byproduct of this process is urea that is excreted by kidneys.

FACTORS AFFECTING METABOLISM

It is common knowledge that smaller mammals have higher heart rates and shorter life spans than larger members of their class. There are three regimens that reliably extend the maximal life span of animals: 1) lowered ambient temperature in cold-blooded animals and hibernating mammals; 2) a decrease in physical activity in cold-blooded animals; and 3) caloric restriction. Among mammals, with the exception of the human species, there is a linear, inverse semi-logarithmic relation between heart rate and life expectancy. Reduction in myocardial metabolic rate, with associated cardiac slowing, may have the potential to prolong human life^(3b).

Several factors influence the basal metabolic rate. The metabolic rate is influenced by the body composition. Metabolic rate increases as weight, height, and surface area increase. Fat tissue has a lower

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metabolic activity than muscle tissue. People with more muscle and less fat generally have a faster metabolic rate, while people with more fat and less muscle generally have a slower metabolic rate.

Therefore, men tend to have a higher metabolic rate than women because women have a higher proportion of fat and men are big, naturally. The BMR averages 5 to 10 percent lower in women than in men.

Aging causes loss of muscle. This makes the metabolic rate to slow down beginning in 20s by about 2% per decade. A decrease in lean muscle mass during adulthood results in a slow and steady decline in BMR after the age of about 30, roughly 0.3 percent decline per year, avoidable by strength training. Genes play a role, also. One of the reasons for some people to stay thin no matter how much they eat, while others find it hard to lose weight, is genes and body types.

Hormones play an important role, too. Thyroid gland regulates the metabolism with the hormones that affect almost every aspect of how the body performs: how fuel (glucose) is burned, when or whether you build proteins or store energy as fat, and how the body responds to other hormones. Thyroxine (T4), the key hormone released by the thyroid glands has a significant effect upon metabolic rate. Therefore, disorders of the thyroid can cause problems in metabolism. Hypothyroidism⁽⁵⁾ (an underactive thyroid gland) results in low levels of thyroid hormone causing a slower metabolism, and, consequently weight gain and other problems. Hypothyroidism is relatively common in women near or after menopause. Hyperthyroidism⁽⁶⁾ (an overactive thyroid gland) results in high levels of thyroid hormone increasing the metabolism and possible weight loss, along with other problems, such as obesity, joint pain, infertility and heart disease due to hypothyroidism and fatigue, tremors, sleep problems, dry skin, heart palpitations etc. due to hyperthyroidism.

Geographical and weather conditions also affect metabolism. Human body has to work hard to maintain its optimal natural temperature, 37 °C (98.4 °F). In cold weather (i.e., below 37 °C) and in hot weather (i.e., above 37 °C), increased metabolism keeps the body at the same temperature, 37 °C. People living in tropical climates have a resting metabolic rate that's 5% to 20% higher than people living in more temperate regions. Fever, illness, or injury may increase resting metabolic rate two-fold.

Metabolism is closely linked to nutrition and the availability of nutrients, i.e., lifestyle including diet and exercise. Body needs three nutrients to thrive: protein, carbohydrates and fats. The pathways of metabolism rely upon nutrients that they breakdown in order to produce energy. Therefore, a well-balanced nutritious diet not only impacts the overall health, but also the body weight.

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For example, the body needs energy for all activity primarily from glucose, which is easily obtained from carbohydrates. As the food is being processed through the mouth and in the stomach, carbohydrates are quickly hydrolyzed to produce glucose, where as the proteins are digested to the basic amino acid monomers, and fats are digested to fatty acid monomers, which then must be converted to glucose, increasing the metabolic rate. High-protein or fat foods require further processing of the digested protein to produce TCA cycle intermediates. For example, the daily safe level of protein intake for men is about 37 g (body wt 50 kg) to about 60 g (body weight 80 kg). Any extra protein adds extra work for the body in terms of 1) conversion of amino acids to produce TCA cycle intermediates, and 2) excretion nitrogen waste produced from the breakdown of amino acids.

Therefore, metabolism increases straining kidneys resulting in ketosis. And of course, loss of weight may occur when the total calories of protein diet intake is lower than the total spent calories, including the extra calories required for the conversion of amino acids to glucose and excretion of resulting nitrogenous waste urea.

BODY WEIGHT MYTHS

Millions have spent years and billions of dollars searching for the perfect diet, one that enables them to lose weight without going hungry, while sitting on the couch, in vain. Alas, there is no such panacea.

Human body burns more calories to stay alive than for physical activity. However, being active can burn up to 30% of the calories used in a day to stay alive, and it's one of the best ways to boost your metabolic rate. Studies show that people who eat less than 1,200 calories per day tend to have a slower metabolic rate - which can make it more difficult to burn calories and lose weight. Even going too long between meals can slow metabolic rate. That is why so-called nutrition experts recommend eating a small healthy meal or snack every 2 to 3 hours ⁽⁷⁾. But, snacking every 2 or 3 hours is going to cause problems, because people end up eating too much several times, which is a major problem causing obesity in the US ⁽⁸⁾. Grazing around the clock prevents the body from burning fat, lose track of calories consumed, leaves feeling unsatisfied ⁽⁹⁾.

Caffeine is a stimulant, so it raises your metabolic rate. This is why it is often an ingredient in weight-loss diet supplements. Studies have shown that one cup of American coffee can increase metabolism by about

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3% to 4% for a short time. Some spicy foods can raise your metabolic rate. In particular, the capsaicin⁽¹⁰⁾ in hot peppers can help burn calories, but probably not enough to lose weight.

There are so many myths about diet and weight gain⁽¹¹⁾. There is a myth that one must eat breakfast to be healthy. Eating breakfast can stave off hunger, and it might prevent random eating later in the day. At the same time, experts tell you to eat many times, every two or three hours. However, a Cornell University study found that the non-breakfast crowd didn't overeat at lunch and dinner, and they ate about 400 fewer calories a day. Skipping breakfast may help some people shed pounds, but not everybody can benefit from it.

America is not in the lead, but it is right up there, in third with 3,680 calories/day per capita consumed. More than a third of Americans are obese, suggesting that diet and exercise alone aren't enough for millions of people needing to slim down. One might eat a lot of food throughout the day, rather than all in one sitting. People simply overeat out of mindless habit, like always sitting down with a bag of chips in front of the TV at night. Some people who overeat have a clinical disorder called binge eating disorder (BED)⁽⁷⁾. People with BED compulsively eat large amounts of food in a short amount of time and feel guilt or shame afterward.

So far, research shows that our bodies absorb added sugars like high-fructose corn syrup and table sugar in a similar way. The real secret to boosting athletic strength and muscle is to focus on intense training and get carbohydrates to get enough calories, but not too many calories or protein. Late-night meals do not cause you to put on weight, but too many calories cause weight gain, and many night eaters do tend to overeat and choose high-calorie foods. Cut back on calories, and get moving. Fewer calories add up to fewer pounds over time no matter how many of your calories come from fat, protein, or carbohydrates.

CONCLUSION

It is well-known for a long time that eating nutritious and well-balanced food⁽¹²⁾. Various cultures around the world have developed well-balanced diets, for example, the Indian vegetarian cuisine is traditionally considered a prime example of the plant based diet recommended by the American Institute for Cancer Research⁽¹³⁾, *but eating less of any food and doing more exercise matter the most to keep a balance of calories consumption to calories used.*

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NEUROBICS FOR THE BRAIN

Neurobics⁽¹⁴⁾ describes mental exercises designed to keep the brain alert and enhance its performance. Neurobics is the use of as many senses as possible to create strong and multiple associations, therefore when remember the information there are more links. People generate new brain cells, and new connections between them, throughout life. The more challenge to brain, the more new nerve pathways it forms. The more connections build up, the better cognition and lesser age-related cognitive decline. Some neurobics to stay smart, sharp, and focused:

- Read books
- Attend lectures
- Listen to the radio
- Visit museums
- Exercise to increase the heart rate
- Play games, both physical and mentally challenging games such as chess, bridge, video games etc.
- Play an instrument like piano, violin, viola, veena etc.
- Learn new languages
- Learn Braille
- Use the other hand (right- or left-handed)
- Use different routes to work
- Test your senses and teach your senses to recognize things without the help of eyes
- Choose foods that are good for your heart and waistline, e.g., vegan or vegetarian, avoid fried foods, colorful fruits and veggies, omega-3 oil containing flax, urad, purselane, spinach, olive, walnuts, etc, avoid alcohol,
- Reduce stress by taking deep breaths, laughing, listening to music, yoga and meditation, talking and socializing
- Sleep enough, about 7-8 hours, per night
- Brainstorm
- Garden
- Play chess

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Additional Sources: The information published here is available from the primary sources cited above, and also from secondary sources such as: New York Times (NYT), Washington Post (WP), Mercury News, Bayarea.com, Chicago Tribune, USA Today, Intellihealthnews, Deccan Chronicle (DC), the Hindu, Hindustan Times, Times of India, AP, Reuters, AFP, womenfitness.net, about.com, mondaq.com, etc

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Om! Asatoma Sadgamaya, Tamasoma Jyotirgamaya, Mrityorma Amritamgamaya, Om Shantih, Shantih, Shantih! (Aum! Lead the world from wrong path to the right path, from ignorance to knowledge, from mortality to immortality, and peace!)

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