



**Q.No-1-5 Carry One Mark Each**

1. Choose the most appropriate word from the options given below to complete the following sentence.

A person suffering from Alzheimer's disease \_\_\_\_\_ short-term memory loss.

- (A) experienced (B) unexperienced  
(C) is experiencing (D) experiences

Answer: (D)

2. Choose the most appropriate word from the options given below to complete the following sentence.

\_\_\_\_\_ is the key to their happiness; they are satisfied with what they have.

- (A) Contentment (B) Ambition  
(C) Perseverance (D) Hunger

Answer: (A)

3. Which of the following options is the closest in meaning to the sentence below?

"As a woman, I have no country."

- (A) Women have no country  
(B) Women are not citizens of any country.  
(C) Women's solidarity knows no national boundaries  
(D) Women of all countries have equal legal rights.

Answer: (C)

4. In any given year, the probability of an earthquake greater than Magnitude 6 occurring in the Garhwal Himalayas is 0.04. The average time between successive occurrences of such earthquakes is \_\_\_\_\_ years.

Answer: 25 to 25

Exp:  $P = 0.04 = \frac{4}{100}$

For 1 earth quake }  
 $\frac{100}{4} P = 1 \text{ earth quake}$  } Reverse probability  
 25 years }

5. The population of a new city is 5 million and is growing at 20% annually. How many years would it take to double at this growth rate?

- (A) 3-4 years (B) 4-5 years (C) 5-6 years (D) 6-7 years

Answer: (A)

Exp:  $\frac{20}{140} \times 8$

After 1 year,  $P = 6$   
 2 years = 7.2

After 3 =  $\frac{20}{100} \times 1.2 = 8.65$

After 4 years =  $\frac{20}{100} \times 8.65 \approx 10$

Time will be in between 3-4 years.

**Q.No-6-10 Carry Two Marks Each**

6. In a group of four children, Som is younger to Riaz. Shiv is elder to Ansu. Ansu is youngest in the group. Which of the following statements is/are required to find the eldest child in the group?

**Statements :**

1. Shiv is younger to Riaz.
  2. Shiv is elder to Som.
- (A) Statement 1 by itself determines the eldest child.  
 (B) Statement 2 by itself determines the eldest child.  
 (C) Statement 1 and 2 are both required to determine the eldest child.  
 (D) Statement 1 and 2 are not sufficient to determine the eldest child.

**Answer: (A)**

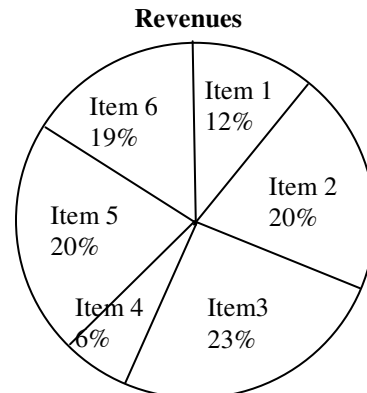
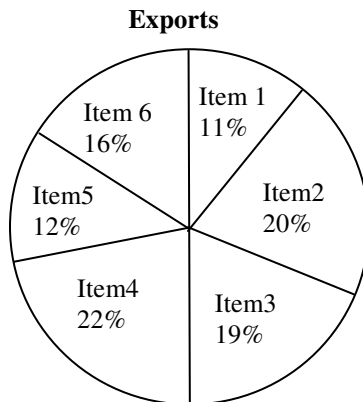
7. Moving into a world of big data will require us to change our thinking about the merits of exactitude. To apply the conventional mindset of measurement to the digital, connected world of the twenty-first century is to miss a crucial point. As mentioned earlier, the obsession with exactness is an artefact of the information-deprived analog era. When data was sparse, every data point was critical, and thus great care was taken to avoid letting any point bias the analysis. *From "BIG DATA" Viktor Mayer-Schonberger and Kenneth Cukier*

The main point of the paragraph is:

- (A) The twenty-first century is a digital world  
 (B) Big data is obsessed with exactness  
 (C) Exactitude is not critical in dealing with big data  
 (D) Sparse data leads to a bias in the analysis

**Answer: (C)**

8. The total exports and revenues from the exports of a country are given in the two pie charts below. The pie chart for exports shows the quantity of each item as a percentage of the total quantity of exports. The pie chart for the revenues shows the percentage of the total revenue generated through export of each item. The total quantity of exports of all the items is 5 lakh tonnes and the total revenues are 250 crore rupees. What is the ratio of the revenue generated through export of Item 1 per kilogram to the revenue generated through export of Item 4 per kilogram?



(A) 1:2

(B) 2:1

(C) 1:4

(D) 4:1

**Answer: (D)**

Exp: Revenue generated through export of item 1 kg

$$\Rightarrow \frac{\text{Item}}{\text{Quantity}} = \frac{11}{100} \times 5 = \frac{11}{20} \text{ (lakhs tows)}$$

$$\left. \begin{array}{l} \text{Revenue generated} \\ \text{Item 1} \end{array} \right\} \frac{12}{100} \times 6 \times 250 \times (C) = \frac{30cr}{11} \times 20 \quad \dots (1)$$

$$\begin{aligned} \text{Revenue gen Item 4} &= \frac{6}{100} \times 250 \cdot (C) \\ &= \frac{15 cr}{22} \times 20 \text{ Lt.} \quad \dots (2) \end{aligned}$$

1 : 2

$$\frac{30}{11} \times \frac{20 \times 22}{15 \times 20} = 4 : 1$$

9. X is 1 km northeast of Y. Y is 1 km southeast of Z. W is 1 km west of Z. P is 1 km south of W. Q is 1 km east of P. What is the distance between X and Q in km?

(A) 1

(B)  $\sqrt{2}$

(C)  $\sqrt{3}$

(D) 2

Answer: (C)

Exp: From the fig:  $zx = \sqrt{2}$ .

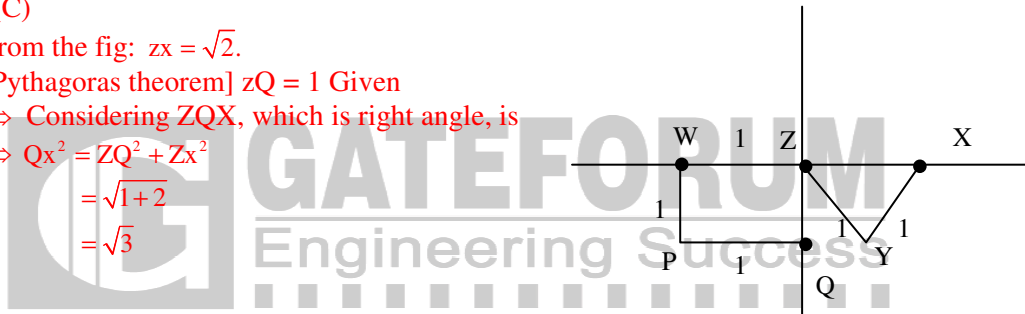
[Pythagoras theorem]  $zQ = 1$  Given

$\Rightarrow$  Considering ZQX, which is right angle, is

$$\Rightarrow Qx^2 = ZQ^2 + Zx^2$$

$$= \sqrt{1+2}$$

$$= \sqrt{3}$$



10. 10% of the population in a town is HIV+. A new diagnostic kit for HIV detection is available; this kit correctly identifies HIV+ individuals 95% of the time, and HIV- individuals 89% of the time. A particular patient is tested using this kit and is found to be positive. The probability that the individual is actually positive is \_\_\_\_\_

Answer: 0.48 to 0.49

Exp: Let total population = 100

HIV + patients = 10

For the patient to be +Ve, should be either +Ve and test is showing +Ve or the patient should be - Ve but test is showing +Ve

$$\Rightarrow \frac{0.1 \times 0.95}{0.1 \times 0.95 + 0.9 \times 0.11}$$

**Q.No-1-25 Carry One Mark Each**

1. The eigen values of  $A = \begin{bmatrix} 1 & -4 \\ 2 & -3 \end{bmatrix}$  are
- (A)  $2 \pm i$  (B)  $-1, -2$   
 (C)  $-1, \pm 2i$  (D) non-existent

Answer: (C)

Exp. Sum of eigen values = Trace of a matrix  
 Product of eigen values = determinant of a matrix  
 For (C)  $-1 \pm 2i$   
 $-1 + 2i, -1 - 2i$   
 Sum =  $-2 = \text{Trace}$   
 Product =  $(-1 + 2i)(-1 - 2i) = 1 + 4 = 5 \rightarrow \text{Determinant}$

2. If an unbiased coin is tossed 10 times, the probability that all outcomes are same will be \_\_\_\_\_  $\times 10^{-5}$ .

Answer: 191 to 199

Exp. P ( all outcomes are same)  
 = P(all heads) (or) P(all tails)  
 = P(all heads) + P (all tails)  
 =  $\frac{1}{2} \cdot \frac{1}{2} \dots (10 \text{ times}) + \frac{1}{2} \cdot \frac{1}{2} \dots (10 \text{ times})$   
 =  $\frac{1}{1024} + \frac{1}{1024} = \frac{2}{1024} = 195 \times 10^{-5}$ .

3. The solution for the following set of equations is  
 $5x + 4y + 10z = 13$

$$x + 3y + z = 7$$

$$4x - 2y + z = 0$$

- (A)  $x=2, y=1, z=1$  (B)  $x=1, y=2, z=0$   
 (C)  $x=1, y=0, z=2$  (D)  $x=0, y=1, z=2$

Answer: (B)

Exp.  $5x + 4y + 10z = 13$   
 $x + 3y + z = 7$   
 $4x - 2y + z = 0$   
 $x = 1, y = 2, z = 0$  satisfies set of equations

4. The limit of the function  $e^{-2t} \sin(t)$  as  $t \rightarrow \infty$ , is \_\_\_\_\_

Answer: 0 to 0

Exp.  $\lim_{t \rightarrow \infty} e^{-2t} \cdot \sin t = 0 \times \text{finite value} = 0$

5. The solution to the following set of equations is
- $$2x + 3y = 4$$
- $$4x + 6y = 0$$
- (A)  $x = 0, y = 0$                       (B)  $x = 2, y = 0$   
 (C)  $4x = 6y$                               (D) None solution

Answer: (D)

Exp. 
$$\left. \begin{array}{l} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{array} \right\} \text{If } \frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2} \Rightarrow \text{no solution}$$

$$\frac{2}{4} = \frac{3}{6} \neq \frac{4}{0} \Rightarrow \text{no solution}$$

6. The unit for specific substrate consumption rate in a growing culture is
- (A)  $\frac{g}{L-h}$                                       (B)  $\frac{g}{h}$   
 (C)  $\frac{g}{g-h}$                                        $\frac{gmoles}{L-h}$

Answer: (C)

7. If the dissociation constant for solute-adsorbent binding is  $K_D$ , the retention time of the solute in a chromatography column
- (A) increases with increasing  $K_D$   
 (B) decreases with increasing  $K_D$   
 (C) passes through minimum with increasing  $K_D$   
 (D) is independent of  $K_D$

Answer: (B)

Exp. The flow rate of the eluent and the distribution of the solute between the mobile and stationary phases determine a solute's retention time. In a system without flow, a solute will achieve equilibrium between the two phases. This equilibrium can be described as the distribution coefficient  $K_D$  and is defined by the equation:

$$K_D = \frac{C_S}{C_M}$$

where  $C_S$  = the concentration of solute in the stationary phase

$C_M$  = the concentration in the mobile phase.

An analyte's retention time is determined by the eluent flow rate and by the distribution of solute between the mobile and stationary phases

Given a particular combination of mobile and stationary phases, any two analytes will generally have distinct distribution coefficients. This difference in  $K_D$ 's is the basis for the differential migration of various components.

- An analyte with a relatively low  $K_D$  favors distribution in the mobile phase of the system where it is subject to the influence of eluent flow. This analyte will be pushed through the column more quickly than one with a higher  $K_D$
- An analyte with a higher  $K_D$  favors distribution towards the stationary phase. This analyte elutes at a slower rate.
- The  $K_D$  describes the ratio of sample in either phase at equilibrium under a given set of conditions. Thus, although a solute favors the stationary phase, it is still present to an extent in the mobile phase and can flow through the column.

From the above statements we conclude that If the dissociation constant for solute-adsorbent binding is  $K_D$ , the retention time of the solute in a chromatography column decreases with increasing  $K_D$ .

8. In a batch culture of *Penicillium chrysogenum*, the maximum penicillin synthesis occurs during the
- (A) lag phase (B) exponential phase  
(C) stationary phase (D) death phase

Answer: (C)

Exp. Antibiotics are produced on an industrial scale using a variety of fungi and bacteria.

- Penicillin is produced by the fungus *Penicillium chrysogenum* which requires lactose, other sugars, and a source of nitrogen (in this case a yeast extract) in the medium to grow well.

During the stationary phase, if viable cells are being counted, it cannot be determined whether some cells are dying and an equal number of cells are dividing, or the population of cells has simply stopped growing and dividing. The stationary phase, like the lag phase, is not necessarily a period of quiescence. Bacteria that produce secondary metabolites, such as antibiotics, do so during the stationary phase of the growth cycle (Secondary metabolites are defined as metabolites produced after the active stage of growth). It is during the stationary phase that spore-forming bacteria have to induce or unmask the activity of dozens of genes that may be involved in sporulation process.

Like all antibiotics, penicillin is a secondary metabolite, so is only produced in the stationary phase.

9. The most plausible explanation for a sudden increase of the respiratory quotient (RQ) of a microbial culture is that
- (A) cells are dying (B) yield of biomass is increasing  
(C) the fermentation rate is increasing relative to respiration rate  
(D) the maintenance rate is decreasing

Answer: (C)

Exp. The metabolic pathways used in batch cultures is obtained by online measurements of gas exchange rates, particularly the carbon dioxide evolution rate ( $q_{CO_2}$ ), the oxygen uptake rate ( $q_{O_2}$ ), and their ratio, known as the respiratory quotient (RQ).

We think of oxygen as essential for life, but oxygen is a reactive and potentially toxic molecule. Many bacteria prefer to grow in the absence of oxygen, and for some strains oxygen is highly toxic. Bacteria are called aerobes, if they require oxygen for growth. These bacteria can only make energy from respiration, which requires oxygen. Many bacteria grow with or without oxygen; these are called facultative aerobes. They have respiration, but can also grow by fermentation, which produces energy without oxygen. Since these bacteria obtain more energy by respiration than by fermentation, they grow faster with oxygen. A third group, called the aerotolerant anaerobes, comprises bacteria that cannot use oxygen because they lack respiration, but are not killed by oxygen. They generally prefer environments without oxygen (anoxic). The fourth group is very sensitive to oxygen. These strains, called strict anaerobes, cannot grow in the presence of any oxygen and must be cultured under special conditions to exclude any air from the growth medium. A major difference between bacteria that tolerate oxygen and those that are killed by it is the presence of enzymes in the tolerant strains that protect against toxic oxygen molecules such as peroxide, superoxide, singlet oxygen, and oxygen radicals

RQ for anaerobes--- fermentation rate is higher than respiration rate, because they are strictly grown in absence of oxygen.

10. Which of the following is employed for the repeated use of enzymes in bioprocesses?  
 (A) polymerization (B) immobilization  
 (C) ligation (D) isomerization

Answer: (B)

Exp. Immobilization of biocatalysts helps in their economic reuse and in the development of continuous bioprocesses. Biocatalysts can be immobilized either using the isolated enzymes or the whole cells. Immobilization often stabilizes structure of the enzymes, thereby allowing their applications even under harsh environmental conditions of pH, temperature and organic solvents, and thus enable their uses at high temperatures in nonaqueous enzymology, and in the fabrication of biosensor probes.

11. Since mammalian cells are sensitive to shear, scale-up of a mammalian cell process must consider, among other parameters, the following (given  $N$  = rotations/time,  $D$ =diameter of impeller)  
 (A)  $\pi ND$  (B)  $\pi N^2 D$  (C)  $\pi ND^2$  (D) isomerization

Answer: (A)

Exp. The impeller power number depends on the design of the impeller and is a function of number of blades, blade width, and blade pitch.  $N_p$  is also a function of the clearance of the impeller from the sides and bottom of the reactor. For various impeller types, the power number is well documented.

Tip speed of the impeller,  $v_i$ , relates to the fluid shear stress in the vicinity of the impeller:  
 $v_i = \pi ND_i$

In the above equations,  $N$ =impeller rotational speed,  $D_i$ =impeller diameter,  $\rho$ =fluid density, and  $\mu$ =fluid viscosity.

12. The degree of reduction of ethanol is \_\_\_\_\_

Answer: 6 to 6

Exp. Degree of reduction of ethanol=

$$C_2H_5OH = 2(4) + 5(1) + 1(-2) + 1(1) = 12$$

$$\text{Degree of reduction of ethanol} = 12/2(\text{number of carbon atoms}) = 6$$

13. Gram-positive bacteria are generally resistant to complement-mediated lysis because  
 (A) thick peptidoglycan layer prevents insertion of membrane attack complex into the inner membrane  
 (B) Gram-positive bacteria import the membrane attack complex and inactivate it  
 (C) membrane attack complex is degraded by the proteases produced by the Gram-positive bacteria  
 (D) Gram-positive bacteria cannot activate the complement pathway

Answer: (A)

Exp. Gram-positive bacteria are generally resistant to complement-mediated lysis because the thick peptidoglycan layer in their cell wall prevents insertion of the MAC into the inner membrane. Although complement activation can occur on the cell membrane of encapsulated bacteria such as *Streptococcus pneumoniae*, the capsule prevents interaction between C3b deposited on the membrane and the CR1 on phagocytic cells.

14. A bacterium belonging to cocci group has a diameter of  $2\mu\text{m}$ . The numerical value of the ratio of its surface area to volume (in  $\mu\text{m}^{-1}$ ) is \_\_\_\_\_

Answer: 3 to 3

Exp. Cocci is sphere shaped structure bacteria

For sphere surface area to volume ratio is  $3/a$

Where  $a$  indicates radius

As per ques, diameter given as  $2\mu\text{m}$  so radius is 1

Therefore surface area to volume ratio is  $3/a = 3/1 = 3$

15. Which of the following essential element(s) is/are required as major supplement to enhance the bioremediation of oil spills by the resident bacteria?

(A) Sulfur

(B) Nitrogen and phosphorus

(C) Iron

(D) Carbon

Answer: (B)

Exp. Biostimulation, the addition of nutrients, is practiced for marine oil spill cleanup when there is an existing population of oil degrading microbes present. When an oil spill occurs, the result is a large increase in carbon and this also stimulates the growth of the already present oil degrading microorganisms. However, these microorganisms are limited in the amount of growth and remediation that can occur by the amount of available nitrogen and phosphorus. By adding these supplemental nutrients in the proper concentrations, the hydrocarbon degrading microbes are capable of achieving their maximum growth rate and hence the maximum rate of pollutant uptake. It has been found that when using nitrogen for the supplemental nutrient, a maximum growth rate is achieved by the oil degrading microorganisms at a concentration of  $2.0\text{ mg/L}$ .

16. The 4-amino or 4-keto group of pyrimidine bases is located in the

(A) major groove of the double stranded DNA

(B) minor groove of the double stranded DNA

(C) minor groove of the B form DNA but not the A form DNA

(D) major groove of the B form DNA but not the A form DNA

Answer: (A)

Exp. in B-DNA, guanine will hydrogen bond to a water molecule from both the minor groove 2-amino- and major groove 6-keto-groups with further single hydration on the free ring nitrogen atoms (minor groove N3 and major groove N7). Cytosine will hydrogen bond to a water molecule from both the major groove 4-amino- and minor groove 2-keto-groups. Adenine will hydrogen bond to a water molecule from the major groove 6-amino-group with further single hydration on the free ring nitrogen atoms (minor groove N3 and major groove N7). Thymine (and uracil, if base-paired in RNA) will hydrogen bond to a water molecule from both the minor groove 2-keto- and major groove 4-keto-groups. Phosphate hydration in the major groove is thermodynamically stronger but exchanges faster.

17. The product(s) resulting from the hydrolysis of maltose is/are

(A) a mixture of  $\alpha$ -D-Glucose and  $\beta$ -D-Glucose

(B) a mixture of D-Glucose and L-Glucose

(C)  $\alpha$ -D-Glucose only

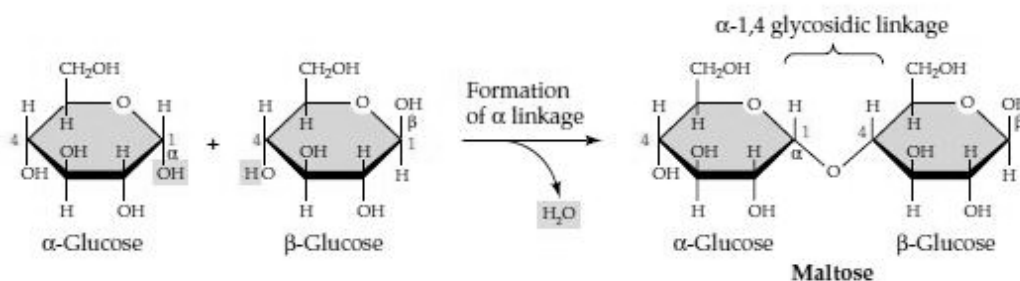
(D)  $\beta$ -D-Glucose only

Answer: (A)



Exp. D-Glucose exists in three different forms. There is an open chain form which we have just described and two cyclic forms -  $\alpha$ -D-glucose and  $\beta$ -D-glucose. The three forms have different physical properties and different specific rotations. The C-5 alcohol group reacts intramolecularly with the aldehyde group forming a six-membered ring hemiacetal. The aldehyde carbon has become a chiral centre in the hemiacetal. If the OH group bonded to the new chiral centre is on the right, it is  $\alpha$ -D-glucose; if the OH group is on the left, it is  $\beta$ -D-glucose.  $\alpha$ -D-glucose and  $\beta$ -D-glucose are called anomers. Anomers are two sugars that differ in configuration at the hemiacetal carbon (the carbonyl carbon). This is called the anomeric carbon (Ano is Greek for upper – anomers differ in configuration at the uppermost chiral center. Anomers, like epimers, are a particular kind of diastereomer.

Structure of maltose



So, upon hydrolysis of maltose produces a mixture of  $\alpha$ -D-Glucose and  $\beta$ -D-Glucose

18. Amino acid residue which is most likely to be found in the interior of water-soluble globular proteins is
- (A) Threonine (B) Aspartic acid  
(C) Valine (D) Histidine

Answer: (C)

Exp. Generally, the interior of water-soluble globular proteins consists, largely, of hydrophobic amino acids, principally leucine, isoleucine, valine, phenylalanine, and methionine. This is important, not only for the stability of the folded protein, but also for the folding pathway that leads to the mature structure. It is also important for the function of some globular proteins; for example, the hydrophobic residues create a nonaqueous environment that is important for oxygen binding in myoglobin and hemoglobin, and for substrate binding and catalysis in a variety of enzymes.

19. The 5' ends of the mature forms of the prokaryotic mRNAs and tRNAs are
- (A) a triphosphate group in mRNAs and a monophosphate group in tRNAs  
(B) triphosphate groups in both mRNAs and tRNAs  
(C) monophosphate groups in both mRNAs and tRNAs  
(D) a monophosphate group in mRNAs and a triphosphate group in tRNAs

Answer: (A)

Exp. Terminator 5'-Phosphate-Dependent Exonuclease\* (Terminator Exonuclease) is a magnesium-dependent 5'-to-3' exonuclease that specifically digests RNA with a 5'-monophosphate, such as prokaryotic 16S & 23S rRNA and eukaryotic 18S and 28S rRNA. It does not digest eukaryotic RNA with a 5'-cap structure, primary prokaryotic mRNA with a 5'-triphosphate or degraded RNA having a 5'-hydroxyl group. The 5S rRNA, which has a 5'-



23. The statistical frequency of the occurrence of a particular restriction enzyme cleavage site that is 6 bases long can be estimated to be
- (A) once every 24 bases                      (B) once every 256 bases  
(C) once every 1024 bases                  (D) once every 4096 bases

Answer: (D)

Exp. The statistical frequency of the occurrence of a particular restriction enzyme cleavage site that is 6 bases long can be estimated to be approximately once every 4096 bases.

The formula for calculating the estimated frequency is  $1/4^N$  where N=number of bases in recognition site. once every 1024 bases.

24. The reactions leading to the formation of amino acids from the TCA cycle intermediates are
- (A) carboxylation                              (B) isomerization  
(C) transamination                          (D) decarboxylation

Answer: (C)

Exp. Amino acids are made from intermediates of the citric acid cycle and other major pathways. A transamination reaction takes place in the synthesis of most amino acids. At this step, the chirality of the amino acid is established. Alanine and aspartate are synthesized by the transamination of pyruvate and oxaloacetate, respectively. Glutamine is synthesized from  $\text{NH}_4^+$  and glutamate, and asparagine is synthesized similarly. Proline and arginine are derived from glutamate. Serine, formed from 3-phosphoglycerate, is the precursor of glycine and cysteine. Tyrosine is synthesized by the hydroxylation of phenylalanine, an essential amino acid. The pathways for the biosynthesis of essential amino acids are much more complex than those for the nonessential ones.

25. The growth medium for mammalian cells contains serum. One of the major functions of serum is to stimulate cell growth and attachment. However, it must be filter sterilized to
- (A) remove large proteins                      (B) remove collagen only  
(C) remove mycoplasma and microorganisms      (D) remove foaming agents

Answer: (C)

Exp. Animal serum and other complex biological materials have been employed in the cultivation of mammalian cells for approximately 100 years. Several factors led to the wide adoption of bovine serum as a standard tissue culture supplement. Filtration with 100-nm (0.1- $\mu\text{m}$ ) pore size filters is an accepted method for removing mycoplasmas and gamma irradiation (> 25 kGy while frozen), and chemical treatments (e.g., with betapropiolactone) are accepted methods of inactivating viruses and mycoplasmas; serum manufacturers routinely use these tools in both production and testing facilities. These treatments do not remove antibodies that may interfere with some applications. Additionally, the treatments do not ensure complete viral removal or inactivation, but can significantly reduce the risk of viral activity. The testing series to screen bovine serum for the absence of adventitious agents typically includes the following:

- Bacterial and fungal sterility testing as described in 9 CFR 113.26
- Mycoplasma testing as described in 9 CFR 113.28
- Viral testing as described in 9 CFR 113.53



30. AT-flask is seeded with  $10^5$  anchorage-dependent cells. The available area of the T-flask is  $25\text{cm}^2$  and the volume of the medium is 25ml. Assume that the cells are rectangles of size  $5\mu\text{m} \times 2\mu\text{m}$ . If the cells grow to monolayer confluence after 50 h, the growth rate in number of cells ( $\text{cm}^2 \cdot \text{h}$ ) is \_\_\_\_\_  $\times 10^5$ .

Answer: 2 to 2

Exp.  $1\text{ cm} = 10^4\ \mu\text{m}$

$1\text{ cm square} = 10^8\ \mu\text{m square}$

$25\text{ cm square} = 25 * 10^8\ \mu\text{m square}$

The number of cells =  $(25 * 10^8\ \mu\text{m square}) / (5\ \mu\text{m} * 2\ \mu\text{m})$

$= 25 * 10^7\ \text{cells}$

Net number of cells =  $(25 * 10^7) - 10^5$

$= 10^5(25*10^2) - 1$

$= 10^5 * 2499\ \text{cells}$

In 50 hrs number of cells produced =  $10^5 * 2499$

Therefore number of cells produced / hour =  $(10^5 * 2499) / 50$

$= 50 * 10^5\ \text{cells}$

In 25 cm square, number of cells produced / hour =  $50 * 10^5$

Therefore in 1 cm square, number of cells produced / hour =  $(50 * 10^5) / 25$

$= 2 * 10^5\ \text{cells / cm square * hour}$

31. Consider a continuous culture provided with a sterile feed containing 10 mM glucose. The steady state cell density and substrate concentration at three different dilution rates are given in the table below.

Dilution rate ( $\text{h}^{-1}$ )	Cell density ( $\text{gL}^{-1}$ )	Substrate concentration (mM)
0.05	0.248	0.067
0.5	0.208	1.667
5	0	10

The maximum specific growth rate  $\mu_m$  ( $\text{in h}^{-1}$ ), will be \_\_\_\_\_,

Answer: 0.795 to 0.805

32. Cholera toxin increases cAMP levels by

(A) modifying  $G_i$  protein

(B) modifying  $G_s$  protein

(C) binding to adenylate cyclase

(D) activating cAMP phosphodiesterase

Answer: (B)

Exp. Disruption of G Protein signaling causes several human diseases.

*Vibrio cholerae* (causes cholera) secretes the cholera toxin which alters salt and fluid in the intestine normally controlled by hormones that activate  $G_s$  G-Protein to increase cAMP and oversecretion of **chloride ions** and water into the gut.

The cholera toxin enzymatically changes  $G_s$  so that it is unable to convert GTP to GDP.  $G_s$  can not then be inactivated and cAMP levels remain high causing intestinal cell to secrete salt and water. Eventually dehydration can lead to death (cholera)

33. Triose phosphate isomerase converts dihydroxy acetone phosphate (DHAP) to glyceraldehyde-3-phosphate (G-3-P) in a reversible reaction. At 298 K and pH 7.0, the equilibrium mixture contains 40 mM DHAP and 4 mM G-3-P. Assume that the reaction started with 44 mM DHAP and no G-3-P. The standard free-energy change in kJ/mol for the formation of G-3-P [ $R = 8.315 \text{ J/mol.K}$ ] is \_\_\_\_\_.

Answer: 2.46 to 2.50

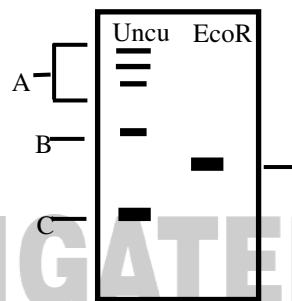
Exp.  $44 \text{ mM DHAP} \rightleftharpoons 40 \text{ mM DHAP} + 4 \text{ mM G-3-P}$

Standard free energy change  $G = -RT \ln K$

Given  $R = 8.315$ ,  $T = 298$ ,  $K = 4/40$

$$G = -8.315 \times 298 \times \ln \frac{4}{40} \\ = 5704.05 \text{ J/mol} = 5.704 \text{ kJ/mol.}$$

34. The plasmid DNA was subjected to restriction digestion using the enzyme *EcoRI* and analysed on an agarose gel. Assuming digestion has worked (the enzyme was active), match the identity of the DNA bands shown in the image in **Group I** with their identity in **Group II**.



**Group I**

- P. Bands labeled as A  
Band labeled as B  
R. Band labeled as C  
S. Band labeled as D

- (A) P-3, Q-1, R-2, S-4  
(C) P-4, Q-3, R-1, S-2

**Group II**

1. Nicked  
2. Supercoiled  
3. Concatemers  
4. Linear

- (B) P-1, Q-4, R-3, S-2  
(D) P-4, Q-1, R-2, S-3

Answer: (A)

Exp. Depending upon the phenomenon of surface tension (contact of DNA to surface) the movement of DNA occurs

As the concatemers is circular in structure it has less surface tension and moves faster and forms band A

Then comes nicked structure which is a ssDNA break takes band B

Then the complex supercoiled structure is thicker in size of band takes band D

Then the linear structure which has maximum contact with the surface takes band C.

35. In a relatively large but finite and closed population of sexually reproducing diploid organisms, the frequency of homozygous genotype PP changes from 0.40 to 0.50 and that of pp changes from 0.40 to 0.41 in a span of 10 generations. Which of the following is the most likely cause for the above change in frequency of the PP genotype?
- (A) Non-random mating  
(B) Random genetic drift  
(C) Selection  
(D) Combination of non-random mating and random genetic drift

Answer: (C)

Exp. There are several reasons to expect that rare species with restricted geographic distributions will have less genetic variation. First, loss of genetic variation caused by chance events (e.g., genetics and the founder effect) will be greater in smaller populations. In addition, species with restricted geographic distributions will occur in a limited number of environments and will therefore be less affected by natural selection to exist under different environmental conditions. Karron (1991) provided a very interesting test of this expectation by comparing the amount of genetic variation at allozyme loci in closely related species. He compared congeneric species from 10 genera in which both locally endemic and widespread species were present. One to four species of each type (rare and widespread) were used in each genus. In nine of 10 cases, the widespread species had a greater number of average alleles per locus.

36. Topological winding number of a 2.0 kb covalently closed circular DNA was found to be 191 with a writhing number of -4. Hence, its LINKING NUMBER and the NUMBER OF BASE PAIR PER TURN when the molecule is laid flat on the surface is \_\_\_\_\_ and \_\_\_\_\_, respectively.
- (A) 187, 10.69 (B) 195, 10.25  
(C) 200, 10.00 (D) 187, 10.50

Answer: (A)

Exp. Topology theory indicates that the sum of Twist and Writhing number equals to linking number ie  $L=T+W$ .

Twist (T) = 191 and Writhing number (W) = - 4

Therefore Linking number (L) =  $191 - 4 = 187$

The circular DNA is of 2 Kb ie 2000 basepairs.

So number of base pairs / turn =  $2000 / 187 = 10.69$ .

37. Consider a population of 10,000 individuals, of which 2500 are homozygotes (PP) and 3000 are heterozygotes (Pp) genotype. The frequency of allele p in the population is \_\_\_\_\_.

Answer: 0.6 to 0.6

Exp.  $P^2 + 2Pp + p^2 = 1$   
 $2500 + 3000 + p^2 = 10000$   
 $p^2 = 10000 - 5500$   
 $p^2 = 4500 = p = 67$   
 Frequency =  $67/100 = 0.6$

38. Match the following photorecep with their prosthetic groups and spectral specificity

Photoreceptor	Moiety that absorbs light	Absorption (nm)
P. Phototropin	1. Chromobilin	a. 400-500
R. Phytochrome	3. FMN	c. 500-600
	2. FAD	b. 600-800

(A) P-3-a, Q-2-a, R-1-b (B) P-1-b, Q-1-a, R-3-b  
(C) P-3-a, Q-1-a, R-1-c (D) P-2-c, Q-1-c, R-1-a

Answer: (A)

Exp. The phototropins use flavin mononucleotide (FMN) as chromophore. The cryptochrome and the BLUF-proteins use flavin adenine dinucleotide (FAD) as chromophore.

if one considers just the visible and near-infrared regions of the light spectrum (400–850 nm), plants have evolved three major classes of photoreceptors—the cryptochromes (cry), the phototropins (phot), and the phytochromes (phy)— the cryptochromes (cry), the phototropins



(phot) are capable of absorbing the blue (400–500 nm) and phytochromes (phy) absorb red/far-red (600–800 nm) portions in particular

39. Match the following plant sources with their secondary metabolites and medical uses
- |                |              |                     |
|----------------|--------------|---------------------|
| P. Belladonna  | 1. Menthol   | a. Cancer treatment |
| Foxglove       | 2. Atropine  | b. Heart disease    |
| R. Pacific yew | 3. Digitalin | c. Eye examination  |
| S. Eucalyptus  | 4. Taxol     | d. Cough            |
- (A) P-2-c, Q-3-b, R-4-a, S-1-d      (B) P-3-c, Q-2-a, R-1-d, S-4-b  
(C) P-2-c, Q-4-b, R-1-a, S-3-d      (D) P-1-b, Q-4-c, R-2-d, S-3-a

Answer: (A)

Exp. Belladonna contains the chemical substance atropine which indeed affects the pupils in the manner described. Even to this day, atropine is used by eye doctors to dilate the pupils during an examination of a patient's retina.

The potential role of the drug digoxin (which is extracted from the foxglove plant) in treating heart conditions such as high blood pressure and heart failure. Digoxin is currently used to control heart rate in some patients with an irregular heartbeat, and has been shown to improve heart failure symptoms. However, the fact that it can be poisonous and needs to be monitored means that it is not commonly prescribed.

**Paclitaxel** is a mitotic inhibitor used in cancer chemotherapy. It was discovered in a US National Cancer Institute program at the Research Triangle Institute in 1967 when Monroe E. Wall and Mansukh C. Wani isolated it from the bark of the Pacific yew tree, *Taxus brevifolia* and named it **taxol**. Later it was discovered that endophytic fungi in the bark synthesize paclitaxel. Eucalyptus - Menthol - cough

40. The pungency of mustard seeds is primarily due to secondary metabolites such as isothiocyanate and nitrile. The pungency is usually felt only when the seeds are crushed. This is because of
- (A) the coat of the intact seeds blocks the pungent volatiles from being released  
(B) the pungent chemicals are stored as inactive conjugates and compartmentalized from the enzymes that convert them into active chemicals  
(C) the pungent chemicals are formed only after the reaction with atmospheric oxygen  
(D) the pungent chemicals are formed only after the reaction with atmospheric carbondioxide

Answer: (B)

Exp. Glucosinolates (GSLs) also known as mustard oils are the compounds which give Brassica species their characteristic smell and taste. If the plant is damaged, the GSLs which are stored in 'S' cells come into contact with an enzyme (myrosinase) stored in separate compartments called myrosin cells (18, 19). The enzyme starts to breakdown the GSL producing highly active secondary metabolites, such as isothiocyanates, epithionitriles and nitriles. It is these breakdown products which help to protect the plant.

41. In a mouse genome, the numbers of functional  $V\alpha$ ,  $J\alpha$ ,  $D\beta$ ,  $J\beta$  gene segments are 79, 38, 21, 2 and 11, respectively. The total number of possible combination for  $\alpha\beta$  T cell receptors are \_\_\_\_\_  $\times 10^6$ .

Answer: 1.38 to 1.40

Exp. The number of functional gene segments are 79,38,21,2,11 respectively.  
The total number of possible combinations for alpha beta T cell receptors  
 $= 79 \times 38 \times 21 \times 2 \times 11 = 1.38 \times 10^6$



42. The percentage SIMILARITIES and IDENTITIES, respectively, between the two peptide sequences given below will be \_\_\_\_\_ % and \_\_\_\_\_ %.
- Peptide I : Ala-Ala-Arg-Arg-Gln-Trp-Leu-Thr-Phe-Thr-Lys-Ile-Met-Ser-Glu  
 Peptide II: Ala-Ala-Arg-Glu-Gln-Tyr-Ile-Ser-Phe-Thr-Lys-Ile-Met-Arg-Asp
- (A) 80, 80                      (B) 80, 60                      (C) 60, 60                      (D) 90, 60

Answer: (B)

43. In an affine gap penalty model, if the gap opening penalty is -20, gap extension penalty is -4 and gap length is 8, the gap score is \_\_\_\_\_ .

Answer: -52 to -52

Exp. Penalty = G + nL

G : Open penalty

L : Extension penalty

n : Size of gap

P = -20 + -4 \* 8 = -20 + (-32) = -20 - 32 = -52

44. For their efficient translation, eubacterial mRNAs possess a Shine-Dalgarno sequence for its recognition by an anti-Shine-Dalgarno sequence (ASD) in the ribosomes. The correct statement is
- (A) ASD is present in 5S rRNA  
 (B) ASD is present in 23S rRNA  
 (C) ASD is present in 16S rRNA  
 (D) ASD is formed by the interaction of the 16S rRNA with the 23S rRNA upon docking of the 50S subunit on the 30S subunit of the ribosomes

Answer: (C)

Exp. Shine-Dalgarno (SD) sequences reside in the 5' untranslated region (5' UTR) of prokaryotic messenger RNAs and facilitate translation initiation. They act as ribosome-binding sites by recognizing a sequence motif at the 3' end of the 16S ribosomal RNA in the 30S ribosomal subunit (referred to as anti-Shine-Dalgarno sequence, ASD) via complementary base pairing [1], [2]. The SD-ASD interaction is conserved across the prokaryotic kingdom and has even been retained in some cell organelles that evolved from prokaryotes more than a billion years ago.

45. Match the items in Group I with Group II:

Group I	Group II
(P) Receptor tyrosine kinase	(1) Inactivation of G-proteins
(Q) Cyclic GMP (cGMP)	(2) Reception of insulin signal
(R) GTPase activating protein (GAP)	(3) Thyroid hormone
(S) Nuclear receptor	(4) Receptor guanylyl cyclase

(A) P-1, Q-3, R-4, S-2

(B) P-2, Q-4, R-3, S-1

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-4, R-1, S-3

Answer: (D)

Exp. Insulin controls organismal and cellular physiology by initiating numerous intracellular signals. Insulin first binds the extracellular domain of the insulin receptor, which activates the receptor's intracellular tyrosine kinase.

During formation of the neuromuscular junction (NMJ), agrin secreted by motor axons signals the embryonic muscle cells to organize a postsynaptic apparatus including a dense aggregate of acetylcholine receptors (AChRs). Agrin signaling at the embryonic NMJ

requires the activity of nitric oxide synthase (NOS). Common downstream effectors of NOS are guanylate cyclase (GC), which synthesizes cyclic GMP, and cyclic GMP-dependent protein kinase (PKG).

GTPase-activating proteins (GAPs) regulate the inactivation of G proteins by accelerating their intrinsic GTPase activity. A number of GAPs that can interact with and have specificity for Rho have been identified

The **thyroid hormone receptor (TR)** is a type of nuclear receptor that is activated by binding thyroid hormone.

46. Match the immunoglobulin class in Group I with its properties in Group II:

Group I	Group II
(P) IgG	(1) Major antibody in external secretions such as bronchial mucus
(Q) IgA	(2) Protects against parasites
(R) IgE	(3) Antibody that appears first in serum after exposure to an antigen
(S) IgM	(4) Antibody present in highest concentration in serum

(A) P-4, Q-1, R-2, S-3

(B) P-3, Q-2, R-1, S-4

(C) P-4, Q-3, R-1, S-2

(D) P-1, Q-4, R-3, S-2

Answer: (A)

Exp. IgG is the immunoglobulin molecule normally present in highest concentration in both intra- and extravascular spaces, with a mean normal adult serum concentration of 1200 mg/dl. I

Immunoglobulin A (IgA) is the major class of antibody in external secretions, such as saliva, tears, bronchial mucus, and intestinal mucus. Thus, IgA serves as a first line of defense against bacterial and viral antigens.

IgE's main function is immunity to parasites such as parasitic worms like *Schistosoma mansoni*, *Trichinella spiralis*, and *Fasciola hepatica*. IgE may also be important during immune defense against certain protozoan parasites such as *Plasmodium falciparum*.

After exposure to an antigen, the first antibodies to appear are IgM. Later, antibodies of other classes appear: IgG predominates in the serum and extra vascular space, while IgA is produced in the gut, and IgE may be secreted at other epithelial surfaces.

47. In a genetic cross between the genotypes WWXX and wwxx, the following phenotypic distributions were observed among the F<sub>2</sub> progeny: WX, 562; wx, 158; Wx, 38; and wX, 42. Likewise, a cross between XXYY and xxyy yielded the following results: XY, 675; xy, 175; Xy, 72; and xY, 78. Similarly, a cross between WWYY and wwyy yielded: WY, 292; wy, 88; Wy, 12; and wY, 8. In all the genotypes, capital letters denote the dominant allele. Assume that the F<sub>1</sub> progeny were self-fertilized in all three crosses. Also, double cross-over does not occur in this species. Which of the following is correct?

(A) Relative position: W-X-Y Distances: W-X = 5 map units, X-Y = 17 map units

(B) Relative position: X-Y-W Distances: X-Y = 15 map units, Y-W = 11 map units

(C) Relative position: Y-W-X Distances: Y-W = 5 map units, W-X = 11 map units

(D) Relative position: X-W-Y Distances: X-W = 5 map units, W-Y = 10 map units

Answer: (C)

48. The length of the minimum unique stretch of DNA sequence that can be found only once in a 3 billion base pairs long genome is

(A) 14

(B) 15

(C) 16

(D) 18

Answer: (C)

49. Lysine is being produced in a lab-scale reactor by a threonine auxotroph. After 2 weeks of operation it was observed that the concentration of lysine in the reactor was gradually decreasing. Microbiological assays of reactor samples showed absence of contamination and recorded data showed no change in the operating conditions. The most probable reason for decrease in lysine concentration may be attributed to
- (A) accumulation of ethanol (B) growth of revertants  
(C) production of citric acid (D) unutilized phosphoenol pyruvate

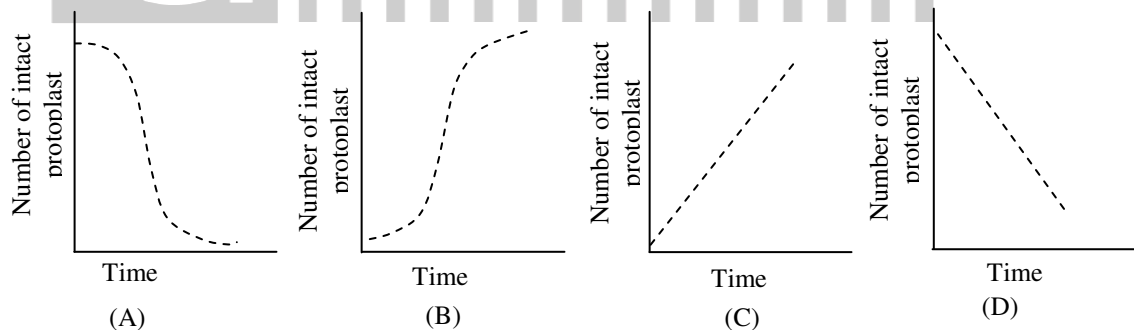
Answer: (B)

50. If a plant is shifted to cold temperature, which of the following changes would take place in its membrane?
- (A) Ratio of unsaturated to saturated fatty acids would increase  
(B) Ratio of unsaturated to saturated fatty acids would decrease  
(C) Absolute amount of both fatty acids would increase keeping the ratio same  
(D) Absolute amount of both fatty acids would remain unchanged

Answer: (A)

Exp. The ratio of saturated and unsaturated fatty acids determines the fluidity in the membrane at cold temperatures. The fatty acid analysis results showed that the unsaturated to saturated fatty acid ratio increased from 1.40 to 3.61 as temperature dropped from 20 to 5°C. The increased cis-9-hexadecanoic acid (C16:1) at 5°C strongly indicated the presence of homeoviscous adaptation in the EBPR bacterial community.

51. If protoplasts are placed in distilled water, they swell and burst as a result of endosmosis. The plot representing the kinetics of burst is

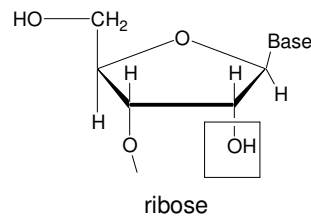
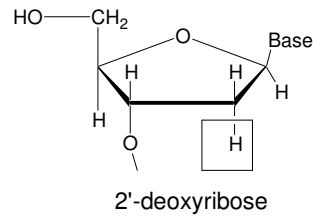


Answer: (A)

52. Which of the following statements with respect to the orientation of the nitrogenous bases to the pentose sugars, and the puckering of the sugar, is correct?
- (A) Anti, and 2'-endo in A form DNA  
(B) Anti, and 2'-endo in B form DNA  
(C) Syn, and 3'-endo in A form DNA  
(D) Syn, and 3' -endo in B form DNA

Answer: (B)

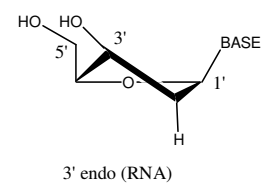
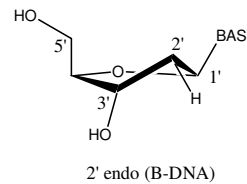
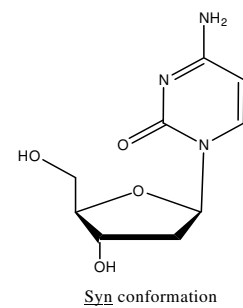
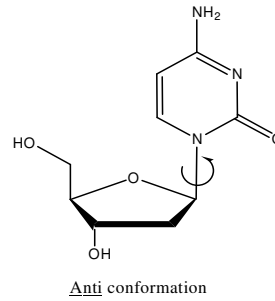
Exp. 2'-deoxyribose is the sugar in DNA and ribose is the sugar in RNA:



The two main base/sugar conformations in nucleic acids are syn and anti. The anti conformation of the glycosidic bond typical for DNA allows specific hydrogen bond formation between the base paired bases in DNA double helix

Two preferred conformations of pentose sugar (sugar pucker) are 2' endo (2'-OH is pointing the same way as the base) and 3' endo (3'-OH is pointing the same way as the base). Sugar conformation is critical for the nucleic acid structure because it defines how the nucleotides are linked to each other in space.

So, the orientation of the nitrogenous bases to the pentose sugars, and the puckering of the sugar, is done in Anti, and 2'-endo in B form DNA.



53. A dioecious plant has XX sexual genotype for female and XY for male. After double fertilization, what would be the genotype of the embryos and endosperms?
- (A) 100% ovules will have XXX endosperm and XX embryo  
 (B) 100% ovules will have XXY endosperm and XY embryo  
 (C) 50% ovules will have XYY endosperm and XY embryo, while other 50% will have XXY endosperm and YY embryo  
 (D) 50% ovules will have XXX endosperm and XX embryo, while the other 50% will have XXY endosperm and XY embryo

Answer: (D)

Exp. **Dioecy** (Greek: "two households"; adjective form: **dioecious**) is characterised by a species having distinct male and female organisms.<sup>[1]</sup> This is opposed to hermaphroditic species, or more correctly, monoecious species, in which on one individual both male and female reproductive organs are present. **Dioecious reproduction** is biparental reproduction.

the embryo sac, where one fuses with the egg and forms a zygote and the other fuses with the two polar nuclei of the central cell and forms a triple fusion, or endosperm, nucleus. This is called **double fertilization** because the true fertilization (fusion of a sperm with an egg) is accompanied by another fusion process (that of a sperm with the polar nuclei) that resembles fertilization

So, on cross

XX \* XY

X X Y

50%XX 50%XY embryos

For endosperm another fertilization with sperm gamets

There is X and Y gamets for sperm which fuses with XX producing 50%XXX and 50%XXY genotype endosperm.

54. The amino acid substitution matrices in decreasing order of stringency for comparing protein sequences are
- (A) PAM250, PAM120, PAM100
  - (B) PAM100, PAM120, PAM250
  - (C) PAM250, PAM100, PAM120
  - (D) PAM120, PAM250, PAM100

Answer: (B)

Exp. PAM stands for Point Accepted Mutations or Percent Accepted Mutations "accepted" means that the mutation has been adopted by the sequence matrices used to score sequence alignment PAM 250 scoring matrix means that about 250 mutations per 100 amino acids, while with PAM 10 only 10 mutations per 100 amino acids are assumed

BLOSUM62 is used as the default matrix. There are Dayhoff matrices of different PAM values and BLOSUM matrices of different percentage identity. Which one should you use? When using a local alignment method (i.e. the Smith-Waterman algorithm as implemented in water), various authors suggest that three matrices should ideally be used: PAM40, PAM120 and PAM250. The lower PAM matrices will tend to find short alignments of highly similar sequences, while higher PAM matrices will find longer, weaker local alignments. For the BLOSUM series of scoring matrices, the stringency increases with the number following the matrix name. I.e. the BLOSUM35 matrix will give a good score even to distantly related amino-acids, whereas the BLOSUM80 matrix gives a positive score only to very closely related amino-acids.

PAM	BLOSUM
PAM100	BLOSUM90
PAM120	BLOSUM80
PAM160	BLOSUM60
PAM200	BLOSUM52
PAM250	BLOSUM45

55. The active site in the alpha/beta barrel structures is usually located
- (A) inside the barrel
  - (B) at the amino side of the strands
  - (C) at the carboxy side of the strands
  - (D) at any arbitrary site

Answer: (C)

Exp. Alpha-Beta domains are the most commonly observed domain structure. In general, they consist of parallel or mixed beta sheets connected and surrounded by alpha helices. Alpha-beta barrels ---Alpha-beta barrels must have at least 8 parallel beta strands (can be more) that form a closed circle and enclose a hydrophobic core. Cross connections between the parallel beta strands are alpha helices as in the beta-alpha-beta motif. All alpha helices are on one side of the beta sheet. The active site of all alpha-beta barrels is found in a pocket formed when carboxy ends of parallel strands loop to connect to amino ends of adjacent alpha helices.