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BIOCHEMISTRY

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Solved Question Papers

Eighth Edition

Singi Yatiraj

Foreword
***Late* Jagadish B Ingin**

JAYPEE

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[*] October 2017 question paper is renamed as December 2017 to maintain uniformity in the book.

MBBS PHASE I EXAMINATION
DECEMBER 2005
(Revised Scheme 2)

LONG ESSAYS

1. Enumerate the compounds formed from glycine, giving their biological importance. Why glycine is nutritionally nonessential?

- Glycine is an aliphatic amino acid (α amino acetic acid)
- Simplest amino acid
- Glucogenic amino acid
- Nutritionally, nonessential because can be synthesized in body from serine, choline, glycoxylic acid and threonine.

Glycine Metabolism

Synthesis of Glycine

a. From serine	Serine + Tetrahydrofolate (FH_4) PFP ↓ Serine hydroxymethyl transferase Glycine + $N^{5,10}$ methylene tetrahydrofolate
b. From ammonia, CO_2 and $N^{5,10}$ methylene FH_4 (By glycine synthase complex)	CO_2 + NH_3 + $N^{5,10}$ Methylene FH_4 + NADH + H^+ PLP ↓ Glycine cleavage system (glycine synthase complex) Glycine + FH_4 + NAD^+
c. From choline	Choline → Betaine → Dimethylglycine → Glycine
d. From glyoxylate	Glyoxylate + Alanine (or glutamate) ↕ PLP alanine glyoxylate aminotransferase Glycine + Pyruvate (or α-ketoglutarate)
e. From threonine	Threonine ↓ Threonine aldolase Acetaldehyde + Glycine

Compounds Formed from Glycine (Metabolic Role)

a. Proteins and peptides
   – Glycine is richly present in collagen (in collagen, every third amino acid is glycine)

b. Creatine

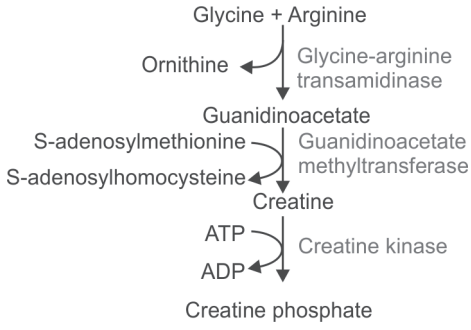


Fig. 1: Formation creatine

Functions of creatine

- Phosphorylated form of creatine storage form of high energy compound in muscle and heart
- Used to regenerate adenosine triphosphate (ATP) required during vigorous muscle contraction or cardiac contractility by donating phosphate for conversion of ADP to ATP by enzyme creatine kinase (Lohmann's reaction).

c. Glutathione

- Glutathione is a tripeptide containing glutamic acid, cysteine and glycine present widely in various tissues but highly concentrated in red blood cells (RBCs).

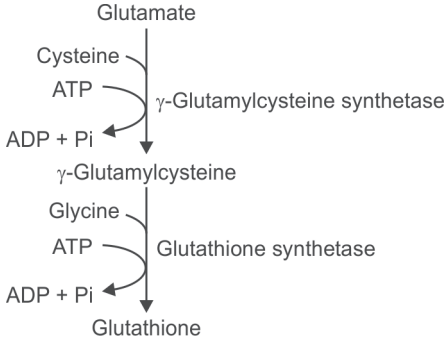


Fig. 2: Formation of glutathione

Functions of glutathione (oxidation-reduction reactions)

- Keeps enzymes in reduced state (active state)
- Suppresses oxidative stress in cell by converting H_2O_2 (oxidant) to H_2O (antioxidant function)
- Reduced glutathione maintenance red cell membrane stability
- Reduced glutathione also prevents oxidation of hemoglobin to methemoglobin
- Helps in absorption of amino acids (gamma-glutamyl cycle).

d. Heme

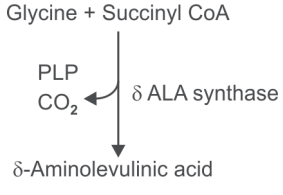


Fig. 3: Formation of ALA (precursor of heme)

Functions of heme

- Required for biosynthesis of hemoglobin, myoglobin and heme-containing enzymes such as cytochrome oxidase, catalase and peroxidise.

e. Bile acids

Cholyl CoA + Glycine → (Conjugation) → Glycocholate

Chenodexycholyl CoA + Glycine → (Conjugation) → Glycochenodeoxycholate

Functions of bile acids

- Sodium or potassium salts of bile acids are required for solubilization of cholesterol, excretion of cholesterol, digestion and absorption of triacylglycerols and fat-soluble vitamins.

f. Purine nucleotides (De novo synthesis)

- Glycine contributes C4, C5 and N-7 of purine ring

5-Phosphoribosylamine + Glycine + ATP → (Glycinamide ribose phosphate synthetase) → Glycinamide ribose-5 phosphate + ADP + Pi

g. Serine

$$N^{5\text{-}10} \text{ methylene } FH_4 + \text{Glycine} \xrightarrow{\text{Serine hydroxy methyl transferase}} \text{Serine} + FH_4$$

h. Glucose

Glycine → Serine → Pyruvate → Glucose

i. Hippuric acid (detoxification of benzoic acid)

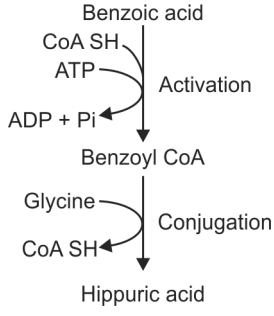


Fig. 4: Formation of hippuric acid

Catabolism

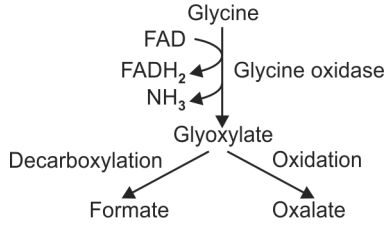
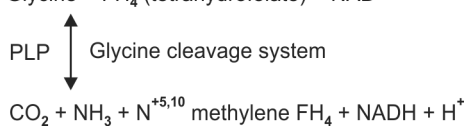
a. To glutamate (by transamination)	
b. To oxalate and formate	
c. To $N^{5,10}$ methylene FH_4 (by glycine cleavage system)	

Fig. 5: Catabolism of oxalate and formate

Fig. 6: Glycine of glycogen cleavage system

Disorders of Glycine Metabolism

a. Hyperglycemia
   – Rare inborn error due to defect in glycine cleavage system.

Inheritance	*Deficiency enzyme*	*Clinical features*	*Biochemical findings*
Autosomal recessive	Glycine synthase	Mental retardation and seizures	↑ blood glycine levels Glycinuria

b. Glycinuria

Inheritance	*Defect*	*Features*
Autosomal recessive	Defective renal tubular reabsorption of glycine	Excretion of large amount of glycine and proline in urine

c. Primary hyperoxaluria

Inheritance	*Types (Defects)*	*Clinical features*
Autosomal recessive	1. Type I hyperoxaluria Defect in transamination of glyoxylate to glycine (due to deficiency of alanine glyoxylate aminotransferase 2. Type II hyperoxaluria Defect in reduction of glyoxylate due to deficinency of D-glyceric acid dehydrogenase	• Seen in infancy • Urolithiasis (urinary oxalate stone formation) and oxalosis (deposition of calcium oxalate stones in renal and extrarenal tissues) • Renal stone formations leads to renal colic, renal hypertension and renal failure

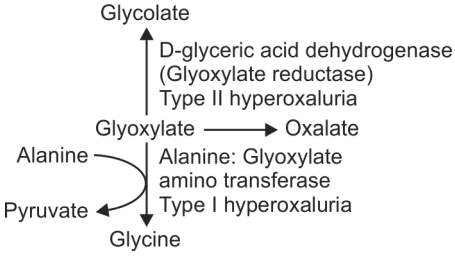


Fig. 7: Hyperoxaluria—types

2. Give an account of the chemistry, sources, daily requirement of vitamin C. Enumerate its biochemical functions and deficiency manifestations.

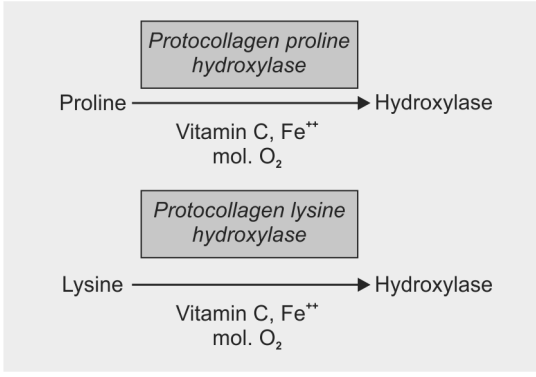
- Vitamin C or L-ascorbic acid is a water-soluble vitamin
- Also called antiscorbutic vitamin.

Chemistry	*Sources*	*RDA*
• Enediol lactone of a hexuronic acid with a C_2–C_3 double bond with empirical formula $C_6H_8O_6$ • Pure vitamin C is a white, crystaline, odorless substance with acidic taste • Highly water soluble and easily destroyed by heat, alkali and storage • Has reducing action and can itself oxidize to dehydro-ascorbic acid	• Citrus fruits (oranges, lemon), tomatoes, strawberries, green vegetables, guava	• Children: 40 mg • Adults: 60 mg • Pregnancy: 70 mg • Lactation: 95 mg

Coenzyme Forms

- Ascorbic acid (reduced form)
- Dehydro-ascorbic acid (oxidized form).

Biochemical functions (based on reversible oxidation and reduction between two coenyzmes)

Collagen formation	Promotes collagen formation through its action on post-translational hydroxylation of proline and lysine residues; thus procollagen is transformed to mature collagen  **Fig. 8:** Hydroxylation of proline and lysine (in collagen maturation)
Bone formation	Essential for formation of bone matrix
Iron and Hb metabolism	• Enhances intestinal iron absorption by maintaining it in ferrous state • Helps in reconversion of methemoglobin to hemoglobin
Tryptophan metabolism	Implicated in hydroxylation of tryptophan to serotonin
Tyrosine metabolism	Facilitates oxidation of parahydroxy phenyl pyruvate to homogentisic acid
Folic acid metabolism	Reduces folic acid to THFA, thus helps in maturation of RBCs
Corticosteroid synthesis	Plays a key role in biosynthesis of adrenal cortical hormones
Sparing action	• Has sparing action on other vitamins for oxidation like vitamin A, E and some B complex vitamins • Stimulates growth of intestinal flora thus augments activities of vitamin B complex
Immunological action	Augments functions of reticuloendothelial system and has stimulating effect on phagocytic action of leukocytes and formation of antibodies
Prevention of cataracts	Reduces the risk of cataract formation (on regular intake)
Prevention of chronic diseases	As an antioxidant, it prevents cancer formation and inhibits formation of nitrosamines, a carcinogen
Cholesterol metabolism	Stimulates 7 alpha hydroxylase step in synthesis of bile acids from cholesterol
Carnitine synthesis	Required for biosynthesis of carnitine from lysine and methionine

Deficiency Manifestations

- Deficiency of vitamin C results in scurvy.

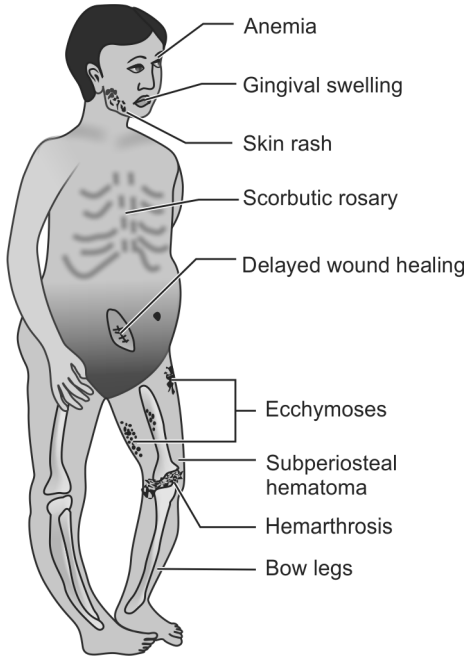


Fig. 9: Scurvy—manifestations

Causes	*Features*	*Biochemical findings*
• Dietary deficiency • Impaired absorption (celiac sprue) • Increased demand (pregnancy, surgery, burns)	• Swollen and bleeding gums due to impaired osteoid tissue formation • Petechial hemorrhages and ecchymoses due to rupture of capillaries, resulting from lack of intracellular substances • Bleeding into bones and joints leads to subperiosteal hematoma and hemoarthrosis • Arthritis due to impaired osteoid tissue formation • Delayed wound healing due to impaired collagen formation • Anemia—normochromic, normocytic (due to bleeding), megaloblastic (due to reduced erythropoiesis) and microcytic hypochromic anemia (due to impaired iron absorption and impaired heme synthesis) • Fatigue, depression and susceptibility to infections	• Decreased plasma, platelet or leukocyte ascorbic acid levels • Decreased vitamin C excretion in urine after a test dose of vitamin C

Significance

- Scurvy is first disease found to be associated with diet; first observed by James Lind in men at sea due to deficiency of fresh fruits in diet and their miraculous recovery following supply of lime.

SHORT ESSAYS

3. Write steps of beta oxidation of fatty acids with energetics.

Refer Question No. 1 Dec. 2008 (RS2).

4. Give outline of gluconeogenesis and mention its significance.

Refer Question No. 1 June 2009 (RS2).

5. What are isoenzymes and give their clinical importance citing two examples.

Refer Question No. 1 Dec. 2007 (RS2).

6. What is P: O ratio? Which are inhibitors of electron transport chain?

Refer Question No. 5 June 2007 (RS2).

7. Write detail with examples reactions involved in detoxification.

- Detoxification refers to series of biochemical reaction occurring in body to convert endogenous or exogenous toxic compounds to nontoxic or less toxic compounds and more easily excretable forms
- Detoxification reactions generate more polar metabolites, that are readily excreted from body
- Liver plays the most important role.

Phases

- Phases I involving oxidation, reduction and hydrolysis
- Phase II involving conjugation reactions.

Phase I Reactions

a. Oxidation reactions (addition of oxygen or removal of hydrogen or electrons)
   – Enzymes involved are:
     - Microsomal oxidation system contains cytochrome P450 system

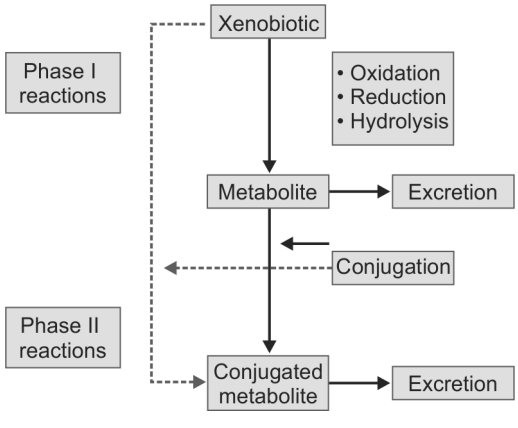


Fig. 10: Phases of detoxification

- Non-microsomal oxidoreductases include mitochondrial cytochrome P450 system, alcohol dehydrogenase (cytosol), aldehyde dehydrogenase (mitochondria) and mono amine oxidase

– Substances detoxified are alcohol aldehydes, amines, aromatic hydrocarbons and sulfur compounds

i. Alcohols

$$\underset{\text{Methanol}}{CH_3OH} \rightarrow \underset{\text{Formic acid}}{HCOOH}$$

$$\underset{\text{Ethanol}}{C_2H_5OH} \rightarrow \underset{\text{Acetic acid}}{CH_3COOH}$$

ii. Aldehydes

$$\underset{\text{Benzaldehyde}}{C_6H\ CHO} \rightarrow \underset{\text{Benzoic acid}}{C_6H_5COOH}$$

$$\underset{\text{Acetaldehyde}}{CH_3CHO} \rightarrow \underset{\text{Acetic acid}}{CH_3COOH}$$

iii. Amines and their derivatives

$$\underset{\text{Aliphatic amine}}{RCH_2NH_2} \rightarrow \underset{\text{Aliphatic acid + Urea}}{R - COOH + NH_2 - CO - NH_2}$$

iv. Aromatic hydrocarbons
Benzene → phenol

v. Sulfur compounds

* Organic sulfur is oxidized to sulfuric acid

b. Reduction reactions (removal of oxygen or addition of hydrogen or electrons)

i. Acetaldehydes

$CCl_3CHO \rightarrow CCl_3CH_2OH$

ii. Aromatic nitro compounds

$$\underset{\text{Picric acid}}{C_6H_2OH(NO_2)_3} \rightarrow \underset{\text{Picramic acid}}{C_6H_2OH(NO_2)_2NH_2}$$

$$\text{Nitrobenzene} \rightarrow \text{Aminobenzene}$$

c. Hydrolysis reaction (breakdown of compound using water)

Acetyl salicylic acid (Aspirin) → Salicyclic acid and Acetic acid
Acetanilide → Aniline + Acetic acid
Atropine → Tropic acid and Tropine
Procaine → p-Aminobenzoic acid + Diethylaminoethanol

Phase II Reactions

- Conjugation reactions
  – Conjugation is process in which a foreign compound combines with a substance produced in body.

Features

– Conjugation is done by substances available in body or some of them are synthesized in body
– It principally occurs in liver but can also occur in kidneys also
– It produces less toxic and more water-soluble compounds
– It occurs independently or follows phase I reactions

Types

– Glucoronic acid
  - Most common detoxification reaction
  - Active form of glucoronic acid (UDP gluocoronic acid) transfers a molecule of glucoronic acid to convert a toxic molecule with hydroyl, carbonyl, sulfhydryl or amino group into a nontoxic compound

Bilirubin + UDP gluocoronic acid → Biliruibin monoglucoronide + UDP
Bilirubin monoglucoronide + UDP gluocoronic acid → Bilirubin diglucoronide + UDP
Phenol + UDP gluocoronic acid → Phenyl glucuronide
Benzoic acid + UDP gluocoronic acid → Benzoyl glucuronide + UDP

- Glycine
  - Many aromatic carboxylic acids are detoxified by conjugation with glycine

Benzoyl CoA + Glycine → Hippuric acid
Phenylacetic acid + Glycine → Phenylaceturic acid
Cholic acid + Glycine → Glycocholic acid

- Cysteine
  - Cystine is used for conjugation reactions of alkyl or aryl halides, alkenes, nitro compounds and epoxides
- Glutamine
  - Phenylacetic acid is conjugated with glutamine to form phenylacetyl glutamine
- Methyl group
  - Methyl group of SAM is frequently used to methylate certain xenobiotics
  - Example: Nicotinamide
- Sulfate
  - PAPS (3'phospho-adenosine 5 phosphosulfate), active form of sulfate is used in detoxification of several aliphatic and aromatic compounds

Phenol + PAPS	→	Phenoxyl sulfate
Indoxyl + PAPS	→	Indoxyl sulfate

- Acetic acid
  - Acetyl CoA, active form of acetic acid also detoxifies many toxic substances
  - Example: Isoniazid, sulfanilamide
- Thiosulfate
  - Thiosulfate conjugates highly toxic cyanides.

Significance

- Detoxification serves as an important defense mechanism in that toxic metabolites are converted into less harmful substances and substances that can be excreted from body
- Detoxification differ from biotransformation (modifications of xenobiotics occurring in body) as biotransformation deals with only exogenous toxic substances and not all reactions of biotransformation yield nontoxic metabolities.

8. What is normal serum calcium level? Explain its regulation.

Refer Question No. 2 June 2009 (RS2).

9. Name the clearance tests used to assess kidney function. Explain any one of the clearance tests and mention its significance.

- Clearance refers to plasma that is completely cleared of the substance (which appears in urine) in a unit time and expressed as mL/min
- Clearance tests are assess kidney function by measuring the glomerular filtration rate
- Measurement of glomerular filtration rate (GFR) provides the most useful general index for assessment of severity of renal damage.

Clearance Tests to Assess Kidney Function

- Creatinine clearance tests (overestimates GFR)
  - Most commonly used clearance test to assess renal functioning

- Inulin clearance test (true measure of GFR)
  - Used as a reference method for the determination of GFR
  - Inulin is readily filtered by glomerulus, not reabsorbed by the tubules and not secreted by tubule
  - However, not used for routine diagnostic use since it is exogenous material and infusion requires monitoring for constant amount of inulin in plasma during the test.
- Urea clearance test (underestimates GFR)
  - Also an index of glomerular filtration and clearance is lower than inulin clearance since it is reabsorbed by the tubules
  - Not used for renal function test since it is subjected to variations due to changes in its production in disease states and enhanced reabsoption in prerenal failure.

Creatinine Clearance Test

- Creatinine clearance is an endogenous cleareance test to asses glomerular function of kidney
- It is calculated by estimating serum and urine creatinine.

Principle

- Creatinine in glomerular filtrate is only minimally absorbed and not secreted by tubules
- Since its excreation rate is relatively constant and its production is independent of metabolism or hormonal factors; it is a good measure for renal glomerular function.

Procedure

- Give 500 mL of water to promote good urine flow
- After about 30 minutes empty the bladder and discard the urine
- Exactly after 60 minutes again void the bladder and collect the urine and note the volume
- At the same time, take a blood sample
- Creatinine level in blood and urine are tested by Jaffe's reaction
- Blood level is tested after removing the serum protein and then adsorbing creatinine on Lloyd's reagent and then reacting with alkaline picarate to give an orange color
- Urine is tested after dilution due to high creatinine concentration and then creatinine clearance is calculated.

Calculations

Uncorrected clearance = $(U/P) \times V$

where U = Urine creatinine concentration

P = Plasma creatinine concentration

V = Urine flow in mL/min

Normal values

- Males : 85–125 mL/min
- Females : 80–115 mL/min

Significance

- A decreased creatinine clearance is a very sensitive indicator of reduced glomerular filtration rate due to acute or chronic damage
- Clearance value up to 75% of average normal value indicates adequate renal function
- Importance of creatinine clearance is in early detection of functional impairment of kidney without overt signs and symptoms
- It is very helpful in long-term monitoring of patients with renal insufficiency under a protein restricted diet.

Advantages and disadvantages of creatinine clearance (as GFR marker)

Advantages	*Disadvantages*
• Extrarenal factors will rarely interfere • Conversion of creatine phosphate to creatinine is spontaneous, nonenzymatic • As production is continuous, blood levels will not fluctuate and blood may be collected at any time • Not affected by diet or exercise	• Creatinine is filtered by glomeruli and actively excreted by tubules. Of total excretion, about 10% is tubular component. When GFR is reduced, the secretion component is increased and will viciate the results. Creatinine clearance is said to overestimate GFR by about 10–20 mL/mt • When GFR is severely reduced, extrarenal excretion increases. Then the major route becomes the degradation by intestinal bacterial flora • Very early stages of decrease in GFR may not be identified (creatinine blind area) • Other prerenal, renal and postrenal causes will influence creatinine clearance

10. Name the buffer system of body fluids. Explain any one of them.

Refer Question No. 2 June 2012 (RS2).

11. Give an account of salvage pathway.

- Salvage pathway is addition of ribose 5-phosphate to preformed purine bases or addition of phosphate to purine nucleosides.

Sources of Purine Bases and Nucleosides

- From degradation of purine nucleotides (nucleotide turnover)
- From dietary sources (in smaller extent).

Salvage Pathway

a. Synthesis of purine nucleotides from purine bases (salvage of purine bases)
   – Adenine is converted to AMP by the enzyme adenine phosphoribosyl transferase (APRT) using PRPP

Adenosine + PRPP	→	Adenosine monophosphate + PPi
	APRT	

   – Hypoxanthine-guanine phosphoribosyl transferase (HGPRT) transfers the phosphoribosyl group from PRPP to hypoxanthine, guanine or xanthine, converting them to IMP, GMP and XMP respectively

Hypoxanthine + PRPP	→	Inosine monophosphate + PPi
	HGPRT	

Guanine + PRPP	→	Guanosine monophosphate + PPi
	HGPRT	

   – These pathways are closely related to de novo synthesis as PRPP is substrate for both the pathways

b. Synthesis of purine nucleotides from purine nucleosides (salvage of purine nucleosides)
   – Adenosine kinase phosphorylates adenosine and deoxyadenosine with ATP to form AMP and dAMP

Adenosine + ATP	→	AMP + ADP
	Adenosine kinase	

Deoxyadenosine + ATP	→	dAMP + ADP
	Adenosine kinase	

   – Deoxycytidine kinase catalyzes addition of phosphate to deoxycytidine and deoxyguanosine

Deoxycytidine + ATP	→	dCMP + ADP
	Deoxycytidine kinase	

Deoxyguanosine + ATP	→	dGMP + ADP
	Deoxycytidine kinase	

   – This salvage and interconversion of purine nucleosides constitute purine salvage cycle

Significance

- Salvage pathways provide a pathway for utilization of purine bases derived from diet (exogenous) and normal turnover of nucleic acids
- It is particularly important in certain tissues such as RBCs and brain where de novo synthesis of purine nucleotides does not takes place due to absence of PRPP amidotransferase
- It also economizes intracellular energy expenditure.

Disorder

Lesch-Nyhan Syndrome

- Inherited disorder of salvage pathway of purine nucleotide synthesis

Inheritance	*Deficient enzyme*	*Clinical feature*	*Treatment*
X-linked recessive	Hypoxanthine guanine phosphoribosyltransferase (HGPRT)	• Excessive uric acid production causing gouty arthritis and neurological abnormalities such as mental retardation, aggressive behavior and learning disabilities • Patients have an urge for self mutilation by biting their own fingers and lips	Allopurinol to reduces uric acid formation (does not improve neurologic symptoms)

12. Hemoglobinopathies.

Refer Question No. 2 Dec. 2013 (RS2).

SHORT ANSWERS

13. Mention the significance of HMP shunt pathway.

Refer Question No. 4 Dec. 2013 (RS3).

14. Name essential fatty acids and mention their importance.

Refer Question No. 4 Dec. 2016 (RS2).

15. What is km value? Explain its importance.

Refer Question No. 6 Dec. 2010 (RS2).

16. Name three important growth factors and mention their function.

- Growth factors are substances which stimulate cell proliferation and regulate cell division by transmitting the message across plasma membrane to cell interior
- They cause mitoses or differentiation of target cells

Growth factor	*Source*	*Function*
a. Platelet derived growth factor (PDGF)	• α granules of platelets • Activated macrophages, endothelium and smooth muscles • Certain tumor cells	• Stimulates growth of mesenchymal cells and glial cells • Causes migration and proliferation of fibroblasts, smooth muscle cells and monocytes • Promotes wound healing in vivo
b. Epidermal growth factor (EGF)	• Fibroblasts, submaxillary gland	• Stimulates growth of epidermal and epithelial cells
c. Fibroblast growth factor (FGFs)	• Activated macrophages (basic FGFs) • Neural tissue (acidic FGFs)	• Binds to heparin and cause fibroblast proliferation and neovascularization
d. Transforming growth factor-α (TGF-α)	• Epithelial cells	• Stimulates growth of epidermal and epithelial cells

Contd...

Contd...

Growth factor	*Source*	*Function*
e. Transforming growth factor-β (TGF-β)	• Platelets, kidney, placenta • T cells • Endothelium and macrophages	• Inhibits growth of most cells except fibroblasts • Inhibits collagen degradation • Deactivates macrophages • Favors fibrogenesis in that stimulates fibroblast chemotaxis and collagen production
f. Erythropoietin (EP)	Renal non-tubular mesangial cells	Stimulates erythropoietic cells to proliferate and mature into erythrocytes
g. Nerve growth factor (NGF)	Salivary glands	Stimulates growth of sensory and sympathetic neurons
h. Insulin like growth factors (IGFI and II)	Serum	• Stimulates incorporation of sulfates in to cartilage • Exerts insulin like action on certain cells • Mitogenic for chondrocytes
i. Tumor necrosis factor-α (TNF-α)	Monocytes	• Necrosis of tumor cells, proliferation of leukocytes
j. Granulocyte monocyte colony stimulating factor (GM-CSF)	• Endothelial cells • T cells • Fibroblasts • Keratinocytes	• Activates granulocytes, monocytes and megakaryocytes • Stimulates hemopoietic progenitor cells of multiple lineage
k. Granulocyte colony stimulating factor (G-CSF)	• Endothelial cells • Fibroblasts	• Stimulates granulocytes • Activates neutrophils
l. Monocyte colony stimulating factor (M-CSF)	• Endothelial cells • Monocytes • Fibroblasts	• Activates monocytes • Stimulates macrophage colony formation
m. Interleukin 1 (IL-1)	• Monocytes, leukocytes • Macrophages • Endothelium • Glial cells	• Stimulates T lymphocytes to produce IL-2 • Stimulates mesenchymal cells to produce CSFs • Chemotactic for fibroblasts and increases collagen synthesis
n. Interleukin 2 (IL – 2)	Activated T lymphocytes	• Stimulates growth of T lymphocytes • Co-stimulates B-cells and monocyte differentiation • Activates and promotes growth of NK cells

Significance

- Growth factors are usually polypeptides
- Can initiate cell migration, differentiation and tissue remodeling
- May be involved in various stages of wound healing
- Can affect many different types of cells, viz. hemopoietic cells, epithelial tissues, nervous system and mesenchymal tissues
- Play a major role in regulating differentiation of stem cells to form various types of mature cells
- Are mitogenic to target cells
- Products of several oncogenes are either growth factors or parts of receptors for growth factors
- Some growth factors may be inhibitory to growth of certain cells, e.g. TGF-β
- Chronic exposure of target cells to increased amounts of a growth factor or to decreased amounts of a growth inhibitory factor may alter the balance of cellular growth (growth autonomy).

17. Explain troponin as a marker for myocardial infarction.

Refer Question No. 5 Dec. 2014 (RS2).

18. What is Bence-Jones proteins? Mention its significance.

- Bence-Jones proteins are free monoclonal light chain immunoglobulins (κ or λ) of smaller molecular weight (Mol weight of 20,000–40,000)

Cause	*Pathogenesis*	*Features*	*Electrophoresis*
They are overproduced in multiple myeloma (plasma cell tumor) wherein it is excreted in urine	This is due to asynchronous production of H and L chains or due to deletion of portions of L chains, so that they cannot combine with H chains	• Precipitate on heating urine to 45°C, maximally precipitated at 60°C but start redissolving at 60°C and forms a clear solution at 100°C • Precipitate reforms on cooling	Serum protein electrophoresis shows presence of prominent M band in $\alpha 2$ to γ globulin region

Significance

- Presence of Bence-Jones proteins in urine is diagnostic and prognostic of multiple myeloma
- Bence-Jones proteinuria is detected by heat test, Bradshaw's test and electrophoresis
- Excretion and deposition of these proteins damage the renal tubules.

19. Name bacterial DNA polymerases. Mention its significance.

- A DNA polymerase is chief enzyme involved in DNA replication (DNA repair and DNA polymerization).

Prokaryotic DNA Polymerase (in Bacteria)

Bacterial DNA polymerases	*Significance*
Pol I Kornberg's enzyme [named after it discoverer Arthur Kornberg (Nobel prize, 1959)]	Implicated in DNA repair and has both 5'->3' (Nick translation) and 3'->5' (Proof-reading) exonuclease activity
Pol II	Involved in replication of damaged DNA and has both 5'->3'chain extension ability and 3'->5' exonuclease activity
Pol III (Main replication enzyme)	• Main polymerase in bacteria (elongates in DNA replication), as such it has 3'->5' exonuclease proofreading ability • Has beta, gamma, delta and delta dash units

Significance

- DNA polymerase of prokaryotes has diverse functional variety, specially DNA Pol I though it does not possess DNA repair function
- Taq DNA polymerase obtained from thermophilic bacteria *Thermus aquaticus*, being heat resistant is used in PCR.

(**Note:** Eukaryotic DNA polymerase has five types, namely α, β, γ, δ and ε)

Bacterial DNA polymerases	*Eukaryotic DNA polymerase*	*Functions*
Pol I	α	Gap filling and synthesis of lagging strand
Pol II	ε	Proof-reading of DNA and repair
—	β	DNA repair
—	γ	Required for mitochondrial DNA synthesis
Pol III	δ	Helps in leading strand synthesis

20. Distinguish between RNA and DNA.

Points of difference	*DNA*	*RNA*
• Bases present	Adenine, guanine, cytocine and thymine	Adenine, guanine, cytosine and uracil
• Bases absent	Uracil	Thymine
• Pentose sugar	Deoxyribose	Ribose
• Intracellular location	Nucleus, mitochondria but never in cytoplasm	Nucleus and cytoplasm
• Number of strands	Double stranded (helical)	Single stranded
• Function	Genetic information (transcription, replication)	Gene expression (translation)

Contd...

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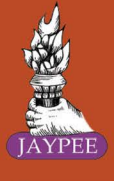

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