1. Which of the following is an important marker for myocardial infarction:  
   a. LDH  
   b. CK-MB  
   c. Troponins  
   d. All of the above  
   September 2005

2. Enzymes are usually:  
   a. Lipid  
   b. Nucleic acids  
   c. Carbohydrates  
   d. Protein  
   September 2005

3. Other name of AST:  
   a. SGOT  
   b. SGPT  
   c. Alkaline phosphatase  
   d. Acid phosphatase  
   September 2009

4. Xanthine Oxidase is associated with which co-factor:  
   a. Zinc  
   b. Copper  
   c. Selenium  
   d. Molybdenum  
   September 2010

5. Which element is required by phosphofructokinase:  
   a. Magnesium  
   b. Inorganic phosphate  
   c. Manganese  
   d. Copper  
   September 2010

6. True regarding isozymes is:  
   a. Forms of the same enzymes that catalyze different reaction  
   b. Forms of the same enzymes that catalyze same reaction  
   c. Forms of the different enzymes that catalyze different reaction  
   d. Forms of the different enzymes that catalyze same reaction  
   March 2011

7. Troponin is a marker for which of the following condition:  
   a. Complete heart block  
   b. Pericardial effusion  
   c. Myoglobinuria  
   d. Myocardial infarction  
   September 2011

8. Ammonia is detoxified in brain by:  
   a. Creatinine  
   b. Uric acid  
   c. Glutamine  
   d. Urea  
   March 2005

9. Thyroxine is synthesized from:  
   a. Phenylalanine  
   b. Tryptophan  
   c. Tyrosine  
   d. None of the above  
   March 2005

10. In intermittent porphyria, what is present in the urine:  
    a. Biliverdin  
    b. Uroporphyrin  
    c. Porphobilinogens  
    d. Bilirubin  
    September 2005

11. Essential amino acids are named so:  
    a. Because they are produced in the body  
    b. Because they are not produced in the body  
    c. They are not important for life  
    d. Every food stuff essentially contains them  
    September 2005

12. Niacin is synthesized from:  
    a. Phenylalanine  
    b. Tryptophan  
    c. Tyrosine  
    d. Methionine  
    September 2005

13. True regarding glutamine is:  
    a. NH3 transporter  
    b. Cannot cross the blood brain barrier  
    c. Toxic substance in the body  
    d. Stored in smooth muscle  
    March 2007

14. Source of nitrogen in urea cycle is:  
    a. Glutamate and aspartate  
    b. Glutamate and NH3  
    c. Arginine and aspartate  
    d. NH3 and aspartate  
    September 2009

15. C peptide is part of:  
    a. Pro-insulin  
    b. Insulin  
    c. ACTH  
    d. Growth hormone  
    September 2007
16. Glutathione is:  
   a. Dipeptide  
   b. Oligopeptide  
   c. Tripeptide  
   d. Polypeptide  

   March 2009

17. True regarding ubiquitin is:  
   a. Product of purine metabolism  
   b. Protein destructions  
   c. Present in prokaryotes  
   d. Protein synthesis  

   September 2009

18. Best indicator of protein quality is:  
   a. Net protein utilization  
   b. Digestibility coefficient  
   c. Biological value  
   d. Amino acid score  

   March 2005

19. Limiting amino acid in wheat are:  
   a. Lysine, arginine  
   b. Threonine, methionine  
   c. Lysine, threonine  
   d. Lysine, methionine  

   March 2005

20. Secretory proteins are synthesized in:  
   a. Cytoplasm  
   b. Endoplasmic reticulum  
   c. Both of the above  
   d. None of the above  

   March 2005

21. Pulses are deficient in:  
   a. Lysine  
   b. Methionine  
   c. Both  
   d. None of the above  

   September 2005, 2010

22. Tyrosine becomes essential in which of the following condition:  
   a. Wilsons disease  
   b. Alkaptonuria  
   c. Thyrosinosis  
   d. Phenylketonuria  

   September 2005

23. Mousy odour urine is present in:  
   a. Phenylketonuria  
   b. Maple syrup urine disease  
   c. Tyrosinemia  
   d. Homocystinuria  

   September 2009

24. Which of the following is found in urine in Hartnup’s disease patients:  
   a. Phenylalanine  
   b. Ornithine  
   c. Cystine  
   d. Glycine  

   September 2010

25. The most direct precursor of taurine is:  
   a. Glycine  
   b. Cysteine  
   c. Methionine  
   d. Glutathione  

   March 2011

26. Which of the following is the precursor of adrenaline and noradrenaline:  
   a. Phenylalanine  
   b. Tyrosine  
   c. Tryptophan  
   d. None of the above  

   March 2011

27. Norepinephrine to epinephrine conversion requires which enzyme:  
   a. Phenylethanolamine-N-methyltransferase  
   b. Transaldolase  
   c. Tyrosine hydroxylase  
   d. Alpha ketoglutarate  

   September 2011

28. Ochronosis is seen in:  
   a. Alkaptonuria  
   b. Cystinosis  
   c. Maple syrup disease  
   d. Homocystinuria  

   March 2011

29. Which of the following substance gets deposited in connective tissue in alkaptonuria:  
   a. Phenylacetate  
   b. Xanthurenate  
   c. 5-Hydroxy indole acetate  
   d. Benzoquinone acetate  

   September 2011

30. Which of the following reaction occur both in mitochondria and cytosol:  
   a. Urea Cycle  
   b. Glycolysis  
   c. Cholesterol Synthesis  
   d. TCA Cycle  

   March 2011
31. Amino acid involved in urea synthesis:  
   - Glutamine  
   - Aspartic acid  
   - Valine  
   - Phenylalanine  
   *September 2011*

32. Hexose sugar is not present in:  
   - Ribose  
   - Glucose  
   - Fructose  
   - Galactose  
   *September 2005*

33. Key glycolytic enzymes in glycolysis are all except:  
   - Phosphofructokinase  
   - Hexokinase  
   - Pyruvate kinase  
   - Glucose-1, 6, diphosphatase  
   *March 2007*

34. Substrate level phosphorylation in TCA cycle involves:  
   - Isocitrinate dehydrogenase  
   - Fumarase  
   - Malate dehydrogenase  
   - Succinate thiokinase  
   *March 2007*

35. Andersen disease is due to lack of:  
   - Branching enzyme  
   - Debranching enzyme  
   - Acid maltase  
   - Myophosphorylase  
   *March 2007*

36. Insulin is required for glucose transport in all of the following except:  
   - RBC  
   - Skeletal muscles  
   - Adipose tissue  
   - Heart muscles  
   *March 2009*

37. Carbamoyl phosphate synthetase I is:  
   - Lysosolic enzyme  
   - Cytosolic enzyme  
   - Mitochondrial enzyme  
   - All of the above  
   *March 2009*

38. What is the end product of anaerobic glycolysis:  
   - Pyruvate  
   - Lactate  
   - Fats  
   - Cholesterol  
   *September 2009*

39. Which of the following enzyme helps in catalyzing conversion of aldose sugars to ketose sugars:  
   - Oxidoreductase  
   - Phosphotriose isomerase  
   - Decarboxylase  
   - Aldolase  
   *March 2010*

40. How many molecules of pyruvate are formed from complete metabolism of 1 molecule of glucose:  
   - 1  
   - 2  
   - 3  
   - 4  
   *March 2005*

41. First substrate of Kreb's cycle is:  
   - Glycine  
   - Lipoprotein  
   - Pyruvate  
   - HCl  
   *September 2005*

42. Carbohydrate, protein and fat metabolism occurs in which cycle:  
   - Glycolysis  
   - Malate shuttle  
   - Urea cycle  
   - Citric acid cycle  
   *September 2008*

43. Accumulation of sphingomyelin in spleen and liver is found in:  
   - Gauchers disease  
   - Obstructive jaundice  
   - Von gierkes disease  
   - Nieman pick disease  
   *March 2005*

44. Saturated fatty acids is maximum in which of the following:  
   - Sunflower oil  
   - Coconut oil  
   - Soyabean  
   - Safflower oil  
   *March 2005*

45. All of the following are essential fatty acids except:  
   - Linolenic acid  
   - Linoleic acid  
   - Lysergic acid  
   - Arachidonic acid  
   *September 2005*
46. All are bad cholesterol except:  
   a. HDL  
   b. LDL  
   c. VLDL  
   d. IDL  

47. Cholesterol is:  
   a. Tocopherol  
   b. Lipoprotein  
   c. Steroid  
   d. Lipopolysaccharide  

48. Apoprotein of cholesterol is:  
   a. Apo A1  
   b. ApoA2  
   c. Apo C1  
   d. ApoE  

49. Carrier of cholesterol:  
   a. VLDL  
   b. LDL  
   c. HDL  
   d. Chylomicrons  

50. L-CAT activator lipoprotein is:  
   a. ApoA1  
   b. ApoC2  
   c. ApoC3  
   d. ApoE  

51. Deficiency of sphingomyelinase causes:  
   a. Niemann-Pick disease  
   b. Marfan’s syndrome  
   c. Gaucher’s disease  
   d. Von-Gierke’s disease  

52. True regarding familial hypercholesterolemia is:  
   a. Deficient VLDL receptors  
   b. Deficient HDL receptors  
   c. HMG CoA reductase deficiency  
   d. Deficient LDL receptors  

53. Reducing agent used in lipogenesis is derived from:  
   a. Pentose phosphate pathway  
   b. Glycolysis  
   c. TCA cycle  
   d. Gluconeogenesis  

54. Prostaglandins are derived from:  
   a. Corticosteroids  
   b. Oleic acid  
   c. Linoleic acid  
   d. Arachidonic acid  

55. Ketone bodies are synthesised in:  
   a. Muscle  
   b. Liver  
   c. Kidney  
   d. Brain  

56. Free fatty acids are transported by:  
   a. Ceruloplasmin  
   b. Pre-albumin  
   c. Albumin  
   d. Transthyretin  

57. Building block for fatty acid biosynthesis is:  
   a. NADH  
   b. Acetyl-CoA  
   c. Acyl-CoA  
   d. Acetate  

58. Rate limiting enzyme in cholesterol synthesis is:  
   a. HMG-CoA reductase  
   b. HMG-CoA synthetase  
   c. HMG CoA lyase  
   d. Mevalonate synthetase  

59. Which is involved in transport of long chain acyl-CoA in mitochondria:  
   a. Ornithine  
   b. Xanthine  
   c. Carnitine  
   d. Albumin  

60. Bile acid synthesized in liver (primary bile acids) is:  
   a. Lithocholic acid  
   b. Cholic acid  
   c. Deoxycholic acid  
   d. All of the above  

61. Function of LCAT is:  
   a. Helps in cholesterol synthesis  
   b. Converts cholesterol to cholesterol ester  
   c. Helps in formation of chylomicrons  
   d. All of the above
62. Which of the following is true about ketone bodies:  
   March 2011
   a. Synthesized in intestine
   b. Normally used by brain in preference to glucose
   c. In peripheral tissues, they are converted to HMG CoA
   d. Ketone bodies are produced during diabetes and starvation

63. Cholesterol is not a precursor of:  
   March 2011
   a. Bile acid
   b. Bile pigment
   c. Vitamin D
   d. Sex hormones

64. Regulation of lipid metabolism by insulin lacks which of the following feature:  
   September 2011
   a. Reduced activity of HMG CoA synthetase
   b. Increased release of fatty acids from stored fat in adipose tissue
   c. Increased availability of glycerol-3-phosphate
   d. Increased Acetyl CoA carboxylase activity

65. Final product of purine metabolism is:  
   March 2010, September 2010
   a. Uric acid
   b. Creatinine
   c. Xanthine
   d. Phosphates

66. Production of uric acid is by:  
   September 2005
   a. Protein metabolism
   b. Lipid metabolism
   c. Pyrimidine metabolism
   d. Purine metabolism

69. Northern blotting technique is used for the separation of:  
   March 2005, September 2010
   a. DNA
   b. Protein
   c. RNA
   d. Protein DNA interaction

70. Which is seen in RNA but not seen in DNA:  
   September 2005
   a. Adenosine
   b. Guanine
   c. Uracil
   d. Thymine

71. DNA has:  
   September 2005
   a. Ribose sugar
   b. Deoxyribose sugar
   c. Both
   d. None

72. Type of collagen found in cartilage:  
   March 2007
   a. Type I
   b. Type II
   c. Type III
   d. Type IV

73. Chaperones are:  
   March 2007
   a. Mediators of the post-translational assembly of protein complexes
   b. Antigen presenting cells
   c. Purine metabolism mediators
   d. None of the above

74. Enzyme deficient in Marfan’s syndrome:  
   March 2007
   a. Cystathione B synthetase
   b. Lysyl oxidase
   c. Collagenase
   d. None of the above

75. Which of the following does not occur in starvation:  
   March 2007
   a. Hypoglycemia
   b. Hypercholesterolemia
   c. Lipolysis
   d. Ketoacidosis
76. The L or D form of a sugar is determined by its relation to:
   a. Fructose
   b. Glycogen
   c. Glyceraldehyde
   d. Glucose

77. Western blotting is done for identifying:

78. Sodium fluoride is added to blood, as it inhibit:

79. Which of the following statement if false regarding mitochondria:
   a. Guanine rich strand is referred to as the heavy strand
   b. Each DNA molecule consists of 15,000–17,000 base pairs
   c. Single stranded straight DNA
   d. Transmitted by maternal nonmendelian inheritance

80. Palindrome is associated with:
   a. Synthesis of DNA
   b. Extrachromosomal molecule of DNA
   c. Sequence of DNA
   d. Small nuclear RNA

81. In DNA structure, maximum number of bonds are seen amongst which of the following pair:
   a. A-T
   b. G-C
   c. A-G
   d. C-T

82. New DNA material is synthesized in which phase:
   a. Prophase
   b. Metaphase
   c. Telophase
   d. Interphase

83. DNA double helix is maintained by:
   a. Hydrogen bond
   b. Vanderwaal forces
   c. Disulfide linkage
   d. Covalent bond

84. Anticoagulant added to blood for estimation of prothrombin time is:
   a. Heparin
   b. Oxalate
   c. Sodium citrate
   d. EDTA

85. Which of the following is the radiosensitive stage of cell cycle:
   a. G0
   b. G1
   c. G2
   d. S

86. Adipocytes use which of following:
   a. GLUT1
   b. GLUT2
   c. GLUT3
   d. GLUT4

87. Methyl-malonyl aciduria is seen in deficiency of:
   a. Pyridoxine
   b. Vitamin B12
   c. Folic acid
   d. Riboflavin

88. Starvation and Diabetes Mellitus can lead on to ketosis. Which of the following features is in favour of ketosis due to diabetes mellitus:
   a. Increase in Glucagon/Insulin ration, increased cAMP and increased blood glucose
   b. Decreased insulin, increased free fatty acid which is equivalent to blood glucose
   c. Decreased insulin, increased free fatty acid which is not equivalent to blood glucose
   d. Elevated insulin and free fatty acid, equivalent to blood glucose

89. Which of the following is required for proper effects of Insulin:
   a. Selenium
   b. Iron
   c. Copper
   d. Chromium
1. LDH is a tetrameric enzyme consisting of two monomers types: H (for heart) and M (for muscle) that combine to yield 5 LDH isoenzymes: HHHH(I1), HHHM(I2), HHMM(I3), HMHM(I4), MMMM(I5).

Tissue injury releases a characteristic pattern of LDH isoenzymes that can be separated by electrophoresis.

The blood test most commonly used to confirm the existence of heart muscle damage is the creatine kinase/CK. CK-MB shows an increase above normal in a person’s blood test about six hours after the start of a heart attack. It reaches its peak level in about 24 hours and returns to normal in 48 to 72 hours. The peak level and the return to normal can be delayed in a person who’s had a large heart attack, especially if they don’t get early and aggressive treatment.

Tests can measure the level of other cardiac muscle proteins called troponins specifically troponin T (cTnT) and troponin I (cTnI). These proteins control the interactions between actin and myosin, which contracts or squeezes the heart muscle. Troponins specific to heart muscle have been found, allowing the development of blood tests (assays) that can detect minor heart muscle injury (“microinfarction”) not detected by CK-MB. Normally the level of cTnT and cTnI in the blood is very low. It increases substantially within several hours (on average four to six hours) of muscle damage. It peaks at 10 to 24 hours and can be detected for up to 10 to 14 days.

Ans. D: All of the above
Ref.: Harper’s Biochemistry, 28th ed., page-59

2. Enzymes are mainly proteins, that catalyze (i.e., increase the rates of) chemical reactions with the exception of catalytic RNA molecules, or ribozymes.

In enzymatic reactions, the molecules at the beginning of the process are called substrates, and the enzyme converts them into different molecules, called the products.

Ans. D: Protein
Ref.: Harper’s Biochemistry, 28th ed., page-51

3. SGOT: Serum glutamic oxaloacetic transaminase, an enzyme that is normally present in liver and heart cells.

SGOT is released into blood when the liver or heart is damaged.

The blood SGOT levels are thus elevated with liver damage (for example, from viral hepatitis) or with an insult to the heart (for example, from a heart attack). Some medications can also raise SGOT levels.

SGOT is also called aspartate aminotransferase (AST).

Ans. A: SGOT
Ref.: Harper’s Biochemistry, 28th ed., page-59 (Table 7-2)


Xanthine oxidase is large protein, having a molecular weight of 270,000, and has 2 flavin molecules (bound as FAD), 2 molybdenum atoms and 8 iron atoms bound per enzymatic unit.
The molybdenum atoms are contained as molybdopterin cofactors and are the active sites of the enzyme.

The iron atoms are part of (2Fe-2S) ferredoxin iron-sulfur clusters and participate in electron transfer reactions

**Ans. D: Molybdenum**  

5. **Phosphofructokinase** (PFK) is ~300 amino acids in length, and structural studies of the bacterial enzyme have shown it comprises two similar (alpha/beta) lobes: one involved in ATP binding and the other housing both the substrate-binding site and the allosteric site (a regulatory binding site distinct from the active site, but that affects enzyme activity). The identical tetramer subunits adopt 2 different conformations: in a ‘closed’ state, the bound **magnesium ion** bridges the phosphoryl groups of the enzyme products (ADP and fructose-1,6-bisphosphate); and in an ‘open’ state, the magnesium ion binds only the ADP, as the 2 products are now further apart

**Ans. A: Magnesium**  

6. **The multiple forms of an enzyme catalyzing the same reaction are isozymes/isoenzymes**

   **Isozymes/isoenzymes**
   - They are enzymes that differ in amino acid sequence but catalyze the same chemical reaction.
   - These enzymes usually display different kinetic parameters (e.g. different $K_M$ values), or different regulatory properties.
   - The existence of isozymes permits the fine-tuning of metabolism to meet the particular needs of a given tissue or developmental stage (for example lactate dehydrogenase (LDH)).
   - In many cases, they are coded for by homologous genes that have diverged over time.
   - Isozymes were first described by R. L. Hunter and Clement Markert who defined them as *different variants of the same enzyme having identical functions and present in the same individual*.
   - This definition encompasses (1) enzyme variants that are the product of different genes and thus represent different loci (described as **isozymes**) and (2) enzymes that are the product of different alleles of the same gene (described as **allozymes**).
   - Isozymes are usually the result of gene duplication, but can also arise from polyploidisation or nucleic acid hybridization.
   - Allozymes may result from point mutations or from insertion-deletion (indel) events that affect the DNA coding sequence of the gene.

**Ans. B: Forms of the same enzymes that catalyze same reaction**  

7. **Although not enzymes, the proteins cardiac troponins are highly useful for the early diagnosis of MI**

   **Troponin**
   - It is attached to the protein tropomysosin and lies within the groove between actin filaments in muscle tissue.
   - In a relaxed muscle, tropomyosin blocks the attachment site for the myosin crossbridge, thus preventing contraction.
When the muscle cell is stimulated to contract by an action potential, calcium channels open in the sarcoplasmic membrane and release calcium into the sarcoplasm.

Some of this calcium attaches to troponin which causes it to change shape, exposing binding sites for myosin (active sites) on the actin filaments.

Myosin binding to actin forms cross bridges and contraction (cross bridge cycling) of the muscle begins.

Troponin is found in both skeletal muscle and cardiac muscle, but the specific versions of troponin differ between types of muscle.

The main difference is that the TnC subunit of troponin in skeletal muscle has four calcium ion binding sites, whereas in cardiac muscle there are only three.

Troponin has three subunits, TnC, TnI, and TnT.

When calcium is bound to specific sites on TnC, tropomyosin rolls out of the way of the actin filament active sites, so that myosin (a molecular motor organized in muscle thick filaments) can attach to the thin filament and produce force and/or movement.

In the absence of calcium, tropomyosin interferes with this action of myosin, and therefore muscles remain relaxed.

Individual subunits serve different functions:

- Troponin C binds to calcium ions to produce a conformational change in TnI
- Troponin T binds to tropomyosin, interlocking them to form a troponin-tropomyosin complex
- Troponin I binds to actin in thin myofilaments to hold the troponin-tropomyosin complex in place

Smooth muscle does not have troponin.

Diagnostic use

Troponin levels can be used as a test of several different heart disorders, including myocardial infarction.

Ans. D: Myocardial infarction

Amino Acids and Proteins Metabolism

8. Ans. C: Glutamine
Ref.: Harper’s Biochemistry, 28th ed., page-242

9. In dopaminergic cells in the brain, tyrosine is converted to levodopa by the enzyme tyrosine hydroxylase (TH). TH is the rate-limiting enzyme involved in the synthesis of the neurotransmitter dopamine.

In addition, in the adrenal medulla, tyrosine is converted into the catecholamine hormones norepinephrine (noradrenaline), and epinephrine.

The thyroid hormones triiodothyronine (T3) and thyroxine (T4) in the colloid of the thyroid also are derived from tyrosine.

Ans. C: Tyrosine
Ref.: Harper’s Biochemistry, 28th ed., page-436

10. Porphyria is diagnosed through spectroscopy and biochemical analysis of blood, urine, and stool.

In general, urine estimation of porphobilinogen (PBG) is the first step if acute porphyria is suspected.
As a result of feedback, the decreased production of heme leads to increased production of precursors, PBG being one of the first substances in the porphyrin synthesis pathway. In nearly all cases of acute porphyria syndromes, urinary PBG is markedly elevated except for the very rare ALA dehydratase deficiency or in patients with symptoms due to hereditary tyrosinemia type I.

**Ans. C: Porphobilinogens**
*Ref.: Harper’s Biochemistry, 28th ed., page-277 (Table 31-2)*

11. Essential amino acids are so called not because they are more important to life than the others, but because the body does not synthesize them, making it essential to include them in one’s diet in order to obtain them. They are-Leucine, Arginine, Histidine, Isoleucine, Methionine, Phenylalanine, Threonine, Tryptophan, Valine and lysine.

Additionally, cysteine (or sulphur-containing amino acids), tyrosine (or aromatic amino acids), histidine and arginine are required by infants and growing children.

**Ans. B: Because they are not produced in the body**
*Ref.: Harper’s Biochemistry, 28th ed., page-234*

12. The liver can synthesize niacin from the essential amino acid tryptophan, but the synthesis is extremely inefficient; 60 mg of tryptophan are required to make one milligram of niacin.

The 5-membered aromatic heterocycle of the essential amino acid, tryptophan, is cleaved and rearranged with the alpha amino group of tryptophan into the 6-membered aromatic heterocycle of niacin.

**Ans. B: Tryptophan**
*Ref.: Harper’s Biochemistry, 28th ed., page-474*

13. • Glutamine is the most abundant naturally occurring, non-essential amino acid in the human body and one of the only amino acids which directly crosses the blood-brain barrier.

• In the body it is found circulating in the blood as well as stored in the skeletal muscles. It becomes conditionally essential (requiring intake from food or supplements) in states of illness or injury.

• Dietary sources of L-glutamine include beef, chicken, fish, eggs, milk and dairy products.

• Glutamine has a variety of biochemical functions including:
  i. A substrate for DNA synthesis
  ii. Major role in protein synthesis
  iii. Primary source of fuel for enterocytes (cells lining the inside of the small intestine).
  iv. Precursor for rapidly dividing immune cells, thus aiding in immune function
  v. Regulation of acid-base balance in the kidney by producing ammonium
  vi. Alternative source of fuel for the brain and helps to block cortisol-induced protein catabolism.

• In catabolic states of injury and illness, GLN becomes conditionally-essential (requiring intake from food or supplements).

It is useful in treatment of serious illnesses, injury, trauma, burns, cancer and its treatment related side-effects as well as in wound healing for postoperative patients. That is why it is now also classified as a “nutraceutical”.
• Glutamine is also marketed as a supplement used for muscle growth in weightlifting, bodybuilding, endurance and other sports. It is also used to reduce muscle wasting in patients with cancer and AIDS.
• Glutamine has also been taken to enhance brain function as it fuels two of the brain’s most important neurotransmitters: glutamic acid and gamma-aminobutyric acid (GABA).
• **One key function of the glutamine is to sequester ammonia in a non-toxic form.** It assists in nitrogen transportation and reduces toxic build up of ammonia in the brain (though is contra-indicated for those with Reye’s Syndrome).
• Glutamine is contraindicated for those with Reye’s Disease, cirrhosis of the liver and kidney disease

**Ans. A: NH3 transporter**
Ref.: Harper’s Biochemistry, 28th ed., page-242

14. **The urea cycle/ornithine cycle** is a cycle of biochemical reactions that produces urea from ammonia. In mammals, the urea cycle takes place only in the liver.

**Function:**
Organisms that cannot easily and quickly remove ammonia usually have to convert it to some other substance, like urea or uric acid, which are much less toxic.

**Reactions:**
The urea cycle consists of five reactions.
The cycle converts two amino groups, one from \( \text{NH}_4^+ \) and one from Aspartate, and a carbon atom from \( \text{HCO}_3^- \), to relatively nontoxic excretion product, urea, at the cost of four “high-energy” phosphate bonds.

**Nitrogen donors in the urea cycle are ammonia and aspartate.**
An excellent way to memorize the Urea Cycle is to remember the phrase:
Ordinarily: L-Ornithine
Careless: Carbamoyl phosphate
Childrens: L-Citrulline
Are: L-Aspartate
Also: Arginosuccinate
Fearful: Fumarate
About: L-Arginine
Urination: Urea

The first letter of each word corresponds to the order in which reactants are combined to give products or intermediates that break apart as one progresses through the cycle.

**Ans. D: NH3 and aspartate**
Ref.: Harper’s Biochemistry, 28th ed., page-243,244

15. **C-peptide is a peptide that is made when proinsulin is split into insulin and C-peptide.**
C-peptide is the abbreviation for “connecting peptide”, although its name was probably also inspired by the fact that insulin is also composed of an “A” chain and a “B” chain. C-peptide was discovered in 1967.
It should not be confused with C-reactive protein or Protein C.

**Ans. A: Pro-insulin**
Ref.: Harper’s Biochemistry, 28th ed., page-439
16. **Glutathione (GSH) is a tripeptide.**
   It contains an unusual peptide linkage between the amine group of cysteine and the carboxyl group of the glutamate side chain.
   Glutathione, an antioxidant, helps protect cells from reactive oxygen species such as free radicals and peroxides.
   Glutathione is not an essential nutrient since it can be synthesized from the amino acids L-cysteine, L-glutamic acid and glycine.

   **Ans. C: Tripeptide**
   *Ref.: Harper’s Biochemistry, 28th ed., page-612*

17. There are two major pathways of protein degradation in eukaryotes.
   One involves lysosomal proteases and does not require ATP. The other way involves ubiquitin and is ATP-dependent.
   Ubiquitin is a small, highly-conserved regulatory protein that is ubiquitously expressed in eukaryotes.
   Ubiquitination (or ubiquitylation) refers to the post-translational modification of a protein by the covalent attachment (via an isopeptide bond) of one or more ubiquitin monomers. **The most prominent function of ubiquitin is labeling proteins for proteasomal degradation.**

   **Ans. B: Protein degradations**
   *Ref.: Harper’s Biochemistry, 28th ed., page-240f, 498, 499f*

18. The net protein utilization, or NPU, is the ratio of amino acid converted to proteins to the ratio of amino acids supplied. It may be affected by the salvage of essential amino acids within the body, but is profoundly affected by the level of limiting amino acids within a foodstuff.
   This value can be determined by determining dietary protein intake and then measuring nitrogen excretion. One formula for NPU is:
   \[
   NPU = \frac{(0.16 \times (24 \text{ hour protein intake in grams})) - ((24 \text{ hour urinary urea nitrogen}) + 2) - (0.1 \times (\text{ideal body weight in kilograms})))}{(0.16 \times (24 \text{ hour protein intake in grams}))}
   \]
   As a value, NPU can range from 1 to 0, with a **value of 1 indicating 100% utilization of dietary nitrogen as protein** and a value of 0 an indication that none of the nitrogen supplied was converted to protein.

   **Ans. A: Net protein utilization**
   *Ref.: Park’s PSM, 20th ed., page-528*

19. Limiting amino acid in various food stuffs
   **Wheat-lysine (the most deficient) and threonine (second limiting amino acid)**
   Rice-lysine
   Legumes-tryptophan or methionine (or cysteine)
   Maize-lysine and tryptophan
   Egg-none; the reference for absorbable protein

   **Ans. C: Lysine, threonine**
   *Ref.: Park’s PSM, 20th ed., page-528*
Biochemistry

20. **Secretory protein** is any protein, whether it be endocrine or exocrine, which is secreted by a cell.

Secretory proteins include many hormones, enzymes, toxins, and antimicrobial peptides. **Secretory proteins are synthesized in endoplasmic reticulum**

**Ans. B: Endoplasmic reticulum**
*Ref.: Harper’s Biochemistry, 28th ed., page-353*

21. **Ans. B: Methionine**
*Ref.: Park’s PSM, 20th ed., page-543*

22. The amino acids arginine, cysteine, glycine, glutamine, histidine, proline, serine and tyrosine are considered conditionally essential, meaning they are not normally required in the diet, but must be supplied exogenously to specific populations that do not synthesize it in adequate amounts.

An example would be with the disease phenylketonuria (PKU). Individuals living with PKU must keep their intake of phenylalanine extremely low to prevent mental retardation and other metabolic complications.

However, phenylalanine is the precursor for tyrosine synthesis. Without phenylalanine, tyrosine cannot be made and so **tyrosine becomes essential in the diet of PKU patients.**

**Ans. D: Phenylketonuria**
*Ref.: Internet resources, Lehninger’s Biochemistry, 5th ed., page-697*

23. **Ans. A: Phenylketonuria**

24. Hartnup disease is inherited as an autosomal recessive trait. Heterozygotes are normal. Consanguinity is common.

In 2004, a causative gene, SLC6A19, was located on band SLC6A19 is a sodium-dependent and chloride-independent neutral amino acid transporter, expressed predominately in the kidneys and intestine

**Ans. A: Phenyalanine**
*Ref.: Harper’s Biochemistry, 27th ed., p-262-498*

25. **Taurine, glutathione, coenzyme A are specialized products contributed by cysteine**

**Taurine/ 2-aminoethanesulfonic acid**
- It is a major constituent of bile and can be found in the large intestine
- It accounts for approximately 0.1% of total human body weight.
- Taurine has many fundamental biological roles such as conjugation of bile acids, antioxidation, osmoregulation, membrane stabilization and modulation of calcium signaling.
- It is essential for cardiovascular function, and development and function of skeletal muscle, the retina and the central nervous system.
- Taurine is unusual among biological molecules in being a sulfonic acid, while the vast majority of biologically occurring acids contain the more weakly acidic carboxyl group.
• Mammalian taurine synthesis occurs in the pancreas via the cysteine sulfinic acid pathway.
• In this pathway, the sulfhydryl group of cysteine is first oxidized to cysteine sulfinic acid by the enzyme cysteine dioxygenase.
• Cysteine sulfinic acid, in turn, is decarboxylated by sulfinoalanine decarboxylase to form hypotaurine.

Ans. B: Cysteine

26. Tyrosine is the contributing amino acid for the formation of thyroxine, tri-iodothyronine, epinephrine, norepinephrine, dopamine and melanin

Ans. B: Tyrosine

27. Methylation of norepinephrine by S-adenosyl-methionine gives epinephrine, reaction being catalysed by phenylethanolamine N-methyltransferase

Catecholamines
• They are produced mainly by the chromaffin cells of the adrenal medulla and the postganglionic fibers of the sympathetic nervous system.
• Dopamine, which acts as a neurotransmitter in the central nervous system, is largely produced in neuronal cell bodies in two areas of the brainstem: the substantia nigra and the ventral tegmental area.
• The similarly melanin-pigmented cell bodies of the locus ceruleus produce norepinephrine.
• Tyrosine is the precursor for the synthesis of catecholamines
• Dopamine is the first catecholamine synthesized from DOPA.
• In turn, norepinephrine and epinephrine are derived from further metabolic modification of dopamine.
• The enzyme dopamine hydroxylase requires copper as a cofactor and DOPA decarboxylase requires PLP.
• The rate limiting step in catecholamine biosynthesis is hydroxylation of tyrosine.
• Catecholamine synthesis is inhibited by alpha-methyl-p-tyrosine (AMPT), which inhibits tyrosine hydroxylase

Phenylethanolamine N-methyltransferase (PNMT)
• It is an enzyme found in the adrenal medulla that converts Norepinephrine (Noradrenaline) to Epinephrine (Adrenaline).
• PNMT is positively influenced by cortisol, which is produced in the adrenal cortex.
• S-adenosyl-L-methionine (SAM) is a required cofactor

Tyrosine/ 4-hydroxyphenylalanine
• It is used by cells to synthesize proteins.
• Its codons are UAC and UAU.
• It is a non-essential amino acid with a polar side group.
• It is called tyrosyl when referred to as a functional group or side chain

Ans. A: Phenylethanolamine-N-methyltransferase
28. **Alkapton deposition occurs in connective tissues, bones and various organs (nose, ear etc.) resulting in ochronosis**

*Ans. A: Alkaptonuria*


29. **Homogentisate gets oxidized by polyphenol oxidase to benzoquinone acetate which undergoes polymerization to produce a pigment known as alkapton**

**Alkaptonuria**
- It is due to the deficiency of homogentisic acid oxidase
- Resulting in accumulation in the tissues of homogentisic acid, an intermediate metabolite of phenylalanine and tyrosine metabolism.
- As homogentisic acid accumulates both intracellularly and extracellularly, it is oxidized to **benzoquinone acetate**, which polymerizes to form melanin-like polymers, resulting in widespread deposition in fibrous tissue and cartilage.
- Some of the homogentisic acid is excreted in the urine.
- Since homogentisic acid has affinity to alkalis, it was named as alkapton and the condition as alkaptonuria.
- Alkaptonuria is often asymptomatic
- But the sclera of the eyes may be pigmented (often only at a later age)
- And the skin may be darkened in sun-exposed areas and around sweat glands
- Sweat may be coloured brown.
- Urine may turn brown if collected and left exposed to open air, especially when left standing for a period of time.
- Kidney stones and stone formation in the prostate (in men) are common and may occur in more than a quarter of cases.
- The main symptoms of alkaptonuria are due to the accumulation of homogentisic acid in tissues.
- In the joints this leads to cartilage damage, specifically in the spine, leading to low back pain at a young age in most cases.
- Valvular heart disease, mainly calcification and regurgitation of the aortic and mitral valves, may occur
- A distinctive characteristic of alkaptonuria is that ear wax exposed to air turns red or black (depending on diet) after several hours because of the accumulation of homogentisic acid
- The diagnosis of alkaptonuria needs to be suspected before diagnostic testing can be performed using paper chromatography and thin layer chromatography.
- Both blood plasma and urine can be used for diagnosis.
- In healthy subjects, homogentisic acid is absent in both blood plasma and urine.
- In alkaptonuria, plasma levels are 6.6 micrograms/ml on average, and urine levels are on average 3.12 mmol/mmol of creatinine.

*Ans. D: Benzoquinone acetate*


30. **Urea synthesis is a 5 step cyclic process, with 5 distinct enzymes.**

*The first 2 enzymes are present in mitochondria while the rest are localized in cytosol*

*Ans. A: Urea cycle*

31. **Urea has 2 amino (-NH2) groups, one derived from NH3 and other from aspartate**

**Urea cycle**
- The urea cycle consists of five reactions: two mitochondrial and three cytosolic.
- In the first reaction, \( \text{NH}_4^+ + \text{HCO}_3^- \) is equivalent to \( \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \).
- Thus, the overall equation of the urea cycle is: \( \text{NH}_3 + \text{CO}_2 + \text{aspartate} + 3 \text{ ATP} + 2 \text{ H}_2\text{O} \rightarrow \text{urea} + \text{fumarate} + 2 \text{ ADP} + 2 \text{ P}_i + \text{AMP} + \text{PP}_i \)
- Since fumarate is obtained by removing \( \text{NH}_3 \) from aspartate, and \( \text{PP}_i + \text{H}_2\text{O} \rightarrow 2 \text{ P}_i \), the equation can be simplified as follows: \( 2 \text{ NH}_3 + \text{CO}_2 + 3 \text{ ATP} + \text{H}_2\text{O} \rightarrow \text{urea} + 2 \text{ ADP} + 4 \text{ P}_i + \text{AMP} \)
- Note that reactions related to the urea cycle also cause the oxidation of 2 NADH, so the urea cycle releases slightly more energy than it consumes.
- These NADH are produced in two ways:
  - One NADH molecule is reduced by the enzyme glutamate dehydrogenase in the conversion of glutamate to ammonium and \( \alpha \)-ketoglutarate.
  - The fumarate released in the cytosol is converted to malate by cytosolic fumarase. This malate is then converted to oxaloacetate by cytosolic malate dehydrogenase, generating a reduced NADH in the cytosol.
- The two NADH produced can provide energy for the formation of 5 ATP, a net production of one high-energy phosphate bond for the urea cycle.
- The fate of oxaloacetate is either to produce aspartate via transamination or to be converted to phosphoenol pyruvate, which is a substrate to glucose.

**Ans. B: Aspartic acid**


**CARBOHYDRATE METABOLISM**

32. **Hexose sugar is present in:**
   i. **Glucose**, “blood sugar”, the immediate source of energy for cellular respiration
   ii. **Galactose**, a sugar in milk (and yogurt), and
   iii. **Fructose**, a sugar found in honey

**Ribose is a pentose sugar**

**Ans. A: Ribose**

Ref.: Harper’s Biochemistry, 28th ed., page-114 (Table 14-1)

33. **Glycolysis/Embden-Meyerhof pathway is the sequence of reactions that converts glucose into pyruvate with the concomitant production of a relatively small amount of adenosine triphosphate (ATP)**

It is the initial process of most carbohydrate catabolism, and it serves three principal functions:
   i. Generation of high-energy molecules (ATP and NADH) as cellular energy sources as part of aerobic respiration and anaerobic respiration.
   ii. **Production of pyruvate for the citric acid cycle as part of aerobic respiration**
   iii. Production of a variety of six- and three-carbon intermediate compounds, which may be removed at various steps in the process for other cellular purposes
In eukaryotes and prokaryotes, glycolysis takes place within the cytosol of the cell. The products all have vital cellular uses:

i. ATP provides an energy source for many cellular functions.

ii. NADH + H⁺ provides reducing power for other metabolic pathways or further ATP synthesis.

iii. Pyruvate is used in the citric acid cycle in aerobic respiration to produce more ATP, or is converted to other small carbon molecules in anaerobic respiration.

For simple anaerobic fermentations, the metabolism of one molecule of glucose to two molecules of pyruvate has a net yield of two molecules of ATP. Most cells ‘repay’ the used NAD⁺ and produce a final product of ethanol or lactic acid.

Cells performing aerobic respiration synthesize much more ATP, but not as part of glycolysis. These further aerobic reactions use pyruvate and NADH + H⁺ from glycolysis. Eukaryotic aerobic respiration produces approximately 34 additional molecules of ATP for each glucose molecule.

The first five steps are regarded as the preparatory (or investment) phase since they consume energy to convert the glucose into two three-carbon sugar phosphates (G3P).

i. The first step in glycolysis is phosphorylation of glucose by a family of enzymes called hexokinases to form glucose 6-phosphate (G6P). This reaction consumes ATP.

In animals, an isozyme of hexokinase called glucokinase is also used in the liver.

ii. G6P is then rearranged into fructose 6-phosphate (F6P) by glucose phosphate isomerase.

The energy expenditure of another ATP in this step is justified in 2 ways: The glycolytic process (up to this step) is now irreversible, and the energy supplied destabilizes the molecule. Because the reaction catalyzed by Phosphofructokinase 1 (PFK-1) is energetically very favorable, it is essentially irreversible. This makes the reaction a key regulatory point.

The same reaction can also be catalysed by pyrophosphate dependent phosphofructokinase (PFP or PPI-PFK), which is found in most plants.

- Hexose ring is then split by aldolase into two triose sugars, dihydroxyacetone phosphate, a ketone, and glyceraldehyde 3-phosphate, an aldehyde.

- Triosephosphate isomerase rapidly interconverts dihydroxyacetone phosphate with glyceraldehyde 3-phosphate (GADP) that proceeds further into glycolysis.

- The second half of glycolysis is known as the pay-off phase, characterised by a net gain of the energy-rich molecules ATP and NADH. Since glucose leads to two triose sugars in the preparatory phase, each reaction in the pay-off phase occurs twice per glucose molecule. This yields 2 NADH molecules and 4 ATP molecules, leading to a net gain of 2 NADH molecules and 2 ATP molecules from the glycolytic pathway per glucose.

- The triose sugars are dehydrogenated and inorganic phosphate is added to them, forming 1,3-bisphosphoglycerate. The hydrogen is used to reduce two molecules of NAD⁺, a hydrogen carrier, to give NADH + H⁺.

- This step is the enzymatic transfer of a phosphate group from 1,3-bisphosphoglycerate to ADP by phosphoglycerate kinase, forming ATP and 3-phosphoglycerate. At this step, glycolysis has reached the break-even point: 2 molecules of ATP were consumed, and 2 new molecules have now been synthesized. This step, one of the two substrate-level phosphorylation steps, requires ADP; thus, when the cell has plenty of ATP (and little ADP),
this reaction does not occur. Because ATP decays relatively quickly when it is not metabolized, this is an important regulatory point in the glycolytic pathway.

- Phosphoglycerate mutase now forms 2-phosphoglycerate.
- Enolase next forms phosphoenolpyruvate from 2-phosphoglycerate.
- A final substrate-level phosphorylation now forms a molecule of pyruvate and a molecule of ATP by means of the enzyme pyruvate kinase. This serves as an additional regulatory step, similar to the phosphoglycerate kinase step.

Muscle cannot make use of glycogen for energy as they lack: Glucose-6-phosphatase

Blood samples for glucose estimation are kept in fluoride tubes as fluoride prevents glycolysis by inhibiting Enolase

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**Ans. D:** Glucose-1, 6, diphosphatase  
*Ref.:* Harper’s Biochemistry, 28th ed., page-151

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**34.**  
**Ans. D:** Succinate thiokinase  
*Ref.:* Harper’s Biochemistry, 28th ed., page-144

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**35.** Andersen disease/Glycogen storage disease type IV is a very rare hereditary metabolic disorder.  
**Synonyms:**  
i. Glycogenosis type IV,  
ii. Glycogen Branching Enzyme Deficiency (GBED),  
iii. Polyglucosan body disease.  
iv. Amylopectinosis  

**It is a result of the absence of the glycogen branching enzyme amylo-1,4-1,6 transglucosidase,** which is critical in the production of glycogen.  

This leads to very long unbranched glucose chains being stored in glycogen (known as amylopectin) which have a low solubility leading to glycogen precipitation in the liver.

These deposits subsequently build up in the body tissue, especially the heart and liver.

The end result is liver failure and eventual death occurring in the first year of life.

**Ans. A:** Branching enzyme  
*Ref.:* Harper’s Biochemistry, 28th ed., page-160 (Table 19-2)

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**36.** Insulin facilitates entry of glucose into muscle, adipose, and several other tissues.

The only mechanism by which cells can take up glucose is by facilitated diffusion through a family of hexose transporters.

In many tissues - muscle being a prime example - the major transporter used for uptake of glucose (called GLUT4) is made available in the plasma membrane through the action of insulin.

**Ans. A:** RBC  
*Ref.:* Harper’s Biochemistry, 28th ed., page-171 (Table 20-2)
37. **Mitochondrial carbamoyl phosphate synthetase I** is an enzyme that catalyzes a reaction that produces carbamoyl phosphate.

This enzyme catalyzes the reaction of ATP and bicarbonate to produce carbonyl phosphate and ADP.

Carbonyl phosphate reacts with ammonia to give carbamate.

**Cytosolic carbamoyl phosphate synthetase II** uses glutamine rather than ammonia as the nitrogen donor and functions in pyrimidine synthesis.

**Ans. C:** Mitochondrial enzyme  
*Ref.:* Harper’s Biochemistry, 28th ed., page-243

38. **Ans. B:** Lactate  
*Ref.:* Harper’s Biochemistry, 28th ed., page-149

39. **Ans. B:** Phosphotriose isomerase  
*Ref.:* Harper’s Biochemistry, 28th ed., page-150

40. **Ans. B:** 2  

41. **Ans. C:** Pyruvate  

42. **Ans. D:** Citric acid cycle  
*Ref.:* Harper’s Biochemistry, 28th ed., page-143

**LIPIDS METABOLISM**

43. Niemann-Pick diseases are genetic diseases which are classified in a subgroup of LSDs called sphingolipidoses or lipid storage disorders in which harmful quantities of fatty substances, or lipids, accumulate in the spleen, liver, lungs, bone marrow, and brain.

In the classic infantile type A variant, a missense mutation causes complete deficiency of sphingomyelinase.

Sphingomyelin is a component of cell membrane including the organellar membrane and so the enzyme deficiency blocks degradation of lipid, resulting in the accumulation of sphingomyelin within lysosomes in the macrophage-monocyte phagocyte lineage.

Histology demonstrates lipid laden macrophages in the marrow, as well as “sea-blue histiocytes” on pathology.

**Ans. D:** Nieman pick disease  
*Ref.:* Harper’s Biochemistry, 28th ed., page-210 (Table 24-1)
44. Saturated fatty acids are a long-chain carboxylic acid that usually has between 12 and 24 carbon atoms that has no double bonds. Thus, saturated fatty acids are saturated with hydrogen (since double bonds reduce the number of hydrogens on each carbon).

Example; 1) Lauric acid (12 C) 2) Myristic acid (14 C) 3) Palmitic acid (16 C) 4) Stearic acid (18 C) 5) Arachidic acid (20 C)

Coconut oil contains approximately **92.1% saturated fatty acids**, 6.2% monounsaturated fatty acids, 1.6% polyunsaturated fatty acids.

Ans. B: Coconut oil
Ref.: Park’s PSM, 20th ed., page-528

45. i. Linolenic acid
ii. linoleic acid-Most important essential fatty acid
iii. Arachidonic acid
iv. Eicosapentanoic acid

Ans. C: Lysergic acid
Ref.: Park’s PSM, 20th ed., page-529

46. HDL can remove cholesterol from atheroma within arteries and transport it back to the liver for excretion or re-utilization, which is the main reason why **HDL-bound cholesterol is sometimes called “good cholesterol”**, or HDL-C.

A high level of HDL-C seems to protect against cardiovascular diseases, and low HDL cholesterol levels (less than 40 mg/dL or about 1mmol/L) increase the risk for heart disease.

Cholesterol contained in HDL particles is considered beneficial for the cardiovascular health, in contrast to “bad” LDL cholesterol.

Ans. A: HDL
Ref.: Harper’s Biochemistry, 28th ed., page-230

47. **Cholesterol** is an amphipathic lipid and is an important structural component of membranes and of the outer layer of plasma lipoproteins.

It is mainly synthesized in many tissues from Acetyl-CoA and is the **precursor of all other steroids** in the body, including corticosteroids, sex hormones, bile acids, and vitamin D.

Ans. C: Steroid
Ref.: Harper’s Biochemistry, 28th ed., page-126

48. **Apolipoprotein E** is a plasma protein that serves as a **ligand for low density lipoprotein** receptors and, through its interaction with these receptors, **participates in the transport of cholesterol** and other lipids among various cells of the body.

Ans. D: ApoE
Ref.: Harper’s Biochemistry, 28th ed., page-213 (Table 25-1)
49. **Ans. B: LDL**  
*Ref.:* Harper’s Biochemistry, 28th ed., page-213 (Table 25-1)

50. **Ans. A: ApoA1**  
*Ref.:* Harper’s Biochemistry, 28th ed., page-213

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51. **Ans. A: Niemann-Pick disease**  
*Ref.:* Harper’s Biochemistry, 28th ed., page-210 (Table 24-1)

52. **Familial hypercholesterolemia have defective LDL receptors**

Many patients with familial hypercholesterolemia have mutations in the *LDLR* gene that encodes the LDL receptor protein, which normally removes LDL from the circulation, or apolipoprotein B (ApoB), which is the part of LDL that binds with the receptor.

Patients who have one abnormal copy (are heterozygous) of the *LDLR* gene may have premature cardiovascular disease at the age of 30 to 40.

Having two abnormal copies (being homozygous) may cause severe cardiovascular disease in childhood.

Patients may have xanthelasma palpebrarum, yellowish patches consisting of cholesterol deposits above the eyelids.

**Treatment**

Heterozygous FH is normally with statins, bile acid sequestrants or other drugs that lower cholesterol levels (hypolipidemic agents).

Homozygous FH often does not respond to medical therapy and may require other treatments, including LDL apheresis (removal of LDL in a method similar to dialysis) and occasionally liver transplantation

**Ans. D: Deficient LDL receptors**  
*Ref.:* Harper’s Biochemistry, 28th ed., page-232 (Table 26-1)
53. **NADPH** is involved as donor of reducing equivalents in both the reduction of the 3-ketoacyl and of the 2, 3-unsaturated acyl derivatives.
   The oxidative reactions of the **pentose phosphate** are the chief source of the hydrogen required for the reductive synthesis of fatty acids.

   **Ans. A:** Pentose phosphate pathway  
   *Ref.:* Harper’s Biochemistry, 28th ed., page-194

54. **Prostaglandins** are derived from **arachidonic acid** through the cyclooxygenase (COX) pathway.
   Two isoforms of COX have been recognized.
   COX-1 is expressed constitutively, whereas COX-2 is induced by growth factors, tumor promoters, and proinflammatory cytokines.
   COX catalyzes oxidative cyclization of arachidonic acid to prostaglandin endoperoxide, which is the immediate precursor of prostaglandins, thromboxane, and prostacyclin.

   **Ans. D:** Arachidonic acid  
   *Ref.:* Harper’s Biochemistry, 28th ed., page-122

55. Ketone bodies are two molecules, acetoacetate and hydroxybutyrate.
   The term “ketone body” is historical: only acetoacetate is an actual ketone.
   **Ketone bodies are synthesized in the liver from acetyl-CoA.**

   **Ans. B:** Liver  
   *Ref.:* Harper’s Biochemistry, 28th ed., page-140

56. **Free fatty acids** are transported in the blood bound to albumin, a serum protein secreted by the liver. Most other lipids are transported in the blood as part of complex particles called lipoproteins.
   Lipoproteins differ in the ratio of protein to lipids, and in the particular apoproteins and lipids that they contain.
   They are classified based on their density:
   i. Chylomicron (largest; lowest in density due to high lipid/protein ratio; highest in triacylglycerols as % of weight)
   ii. VLDL (very low density lipoprotein; 2nd highest in triacylglycerols as % of weight)
   iii. IDL (intermediate density lipoprotein)
   iv. LDL (low density lipoprotein, highest in cholesteryl esters as % of weight)
   v. HDL (high density lipoprotein, highest in density due to high protein/lipid ratio).

   **Ans. C:** Albumin  
   *Ref.:* Harper’s Biochemistry, 28th ed., page-569 (Table 50-2)
57. Fatty acid biosynthesis in the cytosol requires a sufficient concentration of NADPH and acetyl CoA.

NADPH is generated in the cytosol by the pentose phosphate pathway, and by the malic enzyme which oxidizes malate into pyruvate and CO₂, generating NADPH.

Ans. B: Acetyl-CoA
Ref.: Harper’s Biochemistry, 28th ed., page-195

58. Hydroxymethylglutaryl-coenzyme A (HMG-CoA) is the precursor for cholesterol synthesis.

HMG-CoA is also an intermediate on the pathway for synthesis of ketone bodies from acetyl-CoA.

The enzymes for ketone body production are located in the mitochondrial matrix.

HMG-CoA destined for cholesterol synthesis is made by equivalent, but different, enzymes in the cytosol.

HMG-CoA is formed by condensation of acetyl-CoA and acetoacetyl-CoA, catalyzed by HMG-CoA Synthase.

HMG-CoA Reductase is an integral protein of endoplasmic reticulum membranes. The catalytic domain of this enzyme remains active following cleavage from the transmembrane portion of the enzyme.

The HMG-CoA Reductase reaction is rate-limiting for cholesterol synthesis.

Ans. A: HMG-CoA reductase
Ref.: Harper’s Biochemistry, 28th ed., page-224

59. In humans carnitine is synthesized from protein-derived trimethyllysine in liver, brain and kidney.

Muscles take up carnitine from the blood in an exchange-diffusion process with endogenous deoxycarnitine, the immediate precursor of carnitine.

Besides catalysing the transport of long-chain acyl groups in mitochondria, carnitine is necessary for the export of intramitochondrially produced short-chain acyl residues and for the trapping and the elimination of unphysiological compounds (benzoic, pivalic, valproic acids etc.).

Ans. C: Carnitine
Ref.: Harper’s Biochemistry, 28th ed., page-184

60. The synthesis of the primary bile acids takes place in the liver

Cholic acid and the chenodeoxycholic acid are the primary bile acids

Bile acids
- They are steroid acids found predominantly in the bile.
- Bile acid refers to the protonated (-COOH) form.
- Bile salt refers to the deprotonated or ionized (-COO⁻) form.
- Bile salts are bile acids compounded with a cation, usually sodium.
- The salts of taurocholic acid and glycocholic acid (derivatives of cholic acid) represent approximately eighty percent of all bile salts.
- The two primary bile acids are cholic acid, and chenodeoxycholic acid.
• Bile acids, glycine and taurine conjugates, and 7-alpha-dehydroxylated derivatives (deoxycholic acid and lithocholic acid) are all found in intestinal bile.

• An increase in bile flow is exhibited with an increased secretion of bile acids.

• The main function of bile acid is to facilitate the formation of micelles, which promotes processing of dietary fat

• **Bile acids are made in the liver** by the cytochrome P450-mediated oxidation of cholesterol.

• They are conjugated with taurine or the amino acid glycine, or with a sulfate or a glucuronide, and are then stored in the gallbladder, which concentrates the salts by removing the water.

• Rate limiting step is the addition of a hydroxyl group on position 7 of the steroid nucleus by the enzyme cholesterol 7 alpha-hydroxylase.

• Upon eating a meal, the contents of the gallbladder are secreted into the intestine, where bile acids serve the purpose of emulsifying dietary fats.

• Bile acids serve other functions, including eliminating cholesterol from the body, driving the flow of bile to eliminate catabolites from the liver, emulsifying lipids and fat soluble vitamins in the intestine to form micelles that can be transported via the lacteal system, and aiding in the reduction of the bacteria flora found in the small intestine and biliary tract.

• Conjugated bile acids are more efficient at emulsifying fats because at intestinal pH, they are more ionized than unconjugated bile acids.

• The body produces about 800 mg of cholesterol per day and about half of that is used for bile acid synthesis.

• In total about 20-30 grams of bile acids are secreted into the intestine daily.

• About 90% of excreted bile acids are reabsorbed by active transport in the ileum and recycled in what is referred to as the enterohepatic circulation which moves the bile salts from the intestinal system back to the liver and the gallbladder.

**Ans. B: Cholic acid**

*Ref.: Harper’s Biochemistry, 28th ed., p-228; Satyanarayana’s Biochemistry, 3rd ed., p-313*

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61. **The cholesterol (cholesteryl) ester forms an integral part of HDL**

*The cholesterol from the peripheral tissues is trapped in HDL by a reaction catalyzed by LCAT*

**Lecithin-cholesterol acyltransferase / LCAT / Phosphatidylcholine-sterol O-acyltransferase**

- **It converts free cholesterol into cholesteryl ester** (a more hydrophobic form of cholesterol)

- Which is then sequestered into the core of a lipoprotein particle, eventually making the newly synthesized HDL spherical and forcing the reaction to become unidirectional since the particles are removed from the surface.

- The enzyme is bound to high-density lipoproteins (HDLs) and low-density lipoproteins in the blood plasma

**Ans. B: Converts cholesterol to cholesterol ester**

*Ref.: U. Satyanarayana’s Biochemistry, 3rd ed., p-315, 320*

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62. **The production of ketone bodies and their utilization become more significant when glucose is in short supply to the tissues, as observed in starvation, and diabetes mellitus**
Ketone bodies

- They are three water-soluble compounds
- They are produced as by-products when fatty acids are broken down for energy in the liver and kidney.
- They are used as a source of energy in the heart and brain.
- In the brain, they are a vital source of energy during fasting.
- The three endogenous ketone bodies are acetone, acetoacetic acid, and beta-hydroxybutyric acid.
- Although beta-hydroxybutyric acid is not technically a ketone but a carboxylic acid.
- Other ketone bodies such as beta-ketopentanoate and beta-hydroxypentanoate may be created as a result of the metabolism of synthetic triglycerides such as triheptanoin.
- Ketone bodies can be used for energy.
- Ketone bodies are transported from the liver to other tissues, where acetoacetate and beta-hydroxybutyrate can be reconverted to acetyl-CoA to produce energy, via the citric acid cycle.
- The heart gets little energy from ketone bodies except under special circumstances; it uses mainly fatty acids.
- The brain gets a portion of its energy from ketone bodies when glucose is less available (e.g., during fasting, strenuous exercise, low carbohydrate, ketogenic diet and in neonates).
- In the event of low blood glucose, most other tissues have additional energy sources besides ketone bodies (such as fatty acids), but the brain does not.
- After the diet has been changed to lower blood glucose for 3 days, the brain gets 25% of its energy from ketone bodies.
- After about 4 days, this goes up to 70% (during the initial stages the brain does not burn ketones, since they are an important substrate for lipid synthesis in the brain).
- Ketone bodies are produced from acetyl-CoA mainly in the mitochondrial matrix of hepatocytes when carbohydrates are so scarce that energy must be obtained from breaking down fatty acids.
- Because of the high level of acetyl CoA present in the cell, the pyruvate dehydrogenase complex is inhibited, whereas pyruvate carboxylase becomes activated.
- Thus, the oxaloacetate produced will enter gluconeogenesis rather than the citric acid cycle, as the latter is also inhibited by the elevated level of NADH resulting from beta-oxidation of fatty acids.
- The excess acetyl-CoA is therefore rerouted to ketogenesis.
- Such a state in humans is referred to as the fasted state.
- Acetone is produced by spontaneous decarboxylation of acetoacetate, yielding levels of acetone much lower than those of other ketone bodies.
- Acetone cannot be converted back to acetyl-CoA, so it is excreted in the urine, or (as a consequence of its high vapor pressure) exhaled.
- Acetone is responsible for the characteristic “fruity” odor of the breath of persons in ketoacidosis.
- When even larger amounts of ketone bodies accumulate such that the blood’s pH is lowered to dangerously acidic levels, this state is called ketoacidosis.
- Both acetoacetic acid and beta-hydroxybutyric acid are acidic, and, if levels of these ketone bodies are too high, the pH of the blood drops, resulting in ketoacidosis.
- This happens most often in untreated Type I diabetes, and somewhat less often in Type II.

Ans. D: Ketone bodies are produced during diabetes and starvation

Ref.: U. Satyanarayana’s Biochemistry, 3rd ed., p-293-295
63. **The term bile pigments is used to collectively represent bilirubin and its derivative**

1 gram of hemoglobin on degradation finally yields about 35 mg bilirubin

**Cholesterol**
- It is required to build and maintain membranes
- It modulates membrane fluidity over the range of physiological temperatures.
- In this structural role, cholesterol reduces the permeability of the plasma membrane to protons (positive hydrogen ions) and sodium ions.
- Within the cell membrane, cholesterol also functions in intracellular transport, cell signaling and nerve conduction.
- Cholesterol is essential for the structure and function of invaginated caveolae and clathrin-coated pits, including caveola-dependent and clathrin-dependent endocytosis.
- The role of cholesterol in such endocytosis can be investigated by using methyl beta cyclodextrin (MβCD) to remove cholesterol from the plasma membrane.
- In many neurons, a myelin sheath, rich in cholesterol, since it is derived from compacted layers of Schwann cell membrane, provides insulation for more efficient conduction of impulses.
- Cholesterol is the precursor of bile acids [Bile contains bile salts (conjugated bile acids), which solubilize fats in the digestive tract and aid in the intestinal absorption of fat molecules as well as the fat-soluble vitamins, A, D, E, and K].
- **Cholesterol is an important precursor molecule for the synthesis of vitamin D** and the steroid hormones, including the adrenal gland hormones cortisol and aldosterone, as well as the sex hormones progesterone, estrogens, and testosterone, and their derivatives.

**Ans. B: Bile pigment**


64. **The net effect of insulin on lipid metabolism is to reduce the release of fatty acids from the stored fat**

**Among the tissues, adipose tissue is the most sensitive to the action of the insulin**

**Lipogenesis**
- It is the process by which acetyl-CoA is converted to fats.
- The former is an intermediate stage in metabolism of simple sugars, such as glucose.
- Through lipogenesis, the energy can be efficiently stored in the form of fats.
- Lipogenesis encompasses the processes of fatty acid synthesis and subsequent triglyceride synthesis (when fatty acids are esterified with glycerol to form fats).
- The products are secreted from the liver in the form of very-low-density lipoproteins (VLDL)
- Fatty acids synthesis starts with acetyl-CoA and builds up by the addition of two carbon units.
- The synthesis occurs in the cytoplasm in contrast to the degradation (oxidation), which occurs in the mitochondria.
- Many of the enzymes for the fatty acid synthesis are organized into a multienzyme complex called fatty acid synthetase.

**Control and regulation**
- Insulin is an indicator of the blood sugar level of the body, as its concentration increases proportionally with blood sugar levels.
- Thus, a large insulin level is associated with the fed state.
As one might expect, therefore, it increases the rate of storage pathways, such as lipogenesis.

Insulin stimulates lipogenesis in two main ways:

- The enzymes pyruvate dehydrogenase (PDH), which forms acetyl-CoA, and acetyl-CoA carboxylase (ACC), which forms malonyl-CoA, are obvious control points.

- **These are activated by insulin.**

- So a high insulin level leads to an overall increase in the levels of malonyl-CoA, which is the substrate required for fatty acids synthesis.

- **PDH dephosphorylation**
  - Pyruvate dehydrogenase dephosphorylation is increased with the release of insulin.
  - The dephosphorylated form is more active.
  - As insulin binds to cellular surface transmembrane receptors that intracellularly activate the adenylate cyclase enzyme that catalyze cAMP (cyclic AMP) production from ATP.
  - The increased intracellular cAMP, acts as a second messenger, in response to the insulin binding.
  - cAMP activates protein kinase enzyme that in turn activates phosphorylase enzyme that phosphorylates and in doing so activates a number of different intracellular enzymes such as the pyruvate dehydrogenase that dehydrates pyruvate to form AcCoa.
  - So, an extracellular hormone, insulin, can in multistep activation (cascade) activate an enzyme in the cellular matrix.
  - This mechanism leads to the increased rate of catalysis of this enzyme, so increases the levels of acetyl-CoA.
  - Increased levels of acetyl-CoA will increase the flux through not only the fat synthesis pathway but also the citric acid cycle.

- **Acetyl CoA carboxylase**
  - Insulin affects ACC in a similar way to PDH.
  - It leads to its dephosphorylation which activates the enzyme.
  - Glucagon has an antagonistic effect and increases phosphorylation, deactivation, thereby inhibiting ACC and slowing fat synthesis.
  - Affecting ACC affects the rate of acetyl-CoA conversion to malonyl-CoA.
  - Increased malonyl-CoA level pushes the equilibrium over to increase production of fatty acids through biosynthesis.
  - Long chain fatty acids are negative allosteric regulators of ACC and so when the cell has sufficient long chain fatty acids, they will eventually inhibit ACC activity and stop fatty acid synthesis.

- **AMP and ATP concentrations of the cell act as a measure of the ATP needs of a cell and as ATP levels get low it activates the ATP synthetase which in turn phosphorylates ACC.**

- **When ATP is depleted, there is a rise in 5’AMP.**

- This rise activates AMP-activated protein kinase, which phosphorylates ACC, thereby inhibits fat synthesis.

- This is a useful way to ensure that glucose is not diverted down a storage pathway in times when energy levels are low.

- ACC is also activated by citrate.

- This means that, when there is abundant acetyl-CoA in the cell cytoplasm for fat synthesis, it proceeds at an appropriate rate.
• Net effect of insulin on lipid metabolism is to reduce the release of fatty acids from the stored fat and decreased production of ketone bodies.

Other actions of insulin:
• Control of cellular intake of certain substances, most prominently glucose in muscle and adipose tissue (about two-thirds of body cells)
• Increase of DNA replication and protein synthesis via control of amino acid uptake
• Modification of the activity of numerous enzymes
• The actions of insulin (indirect and direct) on cells include:
  o Increased glycogen synthesis – insulin forces storage of glucose in liver (and muscle) cells in the form of glycogen
  o Increased lipid synthesis – insulin forces fat cells to take in blood lipids, which are converted to triglycerides.
  o Increased esterification of fatty acids – forces adipose tissue to make fats (i.e., triglycerides) from fatty acid esters.
  o Decreased proteolysis – decreasing the breakdown of protein
  o Decreased lipolysis – forces reduction in conversion of fat cell lipid stores into blood fatty acids.
  o Decreased gluconeogenesis – decreases production of glucose from nonsugar substrates, primarily in the liver (the vast majority of endogenous insulin arriving at the liver never leaves the liver).
  o Decreased autophagy - decreased level of degradation of damaged organelles.
  o Increased amino acid uptake – forces cells to absorb circulating amino acids.
  o Increased potassium uptake – forces cells to absorb serum potassium.
  o Arterial muscle tone – forces arterial wall muscle to relax, increasing blood flow, especially in microarteries.
  o Increase in the secretion of hydrochloric acid by parietal cells in the stomach
  o Decreased renal sodium excretion

Ans. B: Increased release of fatty acids from stored fat in adipose tissue

NUCLEOTIDE METABOLISM

65. Nucleotides are derived from biosynthetic precursors of carbohydrate and amino acid metabolism, and from ammonia and carbon dioxide.

The liver is the major organ of de novo synthesis of all four nucleotides.

Degradation in humans, however, is only complete for pyrimidines (C, T, U), but not purines (G, A), which are excreted from the body in form of uric acid

Ans. A: Uric acid
Ref.: Harper’s Biochemistry, 28th ed., page-292
66. **Ans. D: Purine metabolism**
   Ref.: Harper’s Biochemistry, 28th ed., page-292

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**MISCELLANEOUS**

67. **Chitin** is a long-chain polymer of a N-acetylglucosamine/structural polysaccharide, a derivative of glucose, and is found in many places throughout the natural world.

   It is the main component of the cell walls of fungi, the exoskeletons of arthropods such as crustaceans (e.g. crabs, lobsters and shrimps) and insects, the radulas of mollusks and the beaks of cephalopods, including squid and octopi.

   Chitin may be compared to the polysaccharide cellulose and to the protein keratin.

   **Ans. C: Polysaccharide**
   Ref.: Harper’s Biochemistry, 28th ed., page-119

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68. Chemically, DNA consists of two long polymers of simple units called nucleotides, with backbones made of sugars and phosphate groups joined by ester bonds.

   This common form of DNA is said to be right handed because as one looks down the double helix, the base residues form a spiral in a clockwise direction.

   These two strands run in opposite directions to each other and are therefore anti-parallel.

   **Ans. D: Right handed, anti parallel**
   Ref.: Harper’s Biochemistry, 28th ed., page-302

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69. **Detection of RNA is termed northern blotting.**

   Detection of post-translational modification of protein is termed eastern blotting.

   The name western blot was given to the technique by W. Neal Burnette and is done for proteins.

   Southern blot, a technique for DNA detection was developed by Edwin Southern.

   Southwestern blot examines protein-DNA interactions.

   **Ans. C: RNA**
   Ref.: Harper’s Biochemistry, 28th ed., page-393

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70. In the Watson-Crick base pairing, adenine (A) forms a base pair with thymine (T), as does guanine (G) with cytosine (C) in DNA.

   In RNA, thymine is replaced by uracil (U).

   Alternate hydrogen bonding patterns also occur—particularly in RNA—giving rise to complex and functional tertiary structures.

   **Ans. C: Uracil**
   Ref.: Harper’s Biochemistry, 28th ed., page-306
71. Ribose sugar moiety is found in RNA

Deoxyribose sugar moiety is found in DNA

**Ans. B: Deoxyribose sugar**

*Ref.: Harper’s Biochemistry, 28th ed., page-306*

72. Collagen has great tensile strength, and is the main component of fascia, cartilage, ligaments, tendons, bone and teeth.

- Along with soft keratin, it is responsible for skin strength and elasticity, and its degradation leads to wrinkles that accompany aging.
- It strengthens blood vessels and plays a role in tissue development.
- It is present in the cornea and lens of the eye in crystalline form.
- The best stain for use in differentiating collagen from other fibers is Masson’s trichrome stain.

There are 28 types of collagen however, commonest ones are of type I, II, III, and IV:

i. Collagen One - bone (main component of bone)

ii. **Collagen Two - cartilage (main component of cartilage)**

iii. Collagen Three - reticulate (main component of reticular fibers)

iv. Collagen Four - floor - forms the basement membrane

Excessive deposition of collagen occurs in Scleroderma

Vitamin C deficiency causes scurvy, a serious and painful disease in which defective collagen prevents the formation of strong connective tissue. Gums deteriorate and bleed, with loss of teeth; skin discolors, and wounds do not heal.

Autoimmune disease results in an immune response in which healthy collagen fibers are systematically destroyed with inflammation of surrounding tissues. The resulting disease processes are called Lupus erythematosus, and rheumatoid arthritis, or collagen tissue disorders.

**Ans. B: Type II**

*Ref.: Harper’s Biochemistry, 28th ed., page-542*

73. Chaperones are proteins that assist the non-covalent folding/unfolding and the assembly/disassembly of other macromolecular structures.

- Molecular chaperone was invented by Ron Laskey to describe the ability of a nuclear protein called nucleoplasmin to prevent the aggregation of folded histone proteins with DNA during the assembly of nucleosomes.
- The term was later extended by John Ellis in 1987 to describe **proteins that mediated the post-translational assembly of protein complexes**.
- Many chaperones are heat shock proteins, that is, proteins expressed in response to elevated temperatures or other cellular stresses.
- The reason for this behaviour is that protein folding is severely affected by heat and, therefore, some chaperones act to repair the potential damage caused by misfolding.
- Other chaperones are involved in folding newly made proteins as they are extruded from the ribosome. Although most newly synthesized proteins can fold in absence of chaperones, a minority strictly requires them.
74. **Marfan syndrome is caused by mutations in the FBN1 gene on chromosome 15, which encodes a glycoprotein called fibrillin-1**, which is essential for the proper formation of the extracellular matrix including the biogenesis and maintenance of elastic fibers.

Elastin fibers are found throughout the body but are particularly abundant in the aorta, ligaments and the ciliary zonules of the eye, consequently these areas are among the worst affected.

Although there are no unique signs or symptoms of Marfan syndrome, the constellation of long limbs, dislocated lenses, and aortic root dilation is sufficient to make the diagnosis with confidence.

**A. Skeletal System**

The most readily visible signs are associated with the skeletal system.

Many individuals with Marfan Syndrome grow to above average height and may have long slender limbs with fingers and toes that are also abnormally long and slender (arachnodactyly).

This long, slender body habitus and long, slender limbs are known as dolichostenomelia.

- Abnormal curvature of the spine (scoliosis) is common, as is abnormal indentation (pectus excavatum) or protrusion (pectus carinatum) of the sternum.

**B. Eyes**

- Nearsightedness and astigmatism are common, but farsightedness can also result.
- Subluxation (dislocation) of the crystalline lens in one or both eyes (ectopia lentis) also occurs
- In Marfan’s the dislocation is typically superotemporal whereas in the similar condition homocystinuria, the dislocation is inferonasal.
- Sometimes weakening of connective tissue may cause detachment of the retina
- Early onset glaucoma can be another complication.

**C. Cardiovascular System**

The most serious conditions associated with Marfan syndrome involve the cardiovascular system.

- The major sign is a dilated aorta or an aortic aneurysm.
- Because of the underlying connective tissue abnormalities that cause Marfan syndrome, there is an increased incidence of dehiscence of prosthetic mitral valve.
- During pregnancy, even in the absence of preconceived cardiovascular abnormality, women with Marfan syndrome are at significant risk of acute aortic dissection, which can be lethal if untreated.

For this reason, women with Marfan syndrome should receive a thorough assessment prior to conception, and echocardiography should be performed every 6-10 weeks during pregnancy, to assess the aortic root diameter.

**D. Lungs**

- Marfan syndrome is a risk factor for spontaneous pneumothorax.
- Marfan syndrome has also been associated with sleep apnea and idiopathic obstructive lung disease.
E. Central nervous system

Another condition that can reduce the quality of life for an individual, though not life-threatening, is dural ectasia, the weakening of the connective tissue of the dural sac.

- Other spinal issues associated with Marfan include degenerative disk disease and spinal cysts.

Following disorders have similar signs and symptoms of Marfan syndrome:
  i. Congenital Contractual Arachnodactyly (CCA) or Beals Syndrome
  ii. Ehlers-Danlos syndrome
  iii. Homocystinuria
  iv. Loeys-Dietz syndrome
  v. MASS phenotype
  vi. Stickler syndrome
  vii. Multiple endocrine neoplasia, type 2B.

**Ans. D: None of the above**  
*Ref.: Harper’s Biochemistry, 28th ed., p531*

75. When food intake ceases, the body’s glycogen stores are used up in about 24 hours.

The level of insulin in circulation is low and the level of glucagon is very high.

The main means of energy production is lipolysis.

Gluconeogenesis converts glycerol into glucose and the Cori cycle converts lactate into usable glucose.

The high demand for glucose by the fetus, and for lactose synthesis in lactation, can lead to ketosis. This may be seen as mild ketosis with hypoglycemia in human beings.

Two systems of energy enter the gluconeogenesis: proteolysis provides alanine and lactate produced from pyrivate, while acetyl CoA produces dissolved nutrients (ketone bodies), which can be detected in urine and are used by the brain as a source of energy.

In uncontrolled diabetes, the ketosis may be severe enough to result in pronounced acidosis (Ketoacidosis).

**Ans. B: Hypercholesterolemia**  
*Ref.: Harper’s Biochemistry, 28th ed., page-141*

76. An optical isomer can be named by the spatial configuration of its atoms.

The D/L system does this by relating the molecule to glyceraldehyde. Glyceraldehyde is chiral itself, and its two isomers are labeled D and L.

**Ans. C: Glyceraldehyde**  
*Ref.: Harper’s Biochemistry, 28th ed., page-114*

77. **Ans. A: Protein**  
*Ref.: Harper’s Biochemistry, 28th ed., page-393*
78. Sodium fluoride is used to conserve tissue samples in biochemistry and medicinal testing as fluoride ions stop glycolysis by inhibiting the enzyme enolase.

Sodium fluoride is often used together with iodoacetic acid, which inhibits the enzyme aldolase.

Ans. D: Enolase
Ref.: Harper’s Biochemistry, 28th ed., page-150

79. In mammals, each small circular, double-stranded mitochondrial (mt) DNA molecule consists of 15,000-17,000 base pairs.

The two strands of mtDNA are differentiated by their nucleotide content with the guanine rich strand referred to as the heavy strand and the cytosine rich strand referred to as the light strand.

A mitochondrion contains outer and inner membranes composed of phospholipid bilayers and proteins. The two membranes, however, have different properties. Because of this double-membraned organization, there are five distinct compartments within the mitochondrion.

There is the outer mitochondrial membrane, the intermembrane space (the space between the outer and inner membranes), the inner mitochondrial membrane, the crista space (formed by infoldings of the inner membrane), and the matrix.

An important feature of human mitochondrial mtDNA is that—because all mitochondria are contributed by the ovum during zygote formation—it is transmitted by maternal nonmendelian inheritance.

Ans. C: Single stranded straight DNA
Ref.: Harper’s Biochemistry, 28th ed., page-319

80. Palindromic DNA - A palindrome is a sentence that reads the same forwards and backwards, e.g. ‘Madam I’m Adam’.

The DNAs of several eukaryotes are shown to have palindromic sequences, in which nucleotides of one strand going in one direction are the same as the nucleotides of the other strand going in the other direction.

The exact significance of palindromic DNA is not known, although several functions have been suggested.

Short palindromes may function as recognition sites of DNA for proteins which also have a two-fold rotational symmetry, e.g. lac repressor protein, CRP protein and many bacterial restriction enzymes.

Palindromes may also give structural strength to the transcribed RNA by hydrogen bonding in the hairpin loops. If the palindromic sequences are not perfectly symmetrical, imperfect loops may result.

Ans. C: Sequence of DNA
Ref.: Harper’s Biochemistry, 28th ed., page-404

81. DNA is a double-stranded molecule twisted into a helix (think of a spiral staircase).

Each spiraling strand, comprised of a sugar-phosphate backbone and attached bases, is connected to a complementary strand by non-covalent hydrogen bonding between paired bases.

The bases are adenine (A), thymine (T), cytosine (C) and guanine (G).

A and T are connected by two hydrogen bonds. G and C are connected by three hydrogen bonds.

Ans. B: G-C
Ref.: Harper’s Biochemistry, 28th ed., page-303
82. In cells with a nucleus (eukaryotes), the cell cycle can be divided in two brief periods:
   a. **interphase**—during which the cell grows, accumulating nutrients needed for mitosis and **duplicating its DNA**
   b. **mitosis (M)** phase, during which the cell splits itself into two distinct cells, often called “daughter cells”.

   **Ans. D: Interphase**
   **Ref.:** Harper’s Biochemistry, 28th ed., page-328

83. In a DNA double helix, two polynucleotide strands come together through complementary pairing of the bases, which occurs by **hydrogen bonding**.

   Each base forms hydrogen bonds readily to only one other — A to T and C to G — so that the identity of the base on one strand dictates what base must face it on the opposing strand.

   Thus the entire nucleotide sequence of each strand is complementary to that of the other, and when separated, each may act as a template with which to replicate the other.

   **Ans. A: Hydrogen bond**
   **Ref.:** Internet resources.

84. There are many variables that can affect the PT/INR result outcome.

   In fact, preanalytical variables account for up to 64% of all errors in PT/INR testing.

   One of the most important factors is the anticoagulant used in drawing the blood specimen.

   **The World Health Organization guidelines recommend the use of 3.2% buffered citrate.**

   The evacuated tube must be completely filled (at least 90% full) to maintain the proper anticoagulant-to-blood ratio.

   It is best to avoid traumatic venipunctures to minimize the release of tissue factor, which can initiate coagulation.

   The blood sample must be centrifuged for sufficient time (10 minutes) to create platelet-poor plasma as the presence of platelets in the specimen can shorten clotting times. Specimens for PT testing may be stored at room temperature and will yield valid results for specimens stored up to 24 hours, provided that the collection tube remains unopened.

   **Ans. C: Sodium citrate**
   **Ref.:** Internet resources

85. Irradiation of cells may not only lead to cell death but to other changes as well.

   Radiation has been shown to alter a cell’s progression through the cell cycle.

   **The delay occurs at particular points in the cell cycle, such as early G2 and the G1/S interface.**

   Multiple factors affect this kinetic alteration, including the radiation dose, dose rate, and cell type. The cell’s position in the cell cycle is a factor also

   **Ans. C: G2**
   **Ref.:** Harrison’s Medicine, 17th ed., page-516
86. **GLUT4 is expressed exclusively in adipocytes and skeletal and heart muscles**, and translocation of GLUT4 from an intracellular pool to the plasma membrane is a major mechanism of the insulin-stimulated glucose uptake in these tissues adipocytes, and Chinese hamster ovary (CHO) cells expressing Gq-coupled bradykinin B2 receptors (BK2Rs). The bradykinin-stimulated GLUT4 translocation may explain the exercise-induced glucose uptake in muscle cells.

**Ans. D: GLUT4**

*Ref.: Harper’s Biochemistry, 28th ed., p-171 (Table 20-2)*

87. The excretion of methylmalonic acid (elevated) in urine and estimation of serum B12 level are used to assess B12 deficiency

**Methylmalonic acidemia/ methylmalonic aciduria**
- It is a classical type of organic acidemia.
- Methylmalonic acidemia stems from several genotypes, presenting as progressive encephalopathy, and secondary hyperammonemia.
- The inherited forms of methylmalonic acidemia cause defects in the metabolic pathway where methylmalonyl-coenzyme A (CoA) is converted into succinyl-CoA by the enzyme methylmalonyl-CoA mutase.
- Mutations leading to defects in vitamin B12 metabolism or in its transport result in the development of methylmalonic acidemia.
- This disorder has an autosomal recessive inheritance pattern, which means the defective gene is located on an autosome, and two copies of the gene - one from each parent - must be inherited to be affected by the disorder.
- The parents of a child with an autosomal recessive disorder are carriers of one copy of the defective gene, but are usually not affected by the disorder.
- Methylmalonyl CoA requires vitamin B12 to form succinyl-CoA.
- **A severe nutritional deficiency of vitamin B12 can also result in methylmalonic acidemia.**
- When the amount of B12 is insufficient for the conversion of cofactor methylmalonyl-CoA into succinyl-CoA, the buildup of unused methylmalonyl-CoA eventually leads to methylmalonic acidemia.
- This diagnosis is often used as an indicator of vitamin B12 deficiency in serum.

**Ans. B: Vitamin B12**


88. **The hormone glucagon stimulates ketogenesis whereas insulin inhibits.**

The increased ratio of glucagon/insulin in diabetes mellitus promotes ketone bodies formation

**Diabetic ketoacidosis**
- It arises because of a lack of insulin in the body.
- **The lack of insulin and corresponding elevation of glucagon leads to increased release of glucose by the liver** (a process that is normally suppressed by insulin) from glycogen and through gluconeogenesis.
- High glucose levels spill over into the urine, taking water and solutes (such as sodium and potassium) along with it in a process of osmotic diuresis.
- Ketones, too, participate in osmotic diuresis and lead to further electrolyte losses.
This leads to polyuria, dehydration, and compensatory thirst and polydipsia.

The absence of insulin also leads to the release of free fatty acids from adipose tissue, which are converted, again in the liver, into ketone bodies (acetoacetate and beta-hydroxybutyrate).

Beta-Hydroxybutyrate can serve as an energy source in absence of insulin-mediated glucose delivery, and is a protective mechanism in case of starvation.

The ketone bodies, however, have a low pH and therefore turn the blood acidic (metabolic acidosis).

The body initially buffers the change with the bicarbonate buffering system, but this system is quickly overwhelmed and other mechanisms compensate for the acidos.

One such mechanism is hyperventilation to lower the blood carbon dioxide levels (a form of compensatory respiratory alkalosis).

This hyperventilation, in its extreme form, may be observed as Kussmaul respiration.

Blood sugars rise, dehydration ensues, and resistance to the normal effects of insulin increases further by way of a vicious circle.

As a result of the above mechanisms, the average adult DKA patient has a total body water shortage of about 6 liters (or 100 mL/kg), in addition to substantial shortages in sodium, potassium, chloride, phosphate, magnesium and calcium.

Glucose levels usually exceed 13.8 mmol/L or 250 mg/dL.

Beta-hydroxybutyrate, despite chemically not actually being a ketone, is the principal "ketone body" in diabetic ketoacidosis.

DKA is common in type 1 diabetes as this form of diabetes is associated with an absolute lack of insulin production by the islets of Langerhans.

In type 2 diabetes, insulin production is present but is insufficient to meet the body’s requirements as a result of end-organ insulin resistance.

Usually, these amounts of insulin are sufficient to suppress ketogenesis.

If DKA occurs in type 2 diabetics, their condition is called "ketosis-prone type 2 diabetes".

The clinical state of DKA is associated, in addition to the above, with the release of various counterregulatory hormones such as glucagon and adrenaline as well as cytokines.

Cerebral edema is the most dangerous DKA complication.

It is more likely in those with more severe DKA, and in the first episode of DKA.

Other factors in the development of cerebral edema are dehydration, acidosis and low carbon dioxide levels.

Ans. A: Increase in Glucagon/Insulin ratio, increased cAMP and increased blood glucose


89. In association with insulin, chromium promotes the utilization of glucose

Chromium is a component of a protein namely chromodulin which facilitates the binding of insulin to cell receptor sites.

Chromium

- It is an essential nutrient for the maintenance of normal glucose tolerance
- Its deficiency causes insulin resistance.
Chromium administration has also been shown in several studies to lower glucose and insulin levels in patients with type 2 diabetes.

It has been classified as not essential for mammals. (Cr (III) or Cr\(^{3+}\)).

Chromium deficiency is controversial or is at least extremely rare.

It has been attributed to only three people on parenteral nutrition, which is when a patient is fed a liquid diet through intravenous drips.

In contrast, hexavalent chromium (Cr (VI) or Cr\(^{6+}\)) is very toxic and mutagenic when inhaled.

Cr (VI) has not been established as a carcinogen when in solution, although it may cause allergic contact dermatitis (ACD).

Dietary supplements for chromium include chromium (III) picolinate, chromium (III) polynicotinate, and related materials.

Must know
- Glutathione peroxidase requires selenium
- Copper is an important constituent of catalase, cytochrome oxidase and tyrosinase.
- Zinc is also necessary for the storage and secretion of insulin

Ans. D: Chromium

Ref.: Satyanarayana’s Biochemistry, 3rd ed., p-422