3.9. RESPIRATION

SYNOPSIS

- Respiration is a **catabolic**, enzyme mediated oxidative process.
- It is an energy releasing process **(Exergonic)**
- The C-C bonds of food materials and Organic acids are broken down in respiration.
- Mitochondria are associated with respiration
- The inner mitochondrial membrane is involved in *energy transduction*.
- The gap between the two membranes of the mitochondria is called as ***perimitochondrial space***.
- The invaginations of the inner mitochondrial membranes are called as Cristae/mitochondrial crests.
- The inner membrane is selectively permeable to few molecules like O_2, CO_2 and H_2O.
- The permeability of the inner membrane to protons is very low or absent. This is a significant factor for ATP synthesis
- The stalked particles on the cristae are called F_0 - F_1 particles. (Formerly called Oxysomes or elementary particles)
- The mitochondrial matrix contains 70 % of respiratory enzymes, 70S type of ribosomes, circular DNA, RNA & several ions.
- In respiration energy is released in the form of heat or temporarily packed in ATP ($C_{10} H_{16} N_5O_{13}P_3$)
- ATP is called as the energy currency of the cell.
- The energy present in the ATP can be immediately released whenever needed.
- The ATP molecules can move within a cell from one place to the other.
- ATP is a nucleotide consisting of three constituents
  i) A nitrogen base adenine,
  ii) A five carbon sugar ribose
  iii) Three inorganic phosphates (α , β and γ)
- The bond attaching the last phosphate (γ) to the rest of the molecule is a high energy bond.
- When this bond is hydrolysed it yields **7.6 K cal** of energy.
- Several respiratory intermediates serve as precursors for bio-synthesis of important organic molecules.
- Respiration is of two types
  a) Aerobic repiration occurs in presence of O_2
  ($C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + 686 K.cal)
  b) Anaerobic repiration occurs in absence of O_2 (
  $C_6H_{12}O_6 \rightarrow 2C_2 H_5OH + 2CO_2$ +56 K. cal)
- Aerobic respiration leads to complete oxidation of glucose molecule involving four different stages They are :
  a) **Glycolysis**
  b) **Oxidative decarboxylation** of pyruvic acid
  c) **Krebs' cycle**
  d) **Electron transport**
- Aerobic respiration involves six oxidation (dehydrogenation) reactions.
  (1 in Glycolysis, 1 in oxidative decarboxylation of pyruvic acid and 4 in Krebs' ' cycle).
- The complete oxidation of glucose into two molecules of pyruvic acid in series of steps is called *Glycolysis*
- Glycolysis is the first phase of respiration and no oxygen is used in the process.
- The common phase for both aerobic and anaerobic repirations is glycolysis.
- Glycolysis occurs in the cytosol.
- The various steps of glycolysis were discovered by Embden, Mayerhoff and Paranas.
- Glycolysis is also known as EMP pathway or Fundamental respiration or common respiratory metabolism or core respiration or Hexose disphosphate pathway
- W.O. James called glycolysis as core respiration.
- Equation representing glycolysis is
  $C_6H_{12} O_6 + 2 (ADP + Pi) + 2 NAD^+ \rightarrow 2CH_3 CO COOH + 2ATP + 2NADH + H^+ + 2H_2O$
- Glucose, ATP are required by living cells to start glycolysis.
- Phosphorylation of glucose is catalyzed by enzyme hexokinase (glucose-6-phosphotransferase)
- Second phosphorylation in glycolysis occurs when Fructose - 6 -phosphate is converted into Fructose - 1, 6-bisphosphate by phospho fructokinase.
- Enzymes hexokinase and phosphofructokinase require Mg^+ ions.
- The enzyme aldolase splits fructose -1, 6-bisphosphate into two trioses.
- The trioses are GAP and DHAP.
- These trioses are inter convertable.
- GAP is also known as PGAL and G-3-P.
- The process of conversion of DHAP to GAP is isomerization.
- A triose not suitable for biological oxidation is GAP.
- A triose suitable for biological oxidation is DHAP.
- GAP undergoes oxidation to form BisPGA (1, 3, bisphosphoglyceric acid).
- During the oxidation of GAP, NAD is reduced to $NADH+H^+$ and a molecule of $H_2PO^-_4$ is used.

- Number of oxidation reactions that occur in glycolysis is One.
- Number of NAD molecules reduced in glycolysis is 2.
- Number of dephosphorylations of glycolysis is 2.
- Number of Isomerisation steps in glycolysis is 3.
- Number of stages at which dephosphorylations occur is 2 (Substrate level phosphorylations.)
  1. BisPGA + ADP PGA + ATP
  2. PEP + ADP Pyruvic acid + ATP
- Enzymes phosphoglycero kinase and pyruvic kinase which catalyse diphosphorylation require co-factor Mg^{+2}.
- ATP formed during glycolysis is by substrate level phosphorylation
- The enzymes enolase catalyses dehydration reaction of glycolysis ($2PGA \rightarrow PEP + H_2O$).
- Number of ATP formed during glycolysis is 4.
- Number of ATP used in glycolysis is 2 (one when glucose is converted to glucose - 6-phosphate and second one when Fructose - 6 phosphate is converted to fructose, 1-6 bisphosphate).
- Net gain of ATP in glycolysis is 2
- Net gain of $NADH+H^+$ in glycolysis is $\rightarrow$ 2 molecules
- The end product of glycolysis is Pyruvic acid (2 molecules).
- Pyuvic acid is the common intermediate substance of aerobic and anaerobic respirations.
- The ultimate fate of pyruvic acid depends upon the avialability of oxygen.
- In glycolysis O_2 is not utilized and CO_2 is not released.

Oxidative decarboxylation of pyruvic acid

- The conversion of pyruvic acid into acetyl Co. A chemically is *oxidative decarboxylation*.
- Product of glycolysis that enters mitochondrial matrix is pyruvic acid.
- A membrane bound protein called pyruvate translocator helps in transport of pyruvic acid from cytosol to matrix of mitochodrion.
- In oxidative decarboxylation pyruvic acid undergoes oxidation (dehydrogenation), decarboxylation and condensation.
- Oxidative decarboxylation of pyruvic acid into acetyl Co. A occurs in mitochondrial matrix.
- It is catalysed by multienzyme complex known as pyruvic dehydrogenase complex (pyruvic oxidase).
- Pyruvic dehydrogenase complex is present in the matrix of mitochondria. This is a cluster of Three enzymes a) pyrivate decarboxylate b) Dihydro lipoyl transacetylase and c) dihydro lipoyl dehydrogenase.
- For the formation of Acetyl CoA, six Cofactors are required.
- The six co-factors are Thiamine pyrophosphate (TPP), Lipoic acid, (LP), NAD+, Coenzyme- A Mg^+ and FAD.
- The product of oxidative decarboxylation of Pyruvic acid is a two carbon compound called acetyl co.A
- Pyruvic acid enter into Kreb's cycle in the form of Acetyl Co. A.
- Acetyl Co.A is the connecting link between glycolysis and Krebs' cycle.
- Connecting reaction between glycolysis and Krebs' cycle is oxidative decarboxylation of pyruvic acid. (2^{nd} step in aerobic respiration)
- Two molecules of pyruvic acid produced in glycolysis undergo oxidative decarboxylation to form two molecules of Acetyl Co-A2NADH+H^+ and $2CO_2$.

KREB'S CYCLE

- The complete oxidation of Acetyl Co. A into CO_2 and water occurs through Kreb's cycle.
- Pyruvic acid enters into Kreb's cycle in the form of acetyl CoA.
- Kreb's cycle occurs in mitochondrial matrix.
- The concerned enzymes of Krebs' cycle are present in the mitochondrial matrix, Except succinic dehydrogenase.
- Kreb's cycle is also known as TCA cycle or citric acid cycle or organic acid cycle or mitochondrial respiration.
- Number of biochemical reactions in Kreb's cycle is ten.
- Opening face (door) of Kreb's cycle is -OAA (oxaloaceticacid)
- The first reaction of Kreb's cycle is condensation of acetyl Co.A with OAA and H_2O to form citric acid
- Citric acid is the first product of Kreb's cycle.
- Enzyme Aconitase catalyses the conversion of citric acid to isocitricacid.
- Conversion of isocitric acid to oxalosuccinic acid is first oxidation step in Kreb's cycle.
- **Citric acid is** the **first** tricarboxylic acid of Kreb's cycle.
- First decarboxylation occurs in conversion of oxalosuccinic acid to α-ketoglutaric acid.
- α-ketoglutaric acid is the first and only 5 carbon intermediate acid of Kreb's cycle.

- The intermediate substance of Kreb's cycle that undergoes oxidation and decarboxylation is α-ketoglutaric acid.
- An organic acid which undergoes dehydrogenation and decarboxylation in TCA cycle in α-Ketoglutaric acid
- The first 4-carbon compound formed in Krebs' cycle is succinyl Co.A.
- Reaction involved in the formation of succinly Co.A is oxidation, decarboxylation and condensation.
- The only substrate level phosphorlation step in Kreb's cycle is formation of succinic acid from succinyl Co.A. This reaciton is catalysed by succinyl thiokinase. Kerb's cycle in animal mitochondrion produces GTP instead of ATP as in plant mitochondrion.
- a) During the conversion of succinic acid to fumaric acid hydrogen is accepted by FAD.
- b) Succinic dehydrogenase catalysis conversion of succinic acid to fumaric acid, it is the only enzyme of citric acid cycle which is located not in the matrix but fixed as the integral protein of the mitochondrial membrane.
- c) It is the catalytic component of complex-II of ETS.
- Fumarase is useful for the conversion of fumaric acid to malic acid. A molecule of water is utilized in this reaction.
- The steps of Kreb's cycle which involves no energy liberation are dehydration of citric acid to cis-aconitic acid, cis-aconitic acid to isocitric acid, conversion of oxalosuccinic acid to α-ketoglutaric acid and hydration of fumaric acid to malic acid.
- Number of decarboxylation steps during Kreb's cycle is 2.
  I) Oxalosuccinicacid $\rightarrow$ α-ketoglutaric acid
  II) α-ketoglutaric acid $\rightarrow$ succinyl Co.A.
- Final oxidation in Kreb's cycle occurs when malic acid is converted to oxaloacetic acid, one NAD is reduced to $NADH_2$
- Number of oxidation steps during Kreb's cycle is 4
  I) Isocitric acid $\rightarrow$ Oxalosuccinic acid.
  II) α-ketoglutaric acid $\rightarrow$ Succinyl co.A.
  III) Succinic acid $\rightarrow$ Fumaric acid.
  IV) Malic acid $\rightarrow$ Oxaloacetic acid
- Irreversible reactions of Kreb's cycle are
  I) OAA+Acetyl Co.A+H_2O $\rightarrow$ Citric acid
  II) α- ketoglutaric acid $\rightarrow$ Succinyl co.A
- A 5 - carbon tricarboxylic acid formed during Krebs' cycle is α-ketoglutaric acid.
- An intermediate substance of Kreb's cycle useful in synthesis of amino acids is α-ketoglutaric acid.
- Six carbon compounds of Kreb's cycle are citric acid, cis -aconitic acid, isocitric acid and oxalosuccinic acid.
- Five carbon compound of Kreb's cycle is α-ketoglutaric acid.
- Four carbon compounds of Kreb's cycle are succinyl CoA. succinic acid, Fumaric acid, Malic acid and oxaloacetic acid.
- In one turn of Kreb's cycle, (complete oxidation of acetyl Co.A) forms-3NADH+H^+, 1$FADH_2$ and ATP (GTP)
- NAD+ is known as universal hydrogen acceptor or Co-enzyme-I.
- Oxidation of food molecules and generation of ATP are important characters of Kreb's cycle.
- Kreb's cycle is a central metabolic pathway playing an important role in both catabolism & anabolism.
- The catabolic role is that it is responsible for oxidation of carbohydrates.
- The anabolic role is that the α keto glutaric acid formed as an intermediate is responsible for the synthesis of amino acids.
- Thus the term amphibolic (dual purpose) is used to signify Kreb's cycle.

Electron Transport system

- During glycolysis, oxidative decarboxylation of pyruvic acid and Kreb's cycle a total of twelve high energy electron pairs are generated for each molecule of glucose. they are 10 NADH+H+ and 2 $FADH_2$.
- Reduced Co-enzymes (NADH+H^+ & $FADH_2$) participate in Electron transport
- Reduced Co-enzymes oxidised completely in the 4th & final step of aerobic respiration.
- Reduced Co-enyzmes donot combine directly with the molecular O_2. Only their hydrogen or electrons are transferred through various e^-carriers and finally reach O_2.
- This O_2 dependent process of aerobic respiration occurs on the inner mitochondrial membrane.
- All electron carriers form a system called electron transport system or electron transport chain or respiratory chain.
- During the oxidation of NADH+H^+ & $FADH_2$, ATP are synthesized. This is called oxidative phosphorylation.
- This process includes the participation of five multi protein complexes (I & V) along with two mobile carriers Ubiquinone and Cytochrome C)
- Components of complex I (NADH - ubiquinone oxidoreductase) has flavin mono nucleotide (FMN) as prosthetic group and six iron - sulphur (Fe-S)

centers. This complex transfers electrons from mitochondrial $NADH+H^+$ to ubiquinone.

- Components of complex -II (Succinic dehydrogenase)- This complex consists FAD as prosthetic group and two iron - sulphur centers. This enzyme transfers electrons from succinate to ubiquinone.
- Ubiquinone - It is a lipid soluble quinone, and structurally similar to plastoquinone. It is a mobile carrier between complexes I and III and also between II and III.
- Components of complex III (Cytochrome C - reductase) - This enzyme complex has two 'b' type cytochromes (b_{560} and b_{565}) and cytochrome C_1. One iron sulphur protein is also present. This complex catalysis the reduction of cytochrome C_1 by facilitating the transfer of electrons from ubiquinol.
- Cytochrome C. It is a hydrophilic, mobile carrier between complex III and IV.
- Components of complex IV (Cytochrome C - oxidase) This contains four units- Cytochrome 'a' cytochrome a_3 and two copper containing proteins. This complex transfers electrons from reduced cytochrome C to molecular oxygen
- Components of complex V (ATP synthase or F_0 - F_1 Complex) -It has two major components F_0 (Base Piece) and F_1 (Head piece). F_0 acts as a proton channel while F_1 is the actual catalytic site for converting ADP and Pi to ATP.

The process of electron transport and proton translocation

- **Step -I :** Two electrons from each $NADH+H_+$ generated in mitochondrial matrix are transferred to FMN, the prosthetic group of complex I. $NADH+H^+$ is oxidised to NAD^+
- **Step -II :** Electrons from complex I move to ubiquinone (UQ). This movement of electrons is associated with translocation of protons from matrix to the inter membrane space. For every two electrons passing through complex -I, pumping of 4 protons from matrix to the inner membrane space occurs
- **Step III :** A quinone cycle operates. During this ubiquinone accepts one electrons from complex I and two H^+ from the mitochondrial matrix and gets reduced to ubiquinol
- **Step IV :** Ubiquinonol moves to complex III, conveys the electron to cytochrome b and releases two protons into the intermembrane space and gets oxidised to ubi semi quinone, which returns to UQ pool. Thus for every two electrons passing through quinone cycle and complex III, there is translocation of $4H^+$ from the matrix into the inter membrane space.
- **Step V :** The electrons from complex III are transferred to the mobile carrier III called cytochrome C. The reduced cytochrome C moves to complex IV and convey the electrons to it. Cytochrome C is oxidised.
- **Step VI :** Electrons from complex IV are transferred to molecular oxygen. For a a pair of electrons moving through the complex IV to the O_2, there is translocation of two protons from mitrochondrial matrix to the inter membrane space. For transfer of every two electrons, 4H+ are removed out of the mitochondrial matrix. Two protons are consumed in the formation of a water and two protons translocated into the inter membrane space.
- The movement of two electrons from each mitochondrial $NADH+H^+$ through the ETS, results in the formation of one water molecule, $10H^+$ into the inter membrane space.
- Step VII : $FADH_2$ formed in Krebs' cycle. For this there is by passing of complex I, the electron transfer (2e) from $FADH_2$ to molecular O_2 results in the translocation of only $6H^+$ into the inter membrane space.
- For cytosolic $NADH+H^+$ produced in glycolysis, there is a pumping of $6H^+$ to inter mitochondrial space unlike matrix of mitochondrial $NADH + H^+$.

OXIDATIVE PHOSPHORYLATION

- The mechanism of mithcondria ATP synthesis is based on Peter Mitchel's chemiosmotic hypothesis
- A proton concentration gradient is established across the inter mitochondrial membrane.
- The F_0 particle of F_0 - F_1 particle permits the returns of H^+ ions into the mitochondrial matrix.
- When H^+ moves down the gradient, energy is released
- This energy rotates the F1 particle leading to the formation of ATP from ADP and Pi.
- The three protons moving down the potential gradient is sufficient to form 1 ATP molecule.
- On oxidation of one $NADH+H^+$ molecule (mitochondrial) which adds 10H+ to the concentration gradient, 3ATP molecules are produced
- External NADH-dehydrogenase (a membrane bound protein) helps in transfer of e^- form cytosolic NADH to UQ pool.
- The cytosolic $NADH+H^+$ and $FADH_2$ which add 6H+ to the concentration gradient,

  Oxidation of cytosol $NADH+H^+$ & $FADH_2$ results production of 2 ATP

Balance sheet of Aerobic respiration.

(A) Glycolysis

(i) ATP produced by

substrate level phophylation = 4 ATP

ATP consumption = (-)2 ATP

Net gain of ATP (4 -2) = 2 ATP

(ii) ATP produced by oxidative phosphorylation

2 NADH + H^+ (2 x 2) = 4ATP

Total ATP produced during aerobic glycolysis 6 ATP

(B) **Oxidative decarboxylation of Pyruvic acid**

2NADH + H^+ (2x 3) = 6ATP

(C) **Krebs' cycle**

6 NADH + H^+ (6x3) = 18 ATP

2 $FADH_2$ (2x2) = 4 ATP

Substrate level phosphoryalation = 2ATP

Total = 38 ATP

Net gain = 36 ATP

Energitics of Aeobic Respiration

One glucose molecules on complete oxidation forms 36 ATP

- No.of ATP formed by complete oxidation of a molecule of glucose (180gm) is - 38.
- No. of ATP utilised during the complete oxidation of a molecule of glucose is - 2
- Net gain of ATP during aerobic respiration is - 36.
- No. of ATP formed through SLP during aerobic respiration is - 6 (4+2)
- No. of ATP formed through oxidative phosphorylation during aerobic respiration is : 32
- Energy stored in ATP after the complete oxidation of glucosemolicule is (36x7.6) = 273.6 K.Cal
- Energy liberated during hydrolysis of one ATP molecule is 7.6 K. Cal
- Energy that is liberated as heat energy during aerobic respiration in 412.4K.Cal
- **Anaerobic respiration** occurs in the absence of O_2. Organisms which carry out this respiration are called anaerobes.
- Anaerobes may be obligative and facultative.
- Obligate anaerobes cannot survive in the presence of O_2

  Eg :- *Clostridium botulinum*

  Facultative anaerobes can tolerate aerobic conditions Eg: - Yeasts
- Anaerobic respiration occurs in two steps

  a) Glycolysis

  b) Fermentation

5. Glucose

$\downarrow$ Glycolysis

Pyruvic acid

Pyruvic decarboxylase $\downarrow$ CO_2

Acetaldehyde

Alcohol dehydrogenase $\downarrow$ $NADH^+H^+ \downarrow NAD^+$

Ethyl alcohol

- The net gain of ATP in anaerobic respiration is two. alcoholic fermentation
- First reported by Gay Lussac & the term Fermentation was coined by L. Pasteur.
- First step in alcoholic fermentation is decarboxylation of pyruvic acid to acetaldehyde and CO_2 under the influence of the enzyme pyruvic decarboxylase
- The second step is reduction- Acetaldehyde is reduced to ethyl alcohol in the presence of NADH+H+.

  The reaction is catalysed by the enzyme alcohol dehydrogenase.
- Alcohol fermentation is used in preparation of beverages by using yeast
- It is also used in bread making
- Fermentation is the dagradation of organic substance in the absence of O_2
- It is the most ancient type of metabolism for obtaining energy from nutrient molecules

Respiratory Quotient (R Q)

- RQ is the ratio between volume of CO_2 evolved and volume of O_2 consumed.
- RQ is an index of the respiratory substrate used
- RQ differs according to the type of respiratory substrate.
- RQ is measured by an instrument called Ganong's respirometer.
- RQ for carbohydrate is one
- RQ for proteins ranges between 0.8 to 0.9
- RQ for Fats is less than one [<1]
- RQ for organic acid is greater than one [>1]

LEVEL-I

491. Respiration is a process

1) endergonic 2) exergonic

3) anabolic 4) reductive

492. During respiration
1) food materials are constructed
2) light energy in utilised
3) bonds in food material are broken down to release energy
4) energy is stored in food materials

493. In aerobic respiration, energy is harvested from glucose molecules in a sequence of
1) four steps 2) three steps
3) two steps 4) six steps

494. The first step in aerobic respiration takes place in
1) Mitochondrial matrix
2) Perimitochondrial space
3) Both in cytosol and mitochondria
4) Cytoplasm

495. Cell organelles associated with the process of aerobic respiration are
1) Chloroplasts 2) Endoplasmic reticulum
3) Mitochondria 4) Peroxisomes

496. Amont of energy released from one glucose molecule during aerobic respiration is
1) 686 K. Cals 2) 56 K.Cals
3) 656 K.Cals 4) 36 K.Cals

497. Repiration is carried out by
1) all plant cells only 2) all animal cells only
3) all bacterial cells only 4) all living cells

498. The stalked particles on the mitochondrial cristae were previously called as
1) Oxysomes
2) elementary particles
3) F_0-F_1 complexes 4) 1 and 2

499. The amount of energy released from ATP by hydrolysis is
1) 76 Kilo.cal 2) 7.6 Kilo. cal
3) 760 Kilo. cal 4) 7 Kilo. cal

500. In which of the following, respiration in absence of O_2 can also takes place
1) men 2) potato plant
3) Spirogyra 4) yeast

501. Which one is considered as energy currency of cell?
1) AMP 2) ADP
3) ATP 4) $NADP^+$

502. The mechanism of aerobic respiration involves.
1) Four oxidation reactions
2) Six dehydrogenation reactions
3) Six - decarboxylation reactions
4) Four dehydrogenation reaction

503. Oxidation of NADH and $FADH_2$ within the inner mitochondrial membrane during aerobic respiration is
1) the last step 2) the second step
3) the first step 4) the third step

504. Glycolysis is also know as
1) Krebs cycle 2) PCR cycle
3) C_2 cycle 4) EMP pathway

505. ATP molecules in glycolysis are synthesized by
1) Oxidative phosphorylation
2) Substrate level phosphorylation
3) Photophosphorylation
4) Both oxidative and photophosphorylation

506. Net gain of Hexose diphosphate pathway
1) 2 NADPH + H^+ and 4 ATP
2) 4 NADH + H^+ and 2 ATP
3) 2 NADH + H^+ and 2 ATP
4) 2 NADH + H^+ and 4 ATP

507. The enzyme which converts glucose to glucose - 6 - phosphate is
1) glucose synthetase 2) phophorylase
3) glucose - 6 - phosphotase 4) hexokinase

508. The metallic activator required for most of the reactions of glycolysis is
1) Mg 2) Fe
3) Mn 4) Cu

509. During the conversion of G-3-P, 1.3.bis PGA, the required phosphate comes from
1) ATP 2) $H_2PO^-_4$
3) NADPH 4) ADP

510. Second step of susbstrate level phosphorylation in EMP pathway is catalysed by
1) Phosphoglyceromutase
2) Triose phosphate isomerase
3) Phosphoglycerokinase
4) Pyruvic kinase

511. The ultimate end products of Glycolysis are
1) CO_2 2) H_2O
3) Pyruvic acids 4) O_2

512. Connecting link between glycolysis and krebs cycle is
1) Pyruvic acid 2) Citric acid
3) Acetyl Co.A 4) T.P.P

513. The multienzyme complex that catalyses the second step of aerobic respiration is
1) Pyruvate decarboxylase
2) Pyruvic dehydrogenase complex
3) NADH - oxidoreductase 4) Cirtic synthetase

514. Krebs cycle enzyme which is not found in the matrix of mitochondrion is
1) Succinic dyhydrogenase
2) Malic dehydrogenase
3) Fumerase
4) Succinyl thiokinase

515. Substrate of oxidative decarboxylation in citric acid cycle is
1) Succinyl CO A
2) α - ketoglutaric acid
3) Oxalosuccinic acid
4) Fumaric acid

516. The only 5 carbon compound in TCA cycle is
1) Cis-aconitic acid 2) Succinic acid
3) α-ketoglutaric acid 4) oxalosuccinic acid

517. Product of 3rd oxidation in Krebs cycle is
1) succinic acid 2) α-ketoglutaric acid 3) oxalosuccinic acid
4) Fumaric acid

518. Krebs cycle is also known as Amphibolic pathway because
1) It plays an important role in both catabolism and anabolism
2) It occurs in mitochondria matrix
3) It starts with participation of C_2 compound
4) It occurs between 2nd and 4th steps of aerobic respiration

519. Mobile carrier which moves along the side of inner mitochondrial mambrane is
1) Cytochrome C_1 2) Ubiquinone
3) Cytochrome a_3 4) Cytochrome C

520. Complex V in ETS is also known as
1) F_0 - F_1 ATP ase 2) Cytochrome 'c' oxidase 3) CF_0 - CF_1 ATP ase
4) succinic-oxidoreductase

521. During electron transport, cytosolic NADH give the electrons to
1) Complex I 2) UQ
3) Complex II 4) Complex IV

522. Final acceptor during ETS is
1) $NADP^+$ 2) Cy + a_3
3) molecular oxygen 4) Complex - IV

523. Oxidative phosphorylation takes place
1) in mitochondrial matrix
2) in thylakoid of grana
3) on cristae of mitochondria
4) in the perimitochondrial space

524. The smallest rotatory machine in the universe is
1) finger like infolding of mitochondrial membrane
2) first enzyme protein complex of ETS
3) UQ pool of ETS
4) F_0 - F_1 ATP ase

525. What is the end products of electron transport chain?
1) CO^2 2) H_2O
3) O_2 4) $C_6H_{12}O_6$

526. Alcoholic fermentatioin was reported by
1) Louis pasteur 2) Gaylussac
3) Peter Mitchel 4) Sir Hans Krebs

527. Enzymatic degradation of sugars in the presence of microbes into ethyl alocohol is called
1) Fermentation 2) Glycolysis
3) Aerobic respiration 4) Respiration

528. One of the following undergoes reduction during alcoholic fermentation
1) Pyruvate 2) Acetaldehyde
3) Acetyl Co. A 4) PEP

529. The universal hydrogen acceptor is
1) NAD 2) ATP
3) CO A 4) FMN

530. Enzymes invoved in the incomplete oxidation of pyruvic acid during anaerobic respiration are
1) Decarboxylase and dehydrogenase
2) Isomerase and Decarboxylase
3) Dehydrogenase and phosphorylase
4) Isomerase and Dehydrogenase

531. Source of hydrogen for the reduction of acetaldehyde into ethyl alcohol is
1) $FADH_2$ 2) $NADPH + H^+$
3) H_2O 4) $NADH + H^+$

532. During fermentation Acetaldehyde undergoes
1) Reduction 2) Oxidation
3) Decarboxylation 4) Hydration

533. Respiratory quotient (R.Q) is the ratio of
1) No. of ADP molecules converted to ATP molecules per oxygen atom
2) Vol. of CO_2 released to Vol. of O_2 taken in respiration
3) Vol. of O_2 taken in and Vol. of CO_2 released in respiration
4) Amount of glucose utilised to Vol. of O_2 taken in respiration

534. R.Q is maximum in
1) Fats 2) Oxalic acid
3) Gluecose 4) Protein

535. Variation among R.Q values depends on
1) Light 2) Temparature
3) Respiratory substrate 4) Respiratory products

536. When fats are the respiatory substrates, then R.Q is
1) Zero 2) One
3) Less than one 4) More than one

537. Which of the following organic substance rarely acts as respiratory substrates
1) Proteins 2) Fats
3) Carbohydrates 4) Organic acid

538. A common phase between aerobic and anaerobic respiration is
1) Glycolysis 2) Krebs' cycle
3) Fermentation 4) E.T.S

539. Evolution of CO_2 is more than the intake of O_2 when
1) Sucrose is respired
2) Glucose is respired
3) Organic acids are respired
4) Fats are respired

540. If respiratory substrate is rich in oxygen, the value of RQ is
1) One 2) <1
3) >1 4) Can't be estimated

541. The main respiratory substrate in plants is
1) Glucose 2) Protein
3) Oxalicacid 4) Tripalmitin

542. When malic acid is respiratory substrate (EAMCET - 2002)
1) The amount of CO_2 released is more than O_2 consumed
2) The amount of CO_2 released is less than O_2 consumed
3) The amount of CO_2 released is equal to O_2 consumed
4) CO_2 not released

543. Which of the following reactions do not take place in the cell organelle, that is referred to as "power house of the cell" (EAMCT - 2003)
1) Glycine decarboxylation
2) G-3-P dehydrogenation
3) Fumaric acid hydration
4) Cytochrome c oxidation

544. Which of the following does not result in substrate level phosphorylation (EAMCET - 2005)
1) 1,3, Bis PGA $\rightarrow$ 3PGA
2) PEP $\rightarrow$ Pyruvic acid
3) Succinyl CoA $\rightarrow$ succinic acid
4) Fumaric acid $\rightarrow$ malic acid

545. Conversion of 3- PGA to 2- PGA in glycolysis is an example for
1) Phosphorylation
2) Intramolecular shift
3) Dehydration 4) Cleavage

546. Glycolysis can be represented by the formula
1) $C_6H_{12}O_6 \rightarrow 2C_3H_4O_3$
2) $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
3) $C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O$
4) $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

547. For every molecule of glucose during glycolysis the ratio between pyruvic acid liberated and net gain ATP molecules formed is
1) 1 : 1 2) 2 : 1
3) 2 : 3 4) 3 : 1

548. Enzyme catalysing the cleavage reaction in Krebs' cycle is
1) Succinic thiokinase
2) Succinic dehydrogenase
3) Fumerase 4) Aconitase

549. The last tricarboxylic acid formed during Krebs' cycle that has more than four carbons is
1) Cis-aconitic acid 2) Citric acid
3) α-Ketoglutaric acid
4) Oxalosuccinic acid

550. Anaerobic respiration is less efficient when compared to aerobic respiration because of
1) Absence of oxygen
2) Glucose has less amount of energy
3) Partial oxidation of glucose
4) Water is not formed

551. Mechanism of anaerobic respiration completes in
1) Four steps 2) Two steps
3) Three steps 4) One step

552. Measurement of R.Q is done by instrument
1) Ganong's potometer 2) Autoradiography
3) Ganong's light screen
4) Ganong's respirometer

LEVEL - II

553. Observe the following data

Substrate	Type of Reaction	End Products
I) Glucose	Aerobic respiration	CO_2 +H_2O
II) Glucose	Glycolysis	Pyruvic acid
III) Pyruvic acid	Glycolysis	Acetyl CoA

The correct combination is
1) I and II
2) II and III
3) III and I
4) III, II and I

554. In aerobic respiration decarboxylation takes place at
I) Glycolysis
II) Krebs' cycle
III)In between glycolysis and Krebs' cycle
The correct combination is
1) II alone is correct
2) II and III are correct
3) I and II are correct
4) I and III are correct

555. Four carbon compounds of Krebs' cycle are
I) Citric acid
II) Malic acid
III) α-Keto glutaric acid
IV) Succinic acid
The correct combination is
1) II and IV are correct
2) I and III are correct
3) II and III are correct
4) I and IV are correct

556. Study the following

Step	Place	Function
I. ETS	On inner membrane of mitochondrian	ATP production
II.Glycolysis	Cytosol	Glucose $\rightarrow$ Pyruvic acid
III. Link reaction	Mitochondrial matrix	Pyruvic acid $\rightarrow$ Acetyl CO. A
IV. TCA cycle	Mitochondrial matrix	Acetyl CO. A $\rightarrow$ CO_2 + H_2O

Identify the correct combination
1) Only I & II are correct
2) Only II & III are correct
3) Only II & III are correct
4) I, II, III & IV are correct

557. Study the following regarding EMP pathway

Reaction	Enzyme	Product
A. Cleavage	Hexokinase	G_3P + DHAP
B. Dehydration	Enolase	PEP + H_2O
C. Intramolecular shift	Mutase	2 PGA
D. Dephosphorylation	Aldolase	Glucose - 6 phosphate

Incorrect combination is/are
1) B and C
2) A and C
3) B only
4) A and D

558. Study the following regarding TCA cycle

Substrate	Biocatalyst	Product
A. OAA	Oxalosuccinic decarboxylase	C_5 acid
B. Fumaric acid	Fumarase	C_3 acid
C. Citric acid	Citric synthetase	C_5 acid
D. Succinic acid	Succinic dehydrogenase	C_4 acid

The correct combination is
1) A and D
2) B and C
3) A, B and C
4) C and D

559. Study the following regarding krebs cycle.

Reaction	H_2O	Product
I. Cleavage	Involved	Succinic acid
II. Condensation	Involved	Citric acid
III. Last hydration	Involved	Malic acid
IV. Last oxidation	Not involved	oxaloacetic acid

The correct combination
1) I, II and III only
2) I, II, III & IV only
3) II & IV only
4) I & II only

560. Study the following regarding aerobic respiration

Stage	$FADH_2$ produced	$NADH_2$ produced
A. Link reaction	1	Zero
B. Hexose diphosphate path way	Zero	2
C. Citric acid cycle	2	6
D. Electron transport system	2	6

The correct combination is
1) A and D 2) C and D 3) B and C 4) B, C and D

561. Study the following table

Complex	Catalytic port	Fe-S centres
A. I	External NADH dehydrogenase	6
B. IV	Cytochrome - C - oxidase	Zero
C. III	Cytochrome - C - reductase	1
D. II	Succinic dehydrogenase	2

The correct combination is

1) B, C and D only 2) C and D only
3) B and D only 4) A, B, C and D

562. Study the following table

Substrate	No. of carbon atoms	R.Q value
I. Triolein	57	0.7
II. Malic acid	4	1.33
III. Oleic acid	18	0.71
IV. Tartaric acid	8	4.0

The correct combination is
1) II and IV only 2) I, II and III only
3) II and III only 4) I and IV only

563. Study the following table

I. Dehydration	Condensation	Decarboxylation
II.Isomerization	Decarboxylation	Hydration
III.Decarboxylation	Condensation	Hydration
IV.Condernsation	Decarboxylation	Isomerization

(EAMCET - 2007)

Select the correct pair of answers in which the former in the pair shows the set of reactions taking place during krebs cycle and the later in the pair shows the set of reactions that donot take place during glycolysin
1) I and III 2) I and II
3) II and III 4) II and IV

564. Study the following List

List - I	List - II
A. L Pasteur	I)Discovery of Fermentation
B. Embden, Mayerhoff, Paranas	II) Citric acid cycle
C. Gay Lussac	III) PCR cyle
D. Krebs'	IV)Coined the term Fermentation
	V)Glycolysis

The correct match is

	A	B	C	D
1)	I	IV	II	V
2)	IV	V	I	II
3)	III	II	IV	I
4)	V	IV	III	II

565. **List - I** **List - II**

List - I	List - II
A. Aerobic net gain of ATP	I) 2
B. Glycolysis net gain of ATP	II) 7.6 K.Cal
C. Energy release from ATP	III)56 K.Cal
D. Energy release in anaerobic respiration	IV) 40
	V) 36

The correct match is

	A	B	C	D
1)	II	I	III	V
2)	V	II	III	IV
3)	V	I	II	III
4)	IV	I	V	II

566. Study the following List regarding Glycolysis

List - I	List -II
A. Cleavage	I) Enolase
B. Intra molecular shift	II) Pyruvic kinase
C. Dehydration	III) Mutase
D. Second dephosphorylation	IV) Aldolase

The correct match is

	A	B	C	D
1)	III	IV	I	II
2)	IV	III	I	II
3)	IV	I	III	II
4)	III	I	IV	II

567. **List - I** **List - II**

List - I	List - II
A. Complex IV	I) Cytochrome C reductase
B. Complex I	II) ATP synthase
C. Complex III	III) NADH- ubi- quinone oxidoreductase
D. Complex V	IV) Cytochrome C Oxidase

The correct match is

	A	B	C	D
A	B	C	D	
1)	IV	III	I	II
2)	IV	III	II	I
3)	IV	I	III	II
4)	II	IV	I	III

568. Study the following lists

List - I	List - II
A. Tartaric acid	I. $C_{18}H_{34}O_2$
B. Tripalmitin	II. $C_{57}H_{104}O_6$
C. Oleic acid	III. $C_6H_{12}O_6$
D. Triolein	IV. $C_{51}H_{98}O_6$
	V. $C_4H_6O_6$

1) A-III; B-V; C-I; D-IV
2) A-II; B-I; C-IV; D-III
3) A-V; B-IV; C-I; D-II
4) A-II; B-III; C-IV; D-I

569. Match the following lists

List - I	List - II
I. No. of oxidation steps in EMP path way	a) Two
II. No. of oxidation steps in TCA cycle	b) Six
III. No.of decarboxylation steps in citric acid cycle	c) One
IV. No. of oxidation steps in aerobic respiration	d) Four
	e) Three

1) I-e; II-b; III-c; IV-a
2) I-b; II-c; III-a; IV-e
3) I-c; II-d; III-a; IV-b
4) I-d; II-b; III-c; IV-a

570. Match the following lists

List - I	List - II
A. Acetyl CO. A	i. Four carbon dicarboxylic acid
B. Isocitric acid	ii. Two carbon compound
C. Pyruvic acid	iii. Six carbon tricarboxylic acid
D. Malic acid	iv. Three carbon compound
	v. Five carbon compound

	A	B	C	D
1)	ii	iii	iv	i
2)	v	`iv	ii	iii
3)	iii	ii	i	iv
4)	iv	ii	iii	v

571. Match the following lists

List A	List B
I Pyruvate Translocator	a. Stalked particles on cristae
II. Oxysomes	b. Cofactor
III. Adenosine Triphosphate	c. Special transport protein
IV. Thiamine pyrophosphate	d. electron donor
	e. Nucleotide

	I	II	III	IV
1)	d	a	b	e
2)	c	a	e	b
3)	c	e	a	b
4)	a	c	d	e

572. Match the following lists

List - I	List - II
A. Total ATP in EMP pathway	I. 36
B. Net gain of ATP in anaerobic respiratioin	II. 2
C. No. of ATP produced in TCA cycle through SLP	III. 2
D. Net total of ATP in aerobic respiration	IV. 4
	V. 8

1) A-IV; B-III; C-II; D-I
2) A-IV; B-V; C-I; D-II
3) A-III; B-II; C-I; D-V
4) A-I; B-II; C-III; D-IV

573. Assertion (A) : Respiration is catabolic and exergonic reaction.
Reason (R) : Organic molecules are oxidised and energy is released in respiration

574. Assertion (A) : Substrate level phosphorylation occurs in cytoplasm.
Reason (R) : All ATP are generated by substrate level phosphorylation during aerobic respiration

575. Assertion (A) : PEP is a substrate for dephosphorylation in glycolysis
Reason (R) : PEP is the substrate for caboxylation in C_4 plants

576. Assertion (A) : Condensation of Acetyl CoA with oxalo acetic acid initiates Krebs' cycle
Reason (R) : First stable product of Krebs' cycle is a dicarboxylic acid

577. Assertion (A) : The substrate for first decarboxylation in Krebs' cycle is oxalosuccinic acid
Reason (R) : The substrate for Oxidative decarboxylation in Krebs' cycle is a 5 carbon compound

578. Assertion (A) : The RQ value of malic acid is 1.33
Reason (R) : Malic acid has more carbon than oxygen in its structure.

579. Assertion (A) : Complete oxidation of food does not occur in prokaryotes
Reason (R) : Mitochondria are absent in prokaryotes

580. Assertion (A) : Complete oxidation of one PGA yields 19 ATP
Reason (R) : DHAP is not suitable for direct oxidation

581. Assertion (A) : During anaerobic respiration most of the substrate energy is stored in end products
Reason (R): The energy produced in anaerobic respiration is more than that of aerobic respiration

582. Assertion (A): RQ value for fats is less than that of carbohydrates
Reason (R): Fats contain very less amount of O_2

583. Which of the following reactions do not take place in the cell organelle, that is referred to as "power house of the cell" (EAMCET - 2003)
1) Glycine decarboxylation
2) G-3-P dehydrogenation
3) Fumaric acid hydration
4) Cytochrome c oxidation

584. When one molecule of glucose is completely oxidised during aerobic respiration, how many molecules of CO_2 are released due to TCA cycle (EAMCET - 2004)
1) One 2) Two
3) Three 4) Four

585. Which of the following does not result in substrate level phosphorylation (EAMCET - 2005)
1) 1,3, Bis PGA $\rightarrow$ 3PGA
2) PEP $\rightarrow$ Pyruvic acid
3) Succinyl CoA $\rightarrow$ succinic acid
4) Fumaric acid $\rightarrow$ malic acid

586. The reaction which is catalysed by a protein that is not found in the matrix of mitochondria is (EAMCET - 2008)
1) Convertion of pyruvic acid to acetyl coenzyme - A
2) Oxidative decarboxylation of α-ketoglutaric acid
3) Oxidation of succinic acid
4) Cleavage of succinyl coenzyme of

587. Product of first biological oxidation in Krebs' cycle is
1) Isocitric acid
2) Oxalosuccinic acid
3) α-Ketoglutaric acid 4) Succinic acid

588. The 5-carbon organic acid of the Krebs' cycle- a key compound in the nitrogen metabolism of the cell is
1. Fumeric acid 2. Oxaloscuccinic acid 3. citric acid 4. α- Ketoglutaric acid

589. When malic acid is the respiratory substrate
1. The amount of CO_2 released is more than O_2 consumed
2. The amount of CO_2 released is less than O_2 consumed
3. The amount of CO_2 released is equal to O_2 consumed 4. CO_2 is not released

590. RQ value will be less than one in edible products of
1. *Saccharum* and *Oryza* 2. *Arachis* and *Ricinus* 3. *Beta* and *Ipomea*
4. *Manihot* and *Beta*

591. During respiration, if CO_2 liberated is more than the amount of O_2 consumed, the respiratory substrate must be
1. Organic acids 2. Proteins
3. Fats 4. Carbohydrates

592. If Triolein is used as a respiratory substrate, then
1. More CO_2 is liberated and less O_2 is absorbed
2. Amount of CO_2 liberated and amount of O_2 absorbed are same
3. No O_2 is absorbed but CO_2 is liberated
4. More O_2 is absorbed and less CO_2 is liberated

593. A common enzyme involved in both photosynthesis and respiration is
1. Enolase 2. Aldolase
3. Mutase 4. Aconitase

594. The inter convertable trioses involved in glycolysis are
1. 3- PGA & 2-PGA
2. Phosphoenol pyruvic acid & Pyruvic acid
3. Glucose-6-Phosphate & Fructose -6- Phosphate
4.GAP & DHAP

595. Pyruvic acid before entering into Krebs' cycle must be converted to Acetyl CoA. During the conversion of pyruvic acid to acetyl CoA, biological oxidation and decarboxylation changes must occur. The various cofactors required for the process are (Hint : LA = Lipoic acid, CoA = Co enzymeA) 1. TPP + LA + Mg + NADP +CoA 2. TPP + LA +Mn + NAD +CoA 3. TPP + LA +Mg + NAD +CoA 4. TPP + LA +Mn + NADP +CoA

596. Following is the sequence of carboxylic acids in Krebs' cycle
i) OAA = Oxalo acetic acid ii) Citric acid (CA) iii) Succinic acid iv)Fumeric acid (FA) v) Malic acid (MA) From the above list, pick out the carboxylic acids, which do not undergo biological oxidation
1. OAA, CA, FA 2. MA, OAA, CA
3. FA, MA, OAA 4. FA, OAA, SA

597. When all the reduced co-enzymes of aerobic respiration with one glucose molecule are oxidised during electron transport system, what is the net gain of ATP obtained?
1) 26 2) 38 3) 36 4) 32

598. Substrate level phosphorylation occurs in
1.Glycolysis and ETS chain 2. Glycolysis and Krebs' cycle 3. Krebs' cycle and transition reaction 4. ETS and transition reaction

599. When one molecule of pyruvic acid is subjected to anaerobic oxidation there is
1. Loss of 3 molecules of ATP
2. Loss of 6 molecules of ATP
3. Gain of 2 molecules of ATP
4. Loss of 4 molecules of ATP

600. The hydrogen acceptor during dehydrogenation reaction in respiration will be
1. NAD only 2. FAD only
3.Both NAD and FAD 4. NADP and FAD

601. An intermediate compound of citric acid cycle which acts as substrate for amino-acid synthesis is
1. Citric acid 2. Cis-Aconitic acid
3. α-Ketoglutaric acid 4.Succinic acid

602. Ultimate chemical reaction of aerobic respiration
1.Formation of Acetyl CoA 2.Conversion of Malic acid into oxalo aceticacid
3.Reduction of cytochrome oxidase
4. Reduction of atmospheric O_2

603. The importance of Krebs' cycle is
1. Production of aminoacid 2. Production of auxins
3. Production of ATP molecules
4. Production of Vitamins

604. One of the following conversions occurs without utlization of ATP during EMP pathway is
1. Glucose to Glycerdehyde-3-phosphate
2. Glucose to pyruvic acid
3. Pyruvic acid to ethyl alcohol
4. CO_2 to glucose

605. Number of phosphorylation reactions involved in glycolysis is
1. 4 2. 3
3. 6 4. 2

606. For every molecule of glucose during glycolysis the ratio between pyruvic acid liberated and net gain ATP molecules formed is
1. 1 : 1 2. 2 : 1
3. 2 : 3 4. 3 : 1

607. Net gain of ATP when pyruvic is respired aerobically
1. 12 2. 15
3. 20 4. 17

608. The net gain ATP in aerobic respiration is
1. 38 2. 40
3. 36 4. 34

609. The net gain of ATP during anaerobic respiration is
1. Zero 2. Two
3. 38 4. 48

610. The value of R.Q If glucose is the respirory substrate
1. One 2. Two
3. Zero 4. Infinity

611. No. of ATP formed when one molecule of 2 PGA is used as a respiratory substrate in aerobic respiration
1. 16 2. 15
3. 12 4. 38

612. No. of ATP liberated if one molecule of Acetyl CoA is respired aerobically
1. 20 2. 15
3. 17 4. 12

613. When fats are the respiratory substrates, RQ is
1. Zero 2. One
3. Less than one 4. More than one

614. How many ATP molecules are formed in electron transport form the reduced Nicotinamide Adenine dinucleotides generated in one turn of Krebs' cycle
1. 3 2. 2
3. 9 4. 12

615. Number of oxygen atoms required for the complete oxidation of one glucose molecule is
1) 6 2) 4
3) 12 4) 8

616. Total number of protons acumulated in the inter membrane space of mitochondria when one glucose molecule is completely oxidised is
1) 80 2) 104 3) 120 4) 110

617. Ratio between number of ATP produced through substrate level phosphorylation and oxidative phosphorylatiion of cytosolic $NADH+H^+$ for one glucose molecule
1) 2:3 2) 1:2 3) 2:1 4) 3:2

618. When one molecule of glucose is completely oxidised during aerobic respiration, how many molecules of CO_2 are released due to TCA cycle

(EAMCET - 2004)

1) One 2) Two
3) Three 4) Four

619. The ratio of ATP produced by substrate level phosphorylation and CO_2 liberate during TCA cycle for one glucose molecule in aerobic respiration is
1) 1:2 2) 1:1
3) 2:1 4) 2:3

620. Assume that krebs cycle occurs four times in a mitochondrion. Calculated the total number of protons, which accumulate in the inter membrane space, on account of the Quinone cycle, due to the oxidation of all the co-enzymes of only the Krebs cycle.
1) 786 2) 156
3) 54 4) 64

621. The reaction which is catalyzed by a protein that is not found in the matrix of mitochondrion is

(EAMCET - 2008)

1) Conversion of pyruvic acid to acetyl co-enzyme A.
2) Oxidative decarboxylation of α-ketoglutaric acid
3) Oxidation of succinic acid
4) Cleavage of succinyl co-enzyme A

622. Pick out the incorrect statement regarding the first step of biological oxidation of glucose
1) It involves two phosphorylation reactions
2) It occurs only in the presence of oxygen
3) It converts a hexose molecule into two trioses
4) It utilises ATP energy

623. Identify the correct statement regarding aerobic respiration
1) Link reaction is catalysed by 6 enzymes
2) Last step takes place in inter membrane space of mitochondrion
3) CO_2 is released during 2nd and 3rd steps
4) O_2 is utilized in all steps

624. Identify the correct statement regarding ETS
1) Oxygen dependent process
2) Occurs in the inner mitochondrial membrane
3) Final acceptor of electrons is molecular oxygen
4) All the above

625. Identify the correct statements regarding aerobic respiration
I. Electons move from mitochondrial NADH to FMN
II. Cytochrome 'C' accepts electron from cytochrome C_1
III. Ubiquinone is firmly fixed to mitochondrial membrane
IV. Pyruvic acid can directly enters into TCA cylce
1) I & II only 2) I, III and IV only
3) II only 4) I, II, III and IV

626. The following involved during the oxidatioin of mitochondrial $NADH + H^+$
A. Complex I B. Complex II
C. UQ D. Complex III
E. Cy + 'C' F Complex IV
1) A, B, D and E 2) B, C, D, E
3) A, B, C, D, E, F 4) A, C, D, E, F

627. Arrange the following substances in ascending order based on the no.of carbon atoms
a. substrate of link reaction b. end product of fermentation
c. starting substrate of EMP pathway
1) b → c → a 2) b → a → c
3) a → b → c 4) c → b → a

628. Arrange the following in descending order with reference to their R.Q values
a. germinating wheat graine
b. germinating castor seed
c. germinating bean seed
1) b → c → a 2) c → b → a
3) a → b → c 4) a → c → b

629. Arrange the following in ascending order based upon carbon atom number
A. Triolein B. Oleic acid C. Malic acid D. Tripalmitin
1) A → D → B → C 2) A → C → D → B
3) C → D → B → A 4) C → B → D → A

630. Arrange the following in descending order based upon number of carbon atoms
A. Pyruvic acid B. α- ketoglutaric acid
C. OAA D. Acetaldehyde
1) B → C → A → D
2) C → D → B → A
3) A → B → D → C
4) D → B → A → C

LEVEL - III

631. Oxalosuccinic acid, an intermediary compound of krebs cycle is a (KACET - 2008)
1) 5 carbon compound 2) 6 carbon compound
3) 4 carbon compound 4) 3 carbon compound

632. If R.Q is less than 1.0 in a respiratory metabolism, it would mean that (KERALA -Med-2008)
1) Carbohydrates are used as respiratory substrates
2) Organic acids are used as respiratory substrates
3) The oxidatioin of the respiratory substrate consumed more oxygen than the amount of CO_2 released
4) The reaction is anaerobic

633. In which of the following reaction of glycolysis, a molecule of water is removed from the substrate? (KERALA - Med-2008)
1) Fructose - 6 - phosphate → Fructose - 1 - 6 bis phosphate
2) 3 - phosphate glyceraldehyde → 1-3-bisphosphoglyceric acid
3) PEP → Pyruvic acid
4) 2 - phosphoglycerate → PEP

634. What is the net ATP molecules gain, when 4 molecules of glucose undergoes anaerobic respiration (Gujarat -Med-2008)
1) 8 2) 20
3) 144 4) 16

635. Through which process, phosphoglyceraldehyde is converted into 1.3 bisphosphoglyceric acid? (Gujarat -Med-2008)
1) Dephosphorylation and dehydrogenation
2) Phosphorylation and oxidation
3) Carboxylation and hydration
4) Decarboxylation and hydrogenation

636. $FADH_2$ is produced during the conversion of (AFMC - 2005)
1) isocitrate to oxalosuccinate
2) succinate to fumarate
3) malate to oxaloacetate
4) pyruvate to acetyl co-enzyme A

637. During which stage in the complete oxidation of glucose are the greatest number of ATP molecules are formed from ADP? (JIPMER- 2007)
1) Conversion of pyruvic acid to acetyl CO.A
2) Electron transport chain
3) Glycolysis 4) Krebs cycle

638. Glycolytic breakdown of one glucose molecule yields (J & K cet - 2006)
1) On molecule of pyruvic acid and 1 molecule of CO_2
2) Two molecules of pyruvic acid and one CO_2 molecule
3) Two molecules of pyruvic acid and 2 moles of CO_2 molecule
4) Only two molecules of pyruvic acid

639. TCA cycle starts with the production of **(Manipal - 2006)**
1) Oxaloacetic acid 2) Cirtic acid
3) Fumaric acid 4) Succimyl CO.A

640. Chemiosmosis is
1) synthesis of ATP using the driving force of proton gradient across a membrane
2) synthesis of ATP by the discharge of chemical potential created on different side of membrane
3) chemical synthesis of ATP by taking energy rich bound from a respiratory substrate
4) synthesis of chemical substances by using ATP energy

641. Complex found in the inner membrance of mitochondrian which contains an enzyme that catalyses a reaction of TCA cycle in
1)II 2)III 3)IV 4)V

642. Identity the correct pair of organic compounds from the following, in which the former is a three carbon compound, where as the latter is a two carbon compound
1)Ethyl alcohol and Acetaldehyde
2)Pyruvic acid and Acetaldehyde
3)Malic acid and Oxalic acid
4)Tartaric acid and Acetyl Co. A

643. Identify the correct statement regarding respiration electron transport system
1) Oxygen dependent process
2) Occurs in the inner mitochondrial membrane
3) Final acceptor of electrons is molecular oxygen
4) All the above

644. Identify the correct pair of complexes of ETS. Which cannot transport the protons from matrix to inner space of mitochondrian
A)Complex I B)Complex II
C) Complex III D) Complex IV
1)C and D 2)A and B
3)B and C 4)A and D

645. End products of respiration carried out by a unicellular heterotophic thalloplyte studied by you are
A)CO_2 B)H_2O C) Pyruvic acid
D) Ethylalcohol
1)A,B and D 2)A and C
3)C and D 4)A and D

646. Terminal oxidation of $FADH_2$ results in the synthesis of only two ATP molecules instead of three because
1) It bypasses complexI of ETS
2) It is formed in the mitrochondrial matrix
3) It bypasses complexII of ETS
4) It is formed during the convertion of malic acid

647. Consider the following
A)Pyruvate translocator
B)Ubiquinine
C)Thymine pyrophosphate
D)Acetyl Co. A
How many of these are memberane bound proteins
1)3 2)4 3)2 4)1

648. Most of the ATP molecules in aerobic oxidation of glucose are synthesized by
1)Substrate level phosphorylation in glycolysis
2) Substrate level phosphorylation in glycolysis
3)Terminal Oxidation of reduced coenzymes produced in HDP pathway
4) Terminal Oxidation of reduced coenzymes produced in Krebs cycle

649. Which of the following reactions of respiration in not catalysed by an enzyme that belongs to the first Major class of IUB classification
1)Conversion of Isocitric acid into Oxalosuccinic acid
2)Conversion of Glyceraldehyde-3-phosphate into 1-3-bis PGA
3)Conversion of Fumaric acid into malic acid
4)Conversion of succinic acid into fumaric acid

650. Number of substrate level phosphorylation reactions and oxidation reactions in anaerobic respiration is respectively
1) One and two 2) Two and Two
3) Two and one 4) Two and six

651. Read the following and select the correct matching

A)Number of Oxidation reactions in TCA cycle — I) One

B)Number of decarboxylation reactions in Krebs cycle — II) Two

C)Number of cleavage reactions inaerobic respiration — III) Three

D)Number of dehydration reactions in EMP pathway — IV) Two

V) Four

1)A=III	B=II	C=IV	D=I
2) A=V	B=II	C=IV	D=I
3) A=III	B=IV	C=II	D=V
4) A=V	B=I	C=II	D=III

652. The reduced co-enzyme formed in glycolysis gives its hydrogens to which compound in anaerobic respiration

1)Alcohol 2)Pyruvic acid

3)NADH 4)Acetaldehyde

653. Which among the following is not related for the formation of pyruvic acid from PEP during Glycolysis

i)Substrate level phosphorylation

ii)Catalysed by an enzyme which belongs to second class

iii)Mg^{+2} is required for the reaction

iv)Dehydration occurs

1) i, ii & iii 2) ii & iv

3) i. ii, iii&iv 4) iv alone

654. Which is not true regarding the complex III of the ETS in aerobic respiration

1)It transfers electrons from ubiquinone to Cyt.C

2)One iron-sulphur protein is present

3)Cyt.a and cyt.a_3 are present

4)It catalyses the reduction of Cyt.C

655. Number of carbons present in the product of first biological oxidation in respiration is

1) Equals to the no.of oxidations in Krebs cycle

2)Double the no.of carbons present in end product of fermentation

3)Half the no.of carbons present in citric acid

4)Equals to the no.of decarboxylation reaction in EMP pathway

656. What is common in photosynthesis and respiration during the formation of ATP

1) Intake of CO_2 2) Intake of O_2

3) Absorption of light 4) Electron transport

657. Which of the following reactions show oxidative decarboxylation?

A)Pyruvic acid $\rightarrow$ Acetyl Co. A

B)Malic acid $\rightarrow$ Pyruvic acid

C)Oxalosuccinic acid $\rightarrow$ α-ketoglutaric acid

D) α-ketoglutaric acid $\rightarrow$ Succinyl co A

1) A, B and C 2) A and B

3) B and C 4) A, B and D

658. Match the following

A)Acetyl co A — I)Four carbon dicarboxylic acid

B)Isocitric acid — II)Two carbon compound

C)Pyruvic acid — III)Six carbon tricarboxylic acid

D)Malic acid — IV)Three carbon compound

V)Five carbin compound

1)A=II	B=III	C=V	D=I
2) A=II	B=III	C=IV	D=I
3) A=II	B=III	C=V	D=IV
4) A=II	B=III	C=I	D=IV

659. Which of the following statements about aerobic respiration is wrong?

1)Glycolysis does not require membrane bound organelle

2)Final stage requires 5 multiprotein complexes

3)Connecting link reaction between glycolysis and TCA cycle is an Oxidative decarboxylation

4)Substrate levels phosphorylation occurs only in cytosol

660. Assertion (A) : Substrate levels phosphorylation occurs only in cytosol and mitochondrial matrix

Reason (R): Substrate level phosphorylation requires ETS

661. Assertion (A): DHAP,undergoes oxidation in the form of G3P,during glycolysis

Reason (R): Dihydroxy acetone phosphate is not a suitable form for biological oxidation

662. Assertion (A) : R.Q.value for germinated castor seed is less than one

Reason (R): Reserve food materials in *Ricinus* seed are fats

663. Assertion (A) : *Clostridium botulinum* cannot survive in the absence of oxygen

Reason (R) : *Clostridium botulinum* is a bacterium

664. Assertion (A) : R.Q value of proteins is less than one

Reason (R) : Proteins require more oxygen for complete oxidation