單選題 (25題，每題4分)

1) Which of the following statements best distinguishes hypotheses from theories in science?
A) Theories are hypotheses that have been proved.
B) Theories are proved true; hypotheses are often falsified.
C) Hypotheses usually are relatively narrow in scope; theories have broad explanatory power.
D) Hypotheses and theories are essentially the same thing.
E) Hypotheses are guesses; theories are correct answers.

2) What is the maximum number of electrons in a single 2 *p* orbital of an atom?

A) 1 B) 2 C) 3 D) 4 E) 5

3) One of the buffers that contribute to pH stability in human blood is carbonic acid (H_2CO_3). Carbonic acid is a weak acid that dissociates into a bicarbonate ion (HCO_3^-) and a hydrogen ion (H^+). Thus,

$H_2CO_3 \leftrightarrow HCO_3^- + H^+$

If the pH of the blood drops, one would expect
A) a decrease in the concentration of H_2CO_3 and an increase in the concentration of HCO_3^-.
B) the HCO_3^- to act as an acid and remove excess H^+ with the formation of H_2CO_3.
C) the concentration of hydroxide ion (OH^-) to increase.
D) the concentration of bicarbonate ion (HCO_3^-) to increase.
E) the HCO_3^- to act as a base and remove excess H^+ with the formation of H_2CO_3.

4) Amino acids are acids because they always possess which functional group?

A) carboxyl B) hydroxyl C) phosphate D) carbonyl E) amino

5) Upon chemical analysis, a particular polypeptide was found to contain 100 amino acids. How many peptide bonds are present in this protein?
A) 98 B) 100 C) 101 D) 97 E) 99

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6) A mycoplasma is an organism with a diameter between 0.1 and 1.0 μm. What does the organism's size tell you about how it might be classified?
A) It must be a single-celled fungus.
B) It could be a typical virus.
C) It could be almost any typical bacterium.
D) It must be a single-celled protist.
E) It could be a very small bacterium.

7) Celery stalks that are immersed in fresh water for several hours become stiff and hard. Similar stalks left in a 0.15 *M* salt solution become limp and soft. From this we can deduce that the cells of the celery stalks are
A) hypertonic to fresh water but hypotonic to the salt solution.
B) hypotonic to fresh water but hypertonic to the salt solution.
C) hypertonic to both fresh water and the salt solution.
D) isotonic with fresh water but hypotonic to the salt solution.
E) hypotonic to both fresh water and the salt solution.

8) Which of the following statements is representative of the second law of thermodynamics?
A) Cells require a constant input of energy to maintain their high level of organization.
B) Conversion of energy from one form to another is always accompanied by some gain of free energy.
C) Without an input of energy, organisms would tend toward decreasing entropy.
D) Every energy transformation by a cell decreases the entropy of the universe.
E) Heat represents a form of energy that can be used by most organisms to do work.

9) Which metabolic pathway is common to both fermentation and cellular respiration of a glucose molecule?
A) synthesis of acetyl CoA from pyruvate
B) glycolysis
C) the electron transport chain
D) the citric acid cycle
E) reduction of pyruvate to lactate

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10) Which of the following are products of the light reactions of photosynthesis that are utilized in the Calvin cycle?
A) H_2O and O_2
B) ATP and NADPH
C) electrons and H^+
D) CO_2 and glucose
E) ADP, $\textcircled{P}_i$, and $NADP^+$

11) In general, a signal transmitted via phosphorylation of a series of proteins
A) allows target cells to change their shape and therefore their activity.
B) brings a conformational change to each protein.
C) requires binding of a hormone to a cytosol receptor.
D) requires phosphorylase activity.
E) cannot occur in yeasts because they lack protein phosphatases.

Use the following information to answer the question (12), below.
Nucleotides can be radio-labeled before they are incorporated into newly forming DNA and can therefore be assayed to track their incorporation. In a set of experiments, a student-faculty research team used labeled T nucleotides and introduced these into the culture of dividing human cells at specific times.

12) The research team used the setup to study the incorporation of labeled nucleotides into a culture of lymphocytes and found that the lymphocytes incorporated the labeled nucleotide at a significantly higher level after a pathogen was introduced into the culture. They concluded that
A) infection causes cell cultures in general to reproduce more rapidly.
B) their tissue culture methods needed to be relearned.
C) infection causes lymphocyte cultures to skip some parts of the cell cycle.
D) the presence of the pathogen made the experiment too contaminated to trust the results.
E) infection causes lymphocytes to divide more rapidly.

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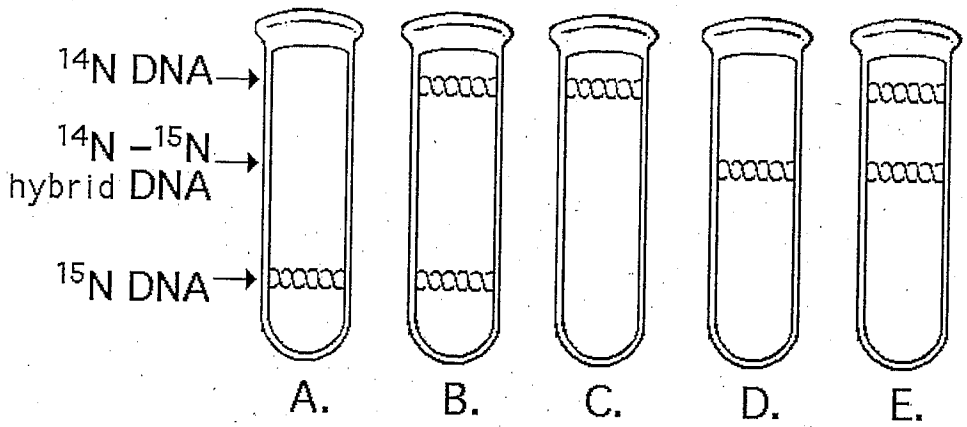
13) Mendel's second law of independent assortment has its basis in which of the following events of meiosis I?
A) crossing over
B) alignment of tetrads at the equator
C) synapsis of homologous chromosomes
D) separation of cells at telophase
E) separation of homologs at anaphase



14) A space probe returns with a culture of a microorganism found on a distant planet. Analysis shows that it is a carbon-based life-form that has DNA. You grow the cells in ^{15}N medium for several generations and then transfer them to ^{14}N medium. Which pattern in the figure above would you expect if the DNA was replicated in a conservative manner?
A) A B) B C) C D) D E) E

15) Which of the following is the best predictor of how much damage a virus causes?
A) how much toxin the virus produces
B) ability of the infected cell to carry on translation
C) ability of the infected cell to undergo normal cell division
D) whether the infected cell produces viral protein
E) whether the viral mRNA can be transcribed

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16) Given a population that contains genetic variation, what is the correct sequence of the following events, under the influence of natural selection?
1. Well-adapted individuals leave more offspring than do poorly adapted individuals.
2. A change occurs in the environment.
3. Genetic frequencies within the population change.
4. Poorly adapted individuals have decreased survivorship.

A) 4 → 1 → 2 → 3
B) 2 → 4 → 1 → 3
C) 2 → 4 → 3 → 1
D) 4 → 2 → 1 → 3
E) 4 → 2 → 3 → 1

17) Living diatoms contain brownish plastids. If global warming causes blooms of diatoms in the surface waters of Earth's oceans, how might this be harmful to the animals that build coral reefs?
A) The coral animals, which capture planktonic organisms, may be outcompeted by the diatoms.
B) The diatoms' photosynthetic output may over-oxygenate the water.
C) The coral animals may die from over-eating the plentiful diatoms, with their cases of silica.
D) The coral animals' endosymbiotic dinoflagellates may get "shaded out" by the diatoms.

18) The members of which clade in the phylum Cnidaria occur only as polyps?
A) Cubozoa B) Scyphozoa C) Anthozoa D) Hydrozoa

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The following question is based on the drawing of root or stem cross sections shown in Figure 19.

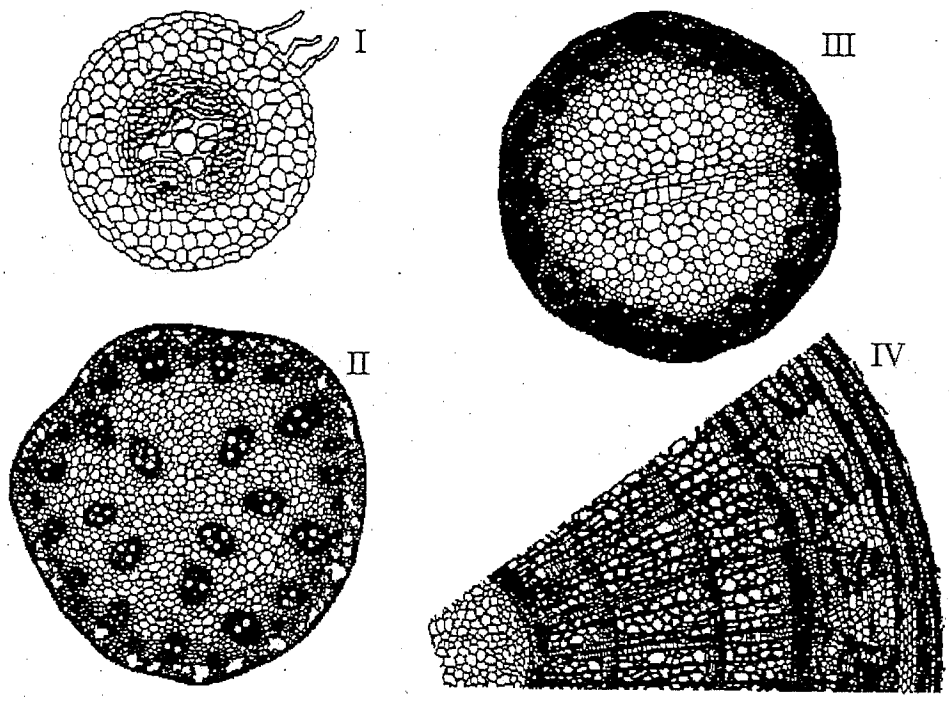

Figure 19

19) A plant that is at least 3 years old is represented by

A) I only.
B) II only.
C) III only.
D) IV only.
E) both I and III.

20) Active transport would be *least* important in the normal functioning of which of the following plant tissue types?
A) stem tracheary elements
B) root endodermal cells
C) leaf mesophyll cells
D) leaf transfer cells
E) root sieve-tube elements

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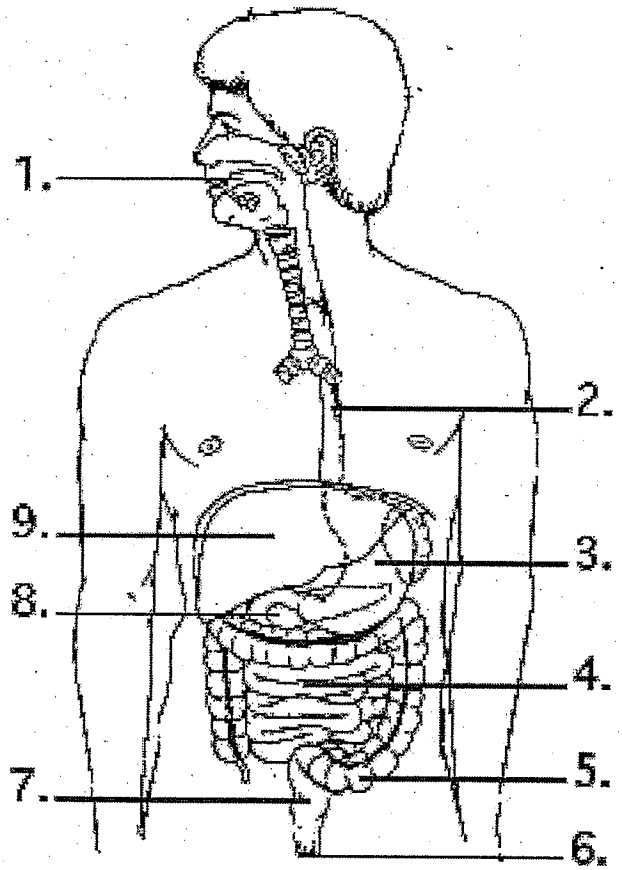

21) Examine the digestive system structures in the figure above. The agents that help emulsify fats are produced in

A) 8 B) 9 C) 2 D) 3 E) 1

22) To become bound to hemoglobin for transport in a mammal, atmospheric molecules of oxygen must cross

A) five membranes—in and out of the cell lining the lung, in and out of the endothelial cell lining the pulmonary capillary, and into the red blood cell—to bind with hemoglobin.

B) one membrane—that of the lining in the lungs—and then bind directly to hemoglobin, a protein dissolved in the plasma of the blood.

C) four membranes—in and out of the cell lining the lung, in and out of the endothelial cell lining the pulmonary capillary–and then bind directly to hemoglobin, a protein dissolved in the plasma of the blood.

D) two membranes—in and out of the cell lining the lung—and then bind directly to hemoglobin, a protein dissolved in the plasma of the blood.

E) zero membranes—oxygen binds directly to hemoglobin, a protein dissolved in the plasma of the blood.

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23) The primary function of humoral immunity is

A) to reject transplanted tissues.
B) to defend against bacteria and viruses that have already infected cells.
C) to defend against fungi and protozoa.
D) to protect the body against extracellular pathogens.
E) to protect the body against cells that become cancerous.

24) Which nitrogenous waste requires hardly any water for its excretion?

A) nitrogen gas
B) amino acids
C) urea
D) uric acid
E) ammonia

25) All hormones

A) are lipid-soluble molecules.
B) are carried to target cells in the blood.
C) are produced by endocrine glands.
D) elicit the same biological response from all of their target cells.
E) are protein molecules.

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(對數計算參考資料：log2 = 0.3010；log3 = 0.4771)

(10%) 1. (a) Write the electron configuration of phosphorus, element 15. (b) How many unpaired electrons does a phosphorus atom possess?

(10%) 2. Arrange these atoms and ions in order of decreasing size: Mg^{2+}, Ca^{2+}, and Ca. Explain your answer.

(10%) 3. What is the bond order of the He_2^+ ion? Would you expect this ion to be stable relative to the separated He atom and He^+ ion?

(10%) 4. Calculate ΔE, and determine whether the process is endothermic or exothermic for the following cases: (a) A system releases 113 kJ of heat to the surroundings and does 39 kJ of work on the surroundings; (b) q = 1.62 kJ and w = −874 J; (c) the system absorbs 77.5 kJ of heat while doing 63.5 kJ of work on the surroundings.

(10%) 5. The safety air bags in automobiles are inflated by nitrogen gas generated by the rapid decomposition of sodium azide, NaN_3:

$$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$$

If an air bag has a volume of 36 L and is to be filled with nitrogen gas at a pressure of 1.15 atm at a temperature of 26.0 °C, how many grams of NaN_3 must be decomposed? (atomic weight: Na = 23, N = 14)

(10%) 6. Calculate the pH of the solution formed when 45.0 mL of 0.100 M NaOH is added to 50.0 mL of 0.100 M CH_3COOH ($K_a = 1.8 \times 10^{-5}$).

(10%) 7. How does the entropy of the system change when the following occur: (a) a solid melts; (b) a liquid vaporizes; (c) a solid dissolves in water; (d) a gas liquefies?

(10%) 8. (a) What is *electrolysis*? (b) Are electrolysis reactions thermodynamically spontaneous? Explain. (c) What process occurs at the anode in the electrolysis of molten NaCl?

(10%) 9. Draw the *cis* and *trans* isomers of the $[Co(en)_2(NH_3)Cl]^{2+}$ ion. Are either or both of these isomers chiral? If so, draw the two enantiomers.

(10%) 10. (a) What is an α-amino acid? (b) How do amino acids react to form proteins?