國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

科目：生物化學

◎請任選四題作答，每題 25 分。答題超過四題者，依考題序號批改四題計分。

1. The correct three-dimensional structure of a protein is essential to its function. Based on your knowledge of protein folding, thoroughly describe the process by which a polypeptide folds into its characteristic and functional three-dimensional structure from random coil.

2. Alzheimer's disease (AD) is the most common form of dementia. There is no cure for the disease, the disease worsens as it progresses, and eventually leads to death. The cause and progression of AD are not well understood. In order to provide a more complete picture of pathogenesis in AD, proteomic analysis of the brain in AD had been suggested. Describe clearly how this can be done and what information can be obtained.

3. Metabolism can be regulated through the control of (1) the amounts of enzymes, (2) the catalytic activities of enzymes, and (3) the accessibility of substrates. Give one example for each control mechanism and describe the mechanism thoroughly.

4. Diabetes is the most common metabolic disease in the world. In the disease, insulin either is not secreted in sufficient amounts or does not efficiently stimulate its target cells, the cells are metabolically starved in both cases. Describe the metabolic effects of diabetes on carbohydrates, proteins, and lipids.

5. A signal transduction pathway can be viewed as a molecular circuit containing the key steps as reception, transduction, and termination. Describe the key steps in the transduction pathway in detail by using insulin as the example.

6. The rapid progress in biotechnology is a result of several powerful techniques listed below. Describe specifically how each technique can be used to explore the gene you are interested in.
(1) Restriction enzyme analysis
(2) Blotting techniques
(3) DNA sequencing
(4) Solid-phase synthesis of nucleic acids
(5) The polymerase chain reaction

國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

科目：生態學

1. Discuss and describe three types of population growth curves and give examples of each. What factors cause these three different types to appear in nature? (30 points)
2. Discuss and describe the relationships between ecology and evolution. (20 points)
3. How do you define, identify, and describe an ecological community with your selected measurements. (50 points)

國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

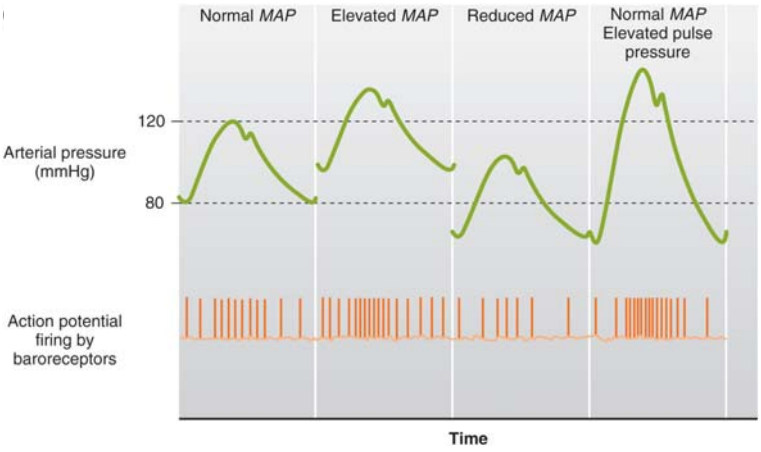
科目：動物生理學

答題規定：請由下列題目中，一～三題中選兩題，四～六題中選兩題，總共四題來回答，回答超過四題者，以最低分四題計算為所得總分。

一、Cardiovascular Physiology (25 %)

A. Baroreceptors are sensors which can detect the blood pressure. Where are location of the primary **two** baroreceptors in mammals ?**(5 %)**

B. The figure shows action potentials of a baroreceptor in response to different blood pressure level. Please summarize the results from this figure. **(6 %)**



C. It has been shown that signals from the baroreceptor can transmit to the nucleus tractussolitarius(NTS) in the brainstem. Please describe how to use **Neurophysiological & Neuroanatomical method** to prove this finding. **(6 %)**

D. Activity of NTS neurons can regulate the autonomic nervous system and then maintain blood pressure at a certain stable range. Please describe how autonomic nervous system regulates blood pressure by modulating **heart rate and stroke volume**.(note: your answer should include type of neurotransmitter, signal transduction pathway, response of target tissue/cell and final outcome of blood pressure) **(8 %)**

二、Respiratory Physiology (25 %)

A. Inspiration is primary generated by contraction of the diaphragm and intercostals muscles in the mammalian. Please describe **three** different experiment approaches to measure intensity of inspiration. **(6 %)**

B. Please define anatomic and alveolar dead space. **(6 %)**

C. The table shows different types of breathing patterns in a health man.

i. Which breathing pattern (A, B or C) may cause higher partial pressure of carbon dioxide ($PaCO_2$) and lower partial pressure of oxygen (PaO_2) in arterial blood.**(3 %)**

ii. Please provide your reason why this breathing pattern causes abnormal blood gas parameters.**(4 %)**

Table 13–4 Effect of Breathing Patterns on Alveolar Ventilation

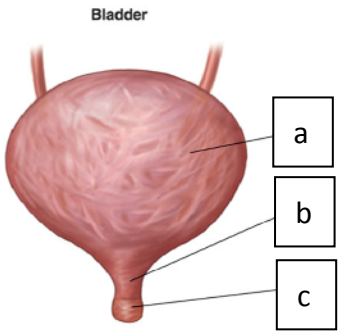
Subject	Tidal Volume (mL/breath)	×	Frequency (breaths/min)	=	Minute Ventilation (mL/min)
A	150		40		6000
B	500		12		6000
C	1000		6		6000

D. Please describe how O_2 and CO_2 transport in the blood. **(6 %)**

三、**Renal Physiology (25 %)**

A. Please draw a nephron and label the following basic structures (Renal corpuscle, Bowman's capsule, glomerular capillary, loop of Henle, proximal convoluted tubule, distal convoluted tubule)**(7 %)**

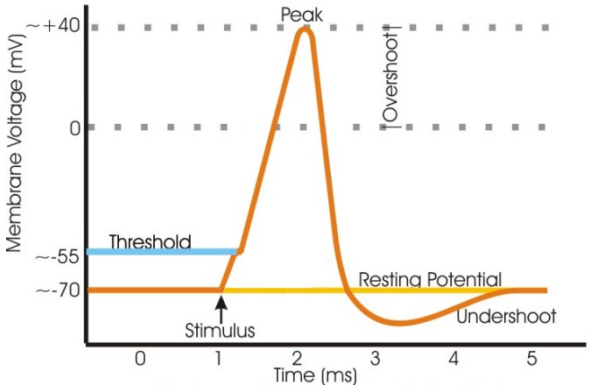
B. Micturition is controlled by three bladder muscles as shown in the figure. Please indicate what type of nerve (parasympathetic, sympathetic or somatic nerve) innervates these muscles and what are their response during micturition (activated or inhibited)**(9 %)**.[Please write your answer in the answer sheet and label (1), (2)…..(6)]



Muscles	**Nerve**	**Response**
a. Detrusor	(1)	(4)
b. Internal urethral sphincter	(2)	(5)
c. External urethral sphincter	(3)	(6)

C. Calcium is an important ion in the human body and involved in regulation of neuronal activity and muscle contraction. When the calcium concentration is lower in the blood, parathyroid hormone (PTH) will release to raise blood calcium level. Please describe how PTH increases blood calcium level by acting on the bone, kidney and intestine. **(9 %)**

四、Action potential is a short-lasting event in which the membrane potential of a neuron rapidly rises and falls. Schematic in right depicts model trajectory of an action potential.



(1) Please define “threshold” and its physiological role.(5%)

(2) Please describe the molecular mechanisms of “overshoot” and “undershoot”. Why the membrane potential does not stop at “0” while it depolarize and does not initially stop at “resting potential”while it hyperpolarize.(20%)

五、Toxin YA-1 was recently purified from *XoudrkMssoutr*, a seaweed in deep ocean. The intoxication of YA-1can be lethal because of its strong respiratory depression effect. A preliminary test suggests YA-1 block the synaptic transmission between presynaptic phrenic nerve and postsynaptic diaphragm. Please discuss the possible action mechanisms of YA-1.(25%)

六、What’s in your mind if you are trying to submit a proposal concerning using skin cells to cure an amyotrophic lateral sclerosis mouse?(25%)

國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

科目：細胞分子生物學

1. Explain how the retrieval signal, KDEL, mediates the rescue of resident ER proteins from the Golgi complex back to the ER. (10 pts)

2. (10 pts) Compare the GLUT1 transporter and the Na+/glucose transporter, indicating
   (1). if it is an example of active or passive transport,
   (2). if active transport what the source of energy driving transport
   (3). mechanism of transport

3. From question 3a and 3b, please choose one to answer. (10 pts)
   3a. All signaling pathways have the ability to adapt to and change their sensitivity to incoming signals. What are three common mechanisms employed by G protein coupled receptors (GPCR) in this type of adaptation?
   3b. Elevated levels of cAMP leads to activattion of cAMP dependent kinase (PKA) which in turn can activate the transcription factor CREB. Imagine a cell that is missing the regulatory subunits of PKA, how would this affect signaling by cAMP and activation of CREB?

4. From question 4a to 4d, please choose one to answer. (10 pts)
   4a. Describe the relationship between the outer microtubule doublets, dynein and nexin in the axoneme of a typical flagella.
   4b. Explain the role of Ca++ in the striated muscle sacromere and describe how an influx of Ca++ leads to a muscle contraction.
   4c. Explain why antibodies to individual intermediate filaments are important tools for monitoring cell differentiation and pathology.
   4d. During mitosis, nuclear lamins must rapidly disassemble and reform. How is nuclear lamin disassembly triggered during mitosis?

5. Both adherens junctions and desmosomes contribute to the stability of a sheet of epithelial cells. Compare and contrast the location, function and composition adherens junctions and desmosome in epithelial cells. (10 pts)

6. The Nobel Prize in Physiology or Medicine 2012 was awarded jointly to Sir John B. Gurdon and Shinya Yamanaka "for the discovery that mature cells can be reprogrammed to become pluripotent". Please describe their different contributions (experiments) in detail. (10 pts)

7. (1) Please explain what and how *cis-acting* and *trans-acting* factors cooperatively involved in gene regulation. (5 pts) (2) Describe the maturation of eukaryotic mRNA transcript, i.e. what is the posttranscriptional processing of eukaryotic mRNA transcript. (5 pts)

8. From question 8A and 8B, please choose one to answer. (10 pts)
   8A. *C. elegans* is an important model organism in biological research. This tiny creature has won the Nobel Prize twice. The Nobel Prize in Physiology or Medicine 2006 was awarded jointly to Andrew Z. Fire and Craig C. Mello "for their discovery of RNA interference - gene silencing by double-stranded RNA". Please describe the molecular mechanism of RNA interference.

8B. The Nobel Prize in Chemistry 2004 was awarded jointly to Aaron Ciechanover, Avram Hershko and Irwin Rose "for the discovery of ubiquitin-mediated protein degradation". Please describe this molecular processing of protein degradation (ubiquitin-protesome pathway).

9. The achievement of using model organism to address biological mysteries is very significant. Please choose one following question and describe their discoveries in details. (10 pts)

9A. In *C. elegans*, the Nobel Prize in Physiology or Medicine 2002 was awarded jointly to Sydney Brenner, H. Robert Horvitz and John E. Sulston "for their discoveries concerning genetic regulation of organ development and programmed cell death"'

9B. In *Drosophila*, the Nobel Prize in Physiology or Medicine 1995 was awarded jointly to Edward B. Lewis, Christiane Nüsslein-Volhard and Eric F. Wieschaus "for their discoveries concerning the genetic control of early embryonic development".

9C. In yeast, the Nobel Prize in Physiology or Medicine 2001 was awarded jointly to Leland H. Hartwell, Tim Hunt and Sir Paul M. Nurse "for their discoveries of key regulators of the cell cycle".

10. (1)一般而言，惡性腫瘤 (malignant tumors) 有許多特性 (fundamental properties)，請描述這些特性為何？ (2)癌症會不會遺傳? 癌症會不會傳染? 請以細胞分子生物學觀點詳細說明之. (10 pts)

國立中山大學生物科學系101學年上學期
博士班資格考試(筆試)

科目：植物生理學

一、 Answer the following questions (10 points per question; Choose 10 from 14 questions for answer)

01. Diffusion of water is governed by the water potential of the solutions. What does waterpotential measure, and what two factors contribute to the water potential of solutions?

02. What is the process called transpiration? Where in the plant does it occur, and what is movedduring this processs?

03. Why is important for plants to have many root hairs?

04. What is meant by the terms apoplastand symplast?What is the function of the Casparian strip at the root endodermis?

05.What is meant by the term carbon fixation, and what enzyme carries out this process in C3plants (in the Calvin Cycle)?

06.In general terms, what happens during the Calvin Cycle?

07. Do you expect the stomata of CAM plants to respond to all environmental signalsin the sameway the stomata of a C3 plant do? Why or why not?

08. Please list three main physiological responses that are related to auxin. Choose one of them and explain how auxin causes the physiological response.

09. Please explain how the ratio between auxinandcytokininaffects the process of organogenesis in plants.

10. (a) What is “triple response” caused by ethylene? (b) Predict and briefly explain the possible phenotypes of triple response in*Arabidopsis* mutants etr1 (ethylene

response 1) and ctr1 (constitutive triple response 1).

11. (a) Please list three main physiological responses that are related to abscisic acid (ABA). (b) Predict and briefly explain their possible phenotypic changes in ABA-insensitive mutant (abi3).

12. GA3 oxidase is a GA biosynthesis-related gene. However, GA2 oxidase is a GA deactivation-related gene. GA content in plants generally affects stem elongation. Please explain how these genes can be used, respectively, in transgenic strategies to produce dwarf cropsfor cultivation.

13. *Arabidopsis* is a facultative long-day plant. Environmental factors such as day length, critical dark time, cold treatment (vernalization), plant growth regulator GA, red light and far-red light may affect flowering in *Arabidopsis*. Please predict and briefly explain how these factors affect flowering in *Arabidopsis*.

14. There are many different biochemical, physiological and morphological changes in plants responding to drought stress. Please list and briefly explain the possible changes in plant in order to cope with drought stress.

國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

科目：微生物免疫學

1. A student is performing the Gram stain technique in the laboratory. In reaching for the alcohol bottle, he mistakenly takes the water bottle and proceeds with the technique. What will be the colors of Gram-positive and Gram-negative bacteria at the conclusion of this process? Give your explanation. (10 points)

2. What is the basic structure of a virus? What is the difference between plus-strand and minus-strand RNA? (10 points)

3. What is the cause of bovine spongiform encephalopathy (mad cow disease)? Describe the pathogenic agent in detail. (10 points)

4. A student has isolated a previously undiscovered species of bacteria from a hot spring. Many organisms that grow in these extreme environments are Archaea, so he wants to determine whether the one he found should be classified with the Archaea or with the Bacteria. Give two characteristics that would help him distinguish between the two. (10 points)

5. Draw a typical bacterial growth curve. Label the X- and Y-axis. Name and define each of the four phases. (10 points)

6. Why Toll-like receptors are recently counted among the key molecules that alert the immune system to the presence of microbial infections? Describe the structure, functions and the signaling pathways of TLR. (20%)

7. All animals have specific and nonspecific defense mechanisms that protect them from a variety of diseases. Mucosal immunology studies different aspects of immunity and inflammation involving mucosal tissues along gastrointestinal, pulmonary, nasopharyngeal, oral, ocular, and genitourinary linings. Explain the immune responses happened at the intestinal mucosa with the cooperation of all involved cells <u>in detail</u>. (10%)

8. What are the immune evasion mechanisms used by the following organisms during their infections in the mammalian hosts? Give an explanation for each of your answers. (4% each, 20% in total)
   (a) Influenza virus
   (b) *Neisseria gonorrhoeae*
   (c) *Plasmodium falciparum*
   (d) *Trypanosoma brucei*
   (e) *Schistosoma mansoni*

國立中山大學生物科學系 101 學年上學期
博士班資格考試(筆試)

科目：演化生物學

一、Using sequences below and Jukes-Cantor substitute model to answer the following questions:(50%)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
S1	G	G	G	A	T	A	A	C	T	G	A	T	A	A	T	T
S2	G	G	G	A	G	T	A	T	C	T	A	G	A	C	T	T
S3	A	T	A	G	T	T	G	T	C	T	C	G	G	C	T	C
S4	A	A	T	G	T	T	G	T	C	G	C	A	G	C	G	C
S5	A	T	T	G	T	T	A	T	C	G	C	A	G	C	G	C

1. Draw UPGMA phylogenetic tree step by step
2. Draw Neighbor Joining tree step by step
3. Draw Maximum Parsimony tree step by step
4. Draw network tree based on MP method step by step

二、As an evolutionary biologist, what is a best way to treat the “creation science” movement in recent years? (15 points)

三、Factors that prevent gene exchange among populations are known as isolating mechanisms. Describe those isolating mechanisms. (35 points)