SREE NARAYANA NURSING COLLEGE

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Sree Narayana Nursing College

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NURSING COLLEGE

SUBJECT: Nutrition

Topic: Carbohydrates

Carbohydrates

- Carbohydrates are broadly defined as polyhydroxy aldehydes or ketones and their derivatives or as substances that yields one of these compounds
- Composed of carbon, hydrogen, and oxygen
- Functional groups present include hydroxyl groups -ose indicates sugar,$C_6H_{12}O_6$

- Carbohydrates are the most abundant of all the organic compounds in nature.
- In plants, energy from the Sun is used to convert carbon dioxide and water into the carbohydrate glucose.
- Many of the glucose molecules are made into long-chain polymers of starch that store energy.
- About 65% of the foods in our diet consist of carbohydrates.
- Each day we utilize carbohydrates in foods such as bread, pasta, potatoes, and rice.
- Other carbohydrates called disaccharides include sucrose (table sugar) and lactose in milk

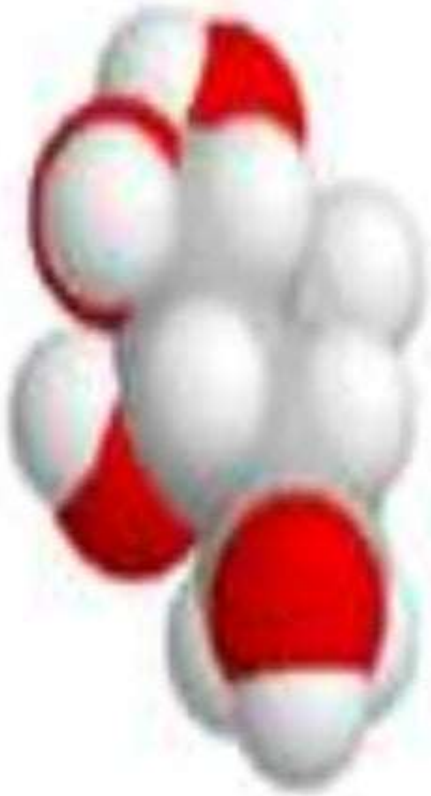
- During digestion and cellular metabolism, carbohydrates are converted into glucose,
- which is oxidized further in our cells to provide our bodies with energy and to provide the cells with carbon atoms for building molecules of protein, lipids, and nucleic acids.
- In plants, a polymer of glucose called cellulose builds the structural framework. Cellulose has other important uses, too.
- The wood in our furniture, the pages in your notebook, and the cotton in our clothing are made of cellulose.

- carbohydrate is a naturally occurring compound, or a derivative of such a compound, with the general chemical formula $C_x(H_2O)_y$, made up of molecules of **carbon (C), hydrogen (H), and oxygen (O)**. Carbohydrates are the most widespread organic substances and play a vital role in all life.

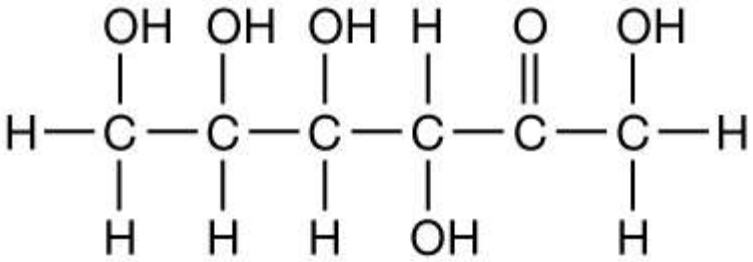
Definition - Carbohydrates are sugar polymers

Carbohydrate = Carbon + Water

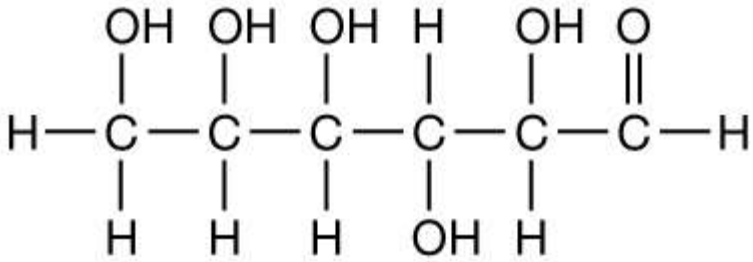
$C_n(H_2O)_n$



or $C_6H_{12}O_6$



Fructose



Glucose

CARBOHYDRATE in DIET

SUGARS

STARCH

CELLULOSE
Undigested

Converts to GLUCOSE

OXIDISATION

ENERGY (ATP)

GLUCOSE in excess forms

GLYCOGEN

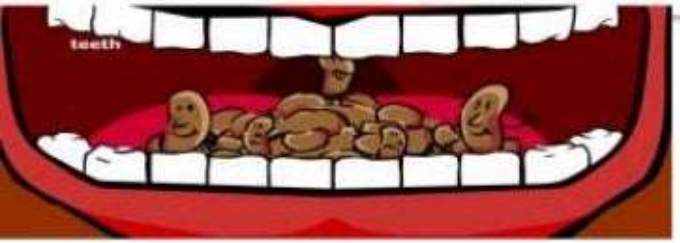
FATS

Non-Essential amino acids

Stored in LIVER

Stored in body

Protein synthesis Diet



What are the different types of carbohydrates

- There are three main types of carbohydrates:
- **Sugars.** They are also called simple carbohydrates because they are in the most basic form. They can be added to foods, such as the sugar in candy, desserts, processed foods, and regular soda. They also include the kinds of sugar that are found naturally in fruits, vegetables, and milk.

Starches.

- They are complex carbohydrates, which are made of lots of simple sugars strung together. Your body needs to break starches down into sugars to use them for energy. Starches include bread, cereal, and pasta. They also include certain vegetables, like potatoes, peas, and corn.

Fiber

- It is also a complex carbohydrate. Your body cannot break down most fibers, so eating foods with fiber can help you feel full and make you less likely to overeat. Diets high in fiber have other health benefits. They may help prevent stomach or intestinal problems, such as constipation. They may also help lower cholesterol and blood sugar. Fiber is found in many foods that come from plants, including fruits, vegetables, nuts, seeds, beans, and whole grains

- **Carbohydrates are organic molecules.**

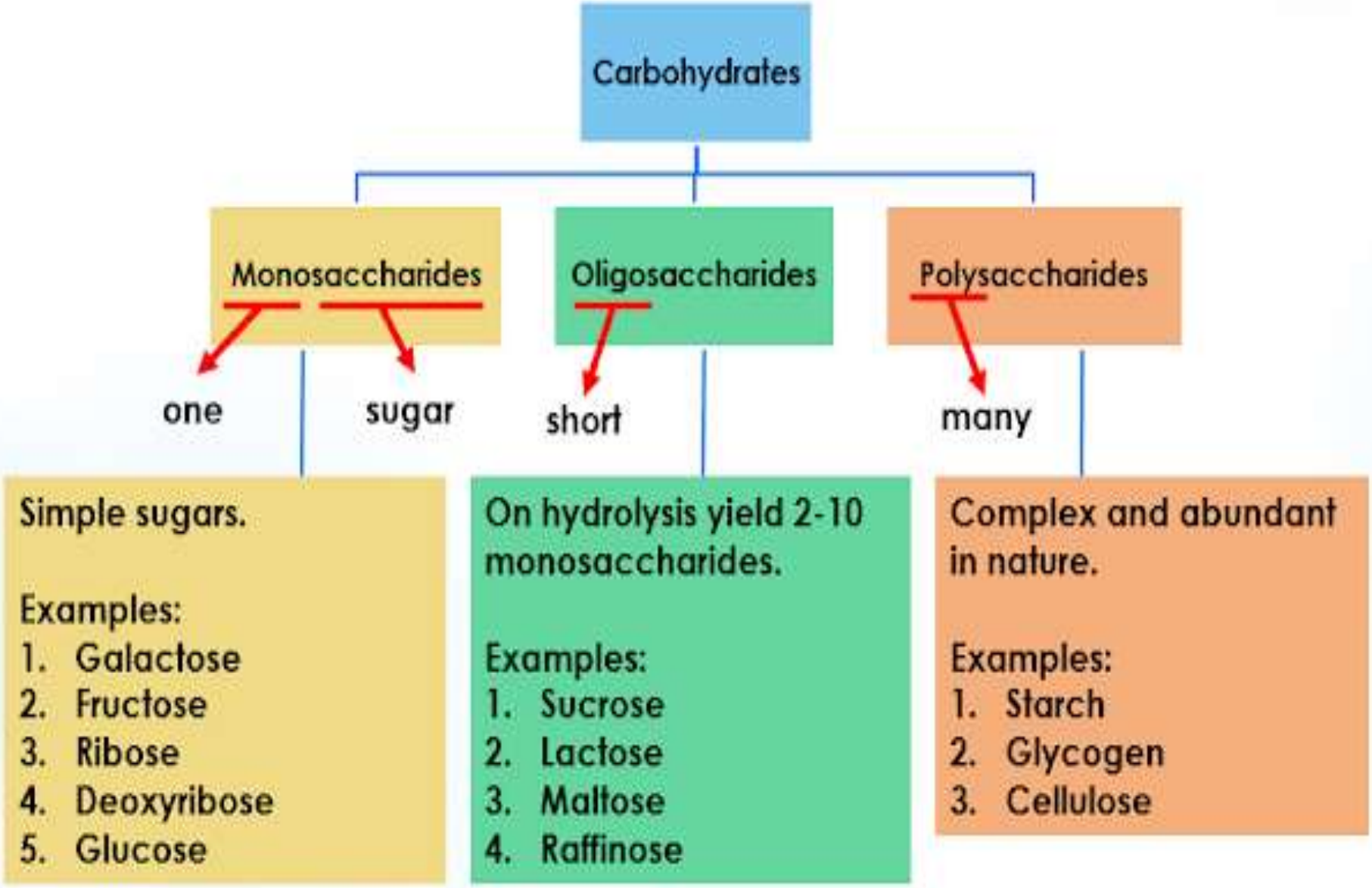
- **Carbohydrates** are one of the main types of nutrients. They are the most important source of energy for your body. Your digestive system changes **carbohydrates** into glucose (blood sugar). Your body uses this sugar for energy for your cells, tissues and organs.

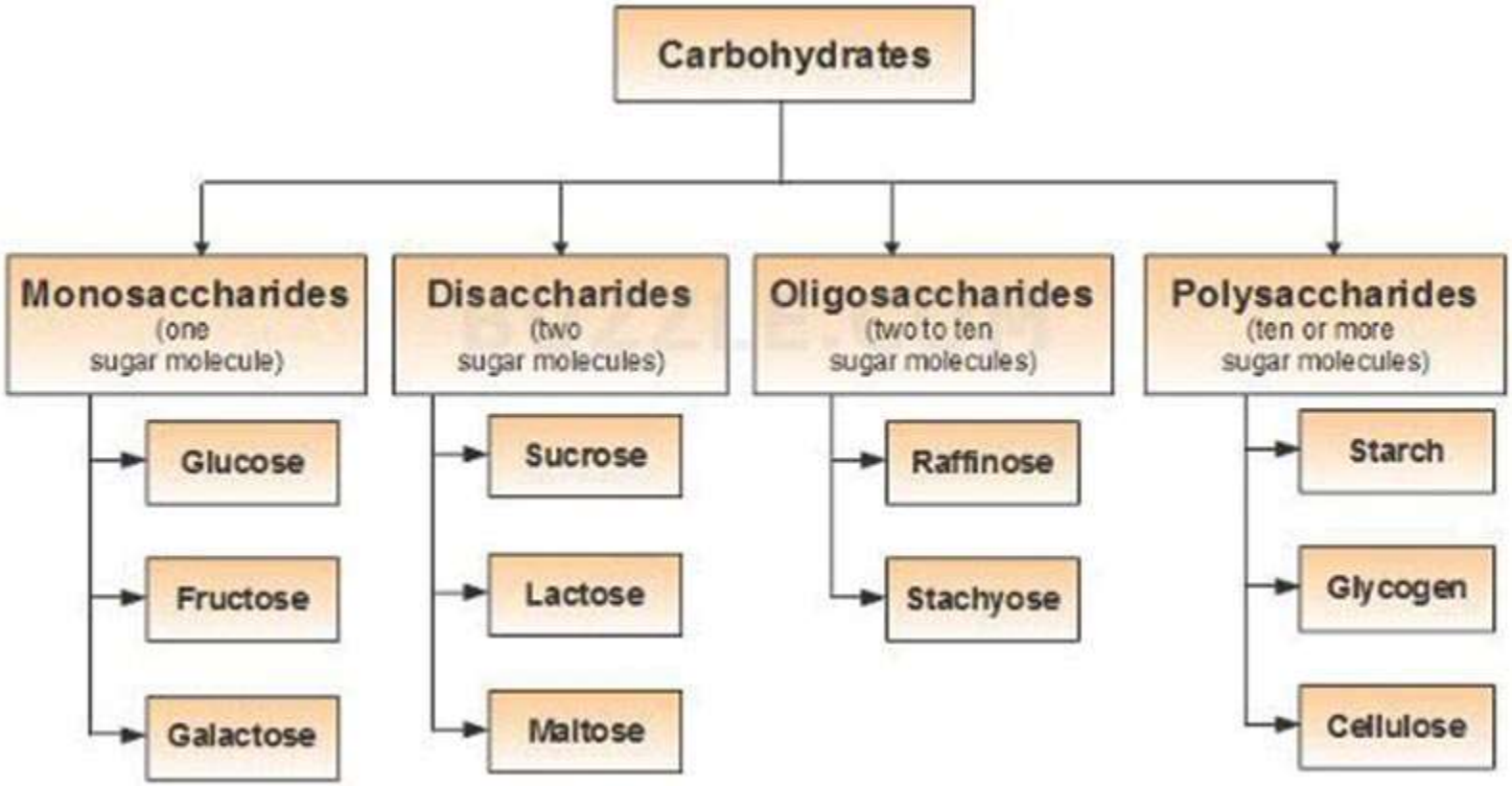
- There are two types of carbohydrates:
  - Simple
  - Complex.

- **Simple carbohydrates** are smaller, more easily processed molecules known as mono- and disaccharides since they contain either one sugar molecule or two sugar molecules linked together.

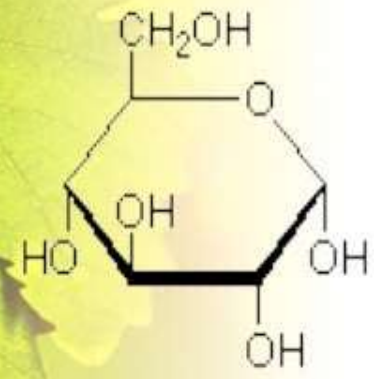
- **Complex carbohydrates**, are called polysaccharides since they have more than two sugar groups linked together.

Carbohydrates and its classification

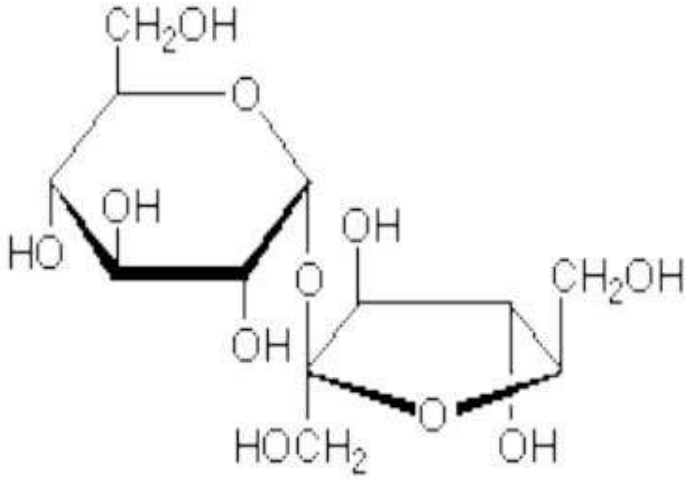



Carbohydrates
Monosaccharides
(one
sugar molecule)
Disaccharides
(two
sugar molecules)
Oligosaccharides
(two to ten
sugar molecules)
Polysaccharides
(ten or more
sugar molecules)
Glucose
Fructose
Galactose
Sucrose
Lactose
Maltose
Raffinose
Stachyose
Starch
Glycogen
Cellulose

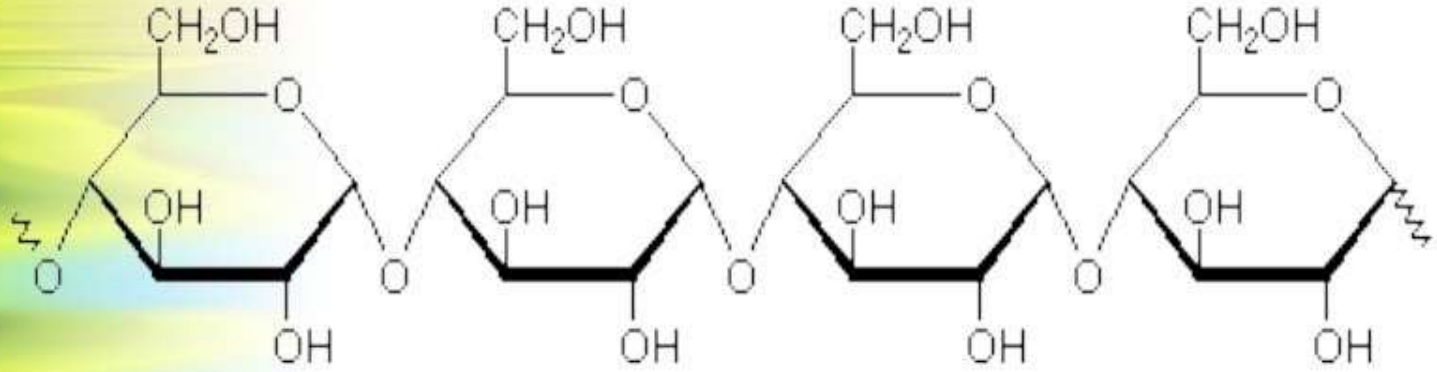
STRUCTURES



monosaccharide (glucose)



disaccharide (sucrose)



polysaccharide (amylose starch)

Monosaccharide's

- a sugar that is not decomposable into simpler sugars by hydrolysis, is classed as either an aldose or ketoses, and contains one or more hydroxyl groups per molecule— called also *simple sugar*
- Monosaccharide's are **the simplest carbohydrates**; they conform to the general chemical formula $(CH_2O)_x$ and are termed simple sugars. The most commonly occurring monosaccharide's contain three to six carbon atoms in an unbranched single-bonded chain. Monosaccharide's are signified by the suffix -ose.

Classification of monosaccharides

classified according to ***number of carbon atoms (3 -7 carbon atoms) & presence of aldehyde or ketone groups***

Trioses : with **three** carbons e.g.		Glyceraldhyde	(aldotriose)
	&	Dihydroxyacetone	(ketotriose)
Tetroses: with **four** carbons e.g.		Erythrose	(aldotetrose)
		Erythulose	(ketotetrose)
Pentoses: with **five** carbons e.g		Ribose	(aldopentose)
	&	Ribulose	(ketopentose)
Hexoses : with **six** carbons e.g.		Glucose	(aldohexose)
		Galactose	(aldohexose)
		Mannose	(aldohexose)
	&	Fructose	(ketohexose)

Disaccharides

- Disaccharides are **one of the four chemical groupings of carbohydrates (monosaccharides, disaccharides, oligosaccharides, and polysaccharides)**. The most common types of disaccharides—sucrose, lactose, and maltose—have 12 carbon atoms, with the general formula $C_{12}H_{22}O_{11}$.

What is RDA?

- Def.: Amount of the nutrient sufficient for the maintenance of health in nearly all people.
- For all nutrients except energy,
  RDA=minimum requirement + safety margin
- RDA doesn't apply to sick people.

Recommended dietary allowances

RDA is defined as the nutrients present in the diet which satisfy the daily requirement of nearly all individuals in a population.

Why RDA is important?

- National Family Health Survey and UNICEF Reports , 46% of preschool children and 30% of adults in India suffer from moderate and severe grades of protein-calorie malnutrition
- Over 50% women (particularly pregnant women) and children suffer from iron deficiency anaemia (IDA),
- diseases such as obesity, diabetes, hypertension, cardiovascular diseases and cancers
- Iodine Deficiency Disease (IDD) has been considerably reduced after the introduction of universal iodised salt

HISTORY OF RECOMMENDED DIETARY ALLOWANCES

- in **1944** by the Nutrition Advisory Committee of Indian Research Fund Association (IRFA)
- now ICMR (Indian Council of Medical Research)

- ICMR Nutrition Advisory Committee revised RDA for Indians on calories and proteins in **1960**

- Such a revision and updating of the nutrient requirement on RDA of Indians was done by Expert Groups of the ICMR in 1978 and 1988

Recommended dietary allowances

This implies addition of safety factor amount to the estimated requirement to cover

- Variation among individuals
- Losses during cooking
- Lack of precision in estimated requirement

Recommended Dietary Allowances = Requirements + Safety factor

Factors that effects RDA

RDA of an individual depends on many factors like:

1. Age
2. Sex
3. Physical work
    1. Sedentary
    2. Moderate
    3. Hard (Heavy)
4. Physiological stress
    1. Pregnancy
    2. Lactation

Factors that effects RDA

For all the nutrients (except energy) estimates of allowances are arrived at by determining the average. Taking mean requirement of nutrients and adding to it twice the standard deviation of the mean.

$$\text{Requirement} = \text{Mean} \pm 2SD$$

The value will meet more than 97.5% of the population which is composed of individuals with a satisfactory normal distribution of requirements.

RDA for Indian nationals

ICMR has defined well nourished Indian adults who had satisfactory growth during childhood as

- Reference man
- Reference woman

ICMR's Reference Woman

1. between 20-39 years of age
2. healthy and weighs 50kg.
3. may be engaged 8 hours in general household work or in light industry or in any other moderately active work.
4. 8 hours in bed
5. spends 4-6 hours sitting or moving around in light activity
6. 2 hours walking or active recreation or household chores.

ICMR's Reference men

1. between 20 – 39 years of age
2. weighs 60 kg
3. free from disease and physically fit for active work.
4. employed for 8 hours
5. 4-6 hours sitting and moving about
6. 2 hours in walking or in active recreation or household duties
7. 8 hours in bed

ICMR's Reference men

Scientists have prescribed RDA for adults, depending on the level of activity of individual.

1. Sedentary workers: Those who sit and do work using brain and hands.

- Ex: teachers; clerks, typists, officers

ICMR's Reference men

2. Moderate workers: Works vigorously for a few hours using many parts of the body like hands, feet and muscles.

- Ex: postman; mali; maid servant; housewife doing all household work.

3. Heavy workers: Use different parts of body for several hours.

- Ex: rickshaw pullers; coolies; workers in mines; sports persons, masons etc.

Nutrient requirements And Recommended dietary allowances For Indians

Energy Requirements

- The unit of energy, which has been in use in nutrition for a long time, is Kilocalories (kcal).
- physical activity ratio (PAR) is expressed as the ratio of the energy cost of an individual activity per minute to the cost of the basal metabolic rate (BMR) per minute.

$$\text{Physical Activity Ratio (PAR)} = \frac{\text{Energy cost of an activity per minute}}{\text{Energy cost of basal metabolism per minute}}$$

Energy Requirements

Comparison of energy cost of some common daily activities in terms of PAR values

Activities	Energy cost of daily activities in PAR values	
	Indian data	International data
Sitting quietly	1.20	1.25
Standing quietly	1.40	1.33
Sitting at desk	1.30	1.36
Standing + doing lab work	2.0	1.95
Harvesting	3.6	3.5
Hand saw	7.4	7.5
Typing (sitting)	1.58	1.69
Walking 3 MPH	3.71	3.77

Energy Requirements

Age	Energy Requirements (kcal/kg)	
	Male	Female
Children (1-3yrs)	910	830
Children (4-6yrs)	1230	1200
(6-7yrs)	1510	1400
(8-10yrs)	1750	1630
(11-12yrs)	2180	2010
Adolescent (13-15yrs)	2580	2140
(16-18yrs)	3060	2450

Adult male 2400-3900 kcal/kg

Adult female 1900-3000 kcal/kg

Pregnant woman 2200 kcal/kg

Lactating women 2600 kcal/kg

REFERENCE MAN AND REFERENCE WOMAN

REF.MAN:

Age:20-39 yr
Wt.:60 kg
Healthy, fit for active work
He spends 8 hr daily on occupational work
(moderate activity)
While not at work he spends 8 hr in bed,
6 hr sitting & moving around,
2 hr walking & household work

REF.WOMAN:

Criteria same as for man except wt. 50 kg

ENERGY

- Energy is a prime requirement for body function and growth.

- <u>Energy requirement</u>:
  in voluntary and involuntary process in our body.

Measurement of Energy

- Expressed as kilo-calorie (kC)

- Energy values:

Carbohydrates	-	4 kC / gm
Proteins	-	4 kC / gm
Fats	-	9 kC / gm

Total energy Requirement

Energy for basal metabolism
1 kC /hr/kg body wt / per day

+

Energy for daily activities
(walking, sitting, standing etc.)

+

Energy for occupational work
(heavy / moderate / sedentary)

CONSUMPTION UNIT

Reference man - one consumption unit

Needed to conduct community diet surveys.

Age group (yr)	Consumption unit
1 - 3	0.4
3 - 5	0.5
5 - 7	0.6
7 - 9	0.7
9 -12	0.8
12 - 21	1.0

Category	Male	Female
Sedentary	1	0.8
Moderate	1.2	0.9
Heavy	1.6	1.2

Categorization of workers

Light worker	Moderate worker	Hard worker
Office worker	Railway worker	Coal miner
Driver	Postman	Steel worker
Shopkeeper	Plumber	Army recruit
Teacher	Bus conductor	Docker
Lawyer	Tailor	Labourer
Doctor	Carpenter	

Factors affecting Energy Requirement

- Age
- Sex
- Working Condition
- Body Composition
- Physical Activity
- Vulnerable / At Risk Groups
    1. Pregnant & Lactating mothers
    2. Infants & Children
    3. Elderly

RDA (per day) for Indians (ICMR)

Group	Particulars	Body Wt. kg	Net Energy kC	Protein gm	Fat gm	Ca mg	Fe mg
Man	Sedentary	60	2425	60	20	400	28
	Moderate	"	2875	"	"	"	"
	Heavy work	"	3800	"	"	"	"
Woman	Sedentary	50	1875	50	"	"	30
	Moderate	"	2225	"	"	"	"
	Heavy work	"	2925	"	"	"	"
	Pregnancy	"	+300	+15	30	1000	38
	Lactation (0-6 m)	"	+550	+25	45	"	30
	Lactation (6-12 m)	"	+400	+18	"	"	"

RDA (per day) for Indians (ICMR)

Particulars	Retinol mcg	Beta Carotene mcg	Thiamin mg	Ribo-flavin mg	Niacin mg	Vit. C mcg	Folic Acid mcg	Vit. B 12 mcg
Sed.	600	2400	1.2	1.4	16	40	100	1
Mod.	"	"	1.4	1.6	18	"	"	"
Heavy	"	"	1.6	1.9	21	"	"	"
Sed.	"	"	0.9	1.1	12	"	"	"
Mod.	"	"	1.1	1.3	14	"	"	"
Heavy	"	"	1.2	1.5	16	"	"	"
Preg.	"	"	+0.2	+0.2	+2	"	400	"
Lact. 0-6 m	950	3800	+0.3	+0.3	+4	80	150	1.5
Lact. 6-12 m	"	"	+0.2	+0.2	+3	"	"	"

RDA (per day) for Indians (ICMR)

Age	Body Wt. kg	Net Energy kC	Protein gm	Fat gm	Ca mg	Fe mg
0-6 m	5.4	108/kg	2 g/kg	-	500	-
6-12 m	8.6	98/kg	1.6g/kg	-	"	-
1-3 yr	12.2	1240	22	25	400	12
4-6 yr	19.0	1690	30	"	"	18
7 9 yr	26.9	1950	41	"	"	26

RDA (per day) for Indians (ICMR)

Age	Body Wt. kg	Retinol mcg	Beta Carotene mcg	Thiamin mg	Vit. C mcg	Folic Acid mcg
0-6 m	5.4	350	1200	55(mcg)	25	25
6-12 m	8.6	"	"	50(mcg)	"	"
1-3 yr	12.2	400	1600	0.6	40	30
4-6 yr	19.0	"	"	0.9	"	40
7 9 yr	26.9	600	2400	1.0	"	60

What is Balanced Diet

A balanced diet is one which provides all the nutrients in required amounts and proper proportions

It can easily be achieved through a blend of the four basic food groups. The quantities of foods needed to meet the nutrient requirements vary with age, gender, physiological status and physical activity.

What is Balanced Diet

- Should provide around **50-60% of total calories from carbohydrates**, preferably from complex carbohydrates
- about **10-15% from proteins** and **20-30% from fat**.
- should provide other non-nutrients such as **dietary fiber, antioxidants and phytochemicals**
- Antioxidants such as **vitamins C and E, beta-carotene, riboflavin and selenium** protect the human body from free radical damage.
- Other phytochemicals such as **polyphenols, flavones**, etc., also afford protection against oxidant damage.

Uses of RDA

- Basis for all feeding program (school lunch program)
- To interpret food consumption record
- To understand nutritional needs
- Guidelines for public food program
- To develop and evaluate the new food product
- To develops the nutritional education program

Source of Carbohydrates

Carbohydrates	Food Source
Glucose	Fruits, Honey, Corn Syrup
Fructose	Fruits, Honey
Galactose	Milk
Maltose	Backed Starch
Sucrose	Cane & Beat Sugar
Lactose	Milk Product
Starch & Dextrin	Grains, Root & Tubers, Legumes
Glycogen	Meat Product, Sea Food
Cellulose	Vegetables, Outer coat of Seed
Pectin & Gums	Fruits, Plant Secretion, seeds.

Sources of Carbohydrates

Dairy

Milk, yogurt, and ice cream

Fruit

Whole fruit and fruit juice

Grains

Bread, rice, crackers, and cereal

Legumes

Beans and other plant-based proteins

Starchy Vegetables

Potatoes and corn

Thank You…

SOURCE: www.ICMR.NIC.in

Functions of Carbohydrates

- Carbohydrates are the primary or the main sources of energy in our human body.
- They are also involved in fat metabolism.
- Carbohydrates prevent ketosis.
- They are a part of **connective tissues**.
- Carbohydrates maintain the digestive system of the body.
- Blood **cholesterol** can be lowered due to the fibers in Carbohydrates.
- Carbohydrates are used to build and repair tissues because it retains **protein** from being burned.
- Carbohydrates give energy to the **central nervous system**.
- They are found in different forms such as sugar, glucose, starch, and fibers.

Functions of Carbohydrates have eight major functions within the body

- :
- 9. Functions of Carbohydrates BLOOD SUGAR AND INSULIN
- 10. Functions of Carbohydrates PROVIDES ENERGY
- 11. Functions of Carbohydrates TRIGGERS APPETITE, HUNGER AND FULLNESS
- 12. Functions of Carbohydrates OUR MOOD
- 13. Functions of Carbohydrates DIGESTION
- 14. Functions of Carbohydrates PREBIOTICS AND COLON HEALTH
- 15. Functions of Carbohydrates BRAIN FUNCTIONALITY
- 16. Functions of Carbohydrates WEIGHT

Which foods have carbohydrates?

- Common foods with carbohydrates include:
- Grains, such as bread, noodles, pasta, crackers, cereals, and rice
- Fruits, such as apples, bananas, berries, mangoes, melons, and oranges
- Dairy products, such as milk and yogurt
- Legumes, including dried beans, lentils, and peas
- Snack foods and sweets, such as cakes, cookies, candy, and other desserts
- Juices, regular sodas, fruit drinks, sports drinks, and energy drinks that contain sugar
- Starchy vegetables, such as potatoes, corn, and peas

Why do we need carbohydrate?

- Carbohydrate function as bio fuel.
- Carbohydrate function as primary source for energy.
- Carbohydrate function as storage o food.
- Carbohydrate function as frame wo in body.
- Carbohydrate function as anticoagulant.
- Carbohydrate function as hormone like FSN,LH.(Glycoprotein)

FUNCTIONS OF CARBOHYDRATES

- Main source of energy in the body. Energy production from carbohydrates will be 4 k calories/g (16 k Joules/g).
- Storage form of energy (starch and glycogen).
- Excess carbohydrate is converted to fat.
- Glycoproteins and glycolipids are components of cell membranes and receptors.
- Structural basis of many organisms. For example, cellulose of plants,exoskeleton of insects etc.

Biomedical Importance Of Glucose

- Glucose is a major carbohydrate
- It is a major fuel of tissues
- It is converted into other carbohydrates

✓ Glycogen for storage.
✓ Ribose in nucleic acids.
✓ Galactose in lactose of milk.
✓ They form glycoproteins & proteoglycans
✓ They are present in some lipoproteins (LDL) .
✓ Present in plasma membrane:glycocalyx.
✓ Glycophorin is a major intergral membrane glycoprotein of human erythrocytes.

METABOLISM

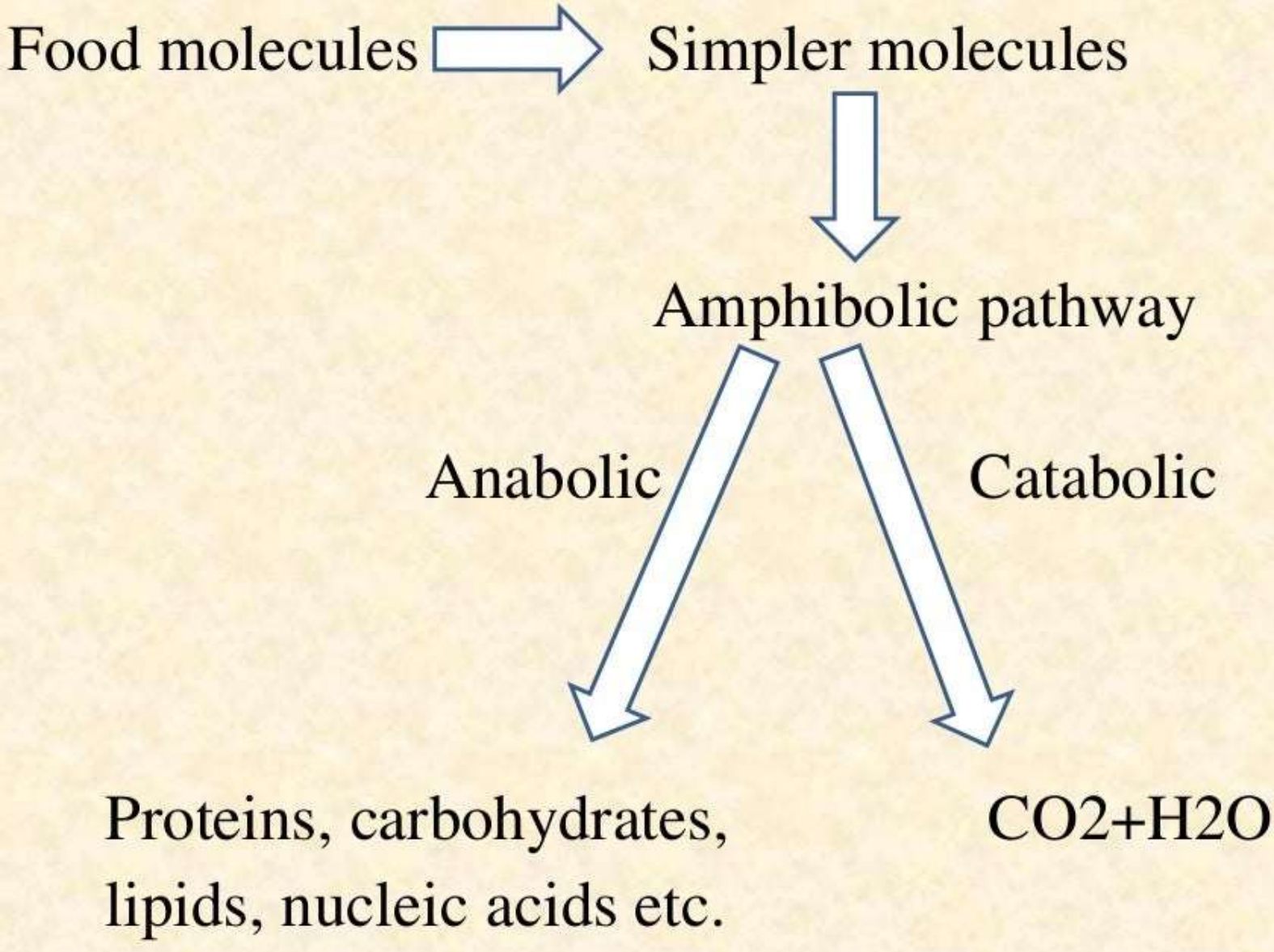
Thousands of chemical reactions are taking place inside a cell in an organized, well co-ordinated and purposeful manner; all these reactions are called as METABOLISM.

TYPES OF METABOLIC PATHWAY:

- ✓Catabolic Pathway
- ✓Anabolic Pathway
- ✓Amphibolic Pathway

STAGES AND PHASES OF METABOLISM:

- ✓Primary
- ✓Secondary
- ✓Tertiary


Food molecules
Simpler molecules
Amphibolic pathway
Anabolic
Catabolic
Proteins, carbohydrates, lipids, nucleic acids etc.
CO2+H2O

MAJOR PATHWAYS OF CARBOHYDRATE METABOLISM

1) Glycolysis

2) Citric Acid Cycle

3) Gluconeogenesis

4) Glycogenesis

5) Glycogenolysis

6) Hexose monophosphate shunt

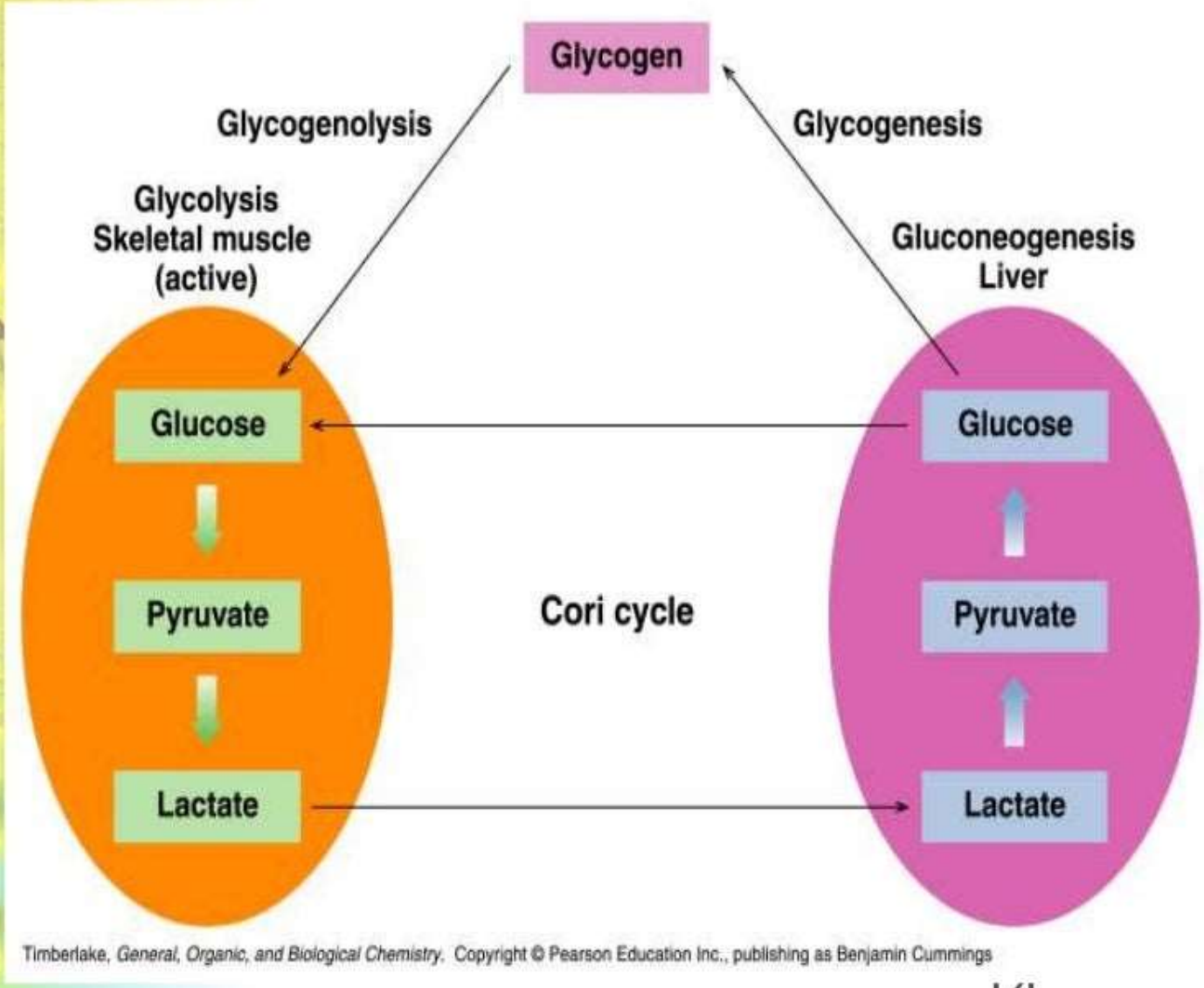
7) Uronic Acid Pathway

8) Galactose Metabolism

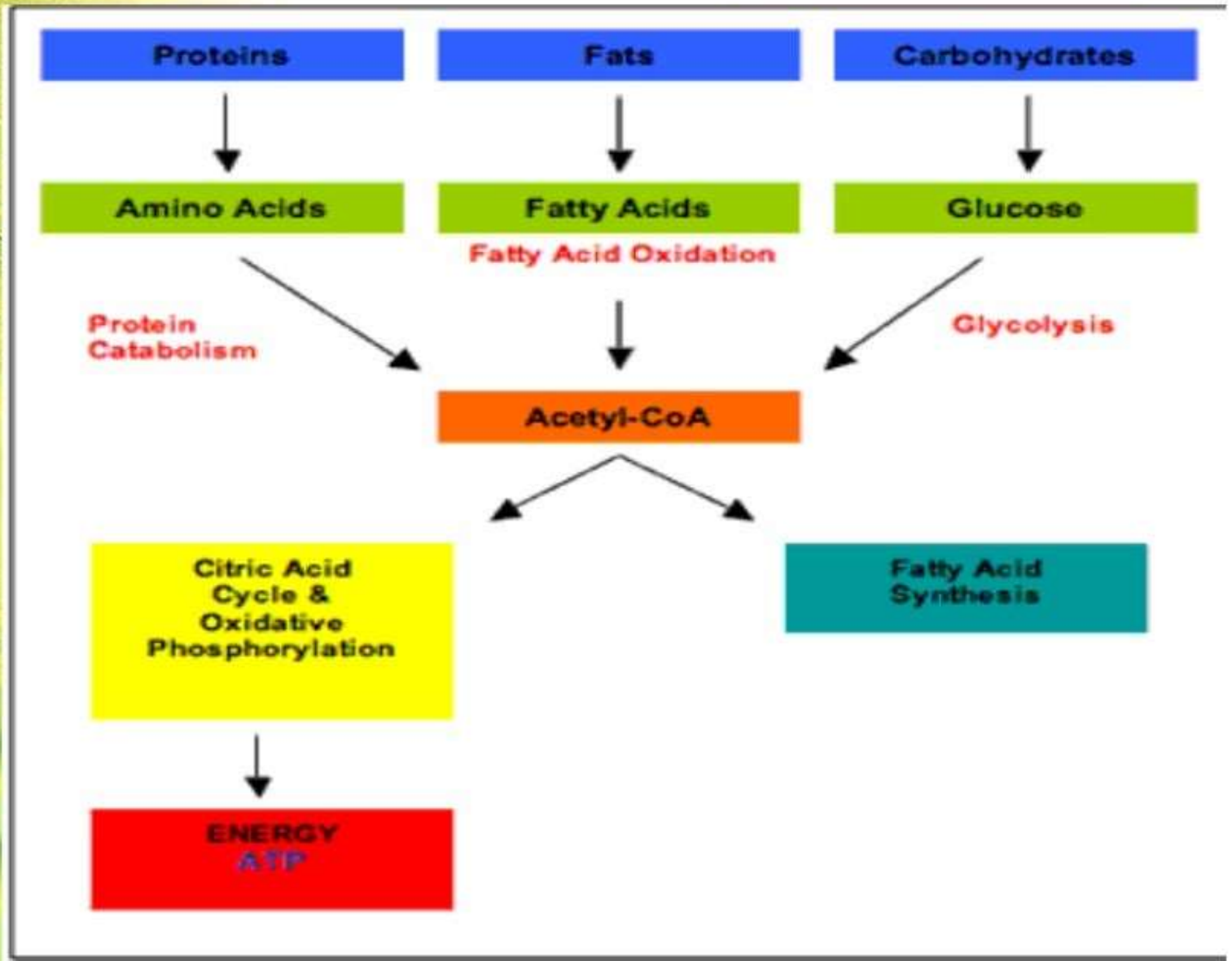
9) Fructose Metabolism

10) Amino sugar metabolism

Pathways for Glucose

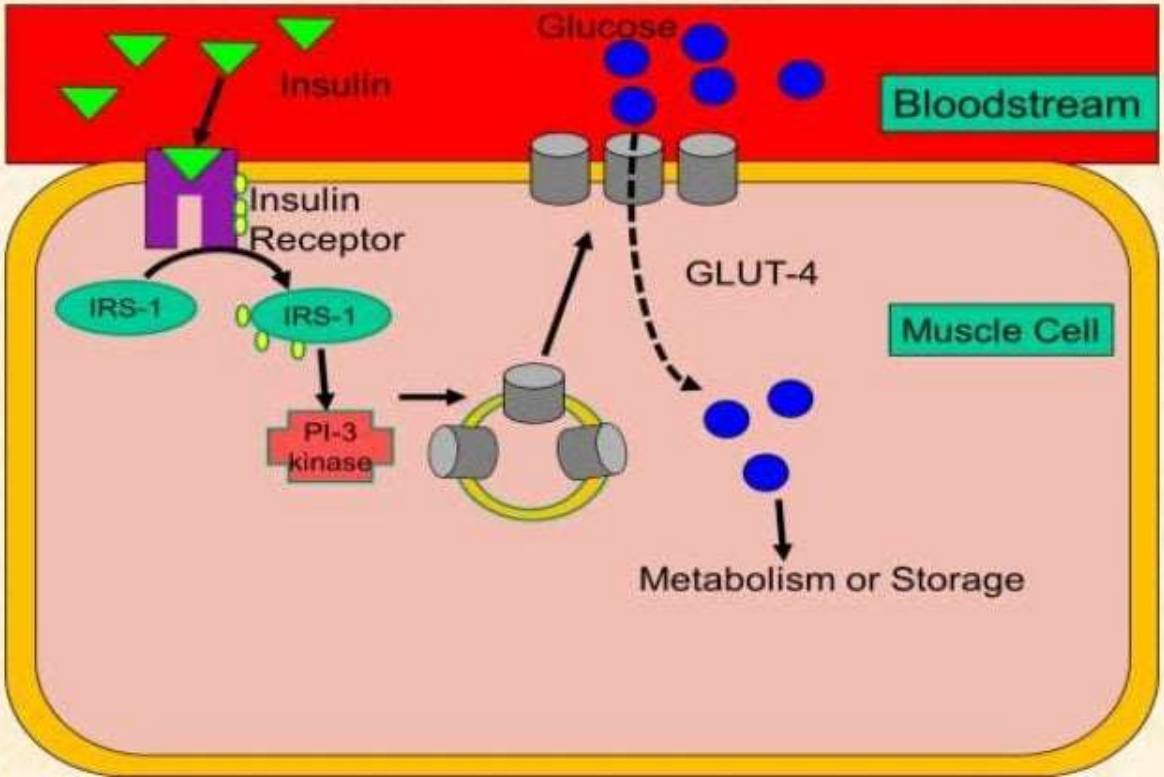


Catabolism


Proteins
Fats
Carbohydrates
Amino Acids
Fatty Acids
Glucose
Fatty Acid Oxidation
Protein Catabolism
Glycolysis
Acetyl-CoA
Citric Acid Cycle & Oxidative Phosphorylation
Fatty Acid Synthesis
ENERGY
ATP

Entry of Glucose into cells

1) Insulin-independent transport system of glucose: Not dependent on hormone insulin. This is operative in – hepatocytes, erythrocytes (GLUT-1) and brain.
2) Insulin-dependent transport system: Muscles and adipose tissue (GLUT-4).



Type 2 diabetes melitus:
-Due to reduction in the quantity of GLUT-4 in insulin deficiency.
-Insuin resistance is observed in tissues.

GLYCOLYSIS

EMBDEN-MEYERHOF PATHWAY

(OR)

E.M.PATHWAY

Definition:

Glycolysis is defined as the sequence of reactions converting glucose (or glycogen) to pyruvate or lactate, with the production of ATP

Salient features:

1) Takes place in all cells of the body.
2) Enzymes present in "cytosomal fraction" of the cell.
3) Lactate – end product – anaerobic condition.
4) Pyruvate(finally oxidized to CO_2 & H_2O) – end product of aerobic condition.
5) Tissues lacking mitochondria – major pathway – ATP synthesis.
6) Very essential for brain – dependent on glucose for energy.
7) Central metabolic pathway
8) Reversal of glycolysis – results in gluconeogenesis.

Reactions of Glycolysis

1) Energy Investment phase (or) priming phase

2) Splitting phase

3) Energy generation phase

Energy Investment Phase

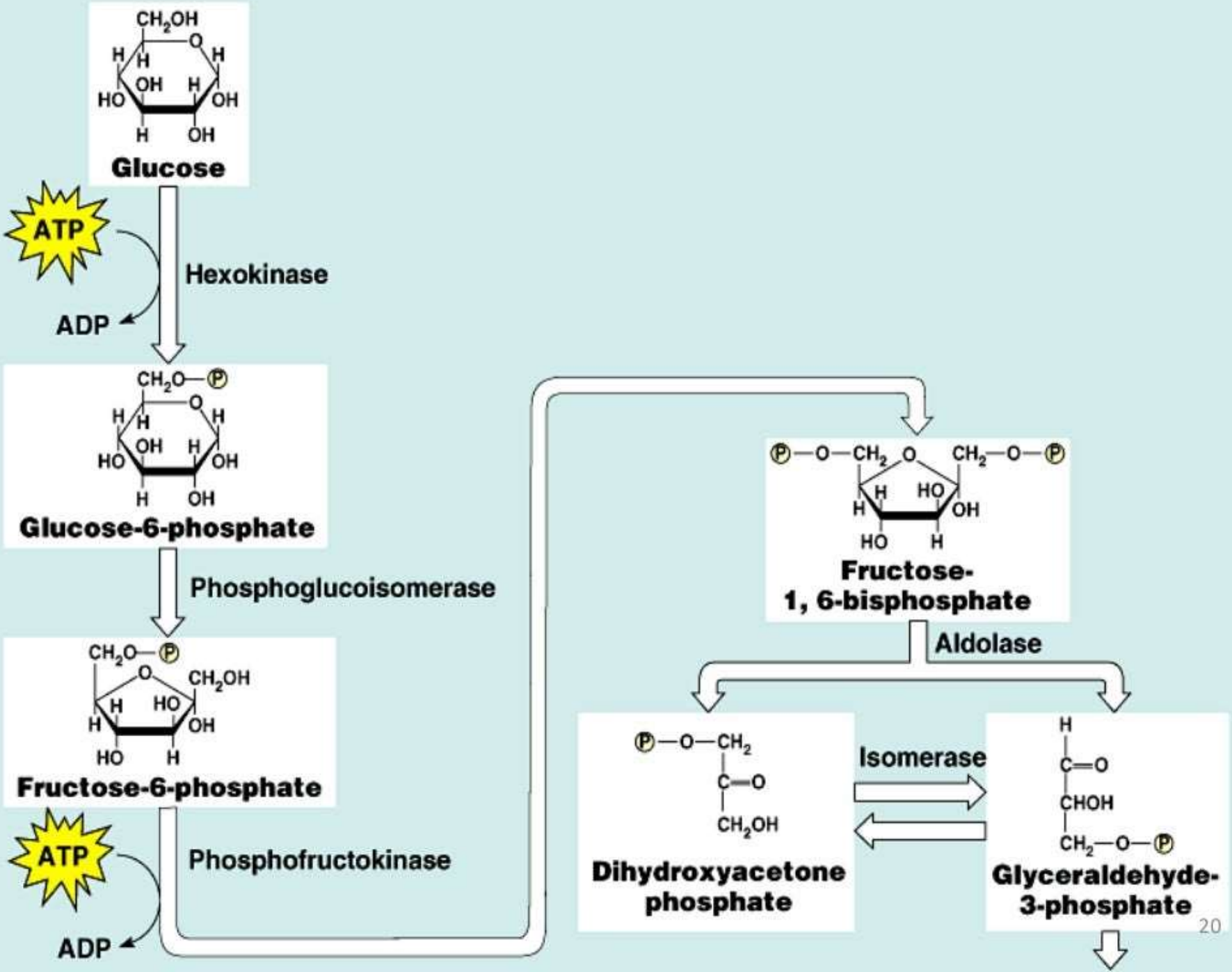
- **Glucose** is phosphorylated to **glucose-6-phosphate** by *hexokinase (or) glucokinase*.
- Glucose-6-phosphate undergoes isomerization to give **fructose -6- phosphate** in the presense of *phospho-hexose isomerase* and Mg^{2+}
- Fructose-6-phosphate is phoshorylated to **fructose 1,6-bisphosphate** by *phosphofructokinase*.

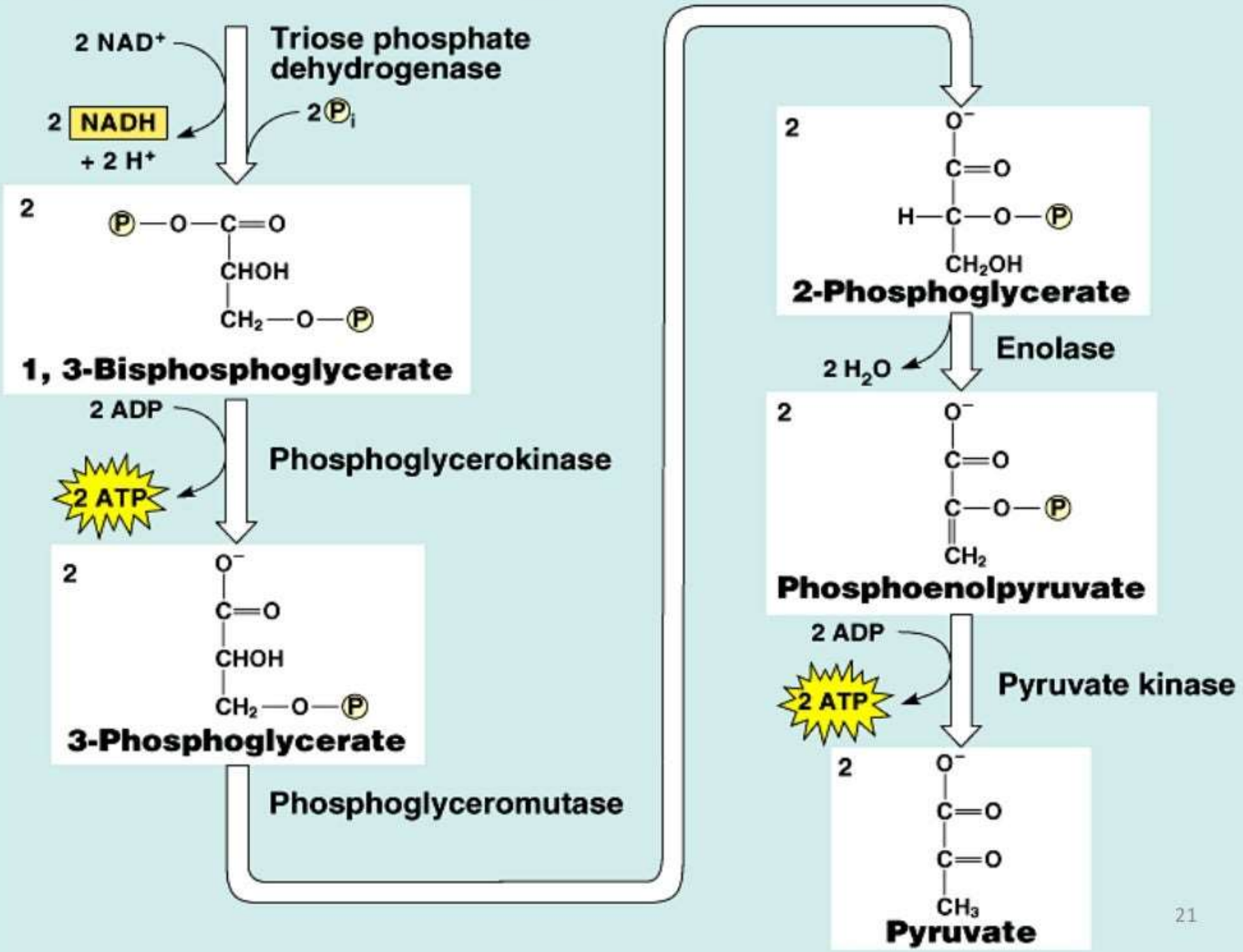
Splitting Phase

- Fructose 1,6-bisphosphate → **glyceraldehyde 3-phosphate + dihydroxyacetone phosphate.**(*aldolase enzyme*)
- **2 molecules** of glyceraldehyde 3-phosphate are obtained from 1 molecule of glucose

Energy Generation Phase

- Glyceraldehyde 3-phosphate → **1,3-bisphosphoglycerate**(*glyceraldehyde 3-phosphate hydrogenase*)
- 1,3-bisphosphoglycerate → **3-phosphoglycerate** (*phosphoglycerate kinase*)
- 3-phosphoglycerate → **2-phosphoglycerate** (*phosphoglycerate mutase*)
- 2-phosphoglycerate → **phosphoenol pyruvate** (*enolase* + Mg^{2+} & Mn^{2+})
- Phosphoenol pyruvate → **pyruvate [enol]** (*pyruvate kinase*) → **pyruvate [keto]** → **L-Lactate** *(lactate dehydrogenase)*


Glucose
ATP
Hexokinase
ADP
Glucose-6-phosphate
Phosphoglucoisomerase
Fructose-6-phosphate
ATP
Phosphofructokinase
ADP
Fructose-
1, 6-bisphosphate
Aldolase
Isomerase
Dihydroxyacetone
phosphate
Glyceraldehyde-
3-phosphate


2 NAD+
Triose phosphate dehydrogenase
2 NADH
+ 2 H+
2 Pi
2
1, 3-Bisphosphoglycerate
2 ADP
2 ATP
Phosphoglycerokinase
2
3-Phosphoglycerate
Phosphoglyceromutase
2
2-Phosphoglycerate
2 H2O
Enolase
2
Phosphoenolpyruvate
2 ADP
2 ATP
Pyruvate kinase
2
Pyruvate

Energy production of glycolysis:

ATP production = ATP produced - ATP utilized

	ATP produced	ATP utilized	Net energy
In absence of oxygen (anaerobic glycolysis)	4 ATP (Substrate level phosphorylation) 2ATP from 1,3 DPG. 2ATP from phosphoenol pyruvate	2ATP From glucose to glucose -6-p. From fructose -6-p to fructose 1,6 p.	2 ATP
In presence of oxygen (aerobic glycolysis)	4 ATP (substrate level phosphorylation) 2ATP from 1,3 BPG. 2ATP from phosphoenol pyruvate. + 4ATP or 6ATP (from oxidation of 2 NADH + H in mitochondria).	2ATP -From glucose to glucose -6-p. From fructose -6-p to fructose 1,6 p.	8 ATP / 6 ATP (Pyruvate dehydrogenase 2NADH,ETC, Oxidative phosphorylation)

CLINICAL ASPECT

1) Lactic acidosis

- Normal value – 4 to 15 mg/dl.
- Mild forms – strenous exercise, shock, respiratory diseases, cancers
- Severe forms – Impairment/collapse of circulatory system – myocardial infarction, pulmonary embolism, uncontrolled hemmorrhage and severe shock.

2) Cancer and glycolysis :

- Cancer cells – increased uptake of glucose and glycolysis.

- Blood vessels unable to supply adequate oxygen – HYPOXIC condition – Anaerobic glycolysis / hypoxic glycolysis – Involvement of Hypoxic inducible transcription factor (HIF).

- Treatment : Use drugs that inhibit vascularization of tumours

- ✓ Pasteur effect : Inhibition of glycolysis by oxygen (Phosphofructokinase) .

- ✓ Crabtree effect : The phenomenon of inhibition of oxygen consumption by the addition of glucose to tissues having high aerobic glycolysis.

ROLE OF HORMONES IN CARBOHYDRATE METABOLISM

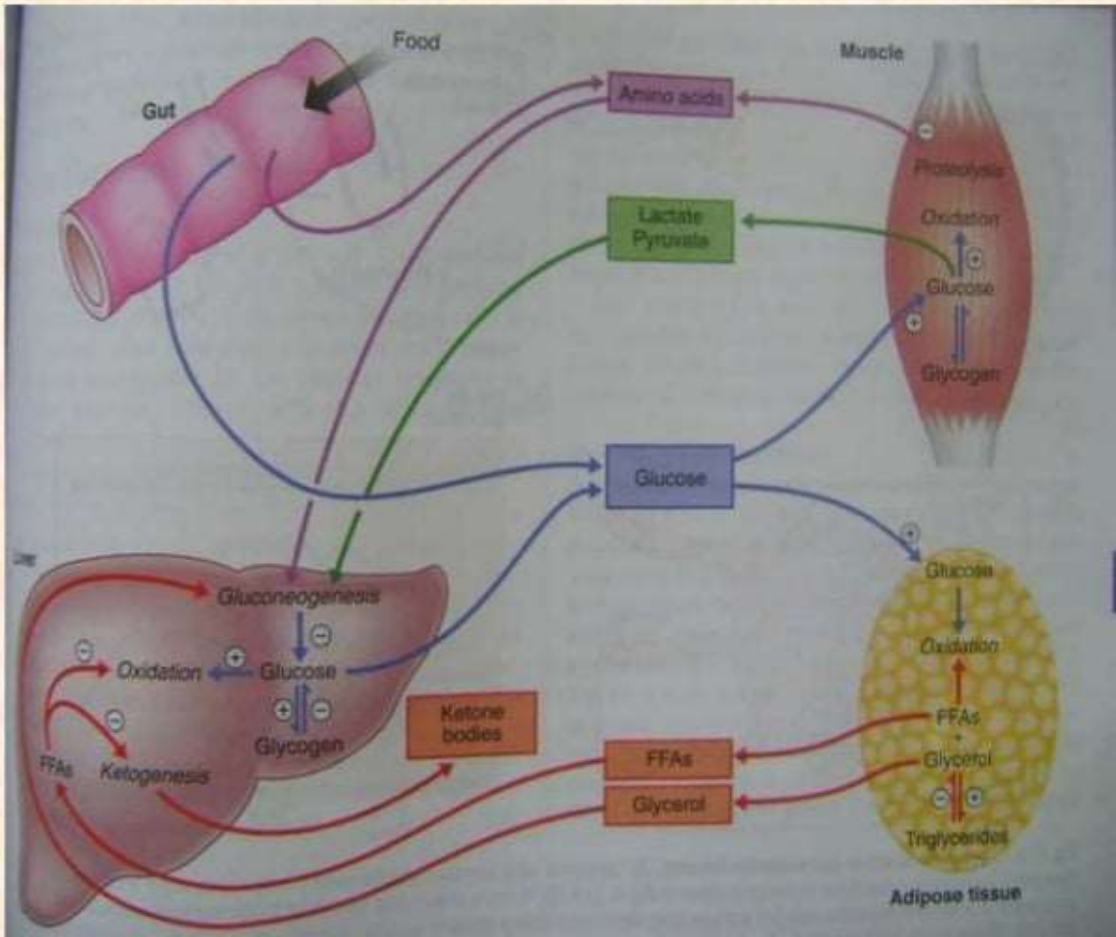
Regulation of Blood glucose

- Postabsorptive state: Blood glucose is 4.5-5.5mmol/L.
- After carbohydrate meal: 6.5-7.2mmol/L
- During fasting : 3.3-3.9mmol/L

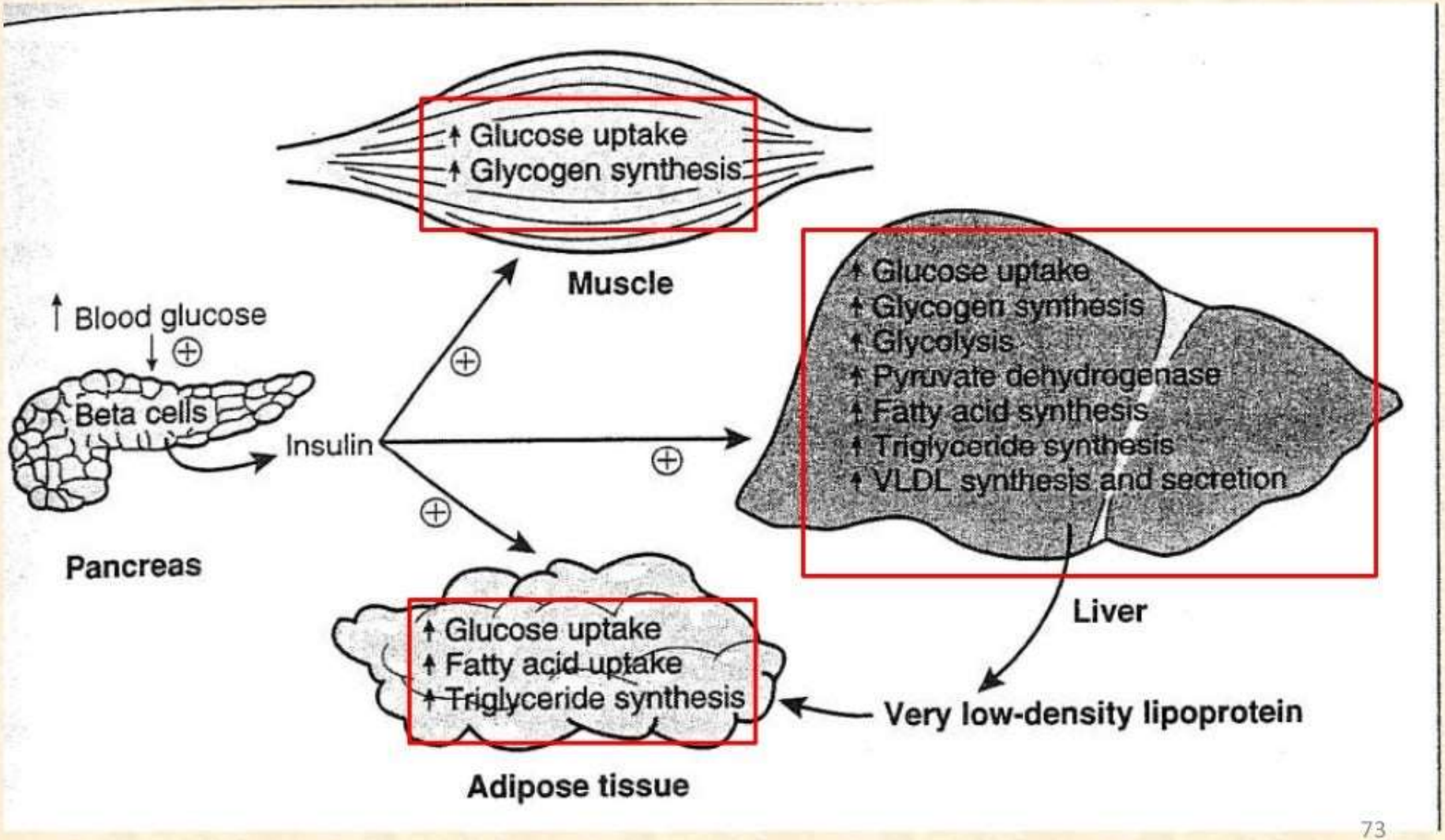
Metabolic & hormonal mechanisms regulate blood glucose level

Maintenance of stable levels of glucose in blood is by

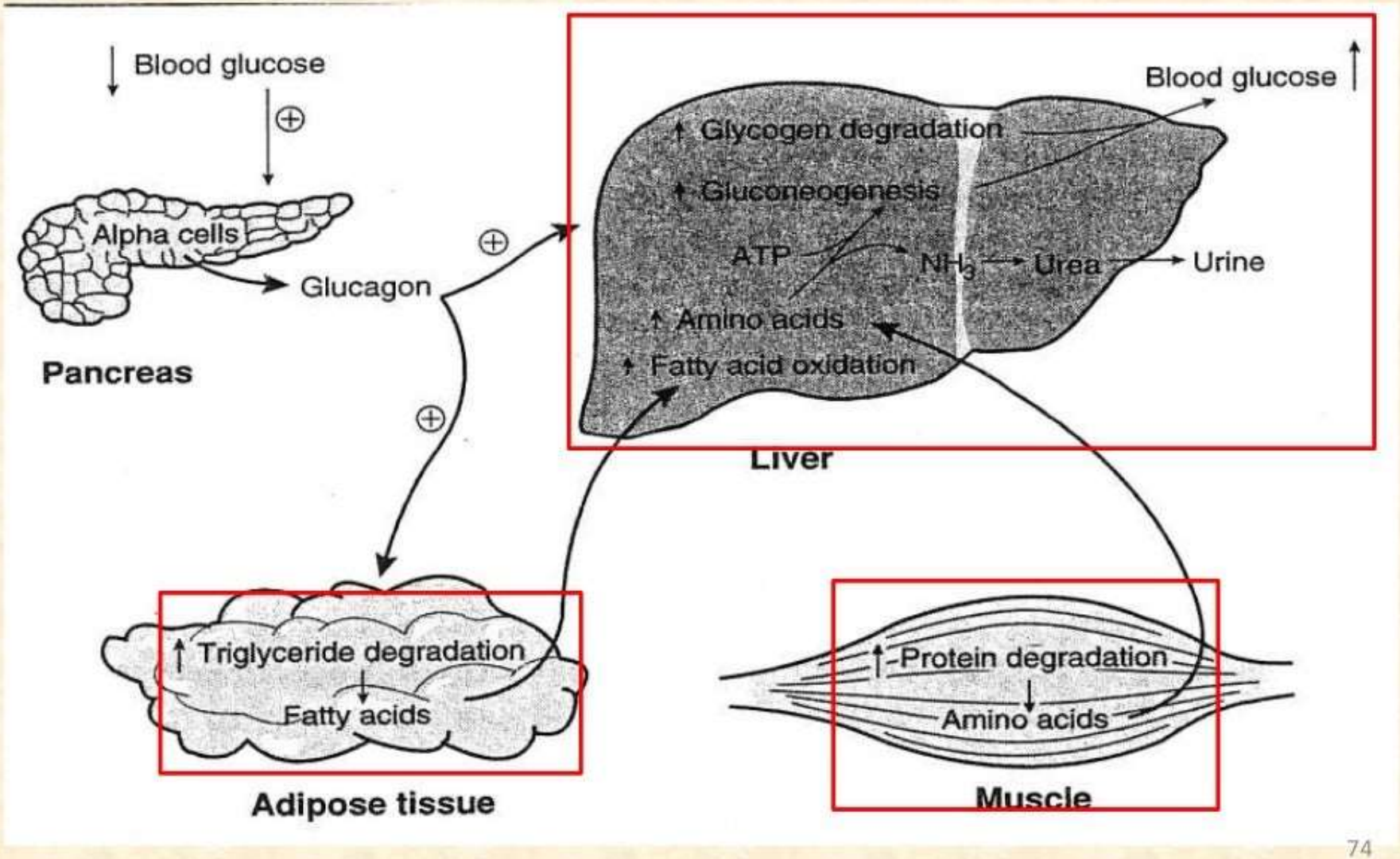
- ✓ Liver.
- ✓ Extrahepatic tissues.
- ✓ Hormones .



Regulation of blood glucose levels
Insulin



Role of glucagon



Role of thyroid hormone

- ✓ It stimulates glycogenolysis & gluconeogenesis.

Hypothyroid

- Fasting blood glucose is lowered.
- Patients have decreased ability to utilise glucose.
- Patients are less sensitive to insulin than normal or hyperthyroid patients.

Hyperthyroid

- Fasting blood glucose is elevated
- Patients utilise glucose at normal or increased rate

Glucocorticoids

- ✓ Glucocorticoids are antagonistic to insulin.
- ✓ Inhibit the utilisation of glucose in extrahepatic tissues.
- ✓ Increased gluconeogenesis .

Epinephrine

- ✓ Secreted by adrenal medulla.
- ✓ It stimulates glycogenolysis in liver & muscle.
- ✓ It diminishes the release of insulin from pancreas.

Other Hormones

- Anterior pituitary hormones

Growth hormone:

- ✓ Elevates blood glucose level & antagonizes action of insulin.
- ✓ Growth hormone is stimulated by hypoglycemia (decreases glucose uptake in tissues)
- ✓ Chronic administration of growth hormone leads to diabetes due to B cell exhaustion.

SEX HORMONES

- ✓Estrogens cause increased liberation of insulin.
- ✓Testosterone decrease blood sugar level.

Hyperglycemia

- Thirst, dry mouth
- Polyuria
- Tiredness, fatigue
- Blurring of vision.
- Nausea, headache,
- Hyperphagia
- Mood change

Hypoglycemia

- Sweating
- Trembling,pounding heart
- Anxiety, hunger
- Confusion, drowsiness
- Speech difficulty
- Incoordination.
- Inability to concentrate

Clinical aspects

- ✓ Glycosuria: occurs when venous blood glucose concentration exceeds 9.5-10.0mmol/L

- ✓ Fructose-1,6-Biphosphatase deficiency causes lactic acidosis & hypoglycemia..

Diabetes Mellitus

A multi-organ catabolic response caused by insulin insufficiency

Muscle

- Protein catabolism for gluconeogenesis

Adipose tissue

- Lipolysis for fatty acid release

Liver

- Ketogenesis from fatty acid oxidation
- Gluconeogenesis from amino acids and glycerol

Kidney

- Ketonuria and cation excretion
- Renal ammoniagenesis.

Energy

Energy is the capacity to do work. We need energy for :

Basal Metabolism

- Basal Metabolic Rate- BMR: energy required for activity of the internal organs and maintaining of body temperature.

Physical Activity

Metabolizing of Food

Calorie: unit used to measure energy

Kilocalorie is a unit of energy commonly used to express energy value of food.

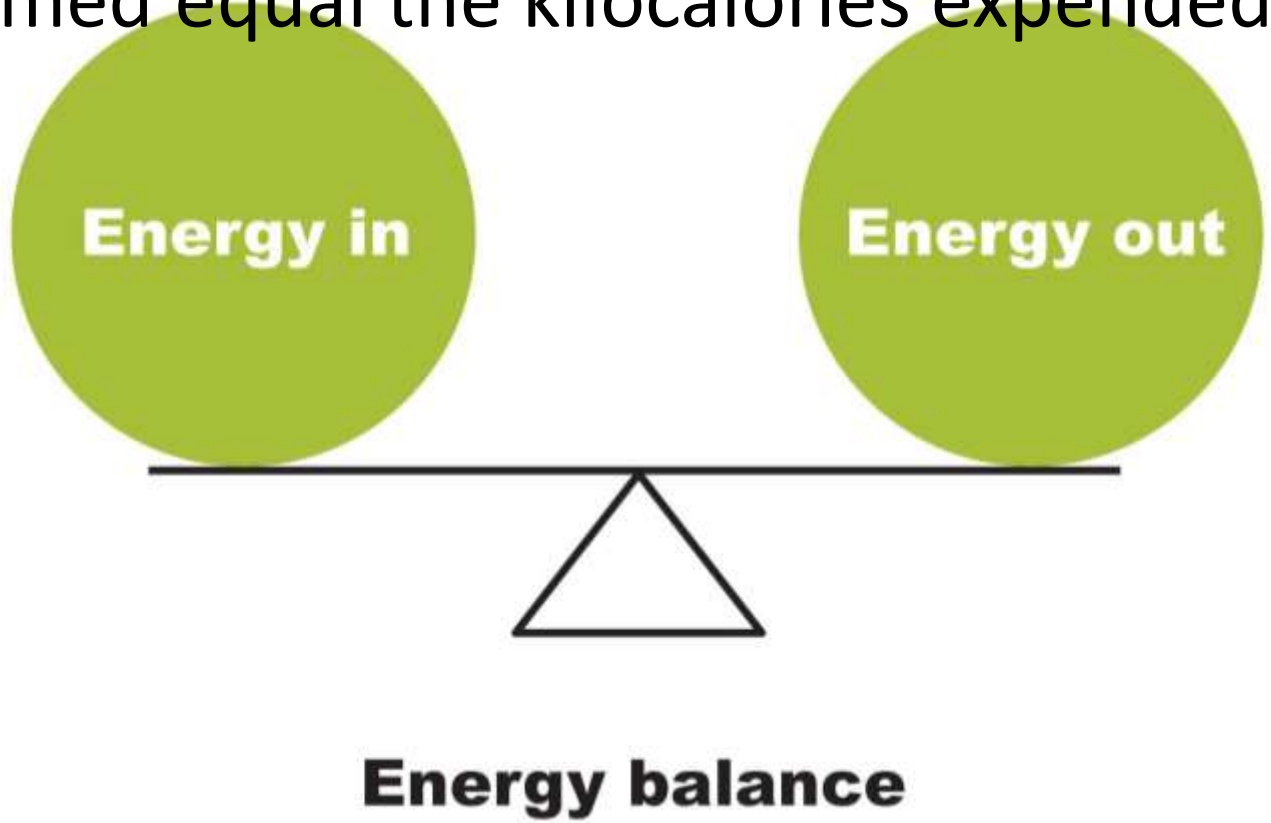
Food energy is the amount of energy in food that is a available through digestion. The energy value of food indicates its value to the body as fuel.

Kilocalories come from foods and beverages

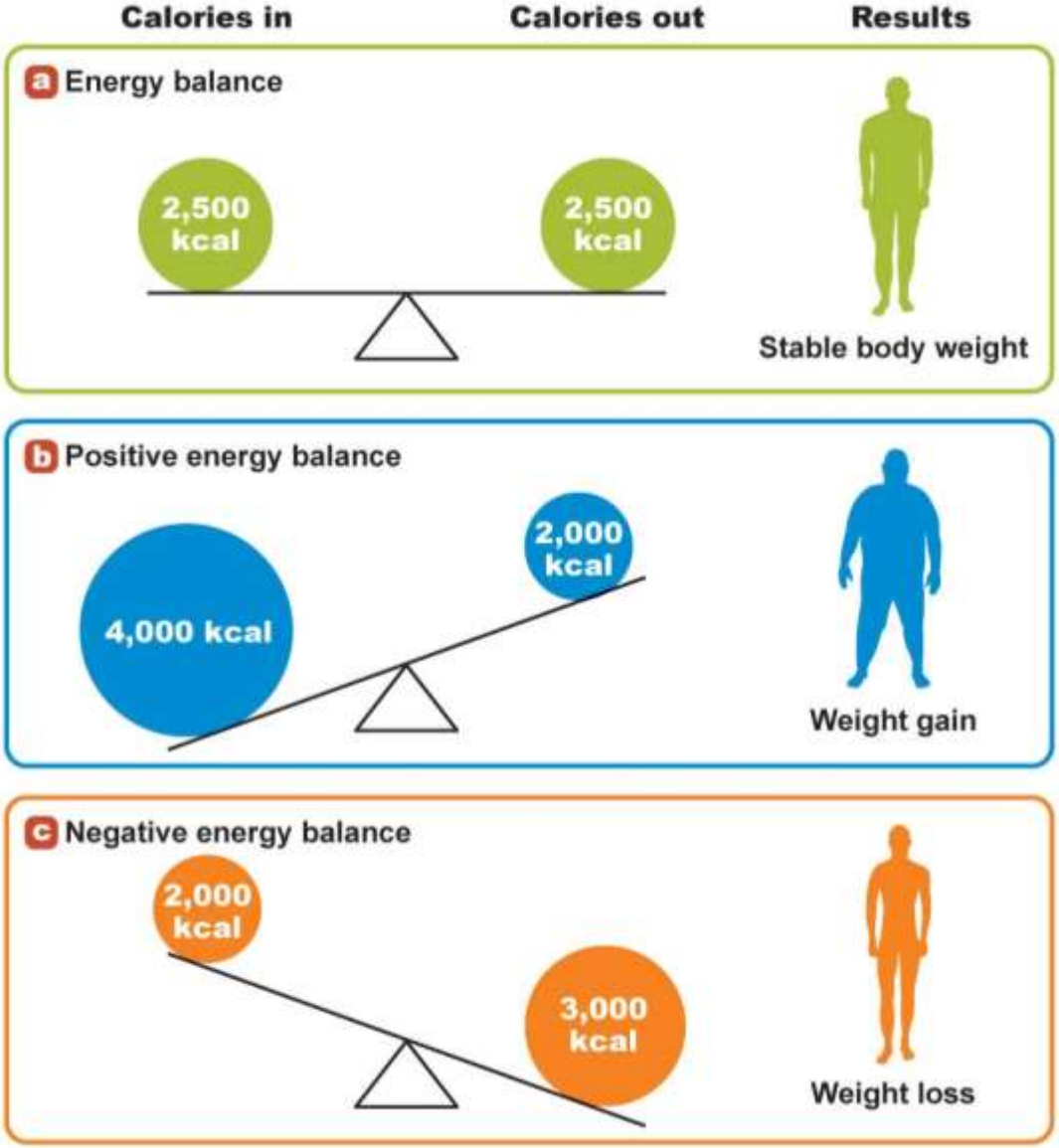
- **Bomb calorimeter** used in laboratories to measure kilocalories in foods and beverages
  - Results must be adjusted for the **physiological fuel values**
- Nutrition analysis software or food composition tables can estimate energy in
  - Carbohydrate and Protein: 4 kcal/gram
  - Fat: 9 kcal/gram
  - Alcohol: 7 kcal/gram

What Is Energy Balance and Why Is It Important?

Energy balance is achieved when the kilocalories consumed equal the kilocalories expended



The Concept of Energy Balance



The Basal Metabolic Rate

The mount of energy required by the body for carrying out involuntary work and maintaining the body temperature is known as the basal metabolic rate Keeping your Basal Metabolic Rate (BMR) as high as possible is vital when it comes to weight loss and maintaining healthy body fat levels

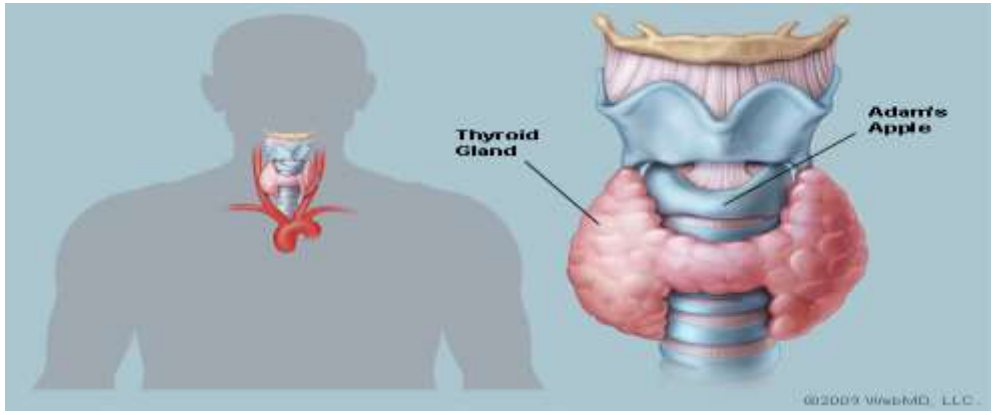
Factors that Affect Basal Metabolic Rate

Exercise: This is one of the biggest factors that influence BMR.

BMR is higher in people who exercise regularly

Hormones: an increase in thyroid hormones increases BMR, decreased levels of the hormone lower BMR

Body Temperature: Excessive heat or cold raise BMR



Gender: Males tend to have higher basal metabolism than females due to an abundance of hormones such as testosterone ad elevated levels of muscle mass compared to females

- **Age**: as we get older basal metabolic rate becomes increasingly slower.

Surface Area: Taller individuals have a higher BMR compared to shorter individuals. More surface area means more heat lost from the body, which causes the metabolism to speed up in order to maintain body temperature.

Stress and Illness: increase in hormone activity due to physical or physiological stress increase BMR.

Starvation: Fasting for more than 48 hrs. will lead to a decrease of 50% of Basal Metabolic Rate.

Table 14.3

Physical Activity Factors for Men and Women

Physical Activity Level	Physical Activity Factor for Men	Physical Activity Factor for Women
Sedentary	1.00	1.00
Low level of activity (walking approximately 2 miles per day at 3 to 4 miles per hour)	1.11	1.12
Active (walking approximately 7 miles per day at 3 to 4 miles per hour)	1.25	1.27
Very active (walking approximately 17 miles per day at 3 to 4 miles per hour)	1.48	1.45

Source: Food and Nutrition Board, National Institute of Medicine. 2005. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids.* Washington, DC: The National Academies Press.

Assessment of OBESITY

- Body mass index= weight in kilograms/(height in meters)2

CLASSIFICATION	BMI
NORMAL	18.5-24.99
OVER WEIGHT	25
GRADE-I	25-29.9
GRADE-II	30-40
GRADE-III	>40

Health Risks Associated with Body Weight and Body Composition

Being overweight increases health risks

- Overweight and obesity associated with increased risk of heart disease, hypertension, stroke, hyperlipidemia, gallstones, sleep apnea, and reproductive problems
- Increases risk of certain cancers including colon, breast, endometrial, and gallbladder cancer
- More than 80% of people with type 2 diabetes are overweight
- Metabolic syndrome is associated with central obesity

Health Risks Associated with Body Weight and Body Composition

Being underweight *also* increases health risks

- Symptomatic of malnutrition, substance abuse, or disease
- Higher risk of anemia, osteoporosis and bone fractures, heart irregularities, and amenorrhea
- Correlated with depression and anxiety, inability to fight infection, trouble regulating body temperature, decreased muscle strength, and risk of premature death
- May be unintentional and due to malabsorption associated with diseases such as cancer, inflammatory bowel disease, or celiac disease


THANK
YOU