11
Food & Nutrition

Food

a. ***Definition*** : Any material that provides the nutritive requirements of an organism to maintain growth and well being.

or *(Ref. Taber's)*

Foods are those chemical substances which an individual takes, digests, assimilates and provides the nutritive requirements of an individual to maintain growth and physical well being.

b. ***Fuctions of food*** :

1. It supply energy for production of heat and for all types of activities.
2. Essential for growth of human body,
3. Essential for the repair of the daily wear & tear.
4. Protects the body from various types of diseases.
5. In a general way, it is involved in the functioning of the body processes.

c. ***Main constituents or proximate principles of food*** :

i. Proteins
ii. Fats
iii. Carbohydrates
iv. Vitamins
v. Minerals (salt) and
vi. Water.

d. ***Calorie value of food*** :

Energy in each gm of the three different food stuffs in diet is :

	Calories
Carbohydrate	4.4
Fat	9.0
Protein	4.0

(Ref. Guyton & Hall-11th edition; page 865)

e. ***Metabolic end product of food*** :

Carbohydrate	:	Energy + CO_2+ H_2O
Fat	:	Energy + CO_2+ H_2O
Protein	:	Energy + Urea, Uric acid, Creatinine

f. ***Percentage of different food in a balance diet*** :

Carbohydrate	:	60-70% of total diet
Fat	:	20-25% of total diet
Protein	:	15% of total diet.

Classification of food

a. *According to the sources of origin :*
   i. Animal foods : Milk, egg, meat etc.
   ii. Plant foods : Vegetables, cereals, pulses etc.

b. *According to the calorigenicity :*
   i. Calorigenic foods : The foods which give calorie that is necessary for energy production, growth and maintenance of tissues, e.g carbohydrate, protein and fat.
   ii. Non-calorigenic foods : The foods which do not provide any calorie but necessary for chemical mechanisms i.e. for utilization of energy, for synthesis of various metabolites, hormones and enzymes. These are vitamins, minerals and water.

c. *According to their main functions :*
   i. Fuel or energy yielding foods : Thses foods are rich in carbohydrates and fats, e.g cereals, sugar, roots, tuber etc.
   ii. Body Building foods : These foods are rich in proteins. e.g. Meat, liver, fish, milk, pulses.
   iii. Protective foods : These foods are rich in proteins, vitamins and minerals, e.g milk, egg, liver, green vegetables and fruits.

Nutrition

Definition : Nutrition is a dynamic process concerning with ingestion, digestion, absorption, and assimilation (metabolism) of food substances by which growth, repair and maintenance of activities in the body as well as a whole or in any of its parts are accomplished.

(Ref. Taber's)

Aim of nutrition :

1. To meet up the calorie demand of the individual.
2. To meet up specific requirements of individual item of food stuff.
3. To formulate and plan a diet.

Criteria of good nutrition :

i. It should protect the body from infection and deficiency diseases.
ii. It should nourish the body and make the person energetic.
iii. It should help in making a fair complexion of the body and protect it from obesity.

Sign of good nutrition :

i. Smooth and shiny skin
ii. Glossy hair
iii. Well developed muscles, bones and teeth
iv. The subject appears to be of strong build and energetic.

Nutrient : Nutrient means chemical ingredients present in food which produce energy. In other words, any substance nourishing the body.

Malnutrition : It may be defined as a pathological state resulting from a relative or absolute deficiency or excess of one or more essential nutrients. Here calorie requirement is adequate but proportion of proximate principles of food is not adequate. That is "Adequate but not proportionate."

Subnutrition : It is a condition which results when insufficient food is eaten over an extended period of time. Here calorie requirement is not adequate but proportion of proximate principles of food is normal. That is "proportionate but not adequate".

Diet

Diet is the designed calculated amount of food for an individual for a particular condition of body. An adequate diet is one which permits-

i. Normal health
ii. Maintenance and
iii. Reproduction.

A normal diet should consists of all the proximate principles of food.

Essential dietary components : An optimal diet includes, in addition to suffucient water, adequate calories, protein, fat, minerals and vitamins.

(Ref. Ganong 22th Edition; Page 311)

Balanced Diet

a. *Definition* : Balanced diet is a diet containing all the proximate principles of food in adequate and proportionate amount; including essential aminoacids and fatty acids for normal growth, activity, reproduction and lactation.

b. *Adequate :* Means the amount that supply the exact calorie.

c. *Proportionate amount :* Means presence of appropriate proportion of different food stuffs.

Carbohydrate : Protein : Fat = 4 : 1 : 1

d. ***Factors considered to formulate a balanced diet*** :

i. Age
ii. Sex
iii. Quality and quantity of food
iv. Socioeconomical values
v. Seasonal factor
vi. Geographical factor
vii. Allergic condition.

e. ***Criteria of a balanced diet*** :

i. It should contain all the proximate principles of food in adequate and proportionate amount.
ii. One third to half of protein and fat should come from animal sources.
iii. It should contain sufficient fruits and vegetables.
iv. It should be easily digestable, absorbable and assimilable.
v. It should be easily available.
vi. It should contain certain amount of cellulose to promote peristalsis.

Calories

i. *Definition* : The standard unit of heat energy is the **calorie (cal)**, defined as the amount of heat energy necessary to raise the temperature of 1 gm of water 1 degree from 15°c to 16°c.

ii. Unit : The unit is also called the gram calorie, small calorie, or standard calorie.

The unit commonly used in physiology, and medicine is the **Calorie (kilocalorie: kcal)**, which equals 1000 cal.

(Ref. Ganong 22th Edition; Page 280)

Approximate calorie requirment :

Group	*Particulars*	*Calorie require*
Adult male (55 kg)	Sedentary worker	2400 kcal/day
	Moderate worker	2800 kcal/day
	Heavy worker	3900 kcal/day
Adult female (45 kg)	Sedentary worker	1900 kcal/day
	Moderate worker	2200 kcal/day
	Heavy worker	3000 kcal/day
Pregnant mother	Additional allowance	+ 300 kcal/day
Lactating mother	Additional allowance	+ 550 kcal/day
Infants	0—6 months	120 kcal/day
	7—12 months	100 kcal/day
Children	1—3 years	1200 kcal/day
	4—6 years	1500 kcal/day
	7—9 years	1800 kcal/day
	10—12 years	2100 kcal/day

Adeloscents	13—15 years - Boys	2500 kcal/day
	Girls	2200 kcal/day
	16—18 years - Boys	3000 kcal/day
	Girls	2200 kcal/day

(Ref. JE park and K Park 11th and others)

Nutrition and food science institute, Dhaka University has recommended the daily calorie requirement as follows :

1. Male (55 kg) : 2400 kcal/day
2. Female (45kg) : 1900 kcal/day
3. Pregnant mother : 2100 kcal/day
4. Lactating mother : 2300 kcal/day

N.B. 25 to 50% of which should come from protein.

Daily calorie requirements depend upon :

i. Basal metabolic rate.
ii. Nature of work to be done.
iii. Specific dynamic action (S.D.A).

Caloric intake and distribution

Dietary intake : The calotic value of the dietary intake must be approximately equal to the energy expended if body weight is to be maintained. In addition to the 2000 kcal/d necessary to meet basal needs, 500-2500 kcal/d (or more) are required to meet the energy demands of daily activities.

Distribution of the calories : The distribution of the calories among carbohydrate, protein, and fat is determined partly by physiologic factors and partly by taste and economic considerations.

Protein : A daily protein intake of 1 g/kg body weight to supply the eight nutritionally essential amino acids and other amino acids is desirable. The source of the protein is also important. ***Grade I proteins***, the animal proteins of meat, fish, dairy products, and eggs, contain amino acids in approximately the proportions required for protein synthesis and other uses. Some of the plant proteins are also grade I, but most are ***grade II*** because they supply different proportions of amino acid and some lack one or more of the essential amino acids. Protein needs can be met with a mixture of grade II proteins, but the intake must be large because of the amino acid wastage.

Fat is the most compact form of food, since it supplies 9.3 kcal/gm. However, often it is also the most expensive. Indeed, internationally there is a reasonably good positive correlation between fat intake and standard of living. In the past, Western diets have contained large amounts (100 g/d or more). The evidence indicating that a high unsaturated/saturated fat ratio in the diet is of value in the prevention of atherosclerosis and the current interest in preventing obesity may change this. In Central and South American Indian communities where corn (carbohydrate) is the dietary staple, adults live without ill effects for years on a very low fat intake. Therefore, provided that the needs for essential fatty acids are met, a low-fat intake does not seem to be harmful, and a diet low in saturated fats is desirable.

Carbohydrate is the cheapest source of calories and provides 50% or more of the calories in most diets.

In the average middle-class American diet, approximately 50% of the calories come from carbohydrate, 15% from protein, and 35% from fat.

When calculating dietary needs, it is usual to meet the protein requirement first and then split the remaining calories between fat and carbohydrate, depending on taste, income, and other factors.

For example, a 65-kg man who is moderately active needs :

i. About 2800 kcal/d.
ii. He should eat at least 65 g of protein daily, supplying 267 (65 x 4.1) kcal. Some of this should be grade I protein.
iii. A reasonable figure for fat intake is 50-60g.
iv. The rest of the caloric requirement can be met by supplying carbohydrate.

(Ref. Ganong 22th Edition; page 311)

Mineral & vitamin reqirements

Alredy discussed in chapter 3 and 4

Diet of growing children

1. *Energy requirment :* With advance in age, there is increase in calore requirements of the child due to more physical activities on their part.

   The energy requirments of a child aged 1 year is about 1,000 kcal/day.

   After the age of 1 year, the energy needs can be computed by adding 100 kcal for every year of life.

   Thus a child of 5 years needs - 1500 Kcal/day.

2. *Proteins* : Extra proteins are needed to ensure proper growth of their tissues. 8 to 10 % of the energy need may be given as proteins.
3. *Calcium and phosphorus* : Adeuqate amount are needed for the growth of bones and teeth.
4. *Iron :* Adequate amount for haemoglobin.
5. *Vtamins :* Adequate amount.

Q. ***What is the minimum carbohydrate requirement to prevent ketosis?***

Ans. A minimum of 5 gm of carbohydrate for 100 calorie of total diet is necessary to prevent the development of ketosis.

Protein, fat, and carbohydrate content of different foods

Food	*% Proteins*	*% Fat*	*% carbohy drate*	*Fuel value per 100 Grams Calories*
Apples	0.3	0.4	14.9	64
Asparagus	2.2	0.2	3.9	26
Bacon, fat	6.2	76.0	0.7	712
broiled	25.0	55.0	1.0	599
Beef, medium	17.5	22.0	1.0	268
Beets, fresh	1.6	0.1	9.6	46
Bread, white	9.0	3.6	49.8	268
Butter	0.6	81.0	0.4	733
Cabbage	1.4	0.2	5.3	29
Carrots	1.2	0.3	9.3	45
Cashew nuts	19.5	47.2	26.4	609
Cheese Cheddar, American	23.9	32.3	1.7	393
Chicken, total edible	21.6	2.7	1.0	111
Chocolate	(5.5)	52.9	18.0	570
Corn (maize) entire	10.0	4.3	73.4	372
Haddock	17.2	0.3	0.5	72
Lamb, leg, interrnediate	18.0	17.5	1.0	230
Milk, fresh whole	3.5	3.9	4.9	69
Molasses medium	0.0	0.0	(60.0)	240
Oatmeal, dry, uncooked	14.2	7.4	68.2	396
Oranges	0.9	0.2	11.2	50
Peanuts	26.9	44.2	23.6	600
Peas, fresh	6.7	0.4	17.7	101
'Pork, ham, medium	15.2	31.0	1.0	340
Potatoes	2.0	0.1	19.1	85
Spinach	2.3	0.3	3.2	25
Strawberries	0.8	0.6	8.1	41
Tomatoes	1.0	0.3	4.0	23
Tuna, canned	24.2	10.8	0.5	194
Walnuts, English	15.0	64.0	15.6	702

(Ref. Guyton & Hall-11th edition; Page 866)

Chart of Energy expenditure of male

A. 8 hours in bed at BMR = 35.5 x 1.62 x 8 = 460 kcal

B. 8 hours non-occupational work : = 1220 kcal

1. 1 hour personal necessities such as dressing, undressing, washing, shaving, bathing etc at 3.0 kcal/kg/hour. = 165 kcal
2. 2 hour walking at 4.0 kcal/kg/hr = 440 kcal
3. 4 hour sitting & standing activites at 1.7 kcal/kg/hr = 374 kcal
4. 1 hour recreation at 4.4 kcal/kg/hr = 241 kcal

Total = 1220 kcal

C_1. 8 hours sedentary occupation overall rate 1.7 kcal/kg/hr. ***or*** = 750 kcal

C_2. 8 hour moderate industrial work overall rate 2.5 kcal/kg./hr. ***or*** = 1000 kcal

C_3. 8 hours heavy work overall rate 5 kcal/kg./hr. = 2200 kcal

Total net calories for :

i. Light or sedentary work = A + B + C_1 = 2430 kcal

ii. Moderate work (Industrial) = A + B + C_2 = 2780 kcal

iii. Heavy work = A + B + C_3 = 3880 kcal

Chart of energy expenditure of female

A. 8 hours in bed at BMR = 31.6x1.4 x 8 = 354 kcal

B. 8 hours non-occupational work = 826 kcal

C_1. 8 hours sedentary-occupational work at 1.7 kcal/kg/hr = 610 kcal

C_2. 8 hours moderate work overall rate at 2.5 kcal/kg/hr = 900 kcal

C_3. 8 hours heavy occupational work at 5 kcal/kg./hr. = 1800 kcal

Total net calories for :

i. Sedentary work : A + B + C_1 = 1790 kcal

ii. Moderate work : A + B + C_2 = 2080 kcal

iii. Heavy work : A + B + C_3 = 2980 kcal

Balanced diet chart

1. ***Sedentary worker*** :

Protein	55 gm	220 kcal
Fat	55 gm	495 kcal
Carbohydrate	400 gm	1600 kcal
Green leafy vegetables	100 gm	25 kcal
Fruits	30 gm	15 kcal
Other vegetables	75 gm	45 kcal
	Total =	2400 kcal

SDA of food 200 kcal.

So, total = 2400 + 200 kcal
= 2600 kcal.

2. ***Heavy worker*** :

Protein	55	gm	220 kcal
Fat	70	gm	630 kcal
Carbohydrate	650	gm	2600 kcal
Green vegetables	125	gm	30 kcal
Other vegetables	150	gm	90 kcal
Fruits	60	gm	30 kcal
			= 3600 kcal

SDA of food = 200 kcal.

So, total = 3600 + 200 kcal
= 3800 kcal.

3. ***Adult woman*** :

Protein	45	gm	180 kcal
Fat	45	gm	405 kcal
Carbohydrate	300	gm	1200 kcal
Green vegetables	100	gm	25 kcal
Other vegetables	75	gm	45 kcal
Fruits	30	gm	15 kcal
			= 1870 kcal

200 Kcal should be added to allow to SDA of food.

So, total = 1870 + 200 kcal
= 2070 kcal

4. ***Pregnant mother*** :

Protein	(45 + 30)	gm	300 kcal
Fat	45	gm	405 kcal
Carbohydrate	350	gm	1400 kcal
Green leafy vegetables	125	gm	30 kcal
Other vegetables	100	gm	60 kcal
Fruits	30	gm	15 kcal
			= 2210 kcal

200 kcal should be added to allow for SDAof food.

So, total = 2210 + 200
= 2410 kcal.

Nutritional deficiency disease

According to WHO expert committee nutritional deficiency diseases are classified as :

A. *Protein-energy malnutrition :*
   i. Kawashiorkor
   ii. Marasmus
   iii. Marasmic Kawashiorkor

B. *Avitaminosis :* Deficiency of vitamins -
   i. Vitamin A deficiency
   ii. Thiamine & Niacin deficiency states
   iii. Deficiency of B. complex components.
   iv. Ascorbic acid deficiency
   v. Vitamin D deficiency

C. *Obesity & other hypervitaminosis :*
   i. Obesity
   ii. Hypervitaminosis A.
   iii. Hypercarotinaemia.
   iv. Hypervitaminosis D.

   N.B. Fe deficiency
   Iodine defiency.

Difference between Kawashiorkor & Marasmus

Features	*Marasmus*	*kawashiorkor*
1. Cause	Due to deficiency of calorie	Due to deficiency of protein.
2. Oedema	Absent	Present in lower legs.
3. Muscle wasting	Severe	Sometimes
4. Growth retardation	Severe	Less than marasmus
5. Appetite	Usually good	Usually Poor
6. Skin change	Usually none	Often diffuse depigmentation
7. Moon face	None	Often.

Marasmus

i. Cause : Due to deficiency of calorie

ii. *Characteristic features of marasmus :*
   a. Muscle wasting : Severe
   b. Growth retardation : Severe
   c. Appetite : Usually good
   d. Skin change : Usually none
   e. Oedema : Absent

Kawashiorkor

i. Cause : Due to deficiency of protein.

ii. *Characteristic features of kawashiorkor :*

a. Oedema	:	Present in lower legs
b. Moon face	:	Often.
c. Muscle wasting	:	Sometimes
d. Growth retardation	:	Less
e. Appetite	:	Usually poor
f. Skin change	:	Often diffuse pigmentation

Phrenoderma

It is a nutritional deficiency disease of skin, results from dietary deficiency of essential fatty acids characterized by horny papular eruptions on the posterior and lateral aspects of the limbs and on the back and buttocks.

It can be cured by the administration of lineseed or sufflower seed oil along with vitamin B-complex.

Neurolathyrism

a. *Definition :* It is a disease of the nervous system characterized by gradually developing paralysis of the lower limbs, caused by Lathyrus sativus.

b. *Cuase* : Diet containing 30-40% Lathyrus sativus (Khesarihdal) for 2 to 6 months will cause the disease. The causative factors is some neurotoxins -

i. Beta-oxalyl amino alanine (BOAA)

ii. Alpha-Beta isomer of mono-oxalyl di-aminopropionic acid.

c. *Clinical stages* : Clinically the disease has 5 stages-

i. Latent stage
ii. No-stick stage
iii. One-stick stage
iv. Two-stick stage
v. Crowler stage.

d. *Prevention :*

i. Banning the crop/Avoiding khesaridal in diet
ii. Removal of toxins from food
iii. Geuetic approach.

(Ref. Community medicine; J.E. Park - 12th - 344)

Colostrum

a. *Definition :* Colostrum is the secretion of breast following child birth for the first 2-3 days which contains a great quantity of proteins and calories.

b. *Contents :*

i. Protenin (Moderate)
ii. Sugar (Few)
iii. Minerals (high)
iv. Antibody specially secretory IgA (high)
v. Fat.

c. *Importance :*

i. Antibodies (IgA) play an important role in protection against infection.
ii. It may help to sterilize the small intestine.
iii. It possesses laxative quality.

Weaning

It is the process starting around the age of 5 to 6 months in which an infant's diet pattern is gradually changed from breast milk to supplementary food.

Weaning should start after 6 months. Breast milk alone can not sustain the growth of the infant. Supplementary foods are- soft cooked rice, washed potatoes, soft cooked vegetables, dhal water, fruit juice, egg etc.

Q. **Why milk is an ideal food?**

Ans. Milk is an ideal food because -

1. Milk is unique in nutritive value and contains all the food factors of a well balanced diet required for human body.
2. It is easily digestable, absorbable and assimilable.
3. Human milk is in sterile form in lower temperature.
4. Skimmed milk powder is devoid of fat & fat soluble vitamins but a good source of protein, calcium and water soluble vitamins.

Milk Injury

Definition : It is a condition where a child becomes flabby, apathetic dull, anaemic and susceptable to all sort of diseases due to consumption of milk only over a long period like 1 to 1.5 year without taking any other food.

Cause : Milk contains less iron & vitamin C. So, continuous consumption of milk after 6 months develops first iron deficiency anaemia and then scurvy. The childs also becomes flabby, edematous due to ingestion of more water in milk.

Prevention : It can be prevented by weaning or supplementary food.

(Ref. Community medicine; J.E. Park)

Humanisation of Cow's Milk

Cow's milk is to be suitably changed to make it comparable to mothers milk and to make a substitute drink for young baby, even a new one.

Principle : The insoluble caseinogen of cow's milk must be reduced to the level as present in human milk, the amount of lactose must be increased to the right proportion and the resulting mixture must be pasteurised.

Procedure : This is done by adding 1 part of water to 1 part of cow's milk, this will bring down the proten content to that of mother's milk, but the sugar & fat content also come down. So, 1 oz of milk sugar and 1 oz of ordinary

centrifused cream should be added to 1 pint of diluted milk. Vit-C should be given from second month on ward.

Pasteurization

i. *Defination* : According to WHO heating of milk to such temperature and for such periods of time as are required to destroy any pathogens that may be present while causing minimal changes in the composition, flavoure and nutritive value.

ii. *Methods* : There are 3 widely used mehtods-

1. *Holder mehtod* : In this method, milk is kept at 63-66°C for at least 30 minutes and then quickly cooled to 5°C.
2. *Flash method or High temperature and short time method* : Milk is rapidly heated to a temperature of nearly 72 C for less than 15 second and is then rapidly cooled to 4°C.
3. *Ultra-High temperature method :* Milk is rapidly heated usually in two stages (the second stage usually being under pressure) to between 125°C for a few second only. It is then rapidly cooled and bottled as quickly as possible.

iii. *Tests of pasteurized milk* :

1. *Phosphatase test* : Phosphatase, an enzyme useally present in milk and inactivated during pasteurization. Its presence in milk indicates inadequate pasteurization.
2. Standard plate count.
3. Coliform count.

Calorie value of an egg

An egg weighting 60 gm, supplies 6 gm protein, 6 gm fat, about 30 mg carbohydrate, 1.5 mg iron and rich in all the vitamins except vit -C.

Total calorie value = (24 + 54)
= 78 kcal.

Basal Metabolic Rate (BMR)

i. *Definition :* The metabolic rate at basal condition of the body is called basal metabolic rate.

(Ref. Guyton & Hall-11th edition)

ii. *The basal conditions are :*

a. The patient should be awake.
b. The patient should be completely both mental and physical rest.
c. The patient should remain in normal condition of environment- normal temperature, pressure and humidity (20-25°C)
d. The person should be without food at least for about 12-18 hours. (post-absorptive state).

(Ref. Guyton & Hall-11th edition)

iii. *Normal value* :

a. In male : 40 cal/sq.m of body surface area/hour.
b. In female : 37 cal/sq.m of body surface area /hour.

v. ***Factors affecting the metabolic rate.***

a. Muscular exertion during or just before measurement
b. Recent ingestion of food
c. High or low environmental temperature
d. Height, weight, and surface area
e. Sex
f. Age
g. Growth
h. Reproduction
i. Lactation
j. Emotional state
k. Body temperature
l. Circulating levels of thyroid hormones
m. Circulating epinephrine and norepinephrine levels

(Ref. Ganong 22th Edition; Page 281)

vi. ***B M R increased in*** :

i. Hyperthyroidism
ii. Leukemia
iii. Polycythemia
iv. Cardiac failure
v. Hypertension
vi. Fever.

vii. ***BM.R decreased in*** :

i. Hypothyroidism
ii. Starvation
iii. Addison's disease
iv. Lipid nephrosis
v. Prolonged malnutrition.

viii. ***Importance of BMR*** :

i. For prescribing a diet of adequate calorie value
ii. For the diagnosis of various pathological condition such as hyperthyroidism, hypothyroidism
iii. To note the effect of different types of food & drug on BMR.

Metabolic rate

a. *Definition :* The amount of energy liberated per unit of timc is the *metabolic rate.*

(Ref. Ganong 22th EDition; Page 279)

b. *Measurement :* Metabolic rate is measured in two ways -
i. Direct calorimetry
ii. Indirect calorimetry.

Direct calorimetry : In this way, metabolic rate is determined by measuring the quantity of heat liberated from the body in

a large specially constructed calorimeter.

Indirect calorimetry : Measurement of BMR in man is conveniently done by indirect calorimetry, using the Benedict-Roth recording spirometer. From the spirometer we have to determine the volume of oxygen consumption and carbondi- oxide expiration. The RQ is assumed to be 0.83 (non-protein RQ on mixed diets). BMR is then calculated from the heat produced by the volume of oxygen consumed, depending on the caloric equivalent of 1 liter O_2 at RQ - 0.83.

Both CO_2 output and O_2 consumed can be directly measured without the need to assume the RQ, if Knipping's spirometer is used.

(Ref. Biochemistry-Debajyote Das)

Respiratory Quotient (RQ)

i. *Definition :* It is the ratio of the volume of CO_2 produced by the volume of O_2 consumed.

RQ = (Volume of CO_2 produced / Volume of O_2 consumed)

ii. *Factors affecting RQ* :

1. *Role of diet :*
   a. Carbohydrate : In case of carbohydrate RQ is unity or 1. Because the volume of CO_2 produced is same as the volume of O_2 consumed.
   b. Fat : In case of fat, respiratory quotient is 0.7.
   c. Protein : In case of protein RQ is 0.8.
   d. For mixed diet : RQ is 0.85.
2. *Acidosis :* RQ is higher or increases, because CO_2 production is more than O_2 consumption.
3. Alkalosis : RQ falls, because respiration is depressed & CO_2 will retain in the body.
4. Temperature : Increase temperature increases RQ.
5. Diabetes mellitus .
6. Prolong starvation .
7. Voluntary hyperpnoea.

Energy balance, metabolism and nutrition

The endocrine system, like the nervous system, adjusts and correlates the activities of the various body systems, making them appropriate to the changing demands of the external and internal environment. Endocrine integration is brought about by chemical signals secreted by ductless glands and transported in the circulation to target cells. Some of the hormones are amines, and others are amino acids, polypeptides, proteins, or steroids.

Metabolism : The hormones regulate metabolic processes. The term *metabolism*, literally meaning "change," is used to refer to all the chemical and energy transformations that occur in the body.

The animal organism oxidizes carbohydrates, proteins, and fats, producing principally CO_2, H_2O, and the energy necessary for life processes. CO_2, H_2O, and energy are also produced when food is burned outside the body.

Catabolism : However, in the body, oxidation is not a onestep, semiexplosive reaction but a complex, slow, stepwise process called *catabolism*, which liberates energy in small, usable amounts.

Aanbolism : Energy can be stored in the body in the form of special energy-rich phosphate compounds and in the form of proteins, fats, and complex carbohydrates synthesized from simpler molecules. Formation of these substances by processes that take up rather than liberate energy is called *anabolism*.

Metabolic rate : The amount of energy liberated per unit of timc is the *metabolic rate.*

(Ref. Ganong 22th EDition; Page 279)

Energy intake and output are balanced under steady-state conditions : Intake of carbohydrates, fats, and proteins provides energy that can be used to perform various body functions or stored for later use. Stability of body weight and composition over long periods requires that a person's energy intake and energy expenditure be balanced.

When a person is *overfed* and energy intake persistently exceeds expenditure, most of the excess energy is stored as fat, body weight increases; conversely, *loss of body mass* and *starvation* occur when energy intake is insufficient to meet the body's metabolic needs.

Because different foods contain different proportions of proteins, carbohydrates, minerals, and vitamins, appropriate balances must also be maintained among these constituents so that all segments of the body's metabolic systems can be supplied with the requisite materials.

(Ref. Guyton & Hall-11th Edition; Page 865)

Average daily requirement for protein is 30 to 50 grams : 20 to 30 grams of the body proteins are degraded and used to produce other body chemicals daily. Therefore all cells must continue to form new proteins to take the place of those that are being destroyed, and a supply of protein is needed in the diet for this purpose. An average person can maintain normal stores of protein, provide the daily intake is above 30 to 50 grams.

Therefore, individuals in economically disadvantaged countries who consume *cornmeal* as the principal source of protein sometimes develop the protein-deficiency syndrome called ***kwashiorkor*** which consists of failure to grow, lethargy, depressed mentality, and edema caused by low plasma protein concentration.

(Guyton & Hall-11th Edition; Page 866)

Carbohydrates and fats act as Protein Sparers : When the diet contains an abundance of carbohydrates and fats almost all the body's energy is derived from these two substances, and little is derived from proteins. Therefore, both carbohydrates and fats are said to be protein sparers. Conversely, in starvation, after the carbohydrates and fats have been depleted. the body's protein stores are consumed rapidly for energy, sometimes at rates approaching several hundred grams per day rather than the normal daily rate of 30 to 50 grams.

(Guyton & Hall-11th Edition; Page 866)

Regulation of food intake and energy storage

Only about 27 per cent of the *energy ingested normally reaches* the functional systems of the cells, and much of this is eventually converted to heat, which is generated as a result of protein metabolism, muscle activity, and activites of the various organs and tissues of the body. Excess energy intake is *stored* mainly as fat, where as a deficit energy expenditure eventually equals energy intake or death occurs.

In athlets and laborers, energy expenditure for the high level of muscle activity may be as high as 6000 to 7000 Calories per day, compared with only about 2000 Calories per day for sedetary individuals.

(Guyton & Hall-11th Edition; Page 867)

Neural centers regulate food intake

The sensation of hunger is associated with a craving for food and several other several physiologic effects, such as rhythmical contractions of the stomach and restlessness, which cause the person to search for an adequate food supply. A person's *appetite* is a desire for food, often of a particular type and is useful in helping to choose the quality of the food to be eaten. If the quest for food is successful, the feeling of ***satiety*** occurs. Each of these feelings is influenced by environmental and cultural factors, as well as by physiologic controls that influence specific centers of the brain, especially the hypothalamus.

(Guyton & Hall-11th Edition; Page 867)

The hypothalamus contains hunger and satiety centers : Several neuronal centers of the hypothalamus participate in the control of food intake. The *lateral nuclei of the hypothalamus* serve as a feeding center, and stimulation of this area causes an animal to eat voraciously *(hyperphagia)*. Conversely, destruction of the lateral hypothalamus causes lack of desire for food and progressive *inanition*, a condition characterized by marked weight loss, muscle weakness, and decreased metabolism. The lateral hypothalamic feeding center operates by exciting the motor drives to search for food.

The *ventromedial nuclei of the hypothalamous* serve as the ***satiety center***. This center is believed to give a sense of nutritional satisfaction that inhibits the feeding center. Electrical stimulation of this region can cause complete satiety, and even in the presence of highly appetizing food, the animal refuses to eat *(aphagia)*. Conversely, destruction of the ventromedial nuclei causes voracious and continued eating until the animal becomes extremely obese, sometimes as large as four times normal.

Paraventricular; *dorsomedial*, and *arcuate nuclei* of the hypothalamus also play a major role in regulating food intake. For example, lesions of the paraventricular nuclei often cause excessive eating, whereas lesion of the dorsomedial nuclei usually depress eating behavior. The arcuate nuclei are the sites in the hypothalamus where multiple hormones released from the gastrointestinal tract and adipose tissue converge to regulate food intake as well as enerrgy expenditure.

Neurons and neurotransmitters in the hypothalamus that stimulate or inhibit feeding : There are two distinct types of neurons in the *arcuate nuclei* of the hypothalamus that are especially important as controllers of both appetite and energy expenditure

i. Pro-opimelanocortin (P0MC) neurons that produce α-melanocyte-stimulating hormone (α-MSH) together with cocaine and amphetamine-related transcript (CA RT).
   Function : Activation of the POMC neurons decreases food intake and increases energy expenditure.
ii. Neurons that produce the orexigenic substances neuropeptide Y (NPY) and *agouti-related protein (AGRP)*.

Function : Activation of the NPY-AGRP neurons increases food intake and reduces energy expenditure.

(Guyton & Hall-11th Edition; Page 867)

Neurotransmenters and hormones that influence feeding and satiety centers in the hypothalamus

a. ***Decrease feeding (Anorexigenic)*** :
   i. a-Melanocyte-stimulating hormone (a-MSH)
   ii. Leptin
   iii. Serotonin
   iv. Norepinephrine
   v. Corticotropin-releasing hormone
   vi. Insulin
   vii. Cholecystokinin (CCK)
   viii. Glucagon-like peptide (GLP)
   ix. Cocaine- and amphetamine-regulated transcript (CART)
   x. Peptide YY.

(Guyton & Hall-11th Edition; Page 869)

b. ***Increase feeding (Orexigenic)*** :
   i. Neuropeptide Y (NPY)
   ii. Agouti-related protein (AGRP)

iii. Melanin-concentrating hormone
iv. Orexins A and B
v. Endorphins
vi. Galanin (GAL)
vii. Amino acids (glutamate and g-aminobutyric acid)
viii. Cortisol
ix. Ghrelin.

(Guyton & Hall-11th Edition; Page 869)

Factors that regulate quantity of food intake

Regulation of the quantity of food intake can be divided into :

i. Short-term regulation
ii. Intermediate-term regulation
iii. Short-term regulation.

Short-term regulation : which is concerned primarily with preventing overeating at each meal.

The following are several types of rapid feedback signals that are important for these purposes :

a. Gastrointestinal filling inhibits feeding
b. Gastrointestinal hormonal factors that supress feeding :
   i. Cholecystokinin : Is releasd mainly in response to fat entering the duodenum.
   ii. Peptide YY (PYY)
   iii. Glucagon-like peptide : Presence of food in the intestine enhances *glucagon-like peptide*, which in turn enhances glucose-depended *insulin* production and secretion from the pancreas. PPY and insulin both tend to suppress appetite.
c. Ghrelin- a gastrointestinal hormone- increases feeding.
d. Oral receptors meter food intake.

Intermediate and long-term regulation : which is concerned primarily with maintenance of normal quantities of energy store in the body.

i. *Effects of blood concentration of glucose, amino acids and lipids on hunger and feeding* :
   a. Glucostatic theory of hunger and feeding regulation.
   b. Amniostatic theory of hunger and feeding regulation.
   c. Lipostatic theory of hunger and feeding regulation.

   A decrease in blood glucose, amino acid and or breakdown products of lipids such as the keto acids and some fatty acids, the desire for feeding is increased, eventually returning the blood metabolic concentrations back toward normal.

ii. *Temperature regulation and food intake* : When an animal is exposed to cold, it tends tto increase feeding and when it is exposed to heat, it tends to decrease its caloric intake. This is caused by interaction within the hypothalamus between the temperature-regulatting system and the food intake-regulating system.

   This is important, because increased food intake in a cold animal-
   a. Increase its metabolic rate
   b. Provides increased fat for insulation.

   Both of which tend to correct the cold state.

iii. *Feedback signals from adipose tissue regulate food intake* : When the amount of adipose tissue increases , the adipocytes produce increased amount of leptin. Stimulation of leptin receptor in the hypothalamic nuclei initiates multiple actions that decrease fat storage.

(Ref. Guyton & Hall-11 Edition; Page 870, 871)