GS2016
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

Joint Graduate Entrance Examination in Biology and
Interdisciplinary Life Sciences [JGEEBILS]

INSTRUCTIONS

Hall Ticket Reference Code:

1. Please provide all the information requested on both sides of the answer sheet. The address and email id provided will be used in all future correspondence. Please make sure the information provided is valid till May-June 2016.

2. This is an objective type test in 4 parts. All 4 parts are to be attempted. All questions are Multiple Choice Questions (MCQs). Each question has only one correct answer and must be indicated by completely blackening the appropriate circle by pencil. Blackening of more than one circle will be regarded as invalid/improper. Fill out the one you choose as shown in the example below:

   eg. (a) (b) (c) (d)   if your choice is 'b'

3. Answers are to be indicated in the answer sheet provided and NOT in this set of question papers.

4. Use only **HB Pencils** to mark your answers on the answer sheet. If you have forgotten to bring one, please request the invigilators to give you one.

5. Do not write below the line drawn on the answer sheets. You will be given paper for rough work. The last page of the question paper can also be used for rough work.

6. Note that there is negative marking. Each correct answer gets you one mark for questions 1-10 and two marks for questions 11-15. Each wrong answer costs you $1/2$ a mark.

7. Calculators may be used for the examination.

8. The time allowed for the exam is **2 hours.** You may submit your answer sheets earlier if you finish earlier.

9. The Answer sheet should not be folded.

JGEEBILS GS2016

Section A: General

1. A researcher observes a moth that is highly attracted to a particular species of flower. The researcher wants to determine if smell is an important factor in this attraction. He or she could do the following and then observe the moth's response:

a. Contain the flower on the plant in a clear plastic bag
b. Contain the flower on the plant in a net which moths cannot pass through
c. Remove the flower from the plant
d. Remove the petals of the flower

2. Fish spend a lot of energy removing oxygen from water. Which one of the following is the most plausible reason?

a. The CO_2 content of their tissues is much higher than that of terrestrial animals
b. Fish haemoglobin is much less efficient than mammalian haemoglobin
c. Water has low oxygen content, a large amount must be pumped through gills
d. Fish have a reduced body temperature which slows down reaction rates

3. Cholesterol levels are measured for a random sample of 1,000 persons. The survey is repeated for the same population, but with the sample size tripled to 3,000. Which one of the following is true?

a. The two sample standard deviations will be approximately equal
b. The new sample standard deviation will be smaller than the first
c. The new sample standard deviation will be larger than the first
d. This cannot be answered without knowing the sample means

4. The term "El niño" refers to:

a. a species of butterfly
b. the ninth thoracic vertebra
c. the chemical element Fluorine
d. a periodic warming of the ocean

5. The area of a hallway is m when measured in square metres, and f when measured in square feet. The equation that relates m to f is

a. $m = 3.3f$
b. $m = 10.8f$
c. $f = 3.3m$
d. $f = 10.8m$

6. What number should come next in this series? 7, 10, 8, 11, 9, 12, …

a. 7
b. 10
c. 12
d. 13

7. Pluto has been reclassified as a "dwarf planet" rather than a "planet" because

a. its orbit around the sun is not circular
b. it is smaller than the Earth
c. it is incapable of supporting life
d. none of the above

8. In a cricket championship there are 36 matches. What is the number of teams participating if each team plays exactly one match with every other team?

a. 8
b. 9
c. 10
d. 11

9. The first quartile of a list of values is:

a. Half the mean of the values
b. One standard deviation below the mean of the values
c. The median of the lower half of the values
d. None of the above

10. The mean of ten exam scores is 20. When two more scores are added, the mean becomes 30. What is the mean of the two scores added?

a. 20
b. 30
c. 60
d. 80

11. A couple have 3 children. None of the children were born in a leap year. The probability that all three children share the same birthday is:

a. 3/365
b. $(1/365)^2$
c. $(1/365)^3$
d. (1/365) x (1/364) x (1/363)

12. In a survey 96 people liked strawberries, 98 liked raspberries, and 120 liked blueberries; 18 people liked only strawberries, 20 liked only raspberries, and 24 liked only blueberries; 38 people liked all three. How many people liked raspberries and blueberries but not strawberries?

a. 29
b. 30
c. 31
d. 32

13. This is a schematic image of a mobile phone SIM card. What is the function of the diagonal cut on the left side?

a. To serve as an electrical contact
b. To dissipate heat during use
c. To ensure it is inserted in the correct orientation
d. To cut costs by reducing material

14. The sign and unit place digit of $(-9)^{99}$ are, respectively:

a. Negative, 9
b. Negative, 1
c. Positive, 9
d. Not possible to determine without calculating the full number

15. You obtain the durations of 3 sequential events using three different timers, as 1.63 seconds, 2.6 seconds and 3.558 seconds respectively. The combined duration of these events is the sum of these three times. This sum should be reported as:

a. 7.7 seconds
b. 7.788 seconds
c. 7.79 seconds
d. 7.8 seconds

Section B: Physics

1. Two objects are acted upon by the same force for the same amount of time. At that point, even though the objects have different masses, they will have the same:

a. velocity
b. acceleration
c. momentum
d. kinetic energy

2. The minimum number of unequal non-zero length vectors which can add up to give a zero resultant is

a. two
b. three
c. four
d. five

3. Assuming the earth is made of matter of uniform density and has radius 8000 km, the acceleration due to gravity in a 2000 km deep mine would be:

a. 2.45 m/s^2
b. 7.36 m/s^2
c. 9.81 m/s^2
d. The answer cannot be determined from this information

4. In a right-handed Cartesian frame of reference a 180° rotation about the X-axis followed by a 180° rotation about the Y-axis is equivalent to

a. an inversion operation through the origin
b. mirror reflection down the X-Y plane
c. 180° rotation about the Z axis
d. 90° rotation about the Z axis

5. You wish to measure how tightly an ant can hold on to its substrate. You place an ant of mass 10 mg on a round, rotating platform at a distance of 30 cm from the centre, and begin increasing the angular velocity of the rotating platform until the ant is dislodged. You find that the maximum angular velocity at which the ant can hold on is 20 rad/s. The maximum force that the ant can exert to hold on is:

a. 0.2 mN
b. 1.2 mN
c. 0.2 N
d. 1.2 N

6. Which of the following exerts a small but measurable effect on the period of a real clock pendulum? X: The amplitude of the pendulum swing. Y: The temperature. Z: Buoyancy due to atmospheric pressure

a. X only
b. X and Y but not Z
c. Y and Z but not X
d. X and Y and Z

7. Two carbon atoms have a non-covalent interaction whose potential energy varies with distance as $E(r) = 32000000/r^{12} - 729/r^6$, where r is measured in Angstroms. The equilibrium inter-atomic distance will be

a. $r = 0$
b. $r = 0.667$
c. $r = 6.67$
d. $r = 66.7$

8. An angle has the following probability distribution: $f(\theta) = (1 + \sin(3\theta))/2\pi$. What is the chance that the angle will lie between 0 and 120°?

a. 1/3
b. 0.5
c. $\pi/4$
d. 1

9. Four tubes of P^{32}-labelled ATP with a half-life of 30 days are dispensed and stored at four different temperatures (25°C, 4°C, -20°C and -80°C). After 30 days, the residual radioactivity will be in which one of the following orders?

a. 25°C > 4°C > -20°C > -80°C
b. 25°C = 4°C > -20°C = -80°C
c. 25°C = 4°C < -20°C = -80°C
d. 25°C = 4°C = -20°C = -80°C

10. A spinning-top is spun anticlockwise (when seen from above). As the top slows down it starts precessing, i.e. its axis of rotation starts revolving around the vertical. What is the direction of this precession when seen from above?

a. clockwise
b. anticlockwise
c. depends on whether you are in the northern or southern hemisphere
d. depends on the type of surface the top is spinning on

11. A 20 cm x 30 cm sheet of paper is illuminated by a candle 10 metres away. The total light power falling on it is X. The paper is now brought to within 10 cm of the candle. The total light power falling on it is now Y. What is the ratio $Y:X$?

a. Below 10000:1
b. Exactly 10000:1
c. Above 10000:1
d. Cannot be determined from the given information

12. Which of the following operators commute?

$$A(f(x)) = [f(x)]^2 \quad B(f(x)) = xf(x) \quad C(f(x)) = df/dx$$

a. A commutes with B
b. B commutes with C
c. A commutes with C
d. No pair of these commute

13. In a closed and well-insulated room, the door of an ordinary running refrigerator is opened and left open for some time. From the time the door is opened, I measure the temperature at some point in the room far from the refrigerator. After some time I find that the temperature increases. This is mainly due to:

a. The second law of thermodynamics
b. Anomalous expansion of water
c. The greenhouse effect
d. None of the above

14. A U-shaped tube with constant cross-section is separated into two halves by a semi-permeable membrane at its midpoint, which allows water to pass freely but not glucose. Initially there is 1 litre of water in each arm. An amount of glucose is added to the left arm, causing the water to rise in that arm. Which of the following do you need to know to calculate the final height difference of water between the two arms?

a. The amount of glucose added
b. The cross-sectional area of the tube
c. Both (a) and (b)
d. Neither (a) nor (b)

15. The elastic deflection of a weightless point-loaded cantilever is given by the equation:

$$\delta = \frac{Fx^2}{6EI}(3L - x)$$

Here, F is the point-loading force, L is the point on the beam where the force is applied, x is the position along the beam ranging from 0 to L, and E and I are constants. Consider a tree branch, which is a natural cantilever. A monkey initially sits on the mid-point of the branch, causing the mid-point to deflect down by some amount δ_1 from horizontal. The monkey then shifts to the end of the branch, causing the <u>mid-point</u> to deflect to a new amount δ_2 from horizontal. What is the ratio δ_2/δ_1?

a. 1.6
b. 2.5
c. 3.2
d. 5.0

Section C: Chemistry

1. A gas contains 50% helium and 50% methane by volume. What is the percentage by weight of methane in the mixture?

a. 25%
b. 40%
c. 50%
d. 80%

2. Which one of the following is a redox reaction?

a. $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
b. $H_2 \rightarrow 2H^+ + 2e^-$
c. $2H_2 + O_2 \rightarrow 2H_2O$
d. $Cl_2 + 2e^- \rightarrow 2Cl^-$

3. Which one of the following amino acids is not chiral?

a. Cysteine
b. Alanine
c. Glycine
d. Leucine

4. The percentage (%) increase in the rate of a chemical reaction will be maximum when the temperature is increased from:

a. 270 K to 280 K
b. 280 K to 290 K
c. 290 K to 300 K
d. In all these cases the increase will be the same

5. Glycerol is more viscous than ethanol because:

a. It can make more H bonds per molecule than ethanol
b. Due to its tendency to form polymers
c. Its molecular weight is greater than ethanol
d. It has more carbon atoms than ethanol

6. Upon ozonolysis which one of the following compounds can produce acetone?

a. 3-methyl-1-butene
b. cyclopentane
c. 2-methyl-2-butene
d. 2-methyl-1-butene

7. Which one of the following is correct order of basic strength?

a. $CN^- > HCO_3^- > ClO_4^- > HS^-$
b. $CN^- > HS^- > HCO_3^- > ClO_4^-$
c. $CN^- > HCO_3^- > HS^- > ClO_4^-$
d. $HS^- > CN^- > HCO_3^- > ClO_4^-$


8. Which one of the following is true? Ionization potential

a. is the energy required to remove an electron from the innermost shell of an atom
b. is the ability of an atom to attract an electron pair
c. generally increases from left to right in a period in the periodic table
d. generally increases from top to bottom in a group in the periodic table

9. Which substance is expected to exhibit the greatest surface tension at 25°C?

a. CH_3OCH_3
b. C_2H_5OH
c. $CH_3CH(OH)CH_3$
d. $CH_2(OH)CH_2OH$

10. What is the role of sulphur in the vulcanization of rubber?

a. It acts as a catalyst for the reaction, thereby accelerating its rate
b. It participates in di-sulphide bonds which cross-link the rubber polymers
c. It is used to increase the temperature of the process, thereby accelerating its rate
d. It preserves rubber from biodegradation

11. You are observing a chemical reaction $(R \rightarrow P)$ either in the absence or presence of an enzyme catalyst, which has $K_M = 10^6 \ \mu M$. At equilibrium 20 moles of reactant and 2 moles of product are present in the un-catalysed reaction. What would the reactant and product concentrations be at equilibrium in the presence of the enzyme?

a. $R = 0, P = 22$
b. $R = 2, P = 20$
c. $R = 20, P = 2$
d. This cannot be answered without knowing the reaction volume

12. The standard enthalpy of formation at 298 K for methane is -74.8 kJ mol^{-1}. What additional information is required to determine the average energy for C–H bond formation?

a. The dissociation energy of H_2
b. The enthalpy of sublimation of carbon
c. Latent heat of vaporization of methane
d. Both (a) and (b)

13. The R group of a particular Grignard's reagent is an un-branched alkyl chain with n carbons. How many chiral carbons do you expect the product to have if this reagent reacts with formaldehyde?

a. 0
b. 1
c. n
d. $n + 1$

14. If the organic reactant in a Wurtz reaction mixture (RX and sodium) has n C-C bonds, the hydrocarbon product will have how many C-C bonds?

a. n/2
b. n-1
c. 2n+4
d. 2n+1

15. In the reaction shown below, in the nitrating mixture HNO_3 act as a:
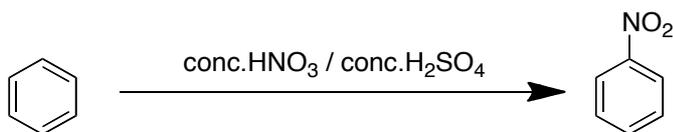
a. acid
b. base
c. catalyst
d. reducing agent

Section D: Biology

1. Single nucleotide polymorphisms (SNPs) are:

a. disease-causing mutations in the human genome
b. an example of standing genetic variation in the human population
c. errors during genome sequencing
d. none of the above

2. The α-helix in proteins is formed due to

a. Intramolecular hydrogen bonds
b. Intermolecular hydrogen bonds
c. van der Waals interactions between amino acids
d. Ionic interactions

3. You discover a simple microbe which has a minimal genome. It only has 30 genes for basic metabolism, 20 genes for the ribosome, and 20 genes for DNA and RNA synthesis and polymerization. Approximately how big will this genome be?

a. 10 kb
b. 100 kb
c. 1000 kb
d. 10000 kb

4. When performing X-ray crystallography to determine protein structure, the scattering of x-rays from the protein crystal is primarily due to:

a. amino acids
b. Carbon atoms
c. electrons
d. protons

5. Parietal cells of the stomach release hydrochloric acid (HCl) to aid in digestion. Why are parietal cells themselves not digested by HCl?

a. They contain inhibitory enzymes that inactivate the HCl
b. They are protected by mucous secreted by cells in the gastric pit
c. HCl has to be activated by pepsinogen which is released by peptic cells
d. Bicarbonate ions inside the parietal cells neutralize HCl

6. A mutation in the 3' un-translated region of an mRNA has a strong phenotype. The phenotype could be because:

a. The mRNA fails to be transcribed
b. The mRNA is transcribed but is unstable
c. The mRNA is not properly translated to protein
d. The protein translated from the mRNA is unstable

7. You are doing a conjugation experiment with two strains of bacteria. The F+ strain is bio+ leu+ pro+ lac+. The F- strain is bio- leu- pro- lac- Str+ (resistant to Streptomycin). What kind of plates would you use to select recombinants?

a. Complete medium with streptomycin
b. Minimal medium
c. Minimal medium with 3 of the supplements
d. Minimal medium with 3 of the supplements and streptomycin

8. When a B-cell undergoes immunoglobulin class switching

a. the variable region of the light chain changes, its constant region stays the same
b. the variable region of the light chain stays the same, its constant region changes
c. the variable region of the heavy chain stays the same, its constant region changes
d. the variable region of the heavy chain changes, its constant region stays the same

9. You are studying an unusual protein which has a pKa of 5. You wish to purify this protein. For this you can:

a. Use anion-exchange chromatography, and a low pH buffer for elution
b. Use anion-exchange chromatography, and a high pH buffer for elution
c. Use cation-exchange chromatography, and a low pH buffer for elution
d. Use cation-exchange chromatography, and a high pH buffer for elution

10. Protein X has two tryptophans and one tyrosine, and its molecular weight is 20,000 Da. One molar tryptophan and one molar tyrosine solutions give you Abs_{280} of 5500 and 1490, respectively (using a one cm path length cuvette). What Abs_{280} would you expect for 0.2 mg/ml of protein X solution?

a. 0.1249
b. 1.249
c. 12.49
d. This cannot be estimated from the given data

11. The figure below shows a pedigree of a family over three generations with respect to a genetic disorder. What sort of inheritance is depicted in this pedigree?
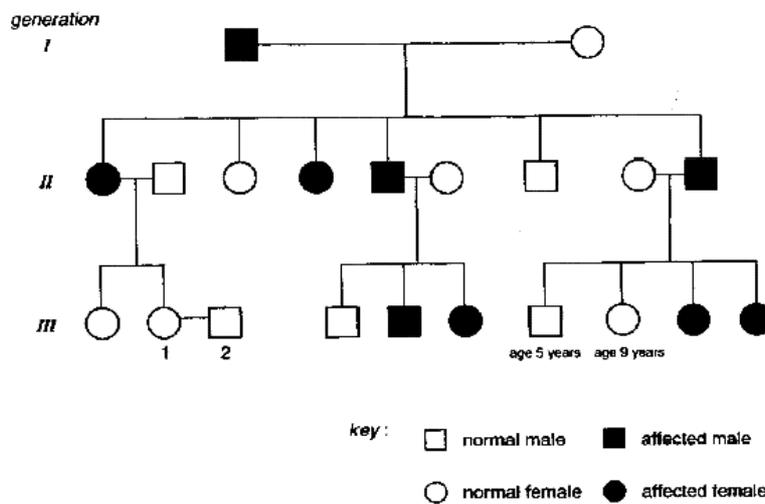
a. Autosomal recessive trait
b. Autosomal dominant trait
c. Sex linked trait
d. Codominant trait

12. Cell signalling pathways I and II were studied independently, and researchers arrived at the following schematics:

$$I: A \rightarrow B \rightarrow C \rightarrow D$$
$$II: E \rightarrow F \rightarrow G \rightarrow H$$
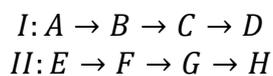
Later these pathways were found to cross-talk. When only pathway I is activated, C and H are phosphorylated. An inhibitor of B inhibits this phosphorylation. When pathway II is activated, G and C are phosphorylated while H is not phosphorylated. An inhibitor of F inhibits phosphorylation of G and C while restoring phosphorylation of H. Identify the kinases and phosphatases.

a. B,F,G are kinases
b. B,C,G are phosphatases
c. B,G are kinases and F is a phosphatase
d. B,F are kinases and G is a phosphatase

13. The transcription of gene *X* is controlled by transcription factor *A*. Gene *X* is only transcribed when factor *A* is phosphorylated. Data on the tissue distribution of factor *A* and the activities of a protein kinase and a protein phosphatase specific for factor *A* are presented in the table below. Of these three tissues, gene *X* will be transcribed in:

| Tissue	Factor A	Protein Kinase Activity	Protein Phosphatase Activity
Muscle	+	−	−
Heart	+	+	−
Brain	+	−	+

a. Muscle only
b. Heart only
c. Brain only
d. Muscle and heart but not brain

14. The upper line in the figure below shows the locations of four genes on the genetic map of an organism; the lower line shows the locations of the same four genes on a physical map derived from the nucleotide sequence of the DNA of that organism. The maps are not identical because:
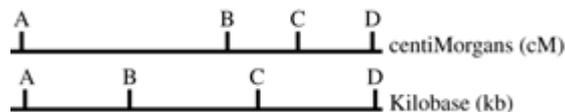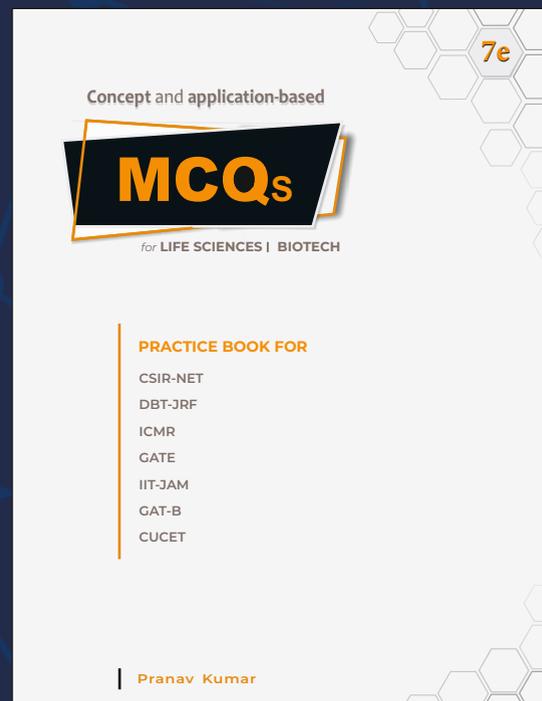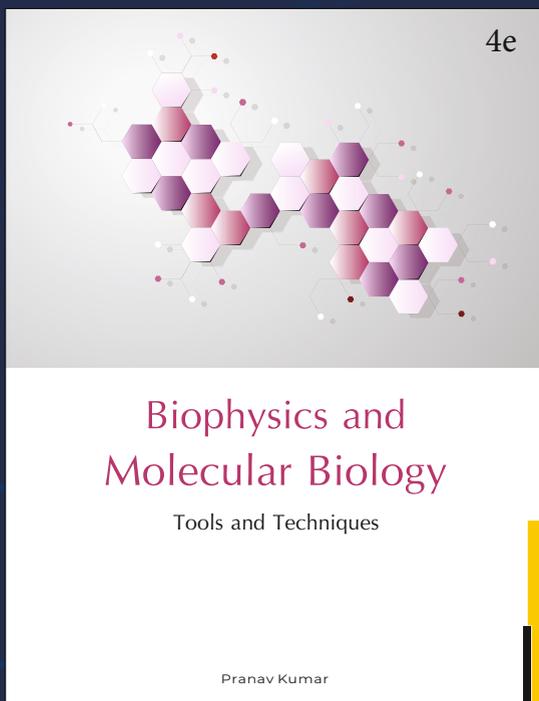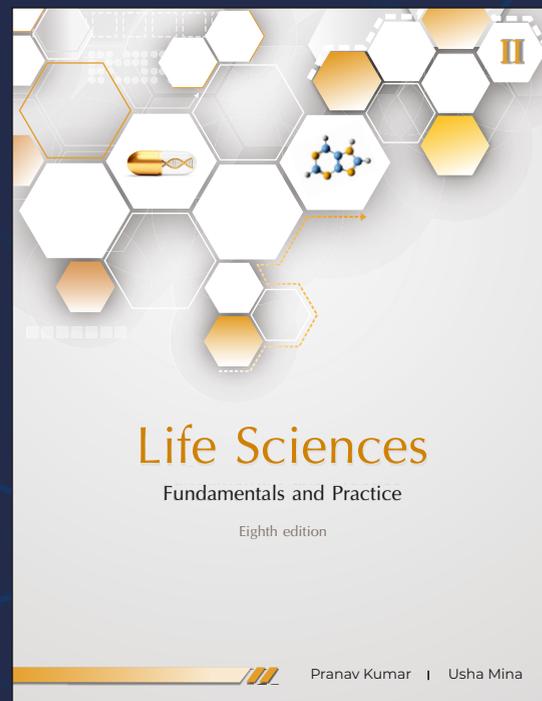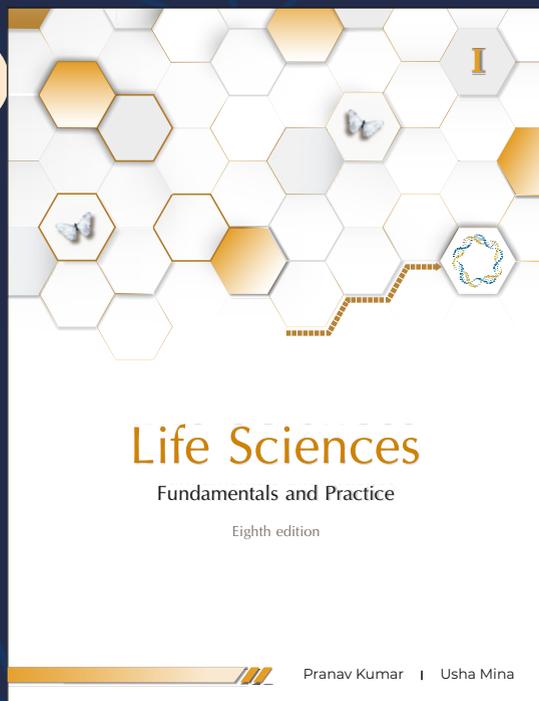

a. genetic maps cannot provide any information about gene positions
b. recombination frequencies per kb of DNA are not uniform across a chromosome
c. the farther apart two genes are, the more likely they are to recombine
d. the closer two genes are, the more likely they are to recombine

15. Invasive alien species are animals and plants that are introduced accidently or deliberately into a natural environment where they are not normally found. Invasive alien species often have serious negative consequences for the biodiversity of their new environment. The graph below shows the number of alien invasive plant species in 10m^2 plots as a function of the species richness of native plant species in the same plots. The measurements are repeated across several mainland locations, each compared with an adjacent island. Which of the following conclusions can be reasonably drawn based solely on this figure?
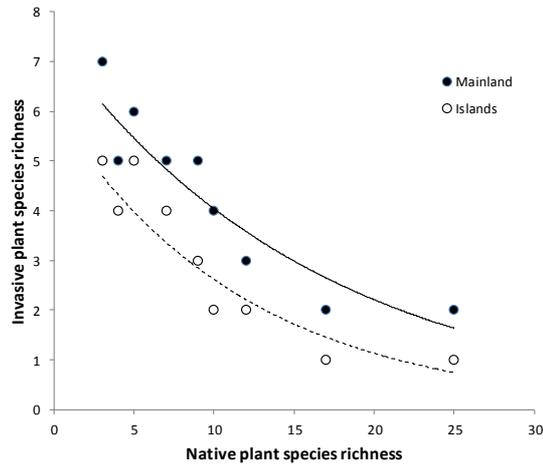
a. Species rich native communities are more resistant to invasion.
b. Islands have fewer species than mainland ecosystems.
c. There tend to be more invasive species on mainlands than on islands.
d. All of the above.

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Answer sheet template of Biology

Question #	Answer
Section # : 1	
Total questions : 15	
Q 1	a
Q 2	c
Q 3	a
Q 4	d
Q 5	d
Q 6	b
Q 7	d
Q 8	b
Q 9	c
Q 10	d
Q 11	b
Q 12	a
Q 13	c
Q 14	a
Q 15	d
Section # : 2	
Total questions : 15	
Q 1	c
Q 2	b
Q 3	b
Q 4	c
Q 5	b
Q 6	d
Q 7	c
Q 8	a
Q 9	d
Q 10	b
Q 11	a
Q 12	d
Q 13	a
Q 14	c
Q 15	b
Section # : 3	
Total questions : 15	
Q 1	d
Q 2	c
Q 3	c
Q 4	a
Q 5	a
Q 6	c
Q 7	b
Q 8	c
Q 9	d
Q 10	b
Q 11	c
Q 12	d

Q 13	a
Q 14	d
Q 15	b
Section # : 4	
Total questions : 15	
Q 1	b
Q 2	a
Q 3	b
Q 4	c
Q 5	b
Q 6	b
Q 7	d
Q 8	c
Q 9	a
Q 10	a
Q 11	b
Q 12	d
Q 13	b
Q 14	b
Q 15	c

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