

Correct answers are marked in red.

Section-A General

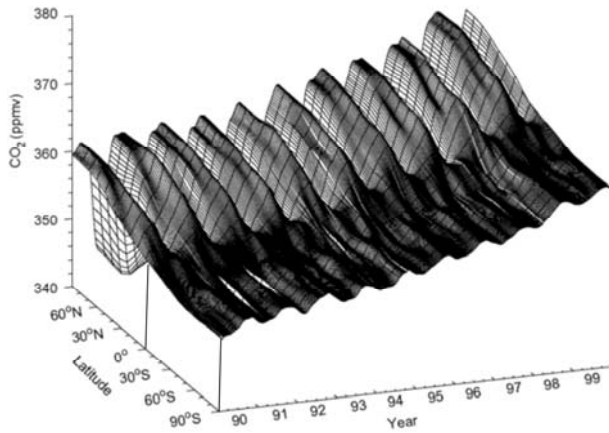
1. In vertebrates, eyes are either positioned frontally or laterally. Frontal eyes allow an enlargement of the binocular field of vision but entail a reduction of the total field of vision. Lateral eyes allow an almost 360° field of vision, but show a reduced binocular field of vision. Which of the following is likely to be true?
 - a. Lateral eyes are good at low light conditions because the larger field of vision allows to collect more photons and thus increases the light sensitivity
 - b. Predators use lateral eyes because they allow to observe a larger area for prey
 - c. Predator use frontal eyes because they allow good spatial vision over a larger area to estimate the distance of the prey**
 - d. Highly preyed animals use frontal eyes because they allow good spatial vision over a larger area to calculate the distance of the predator.

- 2) Two people are clapping their hands, but with different frequencies. Ramya claps her hands 17 times per 3 minutes, and Kumar claps his hands 31 times per 5 minutes. They start clapping at the same time. How many times does each one clap before they clap together at the same time again?
 - a. Ramya: 51; Kumar: 155
 - b. Ramya: 51; Kumar: 93
 - c. Ramya: 85; Kumar: 155
 - d. Ramya: 85; Kumar 93**

- 3) Greenhouse gases in the atmosphere absorb
 - a. more visible radiation than infrared
 - b. visible and infrared equally
 - c. more infrared radiation than visible**
 - d. neither visible nor infrared radiation

- 4) A student, for want of something better to do, decided to go fishing in the NCBS pond. She caught 50 mosquito fish, but rather than take them home for dinner (they were too small anyway) she decided to just mark them and return them to the pond. A week later she went fishing again. This time she caught 40 mosquito fish, of which 5 were marked. Based on these data, what is the estimated size of the mosquito fish population in the pond?
 - a. 400**
 - b. 200
 - c. 250
 - d. 2000

- 5) The graph below plots changes in atmospheric CO₂ concentrations across latitudes as a function of time. Which of the following conclusions can be drawn solely on the basis of this figure?

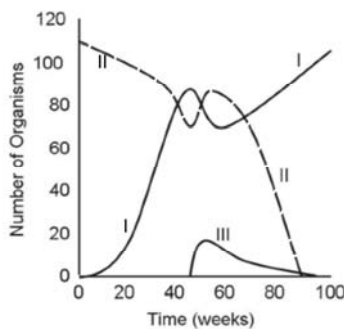


- a. Deforestation rates are lower in the southern hemisphere
- b. Anthropogenic emissions of CO₂ are higher in the Northern Hemisphere
- c. Land area is greater in the Northern hemisphere compared to the southern Hemisphere
- d. None of the above**

- 6) If $f(3) = 15$ and $f(5) = 45$, which of the following could be $f(x)$?
- a. $4x + 3$
 - b. $2x^2 - 2x$
 - c. $2x^2 - x$**
 - d. $2x^2 - 5$

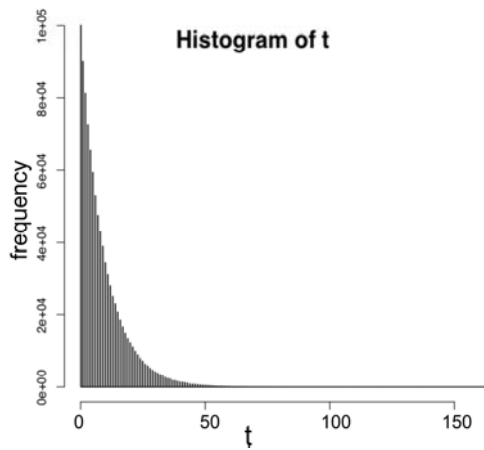
- 7) The minimum distance at which a microscope is capable of distinguishing two points as separate is its
- a. magnification
 - b. illumination
 - c. resolving power**
 - d. fluorescence

- 8) The graph below plots the abundance of three different species over time in a newly formed isolated island ecosystem. Which of the following statements can one reasonably conclude based on the graph?



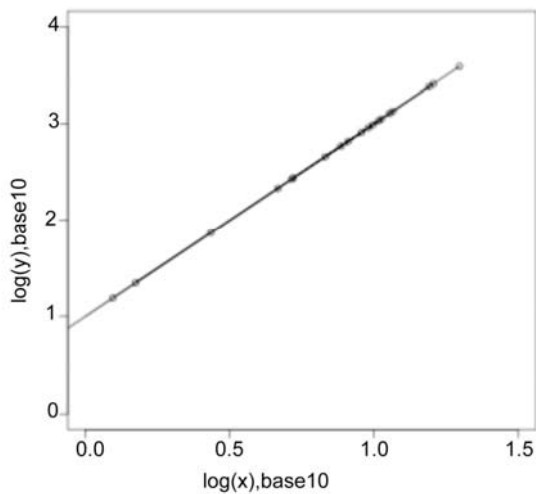
- a. **Species III is a predator of species II but not of species I**
- b. Species III is a predator of species I but not of species II
- c. Species III is a strong competitor of both species I and species II
- d. Species III has a neutral relationship with both species I and II

9) Which of the following about the distribution given in the figure is true?



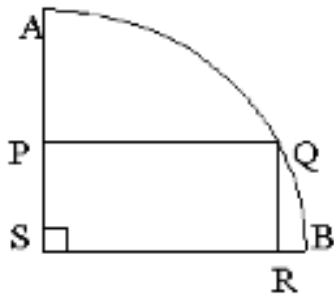
- a. **Mean > Median;**
- b. Mean = Median;
- c. Mean < Median;
- d. Impossible to deduct based on the figure.

10) Study the scatter plot shown. Which of the following relationships between x and y does this represent?



- a. $y = 2^x$;
- b. $y = 2^x + 10$;
- c. $y = 10x^2$;**
- d. $y = x^2 + 10$

11) ASB is a quarter circle. PQRS is a rectangle with sides $PQ = 8$ and $PS = 6$. What is the length of the arc AQB?



- a. 5π**
- b. 10π
- c. 25
- d. 14

12) Which of the following describes the relationship between A and B as shown in the pairs of numbers in the table above?

<u>A</u>	<u>B</u>
2	5
3	10
4	17
5	26

- a. $B = A + 4$
- b. $B = 2A + 1$
- c. $B = 3A - 1$
- d. $B = A^2 + 1$**

Number of accidents:	0	1	2	3	4	5	6
Number of drivers:	16	13	21	4	2	2	1

- 13) The above table shows the results of a survey, which asked auto rickshaw drivers how many accidents they had experienced over the previous 5 years. What is the median number of accidents per driver?
- 0.5
 - 1
 - 1.5
 - 2**
- 14) In response to concerns that a one-child policy may lead to female foeticide, a government adopts the following policy. Couples with a boy child are penalized [and therefore discouraged] from having more children, whereas couples with daughters can continue to produce children but must stop when a boy child is born to them. If implemented, the sex ratios in the population at steady state will be:
- Males \ll Female
 - Females \gg Males
 - Females = Males**
 - Not possible to estimate
- 15) In an assignment, three groups of students were asked to statistically compare the heights of basketball and table tennis players in a large local club. Each group found that the former were taller than the latter, with the basketball players having an average height of 6 ft, and the table tennis players an average height of 5 ft. However, each group used a different sample, and therefore had a different sample size (N) and standard deviation (SD), which are given in the figure below. Rate the three datasets in terms of the statistical confidence one has in the final conclusion that basketball players are taller than table tennis players.
- Dataset 1 = Dataset 2 = Dataset 3;
 - Dataset 1 > Dataset 2 and Dataset 1 > Dataset 3;**
 - Dataset 1 = Dataset 2 > Dataset 3;
 - Dataset 3 = Dataset 2 > Dataset 1

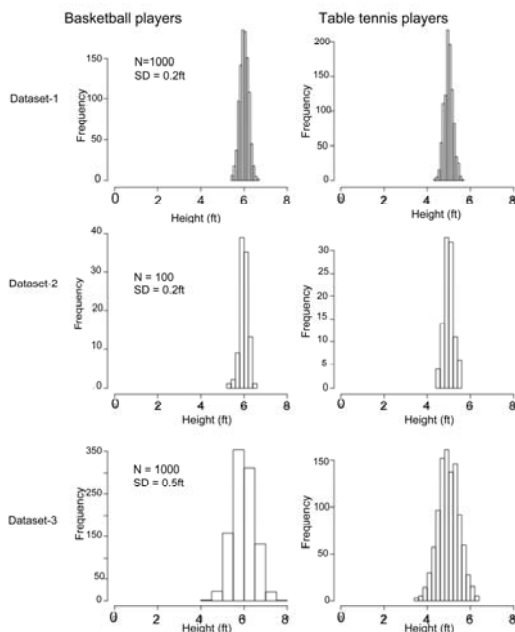
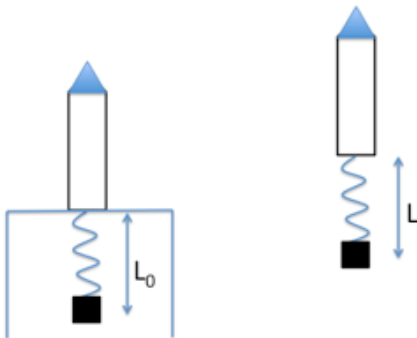


Figure for Q15-Section A.

Section B –Physics

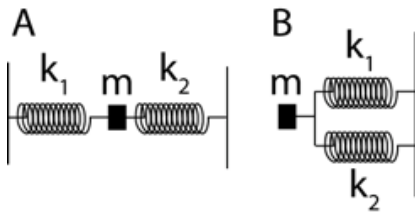
1. A ball is thrown upwards with initial speed v . Assuming that the frictional force due to air resistance is proportional to the speed of the ball, and ignoring the buoyant force exerted by the air, which of the following is true?
 - a. The acceleration of the ball is always equal to g
 - b. The acceleration of the ball is equal to g only at the top of its trajectory**
 - c. The acceleration of the ball is always less than g
 - d. The acceleration of the ball is always more than g
2. A source of 1kHz sound is moving straight towards you at a speed equal to 0.9 times the speed of sound. What is the frequency you observe?
 - a. 0.1 kHz
 - b. 0.5 kHz
 - c. 1.9 kHz
 - d. 10 kHz**
3. A charged particle is initially at rest in a region that has a constant electric field and a constant magnetic field. If the electric and magnetic fields point in the same direction, the subsequent trajectory of the particle will be:
 - a. a circle
 - b. a parabola
 - c. a helix
 - d. a straight line**
4. A cube has a constant electric potential V on its surface. If there are no charges inside the cube, what is the electric potential at its centre?
 - a. 0
 - b. $V/6$
 - c. $V/2$
 - d. V**
5. In a mixture of hydrogen, oxygen, and nitrogen gases at a fixed temperature, which molecules have the greatest kinetic energy?
 - a. hydrogen
 - b. oxygen
 - c. nitrogen
 - d. all have the same average kinetic energy**
6. If the Sun suddenly collapsed to $1/100^{\text{th}}$ its current radius (without exploding or losing/gaining any matter). The Earth would
 - a. continue in its present orbit**
 - b. be pulled apart by tidal forces
 - c. fly off in a tangent path
 - d. be sucked into the sun

7. If you stand rather than sit on a playground swing, the time taken to swing back and forth is:
- Increased
 - decreased**
 - stays the same
 - depends on your weight
8. I attach a stone to a rope and spin it in a circle on the horizontal plane at high speed. Suddenly the rope snaps. What happens in the next instant?
- The stone travels radially outward.
 - The stone travels tangent to the circle.**
 - The stone drops straight to the ground.
 - The stone recoils radially inwards.
9. A collinear beam of light is shone across an air bubble, which is rising through water. Which of the following is correct?
- The bubble acts as a converging lens and focuses the light to a small point.
 - The light passes through the bubble with no deviation.
 - The bubble acts as a diverging lens causing the beam to spread.**
 - The light is reflected back along its original path.
10. The timbre of a sound depends on the mixture of frequencies it contains. When you play a piano key sound is generated by causing a small hammer to strike the piano wire. The frequencies excited by the hammer depend mostly on:
- The position along the wire where the hammer strikes.**
 - The strength of the hammer strike.
 - The angle with which the hammer strikes.
 - Only the properties of the wire, not on how it is hit.
11. I attach a mass to a spring hanging from a rocket on the surface of the earth. The system is initially at rest with the spring extended. Now the rocket accelerates upwards at a constant rate. Assuming that the effect of gravity is constant and that there is no frictional damping, what does the subsequent motion of the mass with respect to the rocket (i.e. the length of the spring) look like?



- a. The length will remain constant at L_0 .
- b. The length will monotonically increase to a new equilibrium $L > L_0$.
- c. The length will initially increase then decrease to a new equilibrium $L > L_0$.
- d. The length will initially increase and subsequently continue to oscillate around a mean value $L > L_0$.**

12. Two springs with spring constant k_1 and k_2 are attached to a body of mass (m) in two different configurations in 2 cases (A and B) as shown. The mass rests on a surface with coefficient of friction between the mass and surface as K .

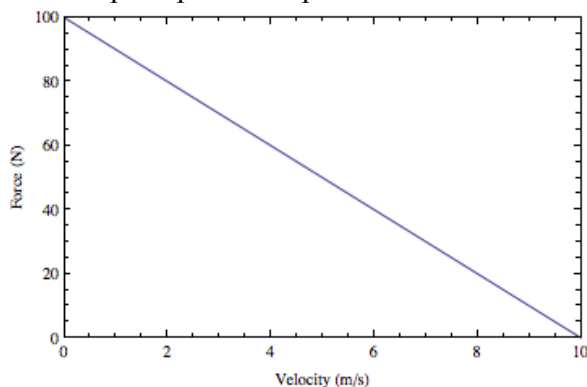


The mass is moved to the right, parallel to the axis of the springs by a distance d (from natural lengths of the springs) and is released. The time taken till the body comes to rest in case A

- a. is greater in B
- b. is equal to that in B**
- c. is less than in B
- d. cannot be determined

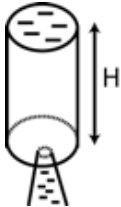
13. We build an electric motor to have properties like skeletal muscle. Like most motors, it shows a trade-off between force output and velocity of contraction at a constant current level of 1 A.

What is the peak power output at this current?

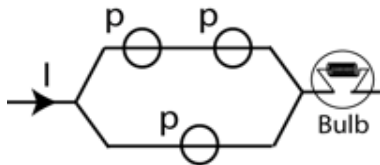


- a. 25 W
- b. 250 W**
- c. 2500 W
- d. 25000 W

14. A cylindrical tank of height H and base area B is full of water at time $t=0$. There is a small orifice at the bottom of the tank with area A . Water from the tank starts to drain through the orifice with a velocity that is proportional to $\sqrt{h(t)}$ where $h(t)$ is the height of remaining water in the tank at time t . Then $h(t)$ is a



- a. linear function of t
 - b. quadratic function of t**
 - c. cubic function of t
 - d. function of square root of t
15. A light bulb is connected as in the circuit shown below. A current I flows through the 2 arms preceding the light bulb with the elements shown. Each element has a probability p of failure to conduct.



What is the probability that the bulb is not lit?

- a. p^3
- b. $1-[1-p]^3$
- c. $p[1-p]^2$
- d. $p^2[2-p]$**

Section C - Chemistry

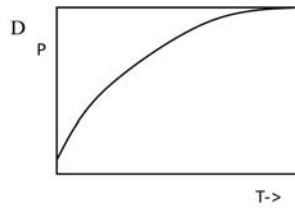
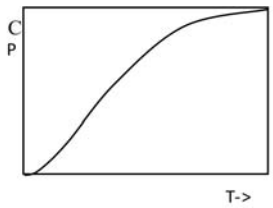
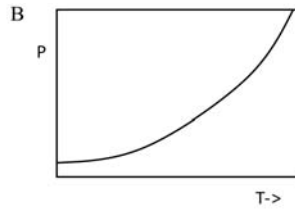
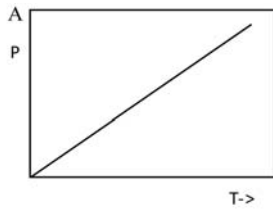
1. Lets assume that taste sensory neurons in flies measure amount of substances in number of molecules, and our behavioral experiment indicates that 30g/100ml sucrose water solution tastes as sweet as 30% glucose water solution. Which of the following is likely to be true?
 - a. Sucrose and glucose are similarly sweet for flies.
 - b. One cannot say.
 - c. Glucose is almost twice as sweet as sucrose.
 - d. Sucrose is almost twice as sweet as glucose.**
2. What is the relationship between edge lengths in case of hexagonal and cubic unit cells?
 - a. a=b not equal to c and a=b=c**
 - b. a not equal to b not equal to c and a=b=c
 - c. a=b not equal to c and a not equal to b not equal to c
 - d. none of the above
3. At STP, which of the following will have highest no. of molecules ?
 - a. 22 grams of carbon dioxide
 - b. 11.2 litres of oxygen
 - c. 0.8 moles of methane**
 - d. 7 grams of nitrogen
4. With increasing temperature pure water dissociates more and $[H^+]$ ion concentration increases above 10^{-7} M. What happens to the pH of water?
 - a. No change.
 - b. Water becomes basic.
 - c. Neutral pH increases.
 - d. pH decreases.**
5. Which of the following cannot be separated by electrophoresis:
 - a. Lysine and Aspartic acid
 - b. n-Butyl amine and Butanoic acid
 - c. 3-ethyl-pentane and n-heptane**
 - d. Benzyl alcohol and Benzoic acid
6. In the ESI-MS, if the peptide peak comes at 1001 m/z corresponding to triply charged ion, what will be the mass of the peptide?
 - a. 1001
 - b. 1501
 - c. 3000**
 - d. 333

7. A system is at equilibrium under conditions of constant temperature and pressure. Which of the following will be at a minimum:
- Enthalpy
 - Entropy
 - Gibbs free energy**
 - Volume
8. Which is the most likely rate constant for the reaction $X + 2Y \rightarrow XY_2$:
- $9 \times 10^{-3} \text{ sec}^{-1}$
 - $5 \times 10^{-3} \text{ M}^{-2} \text{ sec}^{-1}$**
 - $6 \times 10^{-5} \text{ M sec}^{-1}$
 - $8 \times 10^{-4} \text{ M}^{-2} \text{ sec}$
9. The activity of an enzyme is modulated by calcium. Oddly, the shape of the modulation is a bell curve, so that the maximum activity is at intermediate levels of calcium. We know that there are two binding sites for calcium, X and Y. X activates the enzyme. Y inhibits the enzyme. Which of the following mechanisms might account for the bell curve.
- Site X has high affinity, Y has low affinity,**
 - Site X has low affinity, Y has high affinity,
 - Site X and Y have the same affinity
 - Calcium is a divalent cation
10. A cylinder of compressed gas that bears no label is supposed to contain either ethane or ethene. Combustion of the sample shows that 16 cm³ of gas require 48 cm³ of oxygen for complete combustion. This shows that the gas is
- only ethane
 - only ethene**
 - 1:1 mixture of two gases
 - Some known mixture of the two gases
11. How many hydrogen atoms are there in 1 picolitre of water?
- 6.67×10^{13}**
 - 3.33×10^{13}
 - 6.67×10^{10}
 - 1.333×10^{10}
12. The peptide Tyr-Trp-Lys-Val-Arg-Met-Thr-His-Gly is digested with cyanogen bromide (CNBr). Which of the following peptides would be the product of the digested reaction?
- Tyr-Trp-Lys + Val-Arg-Met-Thr-His-Gly
 - Tyr-Trp-Lys-Val-Arg + Met-Thr-His-Gly
 - Tyr-Trp-Lys-Val-Arg-Met + Thr-His-Gly**
 - All above

13. An enzyme reaction obeys the Michaelis-Menten form



Which of the following curves best describes the amount of P as a function of time:



- a. A&C
- b. C alone**
- c. B &C
- d. None of the above.

14. Paper burns at Fahrenheit 451. How would you raise the burning point?

- a. Lower the humidity
- b. Lower the thickness of the paper
- c. Lower the volume of the air
- d. Lower the air pressure**

15. Given the following values of ΔH and ΔS , which one of the following processes can take place at 300°K without violating the second law of thermodynamics?

ΔH	ΔS
(Kcal.Mol ⁻¹)	(cal.Mol ⁻¹ .°K ⁻¹)

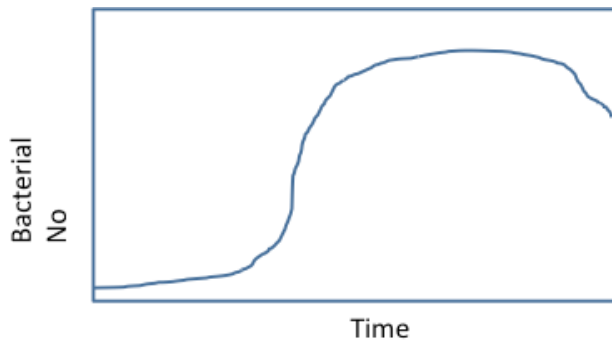
- a. **-20** **+80**
- b. -20 -80
- c. +20 +30
- d. +20 -30

Section D - Biology

- Coat colour in cattle is determined genetically. The progeny of a cattle-pair having a coat colour consisting of red and white patches shows the following ratio with respect to the coat colour: 25% white, 25% red, 50% with red and white patches. Based on these data which of the following statement is correct
 - allele for Red-white patches is dominant over the red allele and white allele
 - red allele is dominant over the white allele
 - red and white may be equally well expressed or are codominant**
 - both red and white are recessive alleles
- Male honeybees (drones) have larger eyes and larger antennae (“nose”) than the fertile female honeybees (queens). Which conclusion on honeybee mating behavior can you draw from this observation?
 - Queens fly faster than drones
 - Queens have a better vision than drones, because their small eyes are sufficient for flight control
 - Drones use a sex-pheromone to attract queens
 - Drones must compete to detect the queen**
- Empedocles hypothesized that we see object by rays emanating from the eye. Which of the following will disprove this
 - A blindfold will not allow you to see an object
 - You need a light to see an object at night**
 - A blind person cannot see even in a brightly lit room
 - A and B
- Human red blood cells (RBCs) cannot be grown in cultures because
 - the culture medium which supports the growth of RBCs has not been defined as yet
 - RBCs are extremely fragile.
 - RBCs are terminally differentiated cells lacking nuclei.**
 - all of the above
- A motor protein hydrolyzes one ADP-P bond to generate the physical force of 5 picoNewtons and takes an 8 nm step at room temperature. What is the information required to estimate the efficiency of the motor?
 - Energy released from ATP-ADP hydrolysis**
 - Mass of the motor
 - Step size
 - No work done since the displacement is close to thermal noise at room temperature

6. How many different transfer RNA molecules are possible in a hypothetical organism where the ribosome detect a quadruplet instead of a triplet codon including the start and stop codon?
- 64
 - 128
 - 20
 - 256**
7. Which of the following DOES NOT contribute to protein diversity (variants of the same protein)?
- RNA editing
 - RNA splicing
 - RNA interference**
 - alternative initiation of translation
8. A competitive inhibitor of an enzyme
- decreases the K_m
 - decreases the V_{max}
 - decreases both the K_m & V_{max}
 - increases the K_m**
9. A scientist studying courtship behavior hypothesizes that while courting female beetles, males display their horns as a signal of their health. If he is correct which of the following must be true?
- Females can estimate male horn length**
 - Female appendages are not affected by their health
 - Females always mate with large males
 - Both a and c
10. A scientist spread bacteria on a nutrient agar plate and after some time transferred the resulting bacterial colonies to three other plates (replica plating) such that the relative positions of the bacterial colonies was the same in all four plates. The fresh plates all contained the same antibiotic. The scientist notes that on each of the antibiotic-containing plates, a few colonies survive the antibiotic. Which of the following is most likely to be observed?
- The number of resistant colonies varies from plate to plate
 - The number of resistant colonies is about the same in all three
 - Both the number and position of resistant colonies are the same on all three plates**
 - Insufficient information is provided to make a prediction

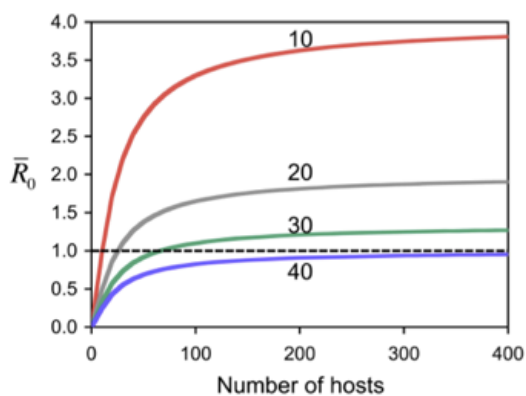
11. Following is the standard Bacterial growth curve in standard media



What will happen if the same experiment is performed with nutrient rich media?

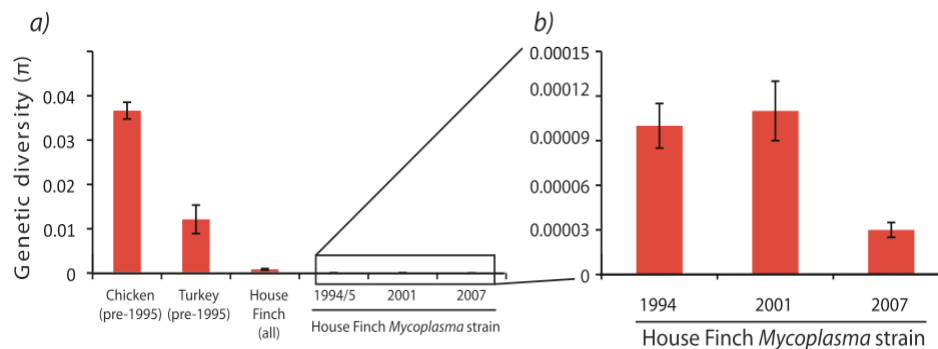
- a. The stationary phase does not change as nutrition does not have any role
- b. The cell density in the stationary phase increases**
- c. Cell density in the stationary phase will decrease as bacteria will grow faster during the log phase
- d. It depends on the bacteria we cannot predict reliably

12. The following figure shows the rate at which a parasite is expected to spread (\bar{R}_0 , calculated as the number of hosts infected each generation) as a function of the number of hosts in the population. Each curve represents expectations for a given level of genetic diversity in the host population (10, 20, 30 or 40 host genotypes). Which of the following is NOT true?



- a. Doubling the number of hosts beyond 100 only marginally increases \bar{R}_0
- b. Increasing host genetic diversity decreases parasite spread
- c. The parasite will always spread in a population with 40 genotypes**
- d. Host genetic diversity limits parasite spread more than the host population size

13. From 1995 to 2007, a *Mycoplasma gallisepticum* infection spread through the house finch population in the US. A student sequenced a 128 Kb stretch of DNA from *Mycoplasma* strains in birds collected before, during and after the epidemic. With these sequences he estimated genetic diversity in *Mycoplasma* at different time points, comparing it to diversity in strains from other infected birds (chicken and turkey). The graph below shows his data. What could have caused the decreasing genetic diversity in *Mycoplasma* strains from house finches if house finch mortality increased as infection spread?



- a. **Selection favoring a more virulent strain of *Mycoplasma***
 b. Recombination between *Mycoplasma* strains from Turkeys and Finches
 c. Both a and b
 d. None of the above
14. Zebrafish exhibit horizontal stripes of pigment cells in the skin. A small fraction of a zebrafish population grown in a pond that is contaminated with a mutagen exhibits blue spots in addition to the horizontal stripes. DNA sequence analysis confirms that cells within the blue spots possess a mutation in a gene that controls pigmentation. However, when these blue spotted fish are crossed to the normal (wild type) fish these spots do not appear either in F1 or F2 generation. This can be explained by the fact that the mutation leading to blue colouration
- a. gets corrected in the subsequent generations
 b. is a recessive mutation
 c. **is a somatic mutation**
 d. is a dominant mutation
15. In Mendel's experiments, the spherical seed character (SS) is completely dominant over the dented seed character (ss). If the characters for height were incompletely dominant, such that TT are tall, Tt are intermediate and tt are short, what would be the phenotypes resulting from crossing a spherical-seeded, short (SStt) plant to a dented-seeded, tall (ssTT) plant?
- a. All the progeny would be spherical-seeded and tall.
 b. 1/2 would be spherical-seeded and intermediate height; 1/2 would be spherical-seeded and tall.
 c. All the progeny would be spherical-seeded and short.
 d. **All the progeny would be spherical-seeded and intermediate height.**