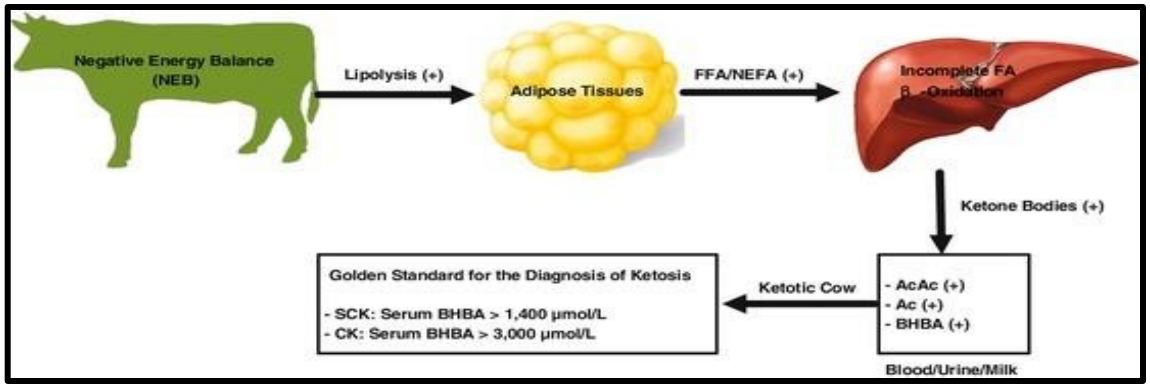
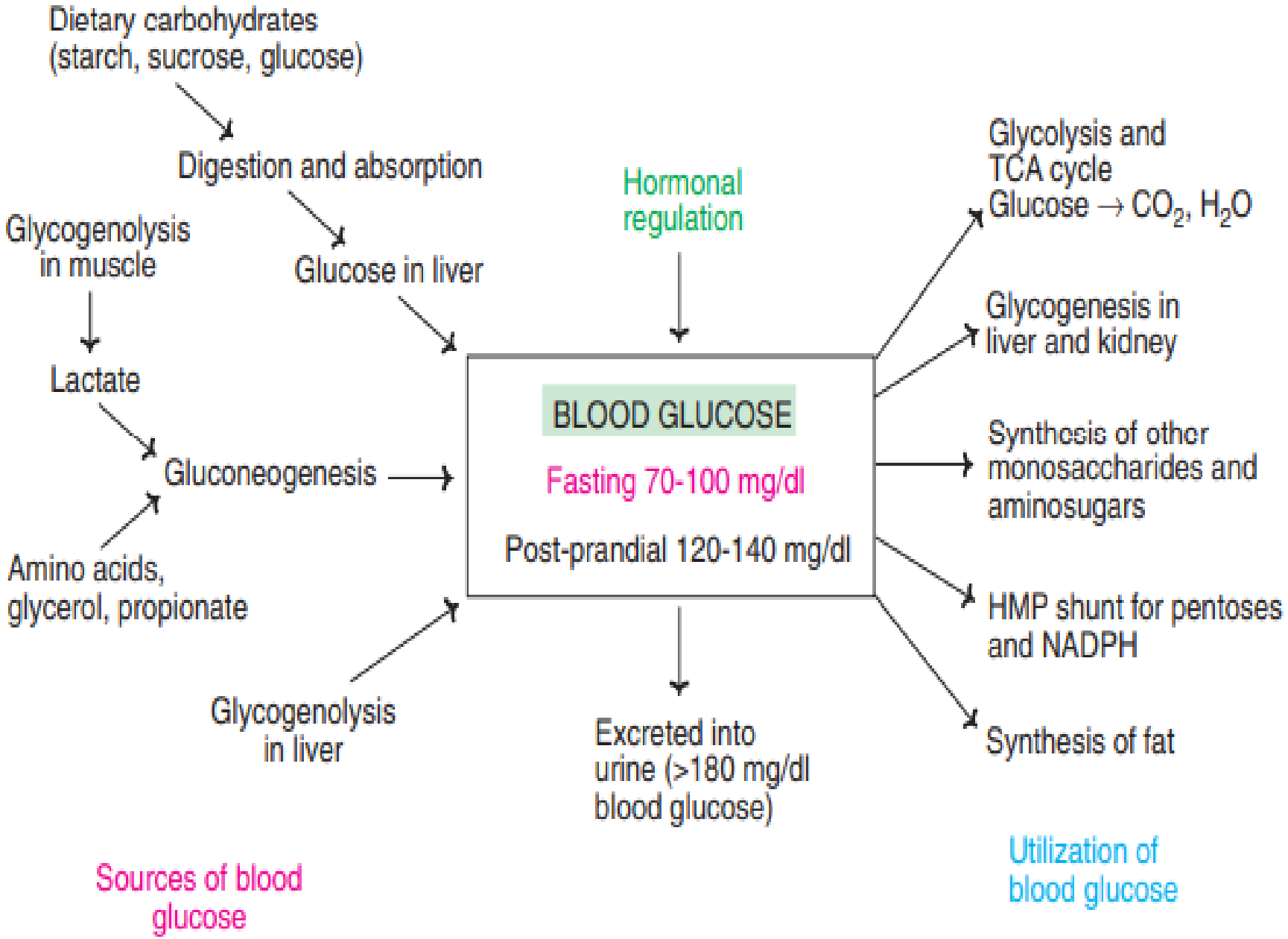
Disorders and Hormonal Control of Carbohydrate Metabolism



Dr. Barkha Gupta
Assistant Professor (Vet. Biochemistry)
PGIVER, Jaipur



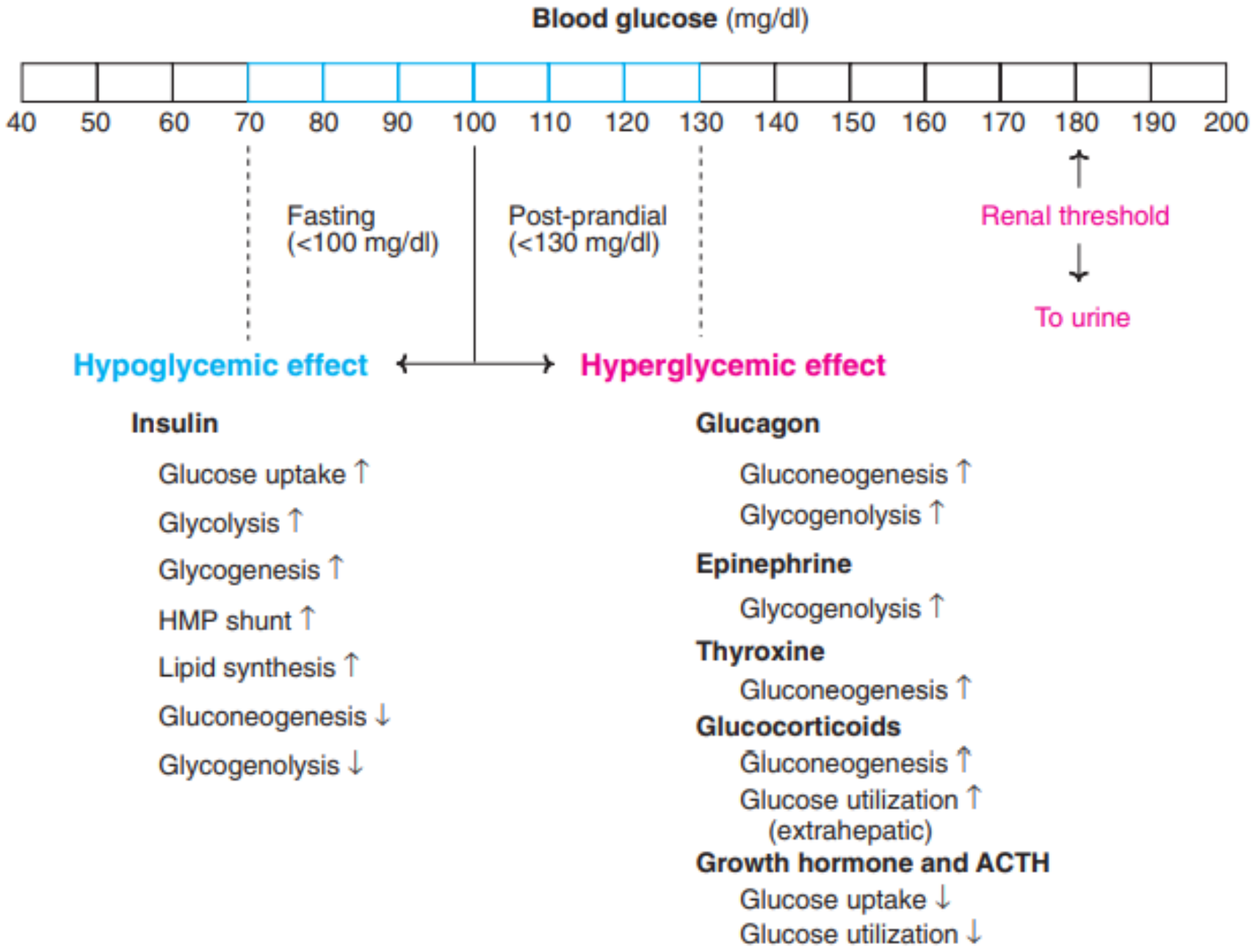
Overview of blood glucose homeostasis.

Metabolic effects of insulin—a summary

Metabolism	Net effect	Effect on important enzyme(s)
Carbohydrate metabolism		
1. Glycolysis	Increased	Glucokinase ↑ Phosphofructokinase ↑ Pyruvate kinase ↑
2. Gluconeogenesis	Decreased	Pyruvate carboxylase ↓ Phosphoenol pyruvate carboxykinase ↓ Glucose 6-phosphatase ↓
3. Glycogenesis	Increased	Glycogen synthetase ↑
4. Glycogenolysis	Decreased	Glycogen phosphorylase ↓
5. HMP shunt	Increased	Glucose 6- phosphate dehydrogenase ↑
Lipid metabolism		
6. Lipogenesis	Increased	Acetyl CoA carboxylase ↑
7. Lipolysis	Decreased	Hormone sensitive lipase ↓
8. Ketogenesis	Decreased	HMG CoA synthetase ↓
Protein metabolism		
9. Protein synthesis	Increased	RNA polymerase ↑
10. Protein degradation	Decreased	Transaminases ↓ Deaminases ↓

Effects of Insulin on Animals

Tissue	Increase	Decrease
Whole animal	Anabolism Food intake Respiratory quotient	
Blood		Glucose Ketones Fatty acids Phosphate Potassium Amino acids Ketone bodies
Enzymes	Glucokinase Phosphofructokinase Pyruvate kinase Lipoprotein lipase AcCoA carboxylase	Glucose-6-phosphatase Fructose 1-6-diphosphatase Pyruvate carboxylase PEP-carboxykinase Carnitine acyltransferase Hormone-sensitive lipase
Liver	Glucose oxidation Glycogen synthesis Lipid synthesis Protein synthesis	Glucose production Ketogenesis
Muscle	(Skeletal/Heart) Glucose uptake Glucose oxidation Glycogen synthesis Amino acid uptake Protein synthesis Potassium uptake	
Adipose	Glucose uptake Glucose oxidation Lipid synthesis Potassium uptake	



Hormonal regulation of blood glucose.

Blood Glucose Levels in Domestic Animals

	Glucose (Reference Range and Mean ± SD)	
Species	mmol/liter	mg/d
Horse	4.2–6.4 (5.3 ± 0.4)	75–115 (95 ± 8)
Cow	2.5–4.2 (3.2 ± 0.4)	45–75 (57 ± 7)
Sheep	2.8–4.4 (3.8 ± 0.3)	50–80 (68 ± 6)
Goat	2.8–4.2 (3.5 ± 0.4)	50–75 (63 ± 7)
Pig	4.7–8.3 (6.6 ± 0.9)	85–150 (119 ± 17)
Dog	3.6–6.5 (5.0 ± 0.4)	65–118 (90 ± 8)
Cat	2.8–4.2 (3.5 ± 0.4)	50–75 (63 ± 7)
Monkey (*Macaca* sp.)	4.7–7.3 (5.9 ± 0.7)	85–130 (107 ± 13)
Llama	5.7–8.9 (7.1 ± 0.9)	103–160 (128 ± 16)
Rabbit	2.8–5.2 (4.1 ± 0.5)	50–93 (73 ± 10)

[a] *Plasma or serum, glucose oxidase method, adult animals.*

Glucose Transporters

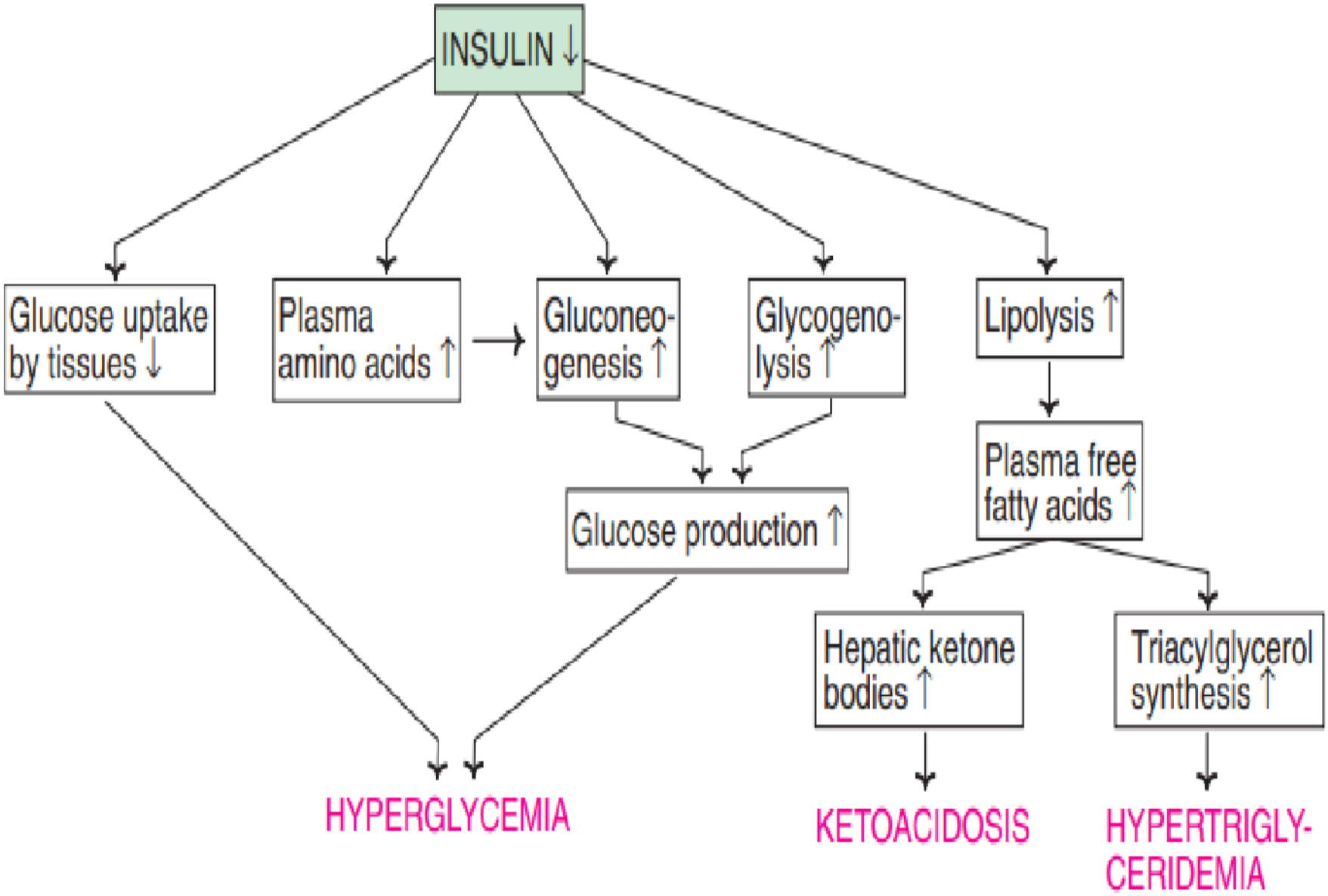
	Tissue Location	Functions
Facilitative bidirectional transporters		
GLUT 1	Brain, kidney, colon, placenta, erythrocytes	Glucose uptake
GLUT 2	Liver, pancreatic β cell, small intestine, kidney	Rapid uptake or release of glucose
GLUT 3	Brain, kidney, placenta	Glucose uptake
GLUT 4	Heart and skeletal muscle, adipose tissue	Insulin-stimulated glucose uptake
GLUT 5	Small intestine	Absorption of glucose & Fructose
Sodium-dependent unidirectional transporter		
SGLT 1	Small intestine and kidney	Active uptake of glucose against a concentration gradient

Diabetes Mellitus

Diabetes mellitus is a syndrome with disordered metabolism and inappropriate hyperglycemia due to either a deficiency of insulin secretion or a combination of insulin resistance and inadequate insulin secretion to compensate.

or

Diabetes mellitus is a metabolic chronic disease, more appropriately a disorder of fuel metabolism with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action/ resistance, or both. It is mainly characterized by hyperglycemia that leads to several long term (chronic) complications. The effects of diabetes mellitus include long–term damage, dysfunction and failure of various organs.



Major metabolic alterations in diabetes mellitus.

Sign and Symptoms of Diabetes Mellitus

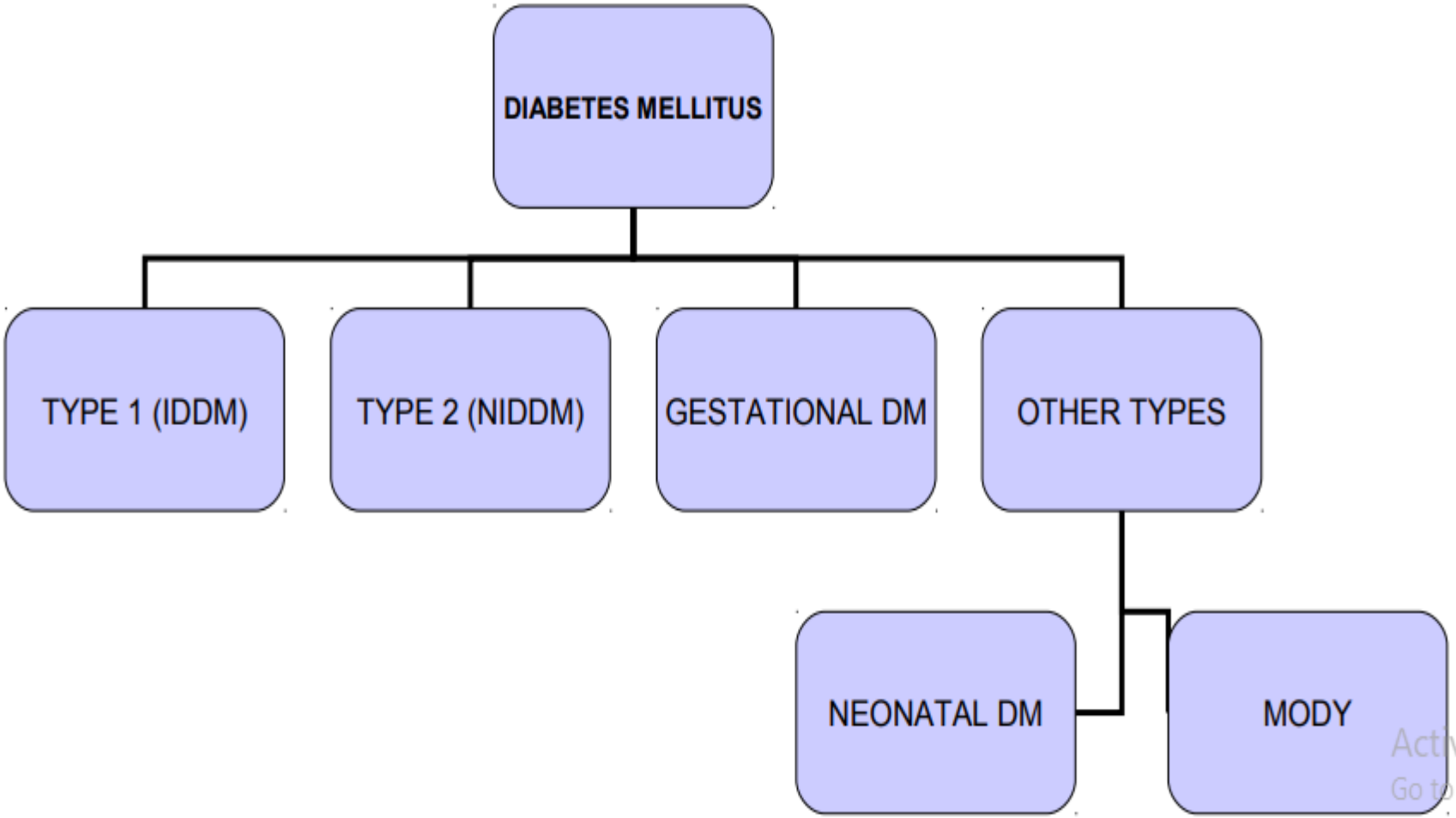
- Increased Thirst
- Frequent Urination
- Unexpected Weight Loss
- Increased Fatigue
- Blurred Vision
- Numbness and Tingling ,Especially in Feet & Hands
- Slow Healing Sores
- Red , Swollen ,Tender Gums
- Skin Itchy
- Irritability

SIGNS AND SYMPTOMS

Diabetes Mellitus in Animals

- Although diabetes mellitus has been reported in virtually all laboratory animals (gerbils, guinea pigs, hamsters, mice, rats, non-human primates) and in horses, cattle, sheep, and pigs, **it is most frequently found in dogs and cats.**
- Estimates of the incidence of diabetes range as high as 1:66 (1.52%) for dogs and 1:800 for cats.

TYPES OF DIABETES MELLITUS

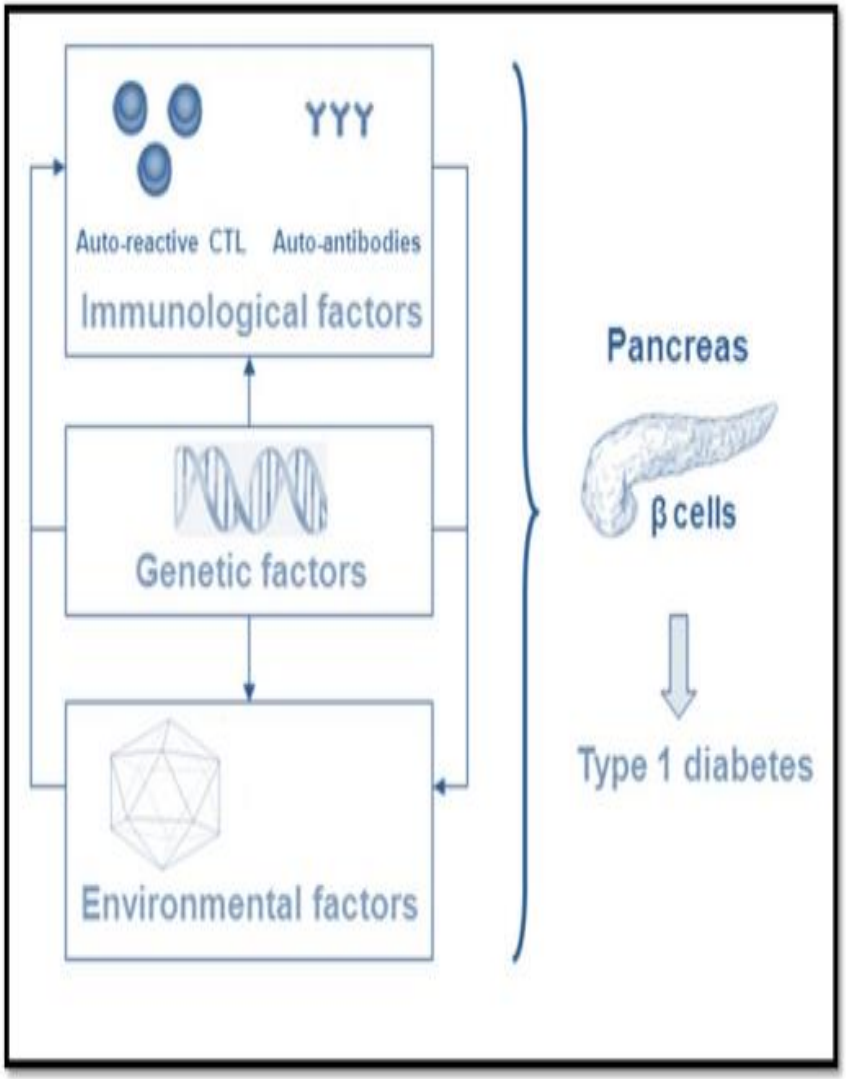


MODY: Maturity onset diabetes of the young

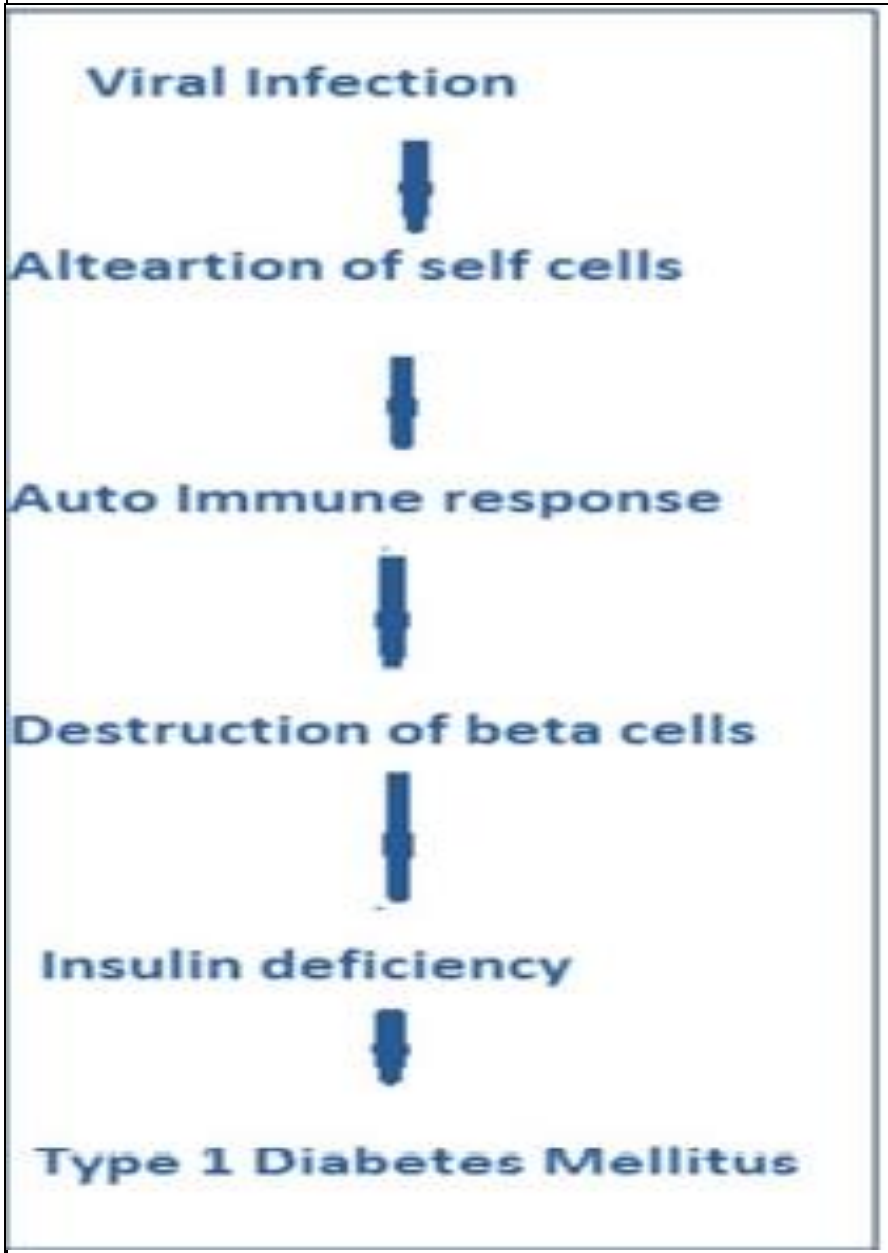
Insulin-dependent diabetes mellitus (IDDM)

- **IDDM**, also known as **type I diabetes** or (less frequently) **juvenile onset diabetes**, mainly occurs in childhood (particularly between 12-15 yrs age).
- IDDM accounts for about **10 to 20%** of the known diabetics.
- This disease is characterized by **almost total deficiency of insulin due to destruction of β-cells of pancreas**. The β -cell destruction may be caused by **drugs, viruses or autoimmunity.** Due to certain genetic variation, the β -cells are recognized as non-self and they are destroyed by immune mediated injury. Usually, the symptoms of diabetes appear when 80-90% of the β -cells have been destroyed. The pancreas ultimately fails to secrete insulin in response to glucose ingestion.
- The patients of IDDM require **insulin therapy**.

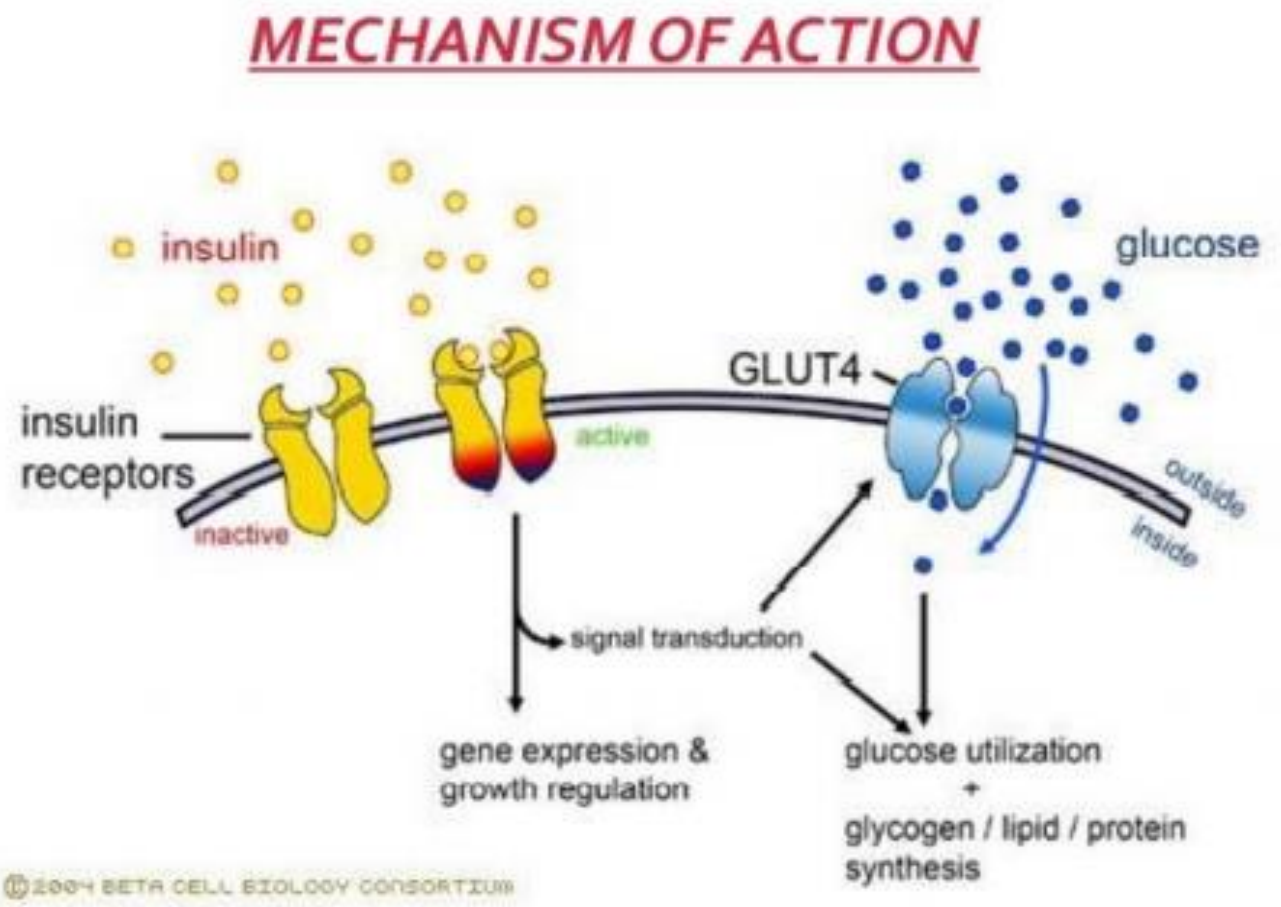
Type 1 Diabetes Mellitus- An Overview of Etiology



Pathophysiology of Diabetes Mellitus Type-I



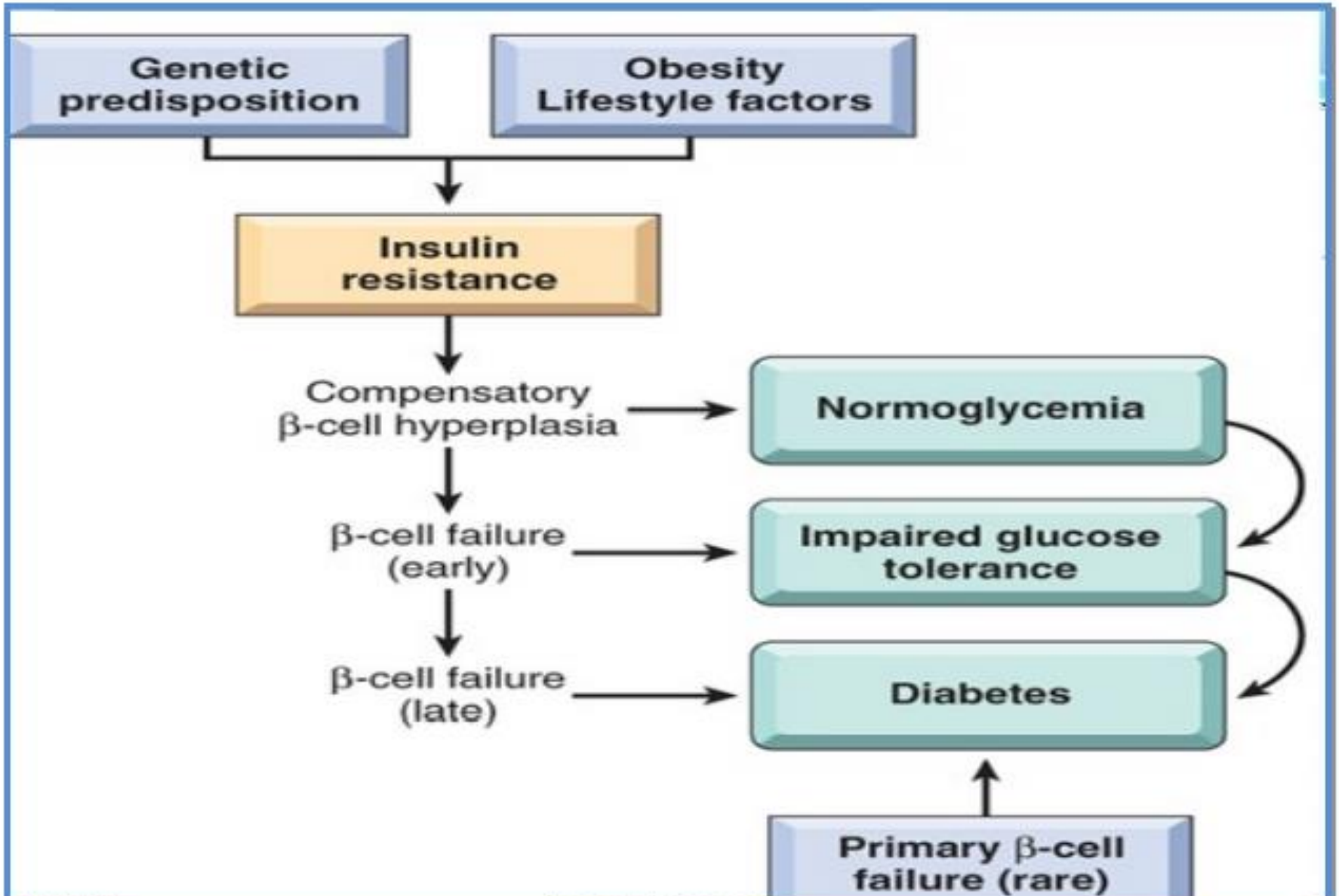
MECHANISM OF ACTION OF INSULIN (IDDM)



Non-insulin dependent diabetes mellitus (NIDDM)

- **NIDDM,** also called **type II diabetes** or (less frequently) **adult-onset diabetes**, is the **most common**, accounting for **80 to 90%** of the diabetic population.
- NIDDM occurs in adults (usually above 35 years) and is less severe than IDDM.
- The causative factors of NIDDM include genetic and environmental.
- NIDDM more commonly occurs in obese individuals. Overeating coupled with underactivity leading to obesity is associated with the development of NIDDM. **Obesity acts as a diabetogenic factor** and leads to a decrease in insulin receptors on the insulin responsive (target) cells.
- Recent research findings on NIDDM suggest that increased levels of tumor necrosis factor-D (TNF-D) and resistin, and reduced seretion of adiponectin by adipocytes of obese people cause insulin resistance (by impairing insulin receptor function).
- The patients of NIDDM may have either normal or even increased insulin levels. Many a times weight reduction by diet control alone is often sufficient to correct NIDDM.

Pathophysiology of Type 2 DM



Comparison of two types of diabetes mellitus

Character	Insulin-dependent diabetes mellitus (IDDM)	Non-insulin dependent diabetes mellitus (NIDDM)
General		
Prevalence	10-20% of diabetic population	80-90% of diabetic population
Age at onset	Usually childhood (<20 yrs)	Predominantly in adults (>30yrs)
Body weight	Normal or low	Obese
Genetic predisposition	Mild or moderate	Very strong
Biochemical		
Defect	Insulin deficiency due to destruction of β-cells	Impairment in the production of insulin by β-cells and/or resistance of target cells to insulin
Plasma insulin	Decreased or absent	Normal or increased
Auto antibodies	Frequently found	Rare
Ketosis	Very common	Rare
Acute complications	Ketoacidosis	Hyperosmolar coma
Clinical		
Duration of symptoms	Weeks	Months to years
Diabetic complications at diagnosis	Rare	Found in 10-20% cases
Oral hypoglycemic drugs	Not useful for treatment	Suitable for treatment
Administration of insulin	Always required	Usually not necessary

Long term effects of DM

- Hyperglycemia is directly or indirectly associated with several complications.
- These include **atherosclerosis, retinopathy, nephropathy and neuropathy.**
- It is believed that at least some of them are related to microvascular changes caused by glycation of proteins.

Laboratory Diagnosis of DM

1. Urine Analysis:

A. Detection of Glucosuria-

- Benedict's and Fehling's test
- A specific and convenient method to detect glucosuria is the paper strip impregnated with glucose oxidase and a chromogen system (Clinistix, Diastix), which is sensitive to as little as 0.1% glucose in urine.

B. Detection of Ketonuria- Qualitative detection of ketone bodies can be accomplished by nitroprusside tests (Acetest or Ketostix), Rothera's test etc.

C. Microalbuminuria- Albumin excretion rate intermediate between normality (2.5-25 mg/day) and macroalbuminuria (250mg/day). Microalbuminuria is a common finding (even at diagnosis) in type 2 diabetes mellitus and is a risk factor for macro vascular (especially coronary heart) disease.

Laboratory Diagnosis of DM

2. Blood Biochemistry:

A. Blood Glucose Estimation

- Fasting blood Glucose
- Random blood Glucose
- Glucose tolerance test

B. Glycated hemoglobin (Hb1C) measurements

C. Serum fructosamine estimation

D. Serum Lipids

Laboratory Diagnosis of DM

3. Immunological Assays:

- Antibodies to insulin, islet cells, or Glutamic acid decarboxylase (GAD) can be estimated to differentiate between the types of diabetes mellitus.
- They are **absent in type 2 diabetes mellitus**.
- Latent autoimmune diabetes of adults, or **LADA,** is a form of slow-onset type 1 diabetes that occurs in middle-aged (usually white) adults.
- It can be differentiated from type 2 diabetes by measuring anti-GAD65 antibodies.

Glucose Tolerance Test (GTT)

- The diagnosis of diabetes can be made on the basis of individual's response to oral glucose load, the **oral glucose tolerance test (OGTT).**
- **Methodology:** Glucose tolerance test should be conducted preferably in the morning (ideal 9 to 11 AM). A fasting blood sample is drawn and urine collected. The subject is given 75 g glucose orally, dissolved in about 300 ml of water, to be drunk in about 5 minutes. Patients should be in an overnight (at least 10 hr) fasting state.
- Blood and urine samples are collected at 30 minute intervals for at least 2 hours. All blood samples are subjected to glucose estimation while urine samples are qualitatively tested for glucose.

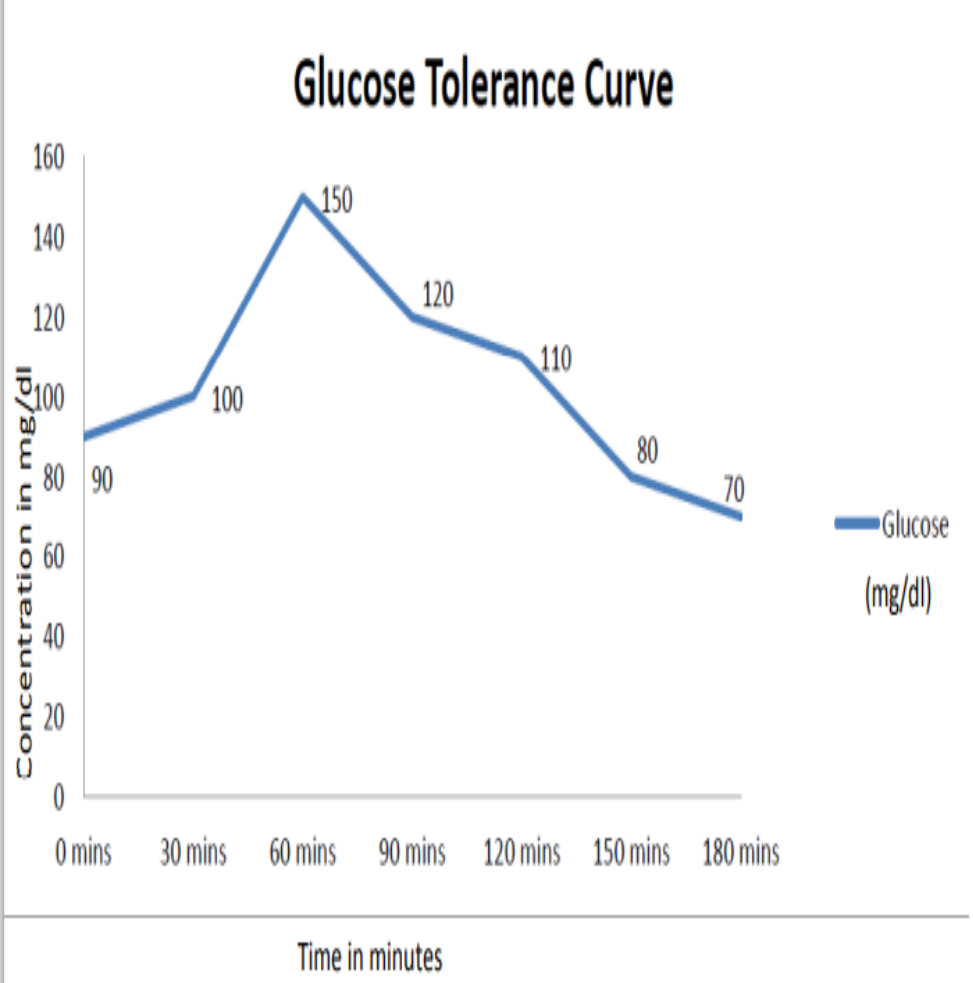
Interpretation of GTT

Diagnostic criteria for oral glucose tolerance test (WHO 1999)

Condition	Plasma glucose concentration as mmol/l (mg/dl)		
	Normal	Impaired glucose tolerance	Diabetes
Fasting	<6.1 (<110)	<7.0 (<126)	>7.0 (>126)
2 hours after glucose	<7.8 (<140)	<11.1 (<200)	>11.1 (>200)

- The fasting plasma glucose level is 75–110 mg/dl in **normal** persons. On oral glucose load, the concentration increases and the peak value (140 mg/dl) is reached in less than an hour which returns to normal by 2 hours.
- In individuals with **impaired glucose tolerance**, the fasting (110-126 mg/dl) as well as 2 hour (140-200 mg/dl) plasma glucose levels are elevated.
- A person is said to be suffering from **diabetes mellitus** if his/her fasting plasma glucose exceeds 7.0 mmol/l (126 mg/dl) and, at 2 hrs. 11.1 mmol/l (200 mg/dl).

Glucose Tolerance Test



Normal Glucose tolerance curve

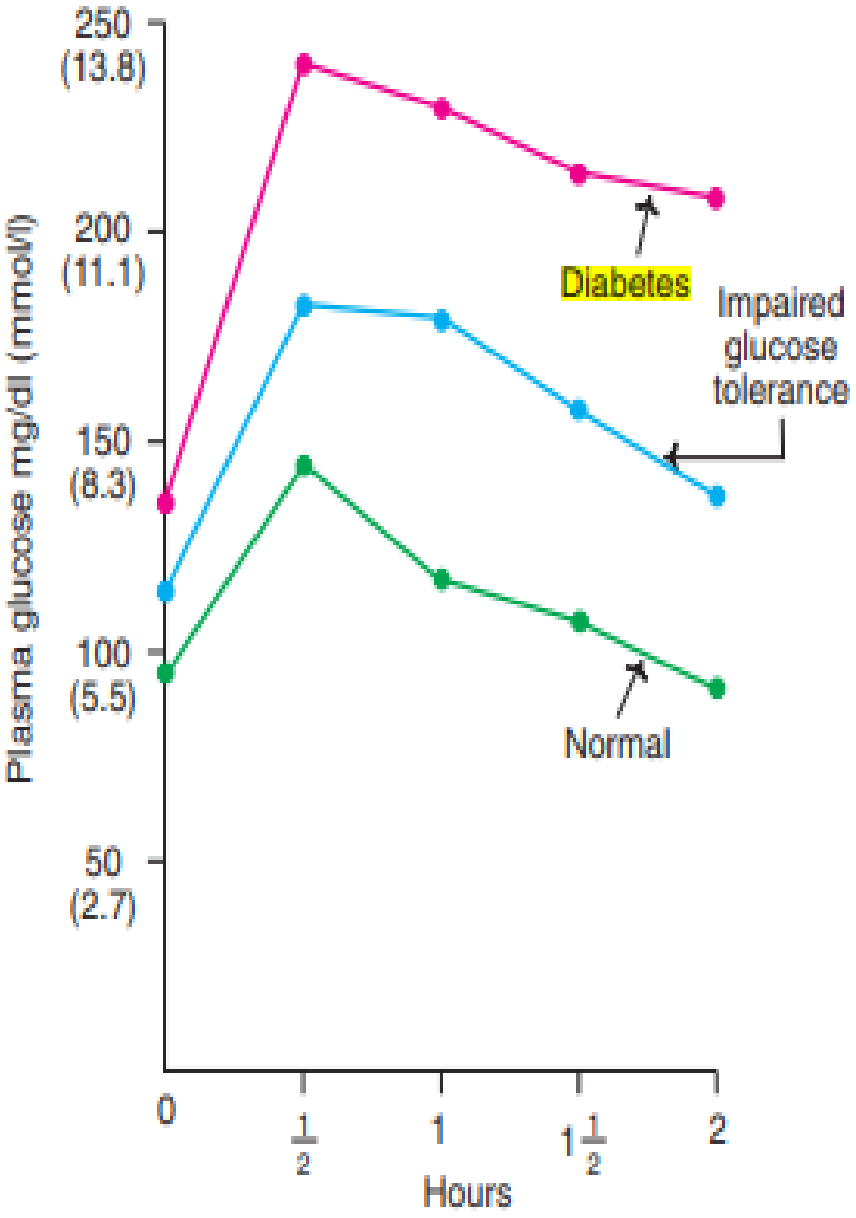


***Fig. 36.8** : Oral glucose tolerance test.*

Management of DM

- The major components of the treatment of diabetes are:

A	• Diet and Exercise
B	• Oral hypoglycaemic therapy
C	• Insulin Therapy

Management of diabetes

Diet, exercise, drug and, finally, insulin are the management options in diabetics. Approximately, 50% of the new cases of diabetes can be adequately controlled by diet alone, 20- 30% need oral hypoglycemic drugs while the remaining 20-30% require insulin.

1. **Dietary management:** A diabetic patient is advised to consume **low calories** (i.e. low carbohydrate and fat), **high protein and fiber rich diet.** Carbohydrates should be taken in the form of starches and complex sugars. As far as possible, refined sugars (sucrose, glucose) should be avoided. Fat intake should be drastically reduced so as to meet the nutritional requirements of unsaturated fatty acids. Diet control and exercise will help to a large extent obese NIDDM patients.

Management of diabetes

2. Hypoglycemic drugs: The oral hypoglycemic drugs are broadly of two categories-sulfonylureas and biguanides. The latter are less commonly used these days due to side effects.

Sulfonylureas such as acetohexamide, tolbutamide and glibenclamide are frequently used. They promote the secretion of endogenous insulin and thus help in reducing blood glucose level.

3. **Management with insulin :** Two types of insulin preparations are commercially available—short acting and long acting.

- The short acting insulins are unmodified and their action lasts for about 6 hours.
- The long acting insulins are modified ones (such as adsorption to protamine) and act for several hours, which depends on the type of preparation.

The advent of genetic engineering is a boon to diabetic patients since bulk quantities of insulin can be produced in the laboratory.

Biochemical indices of diabetic control For a diabetic patient

1. **Glycated hemoglobin:**

- Glycated or glycosylated hemoglobin refers to the glucose derived products of normal adult hemoglobin (HbA).
- Among the glycated hemoglobins, the most abundant form is **HbA1c**. HbA1c is produced by the condensation of glucose with N-terminal valine of each E-chain of HbA.
- Normally, HbA1c concentration is about 3–5% of the total hemoglobin. In diabetic patients, **HbA1c is elevated (to as high as 15%)**. Determination of HbA1c is used for monitoring of diabetes control. HbA1c reflects the mean blood glucose level over 2 months period prior to its measurement. In the routine clinical practice, if the HbA1c concentration is **less than 7%,** the diabetic patient is considered to be in good control.

Biochemical Indices

2. Fructosamine: Besides HbA1c, several other proteins in the blood are glycated. Glycated serum proteins (fructosamine) can also be measured in diabetics. As albumin is the most abundant plasma protein, glycated albumin largely contributes to plasma fructosamine measurements. Albumin has shorter half-life than Hb. Thus, glycated albumin represents glucose status over 3 weeks prior to its determination.

3. Microalbuminuria: Microalbuminuria is defined as the excretion of 30-300 mg of albumin in urine per day. It may be noted that microalbuminuria represents an intermediary stage between normal albumin excretion (2.5–30 mg/d) and macroalbuminuria (> 300 mg/d). The small increase in albumin excretion predicts impairment in renal function in diabetic patients. Microalbuminuria serves as a signal of early reversible renal damage.

4. Serum lipids: Determination of serum lipids (total cholesterol, HDL, triglycerides) serves as an index for overall metabolic control in diabetic patients. Hence, serum lipids should be frequently measured.

Hypoglycemia of Baby Pigs

- Hypoglycemia of baby pigs occurs during the first few days of life and is characterized by hypoglycemias of 2.2 mmol/l (40 mg/dl), apathy, weakness, convulsions, coma, and finally death.
- The newborn baby pig is particularly susceptible to hypoglycemia. At birth, the blood glucose level is 6 mmol/l (110 mg/dl) and, unless the pig is fed or suckles shortly after birth, its blood glucose drops rapidly to hypoglycemic levels within 24 to 36 hours. The liver glycogen, which is high (14.8%) at birth, is almost totally absent at death. In contrast, newborn lambs, calves, and foals are able to resist starvation hypoglycemia for more than a week.
- If the baby pig suckles, its ability to withstand starvation progressively increases from the day of birth. A 10-day-old baby pig can be starved up to 3 weeks before symptoms of hypoglycemia occur.
- Gluconeogenic mechanisms are undeveloped in the newborn pig, which indicates that the gluconeogenic enzymes of the baby pig are inadequate at birth. This also indicates that these enzymes need to be induced by feeding so they can reach their maximal activities within 1 or 2 weeks after birth.
- Starvation of the newborn pig under natural conditions can occur because of factors relating to the sow (agalactia, metritis, etc.) or to the health of the baby pig (anemia, infections, etc.), either case resulting in inadequate food intake.

Hyperinsulinism in Dogs

- It is known to be due to a persistent hyperactivity of the pancreas as the result of insulin secreting islet cell tumors. Excess insulin can be extracted from metastatic foci in liver as well as from the pancreatic tumor. There are many reports on this disease in dogs.
- **Hyperinsulinism is characterized by a persistent hypoglycemia with periods of weakness, apathy, fainting, and during hypoglycemic crises, convulsions, and coma. The symptoms are also relieved by glucose administration.**
- The glucose tolerance curve is generally characteristic of an increased tolerance if the test is modified: (1) the dog is on a standard carbohydrate diet for 3 days; (2) the intravenous test is used, and, most important; (3) blood sampling is continued for 6 to 8 hours. A prolongation of the hypoglycemic phase is the most significant portion of the curve.

Ketosis

- Ketosis is a state the body goes into if it needs to break down body fat for energy. The state is marked by raised levels of ketones (ketone Bodies) in the blood.
- If there is not enough glucose present, the body will resort to an alternative strategy in order to fuel itself.

Bovine Ketosis & Pregnancy Toxemia

- **Hypoglycemia** is such a consistent finding in **bovine ketosis and in ovine pregnancy toxemia.**
- This hypoglycemia has played an important role in ketosis, as a rationale for therapy and as a basis for the concept of **ketosis** and **pregnancy toxemia** as manifestations of **a carbohydrate deficiency, which occurs under conditions of excessive demands**.
- **Bovine ketosis, on the other hand, occurs in the high producing dairy cow, characteristically during the early stages of lactation when milk production is generally the highest. Abnormally high levels of the ketone bodies, acetone, AcAc, 3-OH-B, and isopropanol appear in blood, urine, and in the milk.**
- The clinical signs of ketosis accompany these alterations: **loss of appetite, weight loss, decrease in milk production, and nervous disturbances.**
- The energy metabolism of the ruminant is focused on the utilization of the volatile fatty acids produced by rumen fermentation rather than on carbohydrates as in the non-ruminant.

Bovine Ketosis

- Bovine ketosis occurs in the high producing dairy cows during the early stages of lactation, when the milk production is generally the highest.
- Abnormally high levels of the ketone bodies i. e. Acetone, acetoacetic acid and beta-hydroxy butyric acid and also iso-propanol appear in blood, urine and in milk.
- The alterations are accompanied by loss of appetite, weight loss, decrease in milk production and nervous disturbances.
- **Hypoglycemia (starvation) is a common finding in bovine ketosis.**
- In non-ruminants, liver is the sole source of ketone bodies. In ruminants, the rumen epithelium and mammary gland are also sources of ketone bodies production.
- Among the ketone bodies acetone does not ionize to the appreciable level, whereas, acetoacetic and β- hydroxybutyric acids will ionize readily.
- Acetoacetate and β -hydroxybutyric acid are more powerful acids than the volatile fatty acids.

Ketosis in Lactation

- **During lactation plasma glucose is drained for the synthesis of lactose by the mammary gland.**
- The two sources of plasma glucose are absorption from the gut and gluconeogenesis.
- In ruminants little glucose is absorbed from the gut.
- Most of the glucose is synthesized in the liver and in the kidney.
- **The chief substrates are propionate, which is produced in high grain diet.**
- **When there is a mismatch between mammary drain of glucose for lactose synthesis and gluconeogenesis in liver, hypoglycemia will result. The condition leads to ketosis.**

Hypoglycemic Theory of Ketosis

- The most widely accepted theory of bovine ketosis is the **hypoglycemic theory**.
- During lactation mammary gland might withdraw glucose from the plasma more rapidly than the liver can supply it, which leads to hypoglycemia.
- The hypoglycemia will lead to ketonemia as more of the Long Chain Fatty Acids (LCFAs) will reach the liver and oxidized. The net result of this is an increase in the level of ketone bodies.

Laboratory Test for Ketosis

- Rothera's test is used as a qualitative test for ketone bodies. The test is most sensitive for acetoacetic acid.
- Acetone gives only a slight response, whereas β-hydroxbutyric acid is insensitive to this test.
- A number of drugs (substances) having keto, aldehyde or sulfhydril groups i. e. phenyl-ketones, acetaldehyde etc. can also react with nitroprusside and give false positive result.
- Other tests are Ross test and Cow side test.

Ketoacidosis

- Ketoacidosis is a metabolic acidosis due to an excessive blood concentration of ketone bodies (acetone, acetoacetate and beta-hydroxybutyrate).
- Ketone bodies are released into the blood from the liver when hepatic lipid metabolism has changed to a state of increased ketogenesis.
- The abnormal accumulation of ketones in the body occurs due to excessive breakdown of fats, in deficiency or inadequate use of carbohydrates.
- It is characterized by ketonuria, loss of potassium in the urine, and a fruity odor of acetone on the breath.
- Untreated, ketosis may progress to ketoacidosis, coma, and death.
- This condition is seen in starvation, occasionally in pregnancy if the intake of protein and carbohydrates is inadequate, and most frequently in diabetes mellitus.
- **Different Types of Keto-acidosis**

Diabetes Keto Acidosis (DKA)

- Due to lack of insulin glucose uptake and metabolism by cells is decreased. Fatty acid catabolism increased in resulting in excess production of ketone bodies.

Starvation Ketosis

- Starvation leads to hypoglycemia as there is little or no absorption of glucose from intestine and also due to depletion of liver glycogen. In Fatty acid oxidation leads to excess ketone body.

Diabetic ketoacidosis

- Diabetic Ketoacidosis (DKA) is a state of inadequate insulin levels resulting in high blood sugar and accumulation of organic acids and ketones in the blood.
- It is a potentially life-threatening complication in patients with diabetes mellitus.
- It happens predominantly in type 1 diabetes mellitus, but it can also occur in type 2 diabetes mellitus under certain circumstances.

Digestive Disorder (Gastro-Intestinal Diseases) of Ruminants

1. Acute rumen Indigestion:

- When the animals consuming roughages are overloaded with readily fermentable carbohydrates, high concentrations of lactic acid accumulate in the rumen and subsequently in the blood.
- Rumen bacteria produce mixture of lactic acid, L-lactic acid is absorbed and metabolized but D- lactate cannot be utilized, which contributes to the acid load. This result in metabolic acidosis.
- Lactic acid accumulation in the rumen reduces the pH to 5 or less, which allows the growth of acid producing bacteria. Accumulation of lactate increases the osmolality of the rumen, which results in the absorption of water from the systemic circulation. This causes severe dehydration, which in turn may lead to hypovolemic shock.

Digestive Disorder (Gastro-Intestinal Diseases) of Ruminants

2. Bloat:

- The gases (co_2, methane) produced during the rumen fermentation are removed by the process called eructation. When the process is blocked gas produced by the rumen microbes cannot escape and the pressure is increased, which causes acute tympany, leading to death. Two general types of bloats are Simple bloat (Free gas) and frothy bloat (Foamy).
- When cattle consumes legumes, which contains soluble plant proteins a stable froth is formed in which gas is trapped as small bubbles which are eliminated by eructation. When cattle are with high concentration diet, formation of extracellular dextran slime by amylolytic bacteria in the rumen is the cause of stable foam.
- Non ionic detergent with surfactant property can be used for treatment eg. Sodium alkyl sulfonate.

Digestive Disorder (Gastro-Intestinal Diseases) of Ruminants

3. Urea poisoning:

- Ammonia and other NPN substances metabolized to ammonia are used by microbes to synthesize microbial proteins, which are subsequently utilized by the ruminants for the synthesis of body proteins.
- Urea poisoning the develops when urea is fed at more than 3% level as urea is hydrolyzed to co_2 and NH_3 by urease enzyme of ruminal bacteria. (Excess urea result in release of excess of ammonia in excess of what the liver can tolerate). The free ammonia crosses the cell membrane thereby producing harmful effects.
- When acetic acid is given orally, the proton of acetic acid converts free ammonia to ammonium ion, which reduces the absorption of NH_3. The NH_3, which has no charge, will diffuse freely, whereas ammonium ion is charged, diffusion is prevented.

Digestive Disorder of Non-Ruminants
Gastric dilatation volvulus (GDV)

- **It is an acute GI tract disorder, which is due to the accumulation of gas and fluid in the stomach causing mechanical and functional disturbances to pyloric out flow.**
- The stomach distends and rotates causing obstruction due to which there is necrosis and perforation of the stomach wall.
- There is hyperkalemia, hyperphosphotemia due to reduced renal flow. There is release of intracellular potassium from the damaged tissues. Due to the leakage of fluid from the blood vessels into tissues, there is haemoconcentration, which results in increased blood urea nitrogen and creatinine values.
- Due to degeneration of stomach cells and alteration of liver, the transaminases activities are increased. There is increase lactic acid production, which cause metabolic acidosis.

Digestive Disorder of Non-Ruminants

- **Vomiting:** During vomition, loss of water and HCl. This loses result in dehydration and metabolic alkalosis with increased level of bicarbonate ion and decreased level of chloride ion concentration. Gastric vomition may also cause hypokalemia, which may be due to increased urinary excretion during alkalosis. Potassium deficiency and hypovolemic due to dehydration may cause renal tubular damage and kidney failure
- **Diarrhoea:** Diarrhoea results in dehydration associated with H^+ and electrolyte disturbances. Dehydration cause haemoconcentration, which leads to hypovolemic shock, this is characterized by decreased excretion of hydrogen over production of lactic acid, Hyperkalemia and Hypoglycemia.
- **Lactose Intolerance:** Lactose intolerance-the inability to break down the lactose in milk due to deficiency of enzyme lactase secreted by the intestinal cells. Lactose mal-absorption and milk products intolerance symptoms are the most common alimentary tract disorders. Especially seen in young ones. Diarrhea, gas, and abdominal pain can occur when there is not enough lactase to digest milk products. Lactose intolerance was identified as the cause of bovine neonatal diarrhea. The clinical symptoms of lactose intolerance belong: nausea, vomiting, abdominal distension, cramps, flatulence, flatus, diarrhea and abdominal pain.

THANKS