Student Code: _____

22nd INTERNATIONAL BIOLOGY OLYMPIAD

July 10-17, 2011

Taipei, Taiwan

THEORETICAL TEST: PART B

Duration: 150 minutes

Dear participants,

- Check your **Student Code** on the **Answer Sheet** before starting the test.
- The questions in Part B **may have more than one** correct answer. Fill your answers in the Answer Sheet. The **marks, numbers, or characters** to answer questions in Part B vary depending on questions. Mark the correct answers with "◯" and incorrect answers with "—" on the Answer Sheet clearly, as shown below.

No.	A	B	C	D	E	F
B0.	◯	—	◯	—	—	—

- Write down your results and answers in the **Answer Sheet**. **Answers written in the Question Paper will not be evaluated.**
- Some of the questions may be marked "DELETED". DO NOT answer these questions.
- The maximal points of Part B is 120 (3 points for each question)
- **All answers must be correct** in each question. Then you will get the points.
- Stop answering and put down your pencil IMMEDIATELY after the end bell rings.

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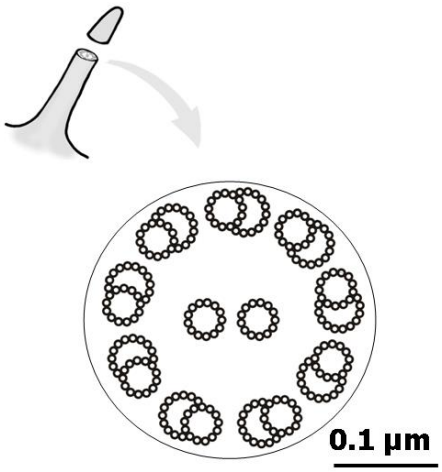
Good Luck!!

I. Cell biology

Problem set: **Figure 1** depicts the cross-section of a certain cell surface structure observed by electron microscope. Answer questions 1 and 2.



B1. Which of the following possess the above structure?

(A) *Paramecium*

(B) *Escherichia coli*

(C) Tracheid of gymnosperm

(D) Sieve tube element of angiosperm

(E) Human tracheal cell

(F) Human intestinal epithelial cell

B2. What is/are the functions and what is the major chemical composition of the structure?

Function options:

(A) Attachment

(B) Locomotion

(C) Transportation

(D) Secretion

(E) Absorption

Composition options:

(P) Cellulose

(Q) Protein

(R) Mucin

(S) Lipid

(T) Nucleic acid

B3. Some pathogens produce exotoxins that can cause human diseases. One type of exotoxins consists of two polypeptides, subunits A and B. Subunit B can bind to surface receptors on the target cells and cause the transport of the subunit A or associated molecules across the plasma membrane into the cell. Once the subunit A enters the cell, it inhibits protein synthesis and destroys the cells. Which of the following statements regarding exotoxins is/are correct?

(A) Subunit A alone can cause disease.

(B) Subunit B alone can bind to target cells.

(C) Subunit A may carry other molecules to kill target cells.

(D) Subunit B may carry other molecules and assist these molecules to enter target cells.

(E) When conjugated with an antibody against breast cancer cells, subunit A can kill breast cancer cells.

Problem set: Some leucocytes can ingest invaded pathogens by phagocytosis. Digestive enzymes that kill pathogens only function in acidic conditions. Please answer questions 4 and 5.

B4. Based on the information provided in the following table, complete the synthesis process of digestive enzymes during phagocytosis:

① Replication	⑤ Endoplasmic reticulum
② Translation	⑥ Vesicle
③ Transcription	⑦ Lysosome
④ Mitochondrion	⑧ Golgi apparatus

(1) mRNA-ribosome complex is transferred to ___a___ to continue ___b___.

(2) Synthesized enzymes enter ___c___ and ___d___ for modification.

(3) The modified enzymes are stored in ___e___.

(A) a: ④ b: ① c: ⑥ d: ⑦ e: ④

(B) a: ⑦ b: ② c: ⑦ d: ⑧ e: ⑤

(C) a: ⑧ b: ③ c: ⑥ d: ⑧ e: ⑥

(D) a: ⑤ b: ② c: ⑤ d: ⑧ e: ⑦

(E) a: ⑥ b: ① c: ⑤ d: ⑦ e: ⑧

B5. Tom isolated phagocytes from a blood sample. He cultured these phagocytes in a test tube for a period of time. To observe phagocytosis, *E. coli* was co-cultured with phagocytes. What will be the consequence if an antacid is added to the culture?

(A) Phagocytes can ingest and kill *E. coli*.

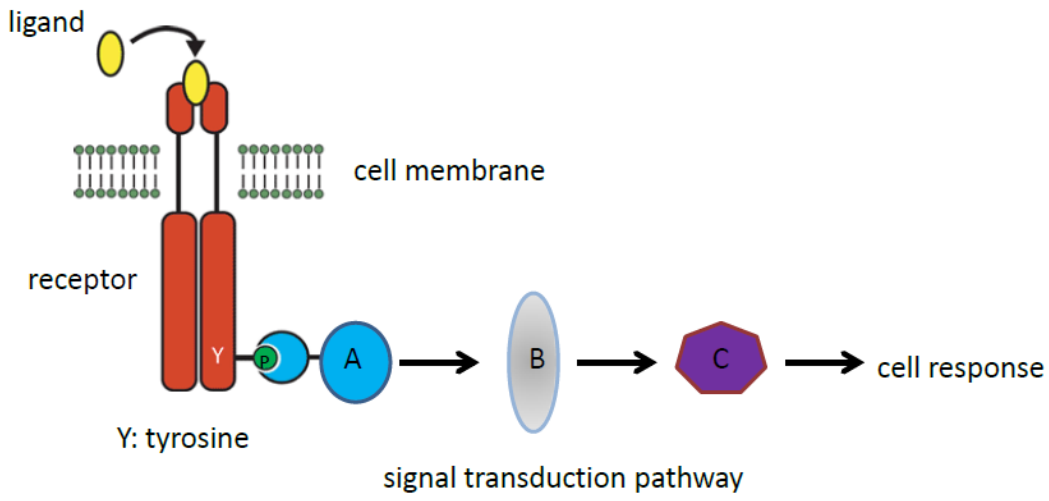
(B) Ingestion of *E. coli* by phagocytes is inhibited.

(C) *E. coli* is viable in phagolysosome.

(D) If phagolysosomes are formed, the digestive enzymes in them are inactive.

(E) Phagocytes can secrete ingested debris out of the cells.

Problem set: Jessica is dissecting a signal transduction pathway (depicted in the following figure) that leads to oncogenesis in cancer cells, in the hope that she can find inhibitors to block the signaling pathway and use them as chemotherapy drugs for cancer treatment. Please answer questions B6-B8.



B6. Components of signal transduction, including A, B and C, usually are activated through phosphorylation or dephosphorylation reactions. What are the mechanisms by which proteins A , B and C are phosphorylated or dephosphorylated?

(A) Receptors may contain enzyme domains which can catalyse phosphorylation/dephosphorylation reactions.

(B) Enzymes that participate in phosphorylation/dephosphorylation reactions may exist in the cytoplasm.

(C) Proteins A, B and C may contain enzyme domains which can catalyse phosphorylation/dephosphorylation reactions.

(D) Phosphorylation or dephosphorylation may not be mediated through enzymatic reactions.

(E) A phosphate group is transferred from the receptor to protein A.

(F) The phosphate group can only be provided by H_3PO_4.

B7. Which of the following experiment can prove that the signal transduction pathway is B→C, but not C→B?

(A) Adding an A antagonist will activate B.

(B) Adding an A agonist will activate C.

(C) Adding a B agonist will activate C.

(D) Adding a B antagonist will activate C.

(E) Increasing the expression level of B will generate more active C molecules.

(F) Cell response can be observed when B antagonist and active C molecules are added to the cell.

B8. If this is a highly activated signal transduction pathway in cancer cells, which of the following processes does the signaling pathway involve?

(A) Inhibiting cell division

(B) Inhibiting cell differentiation

(C) Hypomethylation of some tumor suppressor genes

(D) Activating the transcription of an oncogene

(E) Arresting the cell cycle at S phase

(F) Inhibiting the expression of some DNA repair genes

B9. In protein synthesis, there are 64 codons, 61 codons specify the 20 amino acids and the other 3 for termination "STOP" (**Table**). The following sequence of amino acids occurred in the structure of a polypeptide found in a wild-type organism:

Ser-Arg-Ile-Leu-Ala-Ala-Lys-Tyr. Which of the following may generate the mutant amino acid sequence Ser-Arg-Ile-Trp-Arg-Gln-Lys-Tyr?

Second letter of codon

First letter of codon (5′ end)	U		C		A		G	
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
	UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys
	UUA	Leu	UCA	Ser	UAA	Stop	UGA	Stop
	UUG	Leu	UCG	Ser	UAG	Stop	UGG	Trp
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg
	CUC	Leu	CCC	Pro	CAC	His	CGC	Arg
	CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg
	CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
	AUC	Ile	ACC	Thr	AAC	Asn	AGC	Ser
	AUA	Ile	ACA	Thr	AAA	Lys	AGA	Arg
	AUG	Met	ACG	Thr	AAG	Lys	AGG	Arg
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
	GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly
	GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly
	GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly

(A) 1 nucleotide mutation

(B) 1 nucleotide insertion

(C) 1 nucleotide deletion

(D) 2 nucleotide mutation

(E) 2 nucleotide insertion

(F) 3 nucleotide mutation

II. Plant anatomy and physiology

B10. At the time of pollination, the living pollen grain typically consists of only the tube cell and the generative cell. During the germination of pollen grain, a pollen tube is produced and the nucleus of generative cell divides and forms two sperms. Directed by a chemical attractant (such as GABA) produced by the synergids, the tip of pollen tube enter the ovule through the micropyle. Then in the embryo sac, double fertilization occurs by the two sperms. Which of the followings are correct as concerning the pollination and double fertilization?

(A) Tube cell, sperm, and synergid are haploid, while generative cell and zygote are diploid.

(B) During the pollination, a gradient in GABA content is formed from the stigma (low) to the ovary (high).

(C) The two sperms fertilize two eggs, but only one forming zygote.

(D) After fertilization, one zygote and one endosperm initial are formed.

(E) Germinated pollen grain is male gametophyte, while embryo sac is female gametophyte.

B11. Mary divided 30 pots of plant X of similar condition into 10 plants per group, with each group being treated with different types of light regime. After a month, the flowering phenotypes of each group are shown in the table below:

Treatment	Light regime	Flowering result
(I)	12 hr Light / 12 hr Darkness	All 10 pots flowered
(II)	14 hr Light / 10 hr Darkness	9 pots flowered, and 1 pot failed to flower
(III)	16 hr Light / 8 hr Darkness	All 10 pots fail to flower

According to the information above, which of the following descriptions of plant X are correct?

(A) Plant X is a short day plant

(B) The critical dark-length required by plant X for flowering is less than 10 hours

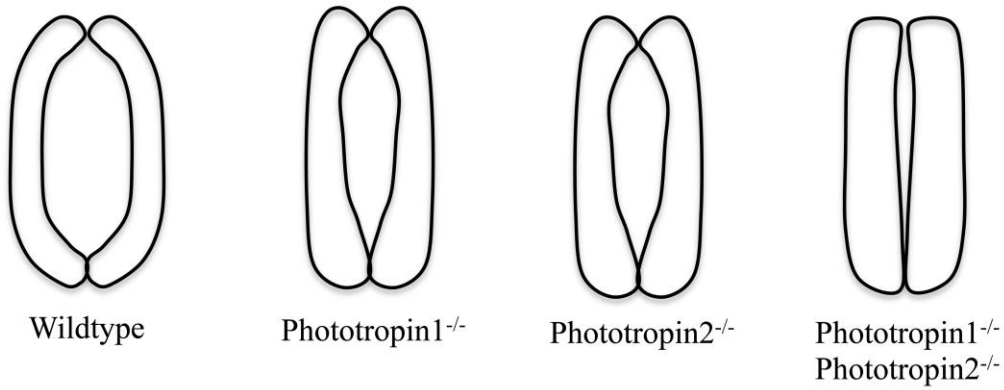
(C) If group III is given an "one-minute dark treatment" in the middle of the light period, after one month, most plants in this group will flower

(D) If group II is given an "one-minute red light treatment" in the middle of the dark period, most plants in this group will not flower right after one month

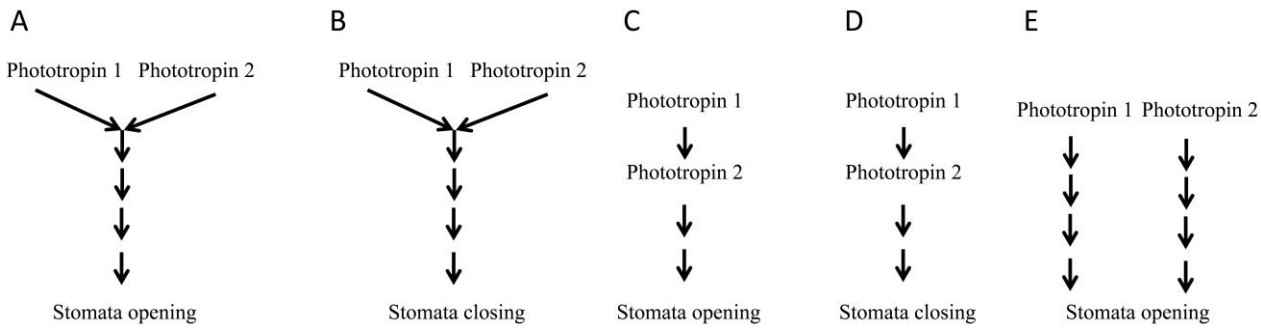
(E) If the apical buds of group I plants are removed before giving the light regime treatment, then most plants will not produce florigen required for flowering after giving light regime treatment.

B12 and B13 are a problem set

Dr. Wang carried out experiments with the model organism *Arabidopsis thatliana*, and identified the two proteins Phototropin 1 and Phototropin 2 as regulators of stomata opening. His experimental results are depicted in the following figure, illustrating the stomata of plants during the day.



B12. Which of the following pathways potentially depicts the relationship of Phototropin 1 and Phototropin 2 on a molecular level?



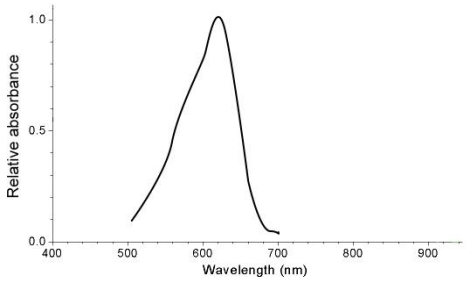
B13. Which of the following processes could be regulated and/or mediated by Phototropin 1 and 2?

(A). K^+ ion efflux (B). K^+ ion influx (C). Na^+ ion influx

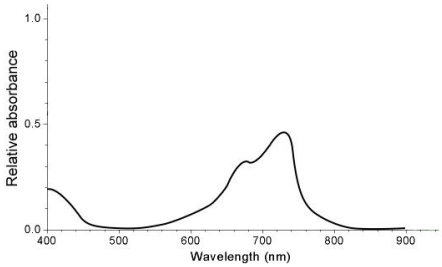
(D). H_2O efflux (E). H^+-ATPase activity (F). Blue light sensing

B14. Phytochromes exist in two isoforms, Pr and Pfr. In darkness, they are synthesized as Pr form, then turned into Pfr form after absorbing red light (most effective at 666 nm). When irradiated with far red light, Pfr transforms back to Pr. According to the description above, which of the following are likely to be the absorption spectra of phytochrome?

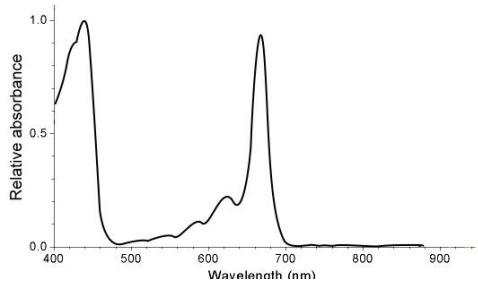
(A)



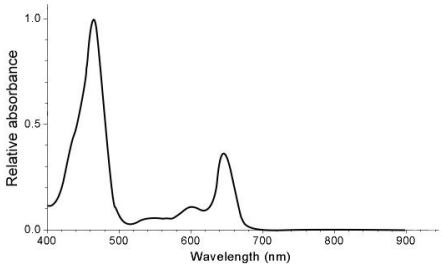
(B)



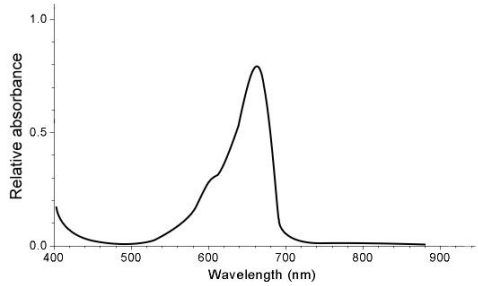
(C)



(D)



(E)



B15. The *AGAMOUS* (*AG*) gene is involved in flower development. Plant mutants without a functional *AG* would produce flowers with only sepals and petals. A scientist generated a transgenic plant harboring a green fluorescence protein (GFP) gene driven by the *AG* promoter in a wild type background that produces normal flowers. In which of the following flower parts, you are likely to observe strong GFP fluorescent signals?

(A) Receptacle

(B) Sepal

(C) Petal

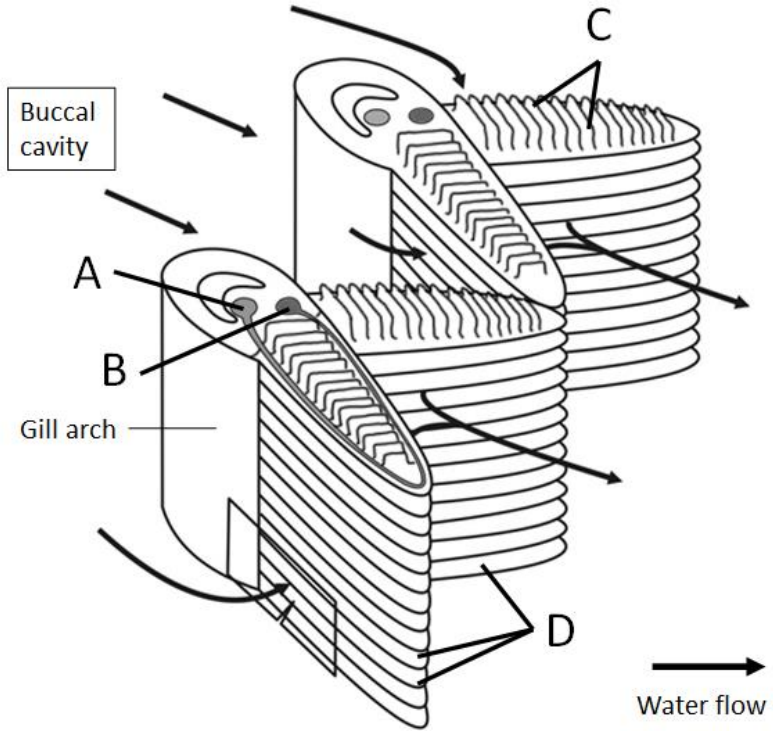
(D) Stamen

(E) Carpel

III. Animal anatomy and physiology

B16 to B18 are a problem set

B16. In the following figure, the structure of fish gills and the direction of water flow in the ventilation are illustrated. Answer the questions.



Which of the following statements are correct?

(A) Vessel A carries oxygenated blood

(B) Vessel B carries deoxygenated blood

(C) Vessel A is an arteriole

(D) Vessel B is a venule

(E) Vessel A and B are portal vessels

B17. During evolution, the gas exchange in gills has become more effective by

(A) A decrease in the thickness of the structure C

(B) A decrease in the number of cell layers in structure C

(C) An increase in the metabolic rate of the structure C

(D) An increase in the cell volume of the structure C

(E) An increase in the surface area of the structure C

B18. Scientists found a kind of epithelial cell (X cell) in the structure of D with which fish can maintain body fluid osmolarity. Consequently, X cells are supposed to

(A) Absorb salt actively in freshwater fish

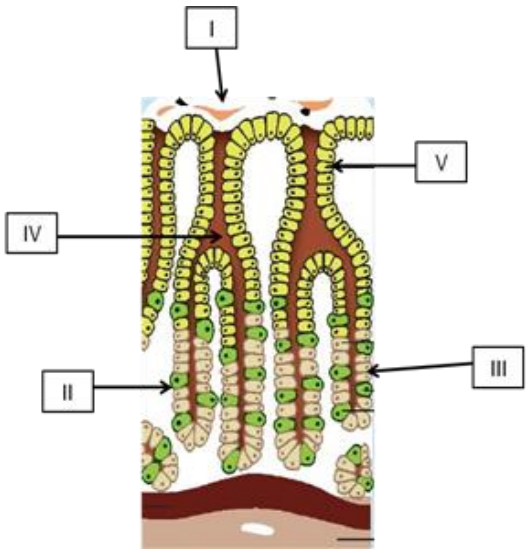
(B) Excrete salt actively in seawater fish

(C) Excrete water actively in freshwater fish

(D) Absorb water actively in seawater fish

(E) be rich in mitochondria

B19. The following image represents a gastric fold from the interior surface of the stomach. The different structures are indicated by roman numerals:



The list below describes the function for each structure.

a. Secretes hydrochloric acid

b. Secretes mucus which lubricates and protects the cells that cover the stomach.

c. Contains a series of ridges or deep pits which lead to the glands

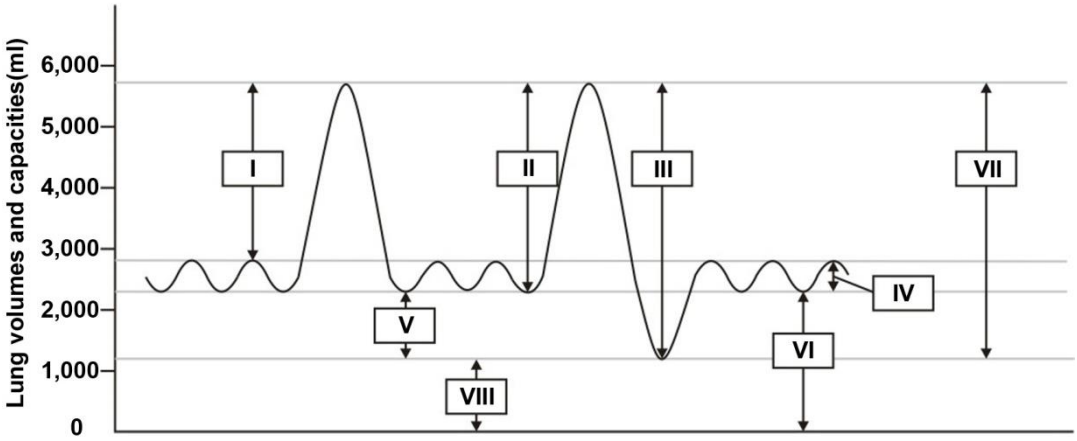
d. Secretes pepsinogen

e. Contains three different types of cells that secrete the components of gastric acid.

Please indicate the correct set of answers relating structure with corresponding function.

Function code	Structure code (I ~ V)
a.	
b.	
c.	
d.	
e.	

B20. The graph below depicts the different pulmonary volumes and capacities:



Below, you will find two charts, please correlate with each other and with the graph above:

1. Tidal volume (TV)	**a. The maximum volume of air inhaled in a normal inspiration. It comprises tidal volume and inspiratory reserve.**
2. Residual volume (RV)	**b. The maximum amount of air inhaled over de resting level of spontaneous inspiration.**
3. Vital capacity (VC)	**c. The volume of air remaining in lung after a strong forced expiration.**
4. Inspiratory capacity (IC)	**d. The volume of air present in lung alter a maximum inspiration.**
5. Expiratory Reserve volume (ERV)	**e. Total amount of air flowing between inspiration and expiration at maximal rate. It includes tidal volume, inspiratory reserve volume and spontaneous expiration rate.**
6. Total lung capacity (TLC)	**f. Amount of air in excess of tidal expiration that can be exhaled with maximum effort.**
7. Inspiratory reserve volume (IRV)	**g. The volume of air present in the lungs, at the end of passive expiration. It is the sum of residual volume and expiratory reserve volume**
8. Functional residual capacity (FRC)	**h. The lung volume representing the normal volume of air displaced between normal inspiration and expiration with or without extra effort applied.**

	I	II	III	IV	V	VI	VII	VIII
Letter								
Number								

B21. Which of the following statements about thermo-adaption in animals are correct?

(A) Blue-fin tuna is able to raise their core temperature. Therefore, it is an endothermic animal.

(B) Some icefish are able to survive in the freezing ice-laden water and maintain a very stable body temperature. Therefore, icefish are homeothermic animals.

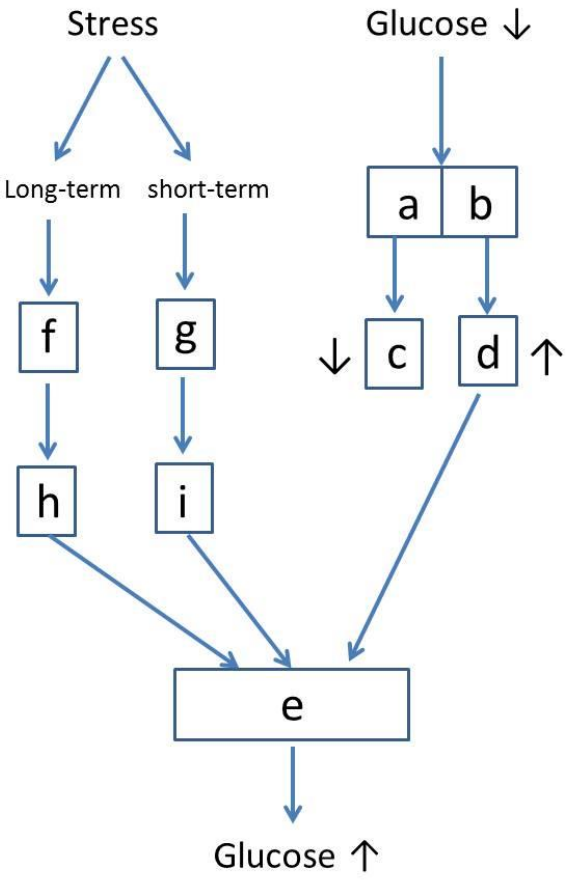
(C) Shivering can help mammals to generate heat, and it is regulated by hypothalamus in mammals.

(D) Brown adipose tissues help mammals to generate heat by supplying energy to skeletal muscles.

(E) Brown adipose cells are rich in mitochondria for heat generation.

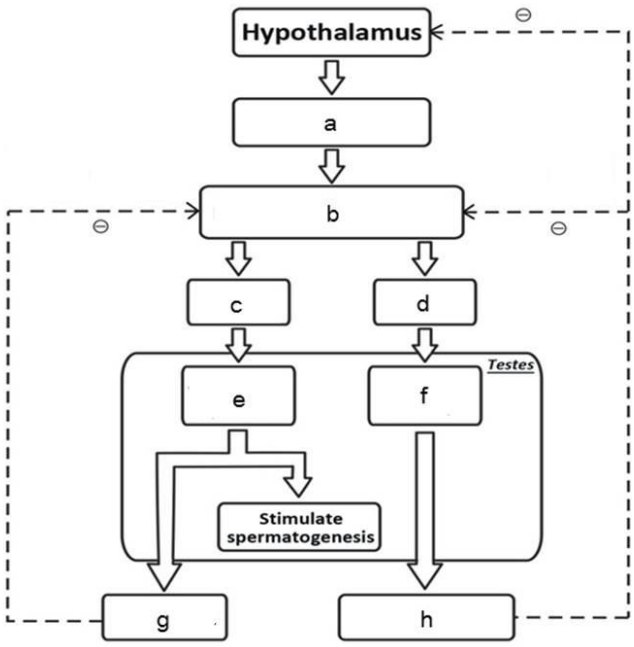
B22. Maintenance of the blood glucose level is important for normal physiological function. It is modulated by both neural and endocrine systems. The diagram below shows two different situations resulting from physiological stress or low blood glucose level. Complete the table in the answer sheet by using appropriate letters shown below.

Structure/hormone	Answer
α cells of the pancreatic islets	
Insulin	
Liver	
Adrenal medulla	
Cortisol	



B23 and B24 are a problem set

B23. Normal spermatognesis and androgen secretion are delicately regulated by hormones in males. The occurrence of infertility in the male could be resulted from the disturbance of hormonal regulation. The following figure partly illustrates the cross interactions among hypothalamus, pituitary gland, and male gonads. The symbols "(-)" indicate negative feedback inhibitions. As shown in the table below, some hormones, cells, or tissues are tried to match to the terms in this figure (a to h).



Structure/hormone	Answer
Sertoli cells	
Anterior pituitary	
Gonadotropin releasing hormone	
FSH	
Inhibin	

B24. The application of available and suitable hormonal therapy to the male patients with gonad failure is very important. Consider how the following case may be improved by a hormonal treatment.

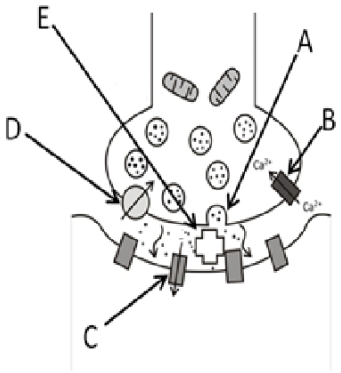
Patient A suffered from testicular cancer and had both testis removed.

According to the figure of Q22, select the most appropriate letter to patient A.

Patient	Answer
A	

B25 and B26 are a problem set

B25. A to E in the diagram below represents the five major steps of synaptic transmission.



A. Release of neurotransmitter.

B. Activation of presynaptic calcium channel.

C. Activation of postsynaptic sodium channel.

D. Re-uptake of neurotransmitter.

Scientists study drug effects on synaptic transmission by using electrophysiological recording. Briefly the postsynaptic current will be recorded and used to determine the possible mechanism which may account for the drug effects. Figure 1 is the typical tract of postsynaptic current before drug administration. Match the figure number with the correct drug effects below

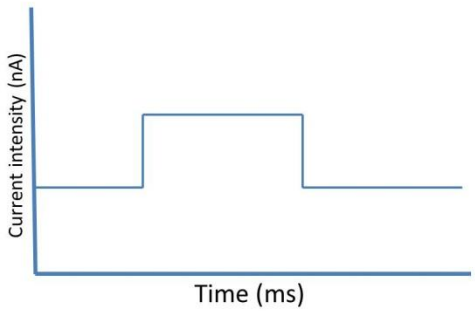
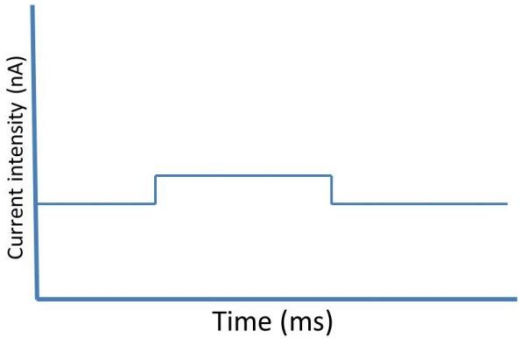
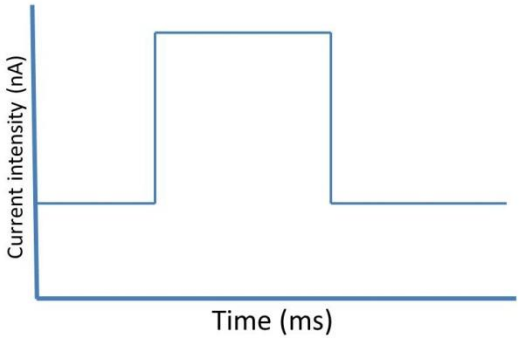


Figure-1

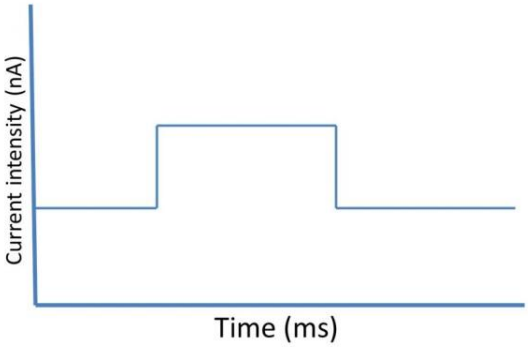
Mechanism	Figure number
Blocking of step A	
Facilitation of step B	
Blocking of step C	
Facilitation of step D	
Blocking of step E	

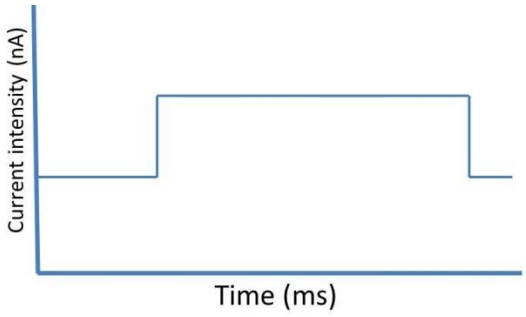
(I) (IV)



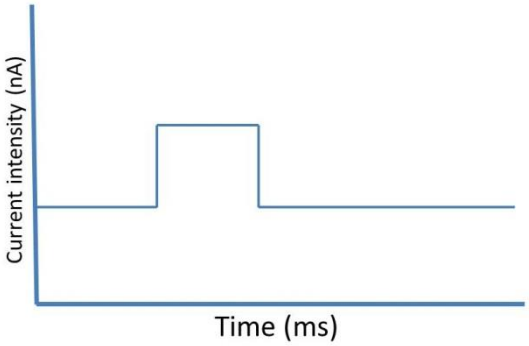


(II)





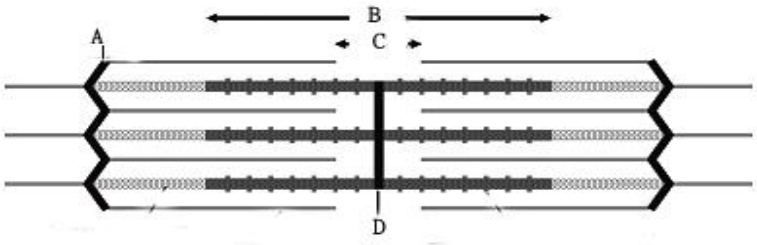
(V)



B26. Epilepsy is a common neurological condition. Patients suffer convulsions which result from hyperactivity of certain cerebral areas. Symptoms can be reduced by using antiepileptic drugs. If the receptor activated in the above figure was a chloride channel instead of a sodium channel, which of the following mechanism(s) may form the basis for an antiepileptic drug?

Mechanism	Answer
Blocking of step A	
Facilitation of step B	
Blocking of step C	
Facilitation of step D	
Blocking of step E	

B27. The following diagram indicates the basic structure of a sarcomere.



Choose and fill in the appropriate answering code shown below to each statement in the following table. The statements are about a muscle fiber undergoing an isotonic contraction.

Statement	Answer
a. D remain the same distance apart	
b. A move closer to the ends of the B	
c. C become shorter	
d. B become wider	
e. D lines move closer to the end of the B	

IV. Ethology

B28. There are two types of bird hatchlings: precocial and altricial. In general, precocial birds are covered with feathers when they hatch, and can find their own food with help and instructions from their mothers. In contrast, altricial hatchlings require feeding and caring for from the parents. Based on this, which of the following statements are correct?

(A) Precocial hatchlings usually take longer to hatch than altricial hatchlings.

(B) Altricial hatchlings usually develop imprinting earlier than precocial hatchlings.

(C) Parents invest more in precocial hatchlings than in altricial hatchlings during nestling period.

(D) For a group of young birds that hatch at the same time, altricial hatchlings tend to develop the ability to fly earlier than precocial hatchlings.

(E) Parents of precocial and altricial hatchlings have the same level of investment in reproduction during the breeding season.

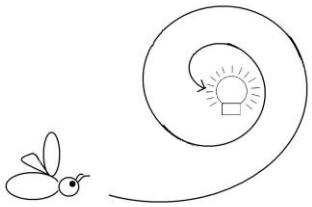
B29. An entomologist found that a species of cockroach use the dramatic change of light intensity at dusk (given as 6:00 pm) to reset its biological clock. He also found out that the circadian (daily) rhythm is 25 hrs. If a student cages a cockroach of this species into a dark box at 6:00 pm, at what time the cockroach will be active after 12 days? Fill in the time in the given space, then circle "am" or "pm" in the Answer Sheet.

B30. A biologist discovered that a species of moth is capable of flying in a straight line at night because it keeps a constant angle (80°) between its body axis and the direction of moon light

using photoreceptors as a tool. If the moth encounters a bright light in a dark night, what kind of flight path of the moth one will expect to see in relation with the light source?

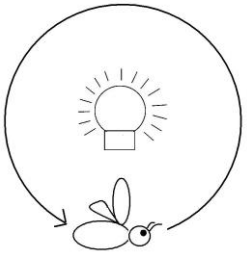
(A)

(D)



(B)

(E)



(C)

B31. A researcher monitored 10 pairs of adult birds during the breeding season. For each of the pairs, he recorded body lengths of the male and female, and their nesting date (Table 1).

Table 1. The body lengths of the males and females, and the nesting dates for the 10 pairs of birds (A to J)

	A	B	C	D	E	F	G	H	I	J
Female body length (cm)	26.4	27.8	25.1	25.0	27.0	28.1	25.5	25.9	28.3	27.4
Male body length (cm)	28.3	28.4	28.9	29.0	27.9	30.2	29.6	27.4	29.7	30.5
Nesting date	5/6	5/3	5/4	4/28	5/1	4/27	4/29	5/2	5/1	4/26

Based on the data in Table 1, the mean body length is 26.65 cm for the females, and 28.99 cm for the males. In comparison with the mean body length of 26.10 cm in females and 27.60 cm in males in the total adult (breeders + non-breeders) population (N=30) of the study area, which of the following statements are correct?

(A) All males in this species are larger than females.

(B) Females tend to pair with males that are larger than themselves.

(C) Male body lengths do not affect female mate choices.

(D) Nesting dates are linked to male body lengths.

(E) The chance of breeding of this species is most likely affected by the body size.

V. Genetics and Evolution

B32. The black, brown and white coat colors of mice are determined by the interaction of B/b and C alleles. B and b alleles control the synthesis of black and brown pigments, respectively. In the presence of the C allele, black and brown pigments are deposited in the fur. In a crossing between BbCc and bbCc, which of the following statements are correct?

(A) The coat colors of parental mice are black and brown respectively.

(B) The ratio of black and brown offspring is 1:1.

(C) 3/4 of the offspring are black.

(D)1/4 of the offspring are brown.

(E) 1/4 of the offspring are white.

(F) Alleles C and B/b are co-dominant.

B33. Fur of Guinea pigs can have different colors (black and white). Hairs can be rough and smooth. Alleles Q and q are coding for color, alleles R and r for type of hair. A number of cavias with exactly the same genotype (parents group) are allowed to mate and the result is a big F1 offspring. Most of these have a black rough fur. A small number has white smooth fur. Besides about the same number of offspring is white and rough, or black and smooth.

B33.1. Using the given letters, indicate the genotype of the guinea pigs in the parents group: _____.

B33.2. If 1024 F1 offspring were born, how many of them are black and smooth? _____.

B33.3. Guinea pigs often have a fur spot pattern. According to a simplified model spot pattern is determined by one gene with two alleles: G and g. If G is present the guinea pig is spotted. Students investigate the population Guinea pigs in a territory and find out that 84 % was spotted. Presuming this population is in (Hardy Weinberg) equilibrium. Calculate the frequency of G. Give your answer in one decimal. _____.

B33.4. At one day all unspotted guinea pigs are caught and transported to another territory. What will be the number of unspotted guinea pigs in the next generation? Give your answer as a percentage without decimals. _____.

B34. It is believed that "land plants" are evolved from charophytes. Which of the following statements support this hypothesis?

(A) Both have alternation of generation in life cycles

(B) Both contain chlorophyll a and chlorophyll b

(C) Both have peroxisomes that contain photorespiration related enzymes

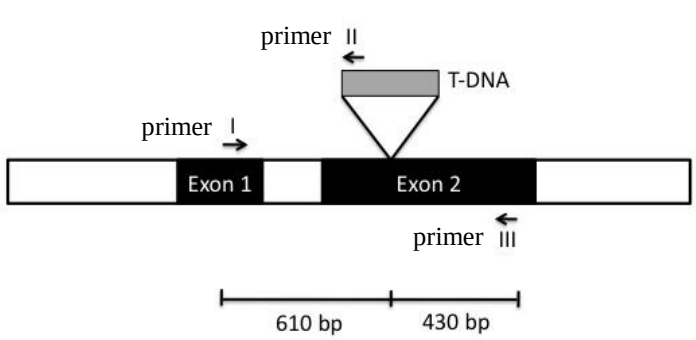
(D) Both can form phragmoplasts during cytokinesis

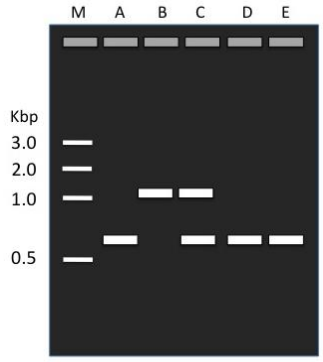
(E) Both contain cellulosic cell walls

(F) Both have the cellulose synthase arranged on the plasma membrane in a rosette pattern

Questions B35a-B35c are a <u>problem set</u>

Dr. Chen was investigating the function of gene *X* in rice by using a mutant with a T-DNA inserted in the exon 2 as diagrammed below. The size of the T-DNA is approximately 5 kilo base pairs (Kbp). She used PCR analysis for genotyping of five individual plants (A, B, C, D, E) with primers I, II, and III as indicated in the diagram. The gel on the right shows the PCR result. The DNA molecular size markers are shown in lane M. Lane A-E are the PCR products from leaf samples of the plant A-E, respectively. It is known that the polymerase being used is unable to effectively amplify DNA fragments above 5 Kbp.





Based on the above information, answer questions B34a-B34b :

B35a. Which pair of primers (I+II, I+III, or II+III) amplified the DNA band in lane B?

B35b. Which plant(s) (A, B, C, D, or E) is/are homozygous mutant(s)?

B35c. Which plant(s) (A, B, C, D, or E) is/are the F1 offspring of homozygous mutant crossed to the wild type?

B36. Doctor Lin isolated a rice mutant with a late flowering time phenotype. The mutant allele responsible for this phenotype was identified by map-based cloning technique and named LFT^m. When Doctor Lin sequenced the whole LFT^m gene, including the promoter region, she could not find any difference in the nucleotide sequence as compared to the wild-type allele. Which of the following phenomena are likely to be responsible for this observation?

(A) The mRNA level of *LFT* in the mutant is the same as that in the wild-type at the same developmental stage

(B) The LFT protein found in the wild type plants cannot be detected or is lower in the mutant

(C) The DNA methylation patterns on *LFT* are altered in the mutant

(D) The levels of histone proteins are dramatically altered in the mutant

(E) Introducing the cloned LFT^m into the wild-type plant generates a transgenic plant with late flowering phenotype

VI. Ecology

B37. The population size of a dragonfly in a pond was estimated to be 50,000 during a survey. Their sex ratio is 1:1. Each female lays approximately 400 eggs. A second survey of the next generation revealed that the population size is still 50,000 and the sex ratio is still 1:1. What is the average survival rate (surviving to adult stage) of the eggs?

(A) 0.2%

(B) 0.25%

(C) 0.5%

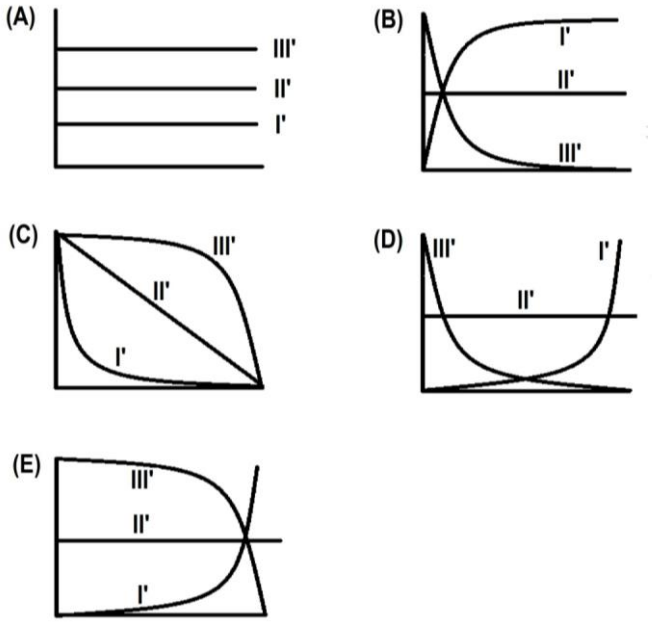
(D) 1%

(E) 5%

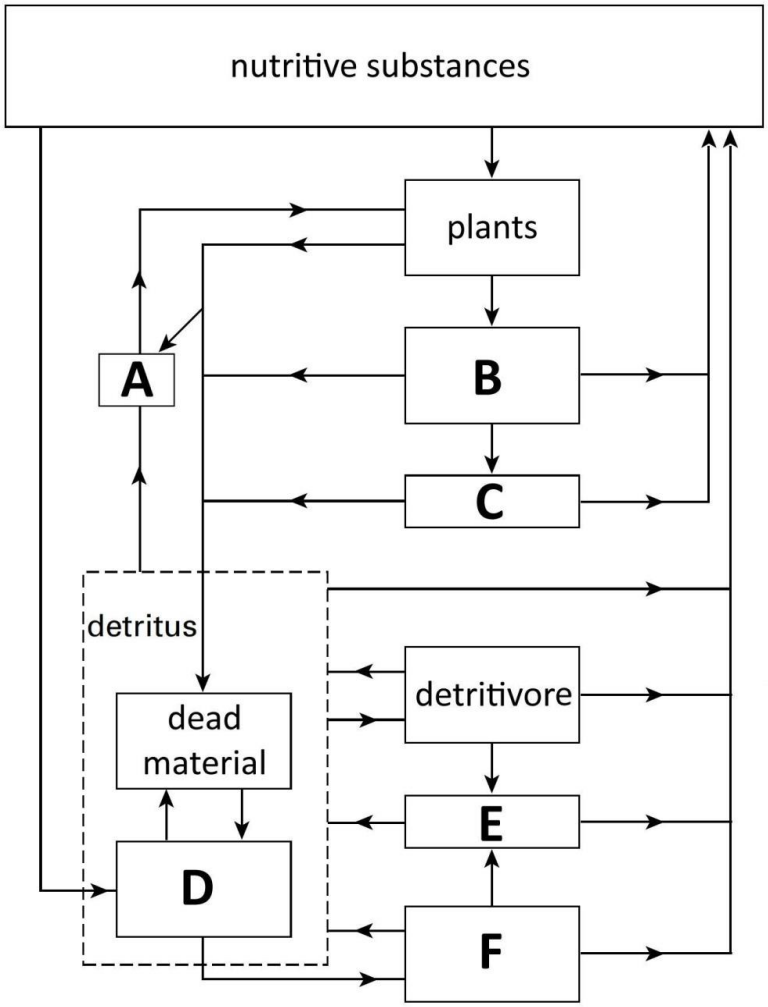
B38. Biologists found that the threshold temperature for development of a mosquito species is 15℃. They also found that the product of (1) the number of days it takes to complete development, and (2) the difference between the temperature during development and threshold temperature, is a constant. That is, the result of multiplying (1) and (2) is a constant. It is known that this mosquito requires 15 days to complete development at 30℃, and given that there was an unusually warm May in India this year with an average temperature of 40℃, how many days it should take this mosquito to complete development this May in India?

B39. Assuming human, birds, and fish respectively have Type I, II, and III survival curves (the

vertical axis is survival rate, and horizontal axis is time), which of the following figures most accurately describes mortality curves (obtained by replacing survival rate with mortality rate) for these three groups of organisms (Type I', II' and III')?



B40. The figure below shows a nutrient cycle, and the six groups of organisms (A to F) involved in this cycle.



Which of the following descriptions are correct?

(A) C and F are carnivores.

(B) C and E are carnivores.

(C) A and B are herbivores.

(D) D includes bacteria and fungi.

(E) F includes bacterivores and fungivores.

B41. When comparing closely-related bird species, mortality of breeding individuals appears to be higher for species in temperate regions than in tropical regions. Therefore, predation risks to parents themselves, their young and eggs are given different priorities for species in different regions. In an experiment where specimen of three different predators (crows, owls, and hawks) were placed at close distances to the nests during the day in the breeding period, which of the following responses from the parents can be expected? Note that crows are predators of the young and eggs, owls are nocturnal predators, and hawks are diurnal predators of adult birds.

(A) The owl specimen is more strongly avoided by the parents than the hawk specimen.

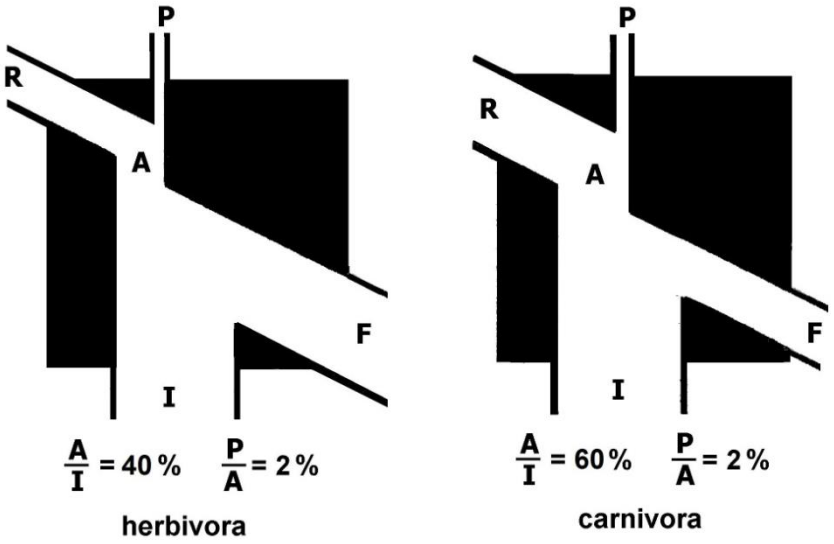
(B) With the crow specimen, the parents of tropical species reduce the frequency of returning to the nests and feeding the young to a lesser degree than parents of temperate species.

(C) With the hawk specimen, the parents of tropical species reduce the frequency of returning to the nests and feeding the young to a lesser degree than parents of temperature species.

(D) With the hawk specimen, the parents of tropical species reduce the frequency of returning to the nests and feeding the young to a greater degree than parents of temperature species.

(E) The degree to which the parents reduce their frequency of returning to the nests and feeding the young when predator specimen is present is not affected by the type of predators or the latitudes in which the species is distributed.

B42. The figure below shows a scheme of the assimilation efficiency (A/I) and production efficiency (P/A) of two groups of mammals in a meadow ecosystem.



A = energy intake in blood after digestion
F = loss of energy through excretion
I = take in of energy present in eaten organic compounds
P = production
R = loss of energy by dissimilation

Suppose I = 100 J

Which of the following descriptions are correct?

(A) Digestion of plant materials costs relatively less energy than digestion of animal materials.

(B) Plant materials that are reabsorbed have less organic contents than animal materials that are reabsorbed.

(C) R ranges between 40 and 60 J in carnivores.

(D) R ranges between 40 and 60 J in herbivores.

(E) R is lower in Bull frogs than in mammals.

B43. Some fungi form symbiotic associations with the roots of vascular plants, which are called mycorrhizae. In such associations, mycorrhizae help plants to absorb water, phosphate salt and other mineral nutrients. Depending on whether the fungus colonizes the roots extracellularly or intracellularly, mycorrhizae can be grouped into ectomycorrhizae or arbuscular mycorrhizae. Which of the following descriptions of mycorrhizae are correct?

(A) Seedlings with mycorrhizae grow more rapidly than seedlings without mycorrhizae in low-phosphorus soils.

(B) Hyphae of arbuscular mycorrhizae can penetrate the cortical cells of the roots and cell membranes to form symbiotic associations intracellularly.

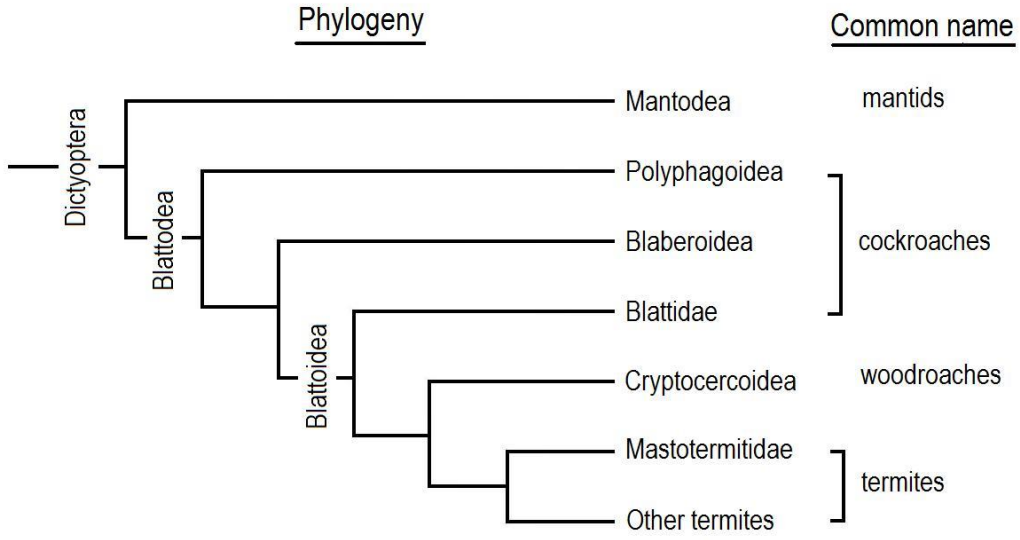
(C) Hyphae of ectomycorrhizae can penetrate the cortical cells of the roots, and form hyphal sheaths around the roots.

(D) Mycorrhizae have similar functions as root hairs of plants, and therefore, plants with mycorrhizae have less-developed root hairs.

(E) Each mycorrhiza forms symbiotic associations with the roots of specific plants.

VII. Biosystematics

B44. Eggleton et al (2007) studied the phylogeny of Dictyoptera, as shown below. According to the proposed phylogeny, determine whether the following statements are true (T) or false (F).



(A) Mantids' sister group is cockroaches.

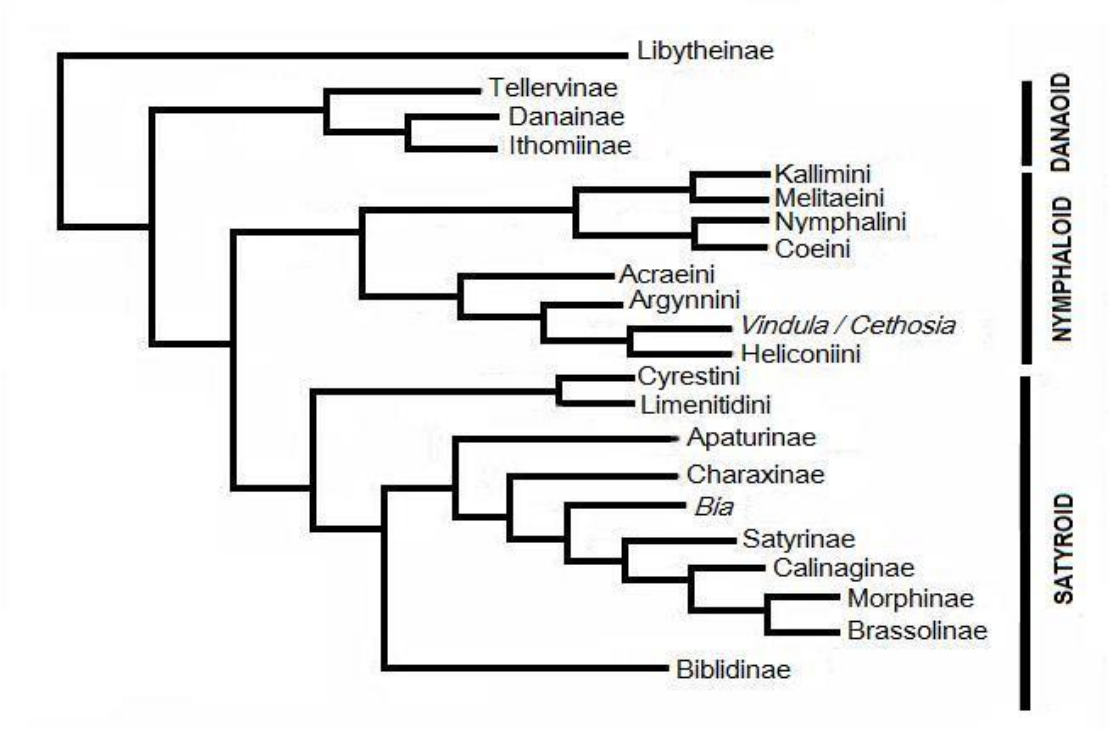
(B) Cockroaches form a paraphyletic group.

(C) Termites should be viewed as highly modified cockroaches.

(D) Mantids should be viewed as highly modified cockroaches.

(E) Termites evolved from mantids.

B45a. Systematic positions of some butterflies such as satyrids (ringlets, etc.), nymphalids (frush foots, etc), danaids (milkweed butterflies, etc.) were controversial. Some researchers regarded them as distinct families, the others disagreed. Recent studies supported the view to pool them into a single family. Below is a phylogeny of these butterflies reconstructed by Freitas & Brown (2004). Answer the following questions based on this phylogeny.



Determine whether the following statements are true (T) or false (F).

(A) Danaid butterflies may still be a distinct family according to Freitas & Brown's phylogeny.

(B) Although Calinaginae butterflies resemble danaid butterflies in appearance, they should be classified as Nymphaloid butterflies.

(C) Satyrinae and Brassolinae were considered distinct families, but Apaturinae was always placed in Nymphalidae. If we want to keep Apaturinae in Nymphalidae, both Satyrinae and Brassolinae should be lumped into Nymphalidae.

(D) Danaid butterflies may be considered as the ancestors of Nymphaloid + Satyroid.

B45b. According to the phylogeny diagram above, fill in the blanks.

If Libytheinae is treated as the outgroup on the phylogeny, and 5 major groups (clades) are recognized for the ingroup. The maximum number of lineages of such a major group shown on THE PHYLOGENY is__(A)__, minimum number is __(B)___.