Modern Biology (BT101) **Quiz 1 Solutions**

1. In pea, tall plant is dominant (T) over dwarf plant (t). A tall plant is crossed with a dwarf plant. In the progeny, about one-half of the plants are tall and the remaining one-half are dwarf. Determine the genotypes of the tall and dwarf plants.

Solution: *Genotypes: Tt (Tall), tt (dwarf)*

2. Give the diagrammatic sketch for double strand DNA having sequence ATGC. Mark the ends and label all components properly. If this sample of double strand DNA is found to contain 32 % adenine; what are the percentage in mole for other nucleotides?

Solution: *T= 32%, G+C=36% (G = C= 18%)*

3. One strand of double strand DNA has the sequence 5' GCGCAATATATTGCGC 3'. Write the base sequence of the complementary strand. What special type of sequence is contained in this DNA segment?

Solution: *3' CGCGTTATATAACGCG 5'*
Palindrome sequence

4. What is difference between conservative and semi-conservative replication?

Solution: *In conservative type of replication of the 2 double helices formed one is made entirely of the old material and the other double helix is entirely new. Hence the old parental double helix remains unchanged. In semi conservative replication both of the double helix will have one old strand and one new strand. It is the most acceptable type of DNA replication.*

5. Calculate weight in grams of a double-helical DNA molecule stretching from the earth to the moon (~ 320,000 km). The DNA double helix weighs about 1 x 10^{-18} g per 1,000 nucleotide pairs; each base pair extends 3.4 A^o. For an interesting comparison, your body contains 0.5 g of DNA!

Solution:

9.4×10^{-4} g

(Weight of DNA per nucleotide pair having a distance of 3.4 A^o

$= 1 \times 10^{-18}$ g / 1000 x 34 x 10^{-14} km *($\rightarrow$ 1 $A^o = 10^{-13}$ Km)*

Weight of double helical DNA stretching from earth to moon

$= 320 \times 10^{3}$ Km x 1 x 10^{-18} g / 1000 x 34 x 10^{-14} km

$= 9.4 \times 10^{-4}$ g

6. A bacterial population starting from a single cell reaches a cell number of 10^7 after 6 h of growth. Assuming all cells continue to divide by geometric progression, how many generations of cell divisions would be required to produce 10^7 cells?

Solution:

The equation for expressing growth is: $\mathbf{b = B \times 2^n}$

Where b = number of cells at the end of division

B = number of cells at the beginning

n = number of generations (number of times the cell population doubles during the time interval)

Thus, $10^7 = 2^n$ *(B = 1 since all cells are derived from a single cell)*

$2 = 10^{log2}$ *and* $2^n = 10^{nlog2}$

Substituting, $10^7 = 10^{nlog2}$

$nlog2 = 7$

$n = 7/log2 = 7/0.301 = 23.2$

7. What is the basis of constructing a phylogenetic tree? What does the length of the branches of such a tree indicate?

Solution:

The ***difference in DNA sequences*** *between organisms form the basis of phylogenetic tree. The length of the branches essentially indicates* **divergence** *i.e. an index of variation.*

8. (a) A microscope with an objective whose numerical aperture is 1.2 is used to look at an opaque disc with regularly spaced holes 0.03 μm in diameter, separated by 20 μm. Light having a wavelength of 540 nm is used to observe the holes with a 10 X eyepiece. Determine the limit of resolution and state whether the number of holes per square millimeter can be distinctly counted?

Solution:

Resolution $= 0.61\lambda/n\sin\theta = 0.61 \times 5.4 \times 10^{-5}/ 1.2 = 0.274\ \mu m$ *approximately*
Since the holes are 20 μm apart, they are visible as separate particles and can be counted

(b) Living cells are by far colorless and translucent and hence their internal features are difficult to study by light microscopy. What are the two principal strategies used to overcome this problem? **(1)**

Solution: *The two principal strategies used are:* ***(A) Phase Contrast Microscopy*** *and* ***(B) Staining*** *cells either with* **colored dyes** *or with* **fluorescent** *dyes or with* **antibodies** *to visualize organelles.*

9. Consider the following two reactions:

(i) Glucose + $6O_2$ $\longrightarrow$ $6CO_2 + 6H_2O$ $\Delta G_i{}' = -686{,}000$ cal/mole
(ii) nADP + nPi $\longrightarrow$ nATP $\Delta G_i{}' = +7700$ cal/mole per n

Given that the efficiency of energy conservation in a cell is 35%. How many moles of ATP per mole of glucose could be obtained? **(2)**

Solution:

The sum of reaction (i) and (ii) gives:

Glucose + $6O_2$ + nADP + nPi $\longrightarrow$ $6CO_2 + 6H_2O$ + nATP

At 35% efficiency the total energy that can be conserved is:

0.35 x 686,000 cal/mole = 240,100 cal/mole

If each mole of ATP requires 7700 cal for its synthesis, then the no. of moles of ATP per mole of glucose obtained is:

240,100/7700 ~ 31 moles of ATP

10. (a) What is the principal source of ATP regeneration during exercise? **(1)**

(b) Consider the following reaction:

Creatine phosphate + ADP + H^+ $\rightleftarrows$ ATP + creatine; $\Delta G°' = -3.0$ kcal/mol

Calculate K'_{eq} for the reaction. **(1)**

Solution:

(a) Creatine phosphate

(b) K'_{eq} = [ATP][creatine]/[ADP][creatine phosphate]

$K'_{eq} = 10^{-\Delta G°'/(2.303RT)} = 10^{3/1.36} \sim 162$

Alternatively

$\Delta G°' = -1364 \log K'_{eq}$

$\log K'_{eq} = \Delta G°'/-1364 = -3000/-1364$

$K'_{eq} \sim 158.3$