IBO Challenge 2020

A Substitute for The 31st IBO 2020 Nagasaki, JAPAN

Clypeaster japonicus

Saccharina japonica

Glirulus japonicus

Leucothea japonica

Branchiostoma japonicum

Mauremys japonica

Hyla japonica

Anguilla japonica

Narke Japonica

Eutrema japonicum

Practical Exam 1

Animal Physiology

signature

2020.8.11.

Cryptomeria japonica

Corbicula japonica

Ulnaria japonica

Hydroglyphus japonicus

Luehdorfia japonica

Halichondria japonica

Nihonhimea japonica

Perkeomeris japonica

Aspergillus japonicus

Fibrocapsa japonica

Meyersia japonica

Alveopora japonica

Omphalotus japonicus

Mimobdella japonica

Ephebe japonica

Coturnix japonica

Oxycomanthus japonicus

Panulirus japonicus

Notholca japonica

Scolopendra subspinipes japonica

Perophora japonica

Lychaete japonica

Delisea japonica

Prasiola japonica

Lotus japonicus

Osmunda japonica

Conocephalum japonicum

Nipponia nippon

Instructions of this exam

1. To see the Photoset No.1 and No.2, you have to connect to the server with information below.

Find the URLs of your country's server at:

https://bit.ly/IBO2020file

or refer to the URL list at the end of this exam file/booklet.

可透過下列方法，連接上伺服器後取得照片組 1 及照片組 2

首先找出你所屬國家伺服器的 URL

https://bit.ly/IBO2020file

或者是透過試題最後所提供的 URL 表單找出你的國家。

Then, enter the server using the following username and password.

Username: ibo2020

Password: ibo2020apnagasaki

進入伺服器後，輸入帳號及密碼

帳號: ibo2020

密碼: ibo2020apnagasaki

If you have a connection problem, try the following alternative servers:

Competitors in Asia, Oceania, or America: 18.181.44.86/index.html

Competitors in Europe: 18.194.137.48/index.html

or 3.126.91.168/index.html

如果無法連結，可以透過下列備份伺服器連結

亞洲，大洋洲，美洲國家的選手: 181.44.86/index.html

歐洲國家的選手: 18.194.137.48/index.html

或 3.126.91.168/index.html

You can see photos in each file when you click it. Click a selected photo to see its enlarged image. Use the Back button on the browser or "previous page" button to return to the previous page. If there is any trouble (for example, it freezes, you can't see pictures anymore, and so on), press the reload button on the browser.

點選每一個檔案時就可以看到檔案內的照片，並點選你所要觀察的照片及其放大圖。若要回前一張圖，可利用瀏覽器上的 Back 鍵或前頁(previous page)鍵。如果你有任何的問題，例如當機或無法再看其他的圖片，請按瀏覽器上的 reload 鍵以重新取得影像。

2. Write your signature on each page of the answer sheet.

請在答案卷上每一頁簽名

To understand functions of various tissues and organs in adult animals, it is important to study how they are created. This practical exam involves two tasks aimed at understanding cellular and molecular mechanisms regulating animal development. Answer the five questions in Part 1 and the two questions in Part 2.

若想了解動物成年後多種組織及器官的功能，則了解他們如何被創造出來是非常重要的。本實作題主要有兩個部分，其主要目的在探討動物發育過程中分子及調節機轉。請回答第一部分的五題以及第二部分的兩題

Part 1

Photo set No.1 on the server has photographs of sections of a 2-day-old chicken embryo (Figure 1). Observe the sections and answer the following questions.

伺服器上的第一個照片組為兩天大的雞胚切片(圖一)，觀察切片並回覆下列問題。

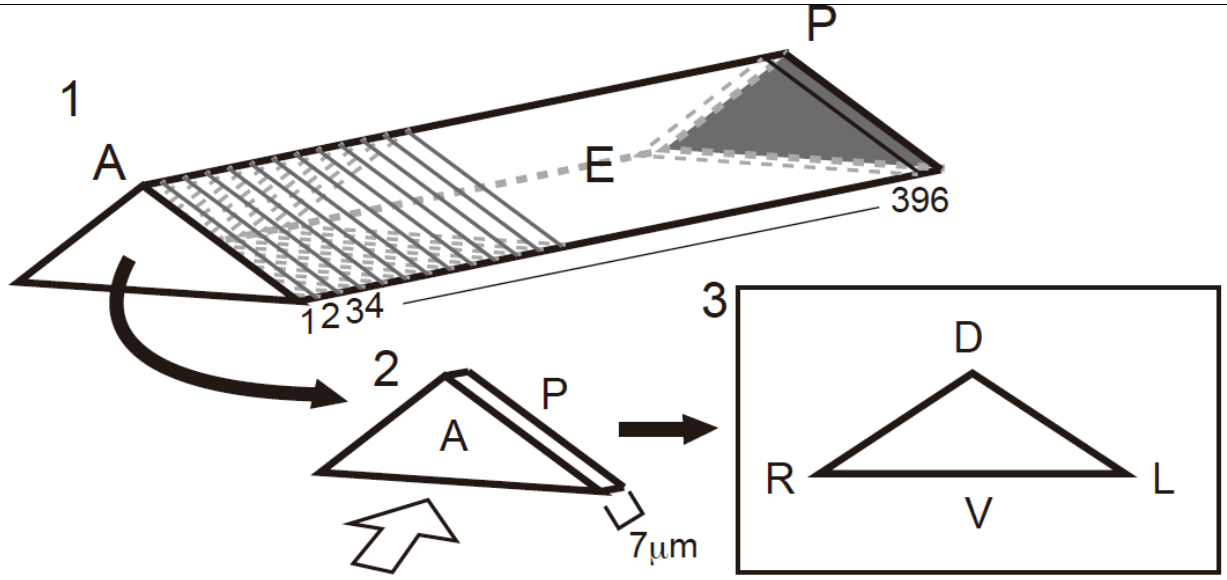


Figure 1

1: A chicken embryo (E) was cut into 7-μm sections from anterior (A) to posterior (P). Here, the chick embryo is represented by a triangular prism.

雞胚從前端(A)到後端(P)以 7-μm 厚度連續切片，在此處之雞胚以三角圖形顯示。

2: A photo of each section (#1-396) was taken from the front side (A).

從(A)側前取出的每一切片(#1-396)所拍下的照片

3: In each photo, dorsal (D), ventral (V), right (R) and left (L) sides of the embryo are shown as indicated.

每張胚胎照片顯示的位置如圖示: 背側(D)，腹側(V)，右側(R)及左側(L)

Q1. You can find several sections that resemble the diagram in Figure 2A. Choose one of them and draw it. Your drawing should show structural characteristics of embryonic tissues as detailed as you see it in Figure 2B (e.g. cell membranes and nuclei). Draw your answer as large as possible in the frame of the answer sheet. No labeling of the embryonic structures in your drawing is required. [20 marks]

圖 2A 為部分切片所組合成的圖片。請任選一個並畫下來，如圖 2B，你所畫的圖必須盡可能詳盡地呈現所觀察到的胚胎組織之結構特徵(例如細胞膜及細胞核)，並盡可能地把圖畫滿整個答案框中，你所繪的圖中不須標出胚胎結構(20 分)

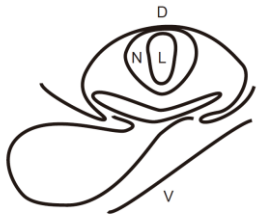
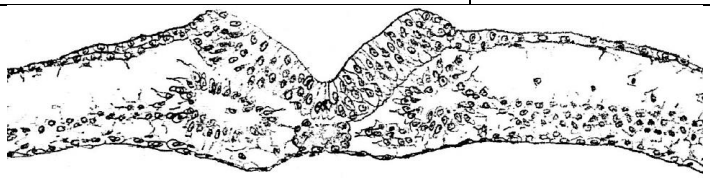


Figure 2A: Schematic diagram of a section of the chick embryo
N: the neural tube
L: lumen of the neural tube
D: Dorsal side of the embryo
V: Ventral side of the embryo

圖 2A.雞胚的切片示意圖

	N: 神經管 L: 神經管的管腔， D: 胚胎背側 V: 胚胎腹側
	Figure 2B: Example answer for a sketch of chicken embryo. 圖 2B: 雞胚手繪圖答案範例

Q2. The neural tube (N in Figure 2A) extends anterior-posteriorly. Examine all sections on the slide. Reconstitute and draw the shape of the entire neural tube from the most anterior to the most posterior end, as if it is viewed from the dorsal side of the embryo. Pay attention to projections and change of the diameter of the neural tube. Draw with the anterior at the top of the frame, and posterior at the bottom of the frame, as large as possible. Note that the embryo may have a slightly curved shape. [15 marks]

神經管（圖 2A 中N）從前端延伸到後端。請檢視玻片上所有的切片，重組並從前端畫到最後端畫下從背側觀察的整個神經管的形狀。請特別注意投射方向及神經管直徑的變化，將前端畫在答案格上方，後端畫在答案格下方，盡可能畫大一點。注意，胚胎可能呈現些微彎曲的形狀。

Q3. When an external electric field is applied to a cell, structure of cell membrane changes and small holes are formed temporarily, allowing macromolecules to enter the cell. Plasmid DNA for expressing GFP, green fluorescent protein, in cells was injected into the lumen of the neural tube of a chick embryo (L in Figure 2A). Electrodes were placed on the left and right sides of the embryo, and an electric field of direct current was applied. Using this method, GFP can be expressed in neural tube cells. In Figure 3, an embryo was sectioned and sections were viewed from the front side. GFP protein signals were observed. Consider how the positive and negative electrodes are aligned, and fill in the blanks A-D in the following sentence. [4 marks]

若對細胞給予一個外在的電刺激，可觀察到細胞膜的形狀開始改變而且會暫時形成一個小孔讓大分子的物質能夠進入細胞。科學家可以用這個方法將表現 GFP（綠螢光蛋白）的質體 DNA 打入雞胚的神經管腔中（圖 2A 的 L）。 將電極放在雞胚左右兩邊， 並用電流刺激，即可使神經管細胞表現 GFP。圖 3 所示為自前到後且可觀察到 GFP 蛋白表現之雞胚切片。請注意正電極與負電極如何排列，並在下列句子中選出最適合 A 到 D 的描述(4 分)。

DNA contains A which are B, and therefore, plasmid DNA moves towards the C electrode. The D electrode is placed on the right side of the embryo.

含 A 的 DNA 是 B，且質體的 DNA 向 C 電極移動。D 電極置放在胚胎的右側

choices of A:
1. phosphate groups
2. bases
3. pentose sugars
4. hydroxyl groups

A 的選項

1. 磷酸根
2. 鹼基
3. 五碳糖
4. 氫氧根

choices of B:
5. negatively charged
6. positively charged
7. neutral

B 的選項

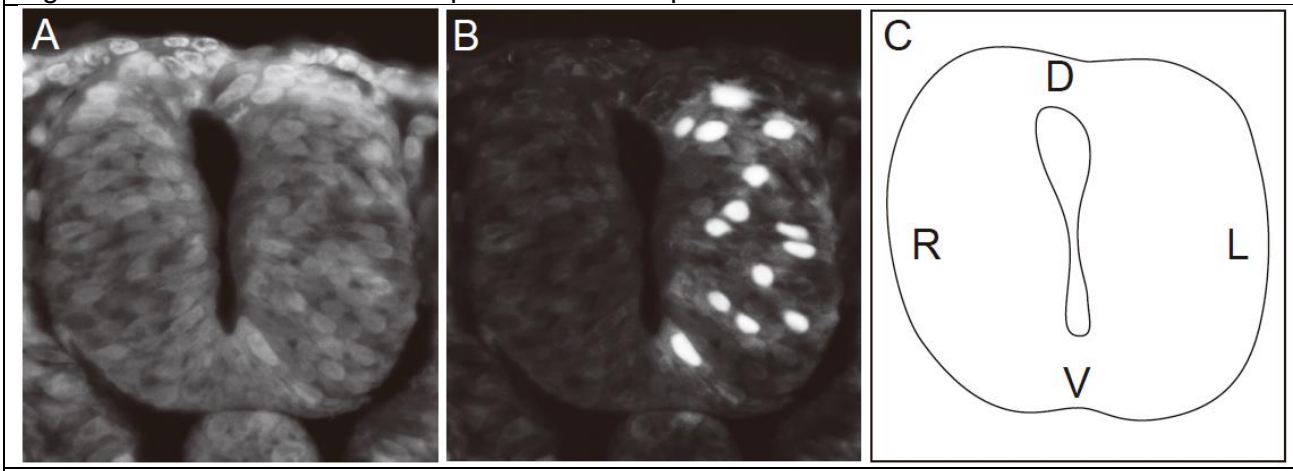
5. 帶負電
6. 帶正電
7. 電中性

choices of C and D:
8. negative
9. positive
10. neutral

C 及 D 的選項

8. 帶負電
9. 帶正電
10. 電中性

Figure 3: Neural tube with overexpression of GFP protein.



A: Nuclear DNA staining in a section of the neural tube. B: Bright white GFP-positive nuclei were detected.
C: A schematic drawing of the neural tube in A and B showing dorsal (D), ventral (V), right (R) and left (L) sides.

圖三，過度表現 GFP 蛋白的神經管

A. 神經管切片上染色的 DNA

B. 細胞核中可測得亮白色含 GFP 的細胞核

C. 在 A B 兩圖中神經管之示意圖，其中 D 表背側，V 表腹側，R 為右側，L 為左側。

Q4. The neural tube is regionalized along the dorsoventral axis, as shown in Figure 4. Different types of neurons are generated in each region. An experiment was conducted to examine how a secreted factor, Wnt3a, is involved in the regionalization of the neural tube. Wnt3a is the ligand of the Wnt signaling pathway (Figure 5) and its mRNA was detected only in the D1 region.
Wnt3a gene was overexpressed in the neural tube of the chicken embryo using the same method and position of the electrodes described in Q3. The embryos were sectioned as described in Q3 and localization of three proteins, P1, P2 and P3, was examined (Figure 6).

如圖 4 所示，神經管沿著背腹軸可以區分成不同的區域。每個區域可產生不同種類的神經元，下列實驗即檢測特定分泌的因子 Wnt3a 是否與神經管的分區現象有關。Wnt3a 是 wnt 訊息傳遞路徑的配體(ligand)(如圖五)，Wnt3a 的 mRNA 僅可在 D1 這個區域被偵測到。利用與第三題所描述的相同方法及電極配置，科學家可在神經管中表現大量的 Wnt3a 基因。如問題 3，將雞胚切片後，檢視下列三種蛋白質 P1，P2 及 P3 的表現位置 (圖六)。

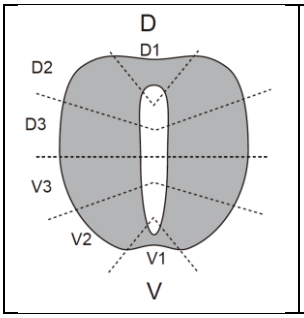


Figure 4: Schematic diagram of neural tube differentiation
The neural tube is divided into several dorsoventral regions, and different neurons develop in each region.
圖四，神經管分化的示意圖
神經管可分成數個背腹區，且每一個區域中發育出不同神經元。

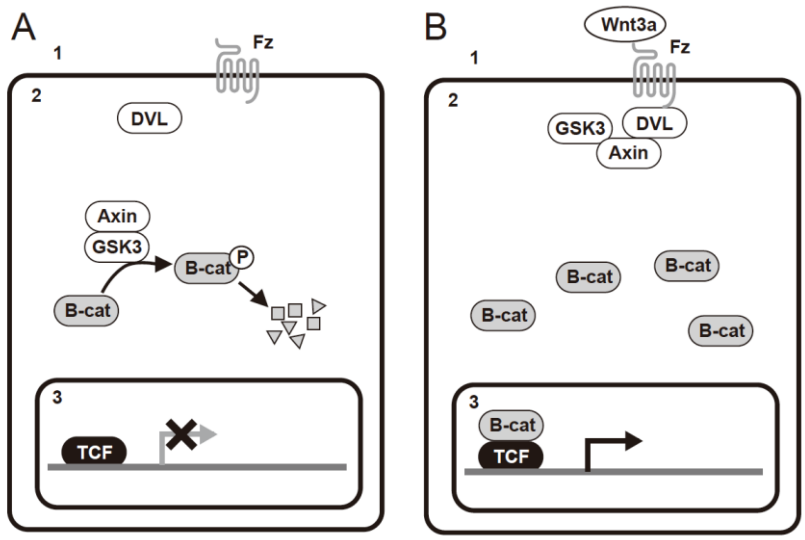
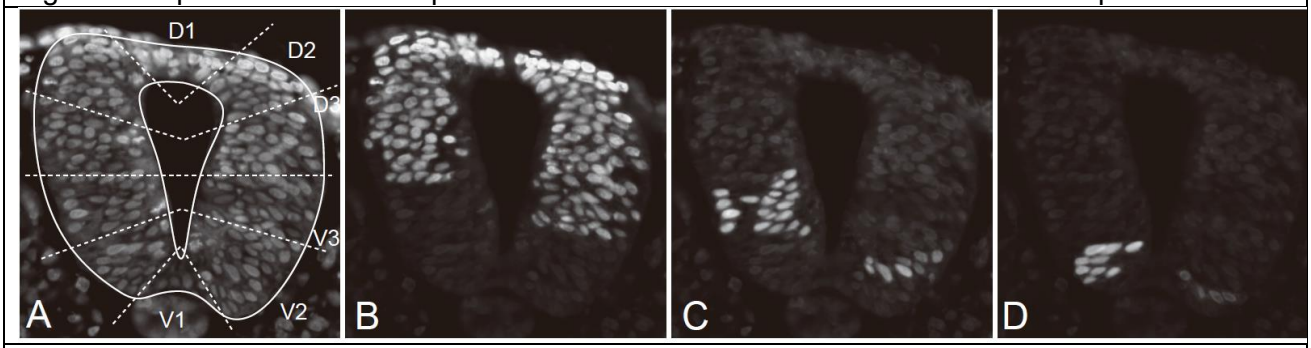


Figure 5: Schematic diagrams of Wnt signaling pathway
A: In the absence of the Wnt ligand, the complex of GSK3 and Axin phosphorylates B-cat and degrades phosphorylated B-cat. In the nucleus, TCF binds to the regulatory region of the Wnt t signal target gene and inhibits its transcriptional activity.
B: In the presence of the Wnt ligand, the Wnt ligand binds to the receptor Fz, and upon stimulation, intracellular DVL binds to the intracellular domain of Fz and inhibits GSK3 function. As a result, B-cat is not degraded and translocates to the nucleus. In the nucleus, B-cat / TCF complex binds to the regulatory region of the target gene of the Wnt signal and activates its transcription.
1: extracellular space, 2: cytoplasm, 3: nucleus
圖五，Wnt 訊息傳遞路徑之示意圖
A：在缺乏 Wnt 配體的狀況下，GSK3 跟 Axin 的複合體可磷酸化 B-cat 並進一步降解磷酸化的 B-cat。 在細胞核內，TCF 會跟 Wnt 調節區域結合並且抑制轉錄活性
B：在 Wnt 配體存在時，Wnt 配體會跟 F z 結合並且刺激細胞內的 DVL 跟細胞內 Fz 之區位結合以抑制 GSK3 的功能，因此 B-cat 就不會被降解並且跑到細胞核中。在細胞核中，B-cat 與 TCF 會形成複合體 B-cat / TCF 並與 Wnt 訊號之目標基因的調節區域結合而活化轉錄作用。
1：細胞外空間，2：細胞質，3：細胞核

Figure 6: Expression of various proteins in the neural tube when *Wnt3*a was overexpressed.



A: Nuclear DNA staining of a section of neural tube with region names. Localization of P1 (panel B), P2 (panel C) and P3 (panel D) protein shown in the same section of A. Top of the pictures is the dorsal side.

圖六，當 *Wnt3a* 被過度表現時。神經管中所表現的多種蛋白質如下

A.標有不同區域之神經管切片上核內 DNA 的染色。

B. P 1 的分布位置(與 A 相同切片)

C. P 2 的分布位置(與 A 相同切片)

D. P 3 的分布位置(與 A 相同切片)

圖片頂端為背側

4-1. Based on data from these experiments, identify the localization of the following proteins in the neural tube of a **NORMAL** developing chicken embryo. Choose the best choice of localization. [4 marks]
proteins:
4-1-1: B-cat in nuclei
4-1-2: TCF in nuclei

依據實驗所得數據 請確認正常發育之雞胚神經管所表現的蛋白質及其區域，選出對表現區域最適當的描述(4 分)

4-1-1: B-cat 在細胞核內

4-1-2: TCF 在細胞核內

choices of localization:
a. Present with similar expression levels throughout the neural tube
b. Present throughout the neural tube, but stronger on the ventral side and weaker on the dorsal side
c. Present throughout the neural tube, but stronger on the dorsal side and weaker on the ventral side
d. Localize only in D1.
e. Localize only in V1.

表現位置的選項

a.在整個神經管中都會表現且表現量都類似

b.在整個神經管中都會表現，但是在腹側的表現量比較強，背側量比較弱

c.在整個神經管中都會表現，但是在背側表現量比較強，腹側表現量比較弱

d.只表現在 D1

e.只表現在 V1

4-2. P2 protein regulates differentiation of neurons in V3 region of the **NORMAL** developing neural tube. Which of the following is the most probable mechanism of P2 to regulate neural differentiation? Please answer based on localization of P2 protein in cells of V3 region in Figure 6 C? [2 marks]
a. P2 acts as a transcription factor and represses the expression of another gene.
b. P2 is secreted extracellularly and activates a signal in another cell.
c. P2 acts in the cytoplasm and transmits the signal received by the expressing cell.
d. As a transmembrane receptor, P2 binds extracellular proteins.

4-2 神經管正常發育時，P2 蛋白會調節 V3 的神經分化現象。

下列何者可最清楚說明 P2 調節神經分化之機制? 請依據圖 6C 中 V3 區 P2 蛋白之位置回答下列問題(2 分)

a.P2 扮演轉錄因子的角色而且會抑制其他的基因的表現

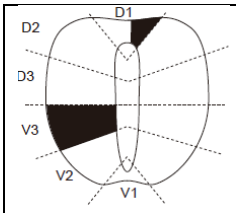
b.P2 由細胞外分泌且會活化其他細胞的訊號

c.P2 作用在細胞質內而且傳送表現細胞所接收的訊號

d. P 2 扮演細胞膜上接受器的角色，會跟細胞外的蛋白質結合

4-3. In the following experiments (4-3-1, 2, and 3), wild-type or mutated components of the Wnt signaling pathway (see Figure 5) were overexpressed or inhibited in the neural tube. Indicate the expression region of the specified protein using Figure 6 as reference. The schematic diagram of the neural tube on the answer sheet shows the dorsal side at the top. Indicate the protein expression regions by painting a schematic diagram of the neural tube with a pencil. [12 marks]

4-3 在下列實驗中(實驗 4-3-1, 2, and 3)，將野生型及突變型的 Wnt 訊息路徑的組成單元，在神經管中過度或抑制其表現，探討 wnt 訊息的路徑所扮演之角色。請參考圖六，指出特殊蛋白的表現位置，答案卷中示意圖上方為神經管的背側。利用鉛筆在神經管上畫出不同蛋白質的表現區域(12 分)



Example answer 2:
Protein P1 is expressed in D1 and V3 on the left and right sides of the neural tube, respectively. Note that this schematic figure of a section of the neural tube is viewed from the front (see Figure 3C for its orientation).

答案範例

蛋白質 P1 依序表現在神經管左側及右側的D1 及V3。請注意本神經管切片是從前方觀看(方向請參考圖 3C)

4-3-1. What is the expression region of protein P1, when the gene encoding a mutant B-cat protein (with an amino acid mutation that makes it non-phosphorylatable by GSK3) is overexpressed in the neural tube with the method and position of the electrodes described in Q3?

利用與第三題所描述的相同方法及電極配置，若神經管過度表現突變的 B-cat 蛋白（即一個胺基酸變異導致無法被 GSK 磷酸化），則 P1 蛋白質所表現的區域為何？

4-3-2. What is the expression region of P2, when the translation of both DVL and GSK3 is inhibited on both sides of the neural tube?

若神經管兩側 DVL 與 GSK3 的轉譯均被抑制時，則 P2 蛋白質表現的區域為何？

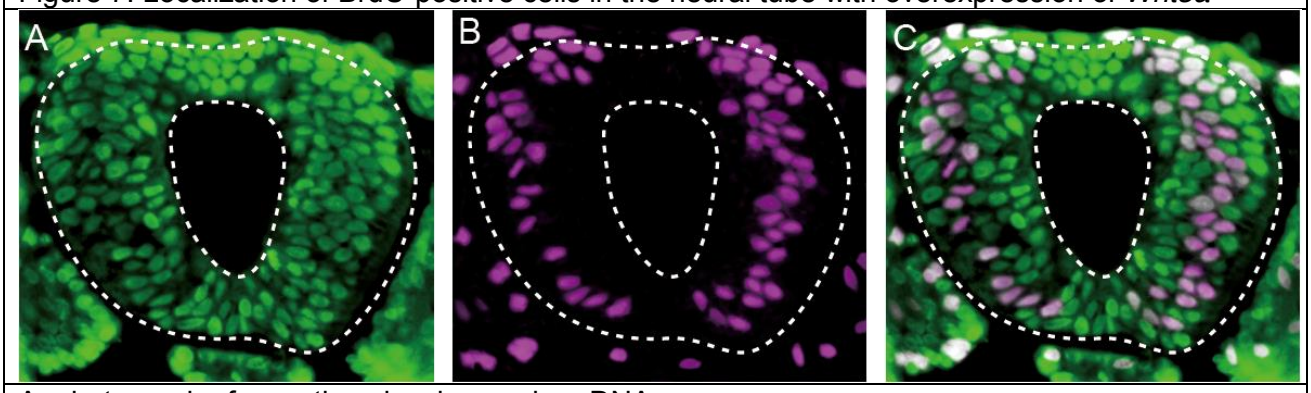
4-3-3. What is the expression region of P3, when the gene encoding the TCF protein is overexpressed in the neural tube with the method and position of the electrodes described in Q3?

利用與第三題所描述的相同方法及電極配置，若神經管過度表現 TCF 蛋白，則 P3 蛋白質所表現的區域為何？

Q5. After *Wnt3a* was overexpressed in the neural tube as described in Q4, 5-bromo-2'-deoxyuridine (BrdU), a thymidine analogue, was added to culture for 4 hours. The embryos were then sectioned, BrdU was detected with anti-BrdU antibody and nuclear DNA was stained (Figure 7).

如問題 4 所述，當神經管過度表現 Wnt3a 蛋白質時，在細胞培養基中加入 5-bromo-2'-deoxyuridine (BrdU)（thymidine 之似構物）培養四小時後切片，分別利用 BrdU 之抗體來偵測及染細胞核內 DNA(圖 7)。

Figure 7: Localization of BrdU-positive cells in the neural tube with overexpression of *Wnt3a*



A: photograph of a section showing nuclear DNA.
B: the same section in A showing the location of BrdU. C. merging of A and B photos.
The dashed white line indicates the neural tube.

圖七，過度表現Wnt3a 之雞胚神經管中含 BrdU 之細胞位置

A．顯示染出細胞核 DNA 切片之照片

B. 與A 相同切片中 BrdU 之照片

C．A B 兩圖之合併照片

白色虛線為神經管

5-1: Where is BrdU detected, concerning their cell cycle stage? Choose all possible options. [2 marks]

a. in all cells in the neural tube
b. in cells that were in G1 phase during culture with BrdU
c. in cells that were in M phase during culture with BrdU
d. in cells that were in S phase during culture with BrdU
e. in cells that were in G2 phase during culture with BrdU
f. in cells that were in S phase at the onset of culture with BrdU, and entered G2 phase during four-hour culture with BrdU.
g. in cells that were in G1 phase at the onset of culture with BrdU, and entered S phase during four-hour culture with BrdU.
h. in cells that were in M phase at the onset of culture with BrdU, and entered G1 phase during four-hour culture with BrdU.
i. in cells that were in G2 phase at the onset of culture with BrdU, and entered M phase during four-hour culture with BrdU.

5-1 考量所對應之細胞週期，那些細胞可以測到 BrdU? 選出所有可能的選項 (2 分)

a. 所有神經管的細胞

b. BrdU 培養時處於 G1 期的細胞

c. BrdU 培養時處於 M 期的細胞

d. BrdU 培養時處於 S 期的細胞

e. BrdU 培養時處於 G2 期的細胞

f. BrdU 剛加入時處於 S 期的細胞，BrdU 四小時培養時進入 G2 期的細胞。

g. BrdU 剛加入時處於 G1 期的細胞，BrdU 四小時培養時進入 S 期的細胞。

h. BrdU 剛加入時處於 M 期的細胞，BrdU 四小時培養時進入 G1 期的細胞。

i. BrdU 剛加入時處於 G2 期的細胞，BrdU 四小時培養時進入 M 期的細胞。

5-2: From the previous experiment, you hypothesized that higher levels of Wnt3a protein promote cell division in the neural tube. Using Photos in Figure 7, you decide to design an experiment to test this hypothesis. In this experiment, you will determine numerical values from counting the number of cells in two of three groups listed below, each in two different selected regions of the neural tube. [15 marks]

Value Options:
a. Total number of cells
b. Number of BrdU-positive cells
c. Number of BrdU-negative cells

從之前的實驗，你可以假設高濃度的 Wnt3a 可促進神經管中細胞的分裂。利用圖 7 的照片，你可以設計一個實驗來驗證這個假說，在這個實驗中，從以下所列三項數據任選兩項，計算並寫出在神經管中選出的兩個不同區域中細胞的數目 (15 分)

數值選項

A. 細胞總數

B. 可染出 BrdU 細胞的數目

C. 無法染出 BrdU 細胞的數目

The answer should be written down in the following way:

- In A1 and A2: enclose in a box the part of the neural tube which you have used for counting.
- A3 and A4: write down the cell number you have obtained through counting (choose two values from Value Options, i.e. choose only two-rows to fill out in both columns.).
- A5: write down the formula you have used to obtain final numerical value for comparison.

◊ A6 and A7: Write down final numerical values in the two regions, based on which your conclusion will be drawn.

請依下列指示寫出答案

A1 與 A2: 在神經管上以方格畫出你所要計算的區域

A3 與 A4: 寫下你計算所得的細胞數目(從數值選項任填兩項即可，亦即兩欄中僅需填兩行)

A5: 寫下你獲得最終數值用以計算與比較的公式

A6 與 A7: 寫下兩個區域中的最終數值，以此為依據得出結論。

Part 2
第二部分

Q1. The development of the ascidian embryo has been studied for more than a century. The lineage of the embryonic cells is invariant, which means that the number and position of the cells are the same between individuals. Figure 8 is a schematic diagram of the 32-cell stage embryo and shows the cells' names. Researchers identified various transcription factors expressed in specific cells at the 32-cell stage.
Embryos in photo set No.2 are 32-cell stage embryos stained to show mRNA for gene *W* in bluish-black color. Several individuals are shown from various viewing angles.
題目 1、海鞘類胚胎發育過程之研究已超過 1 世紀，胚胎細胞的譜系具不變性，即不同個體間的細胞數量及位置均是相同的。圖 8 為一個 32 細胞階段胚胎的示意圖，圖中呈現了各細胞的名稱。研究人員在 32 細胞階段胚胎的特定細胞中，辨識出多種轉錄因子。
第 2 組照片為 32 細胞階段的胚胎，其基因 *W* 的 mRNA 被染成藍黑色，該圖以不同的角度觀察數個個體。

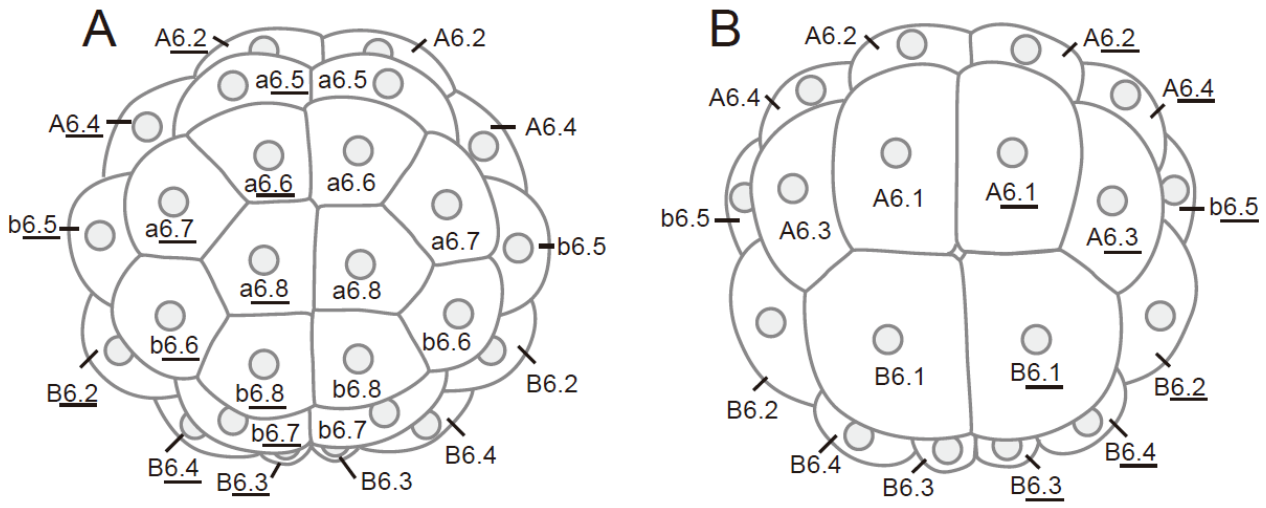


Figure 8: Schematic diagram of the ascidian embryo at the 32-cell stage.
A: Animal pole (top) view, B: Vegetal pole (bottom) view.
Names of the cells are shown in the diagram (ex. A6.1, b6.5). Names of cells in the animal hemisphere begin with a or b. Names of cells in the vegetal hemisphere begin with A and B. Anterior cells begin with A, a, and posterior cells begin with B, b. Cells that contribute to the right side of the bilaterally symmetrical larvae are distinguished by underlining. Cells in the periphery are shown in both diagrams. Gray circles are nuclei.
圖 8. 海鞘類 32 細胞階段胚胎的示意圖
從動物極(頂部)觀察, 從植物極(底部)觀察
圖中顯示了細胞的名稱 (例如：A6.1; b6.5)
動物半球的細胞以 a 和 b 開首命名，植物半球的細胞以 A 或 B 開首命名；近前端方向的細胞以 A, a 開首命名，後端方向的細胞以 B, b 開首命名。後來發育成雙側對稱的幼蟲右邊的細胞以底線標示，位於邊緣的細胞於兩張圖中均會呈現。灰色圓圈代表細胞核

Photo set No.2
Images of each embryo are placed in separate lines on the server. The focal plane is arranged from the front to the back.
mRNA of gene *W* was stained blueish black. In ascidian embryos, mRNA is detected primarily in the nucleus. 第 2 組照片
各胚胎的圖像置放於伺服器的不同位置，焦距的切面由前向後排列，
基因 *W* 的 mRNA 被染成藍黑色，該 mRNA 主要在海鞘類胚胎的細胞核中被偵測到。

1-1. Observe the images in photo set No. 2 and identify cells that are stained. Use the information shown in Figure 8 to identify the cells. Circle the name of stained cells on the answer sheet. [15 marks]

1.1 觀察第 2 組照片中的影像並辨識被染色的細胞。利用圖 8 所顯現的資訊來辨識各細胞，在答案卷中圈出被染色細胞的名稱。(15 分)

Q2. In cells, whose names are enclosed by boxes in Figure 9, mRNA of the gene that encodes secreted factor X is detected at the 32-cell stage.

Q2.在 32 細胞階段，分泌因子 X 的基因的 mRNA，在圖 9 中哪些以方格框示的細胞內被偵測到？

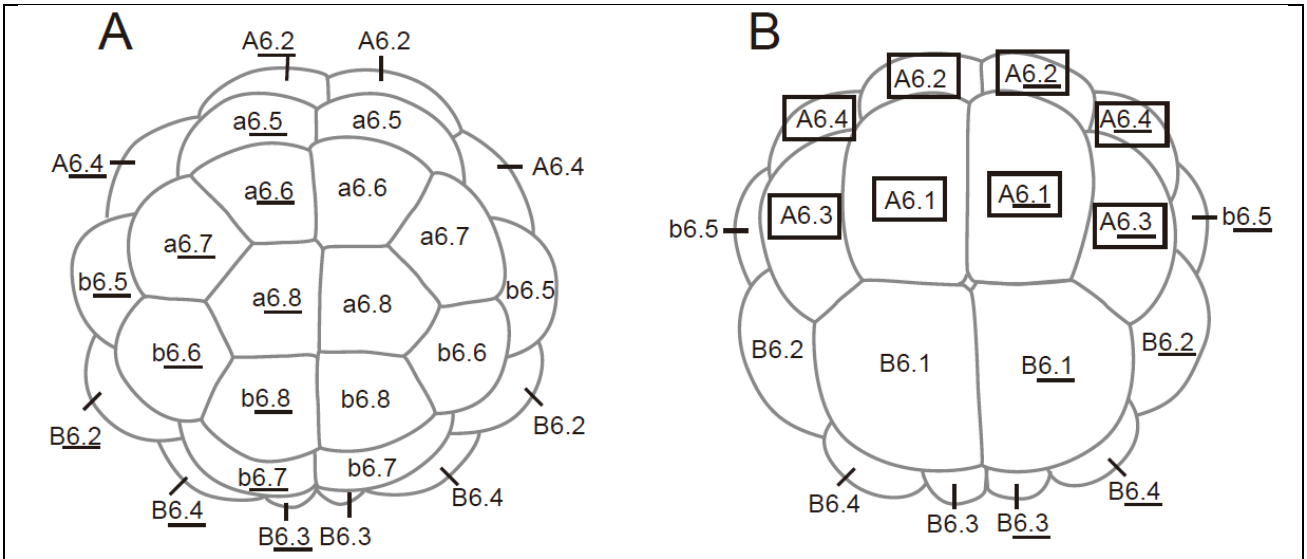


Figure 9: Expression of a gene that encodes a secreted factor X at the 32-cell stage. The names of the cells that express this factor is enclosed in a box. A: Animal pole view, B: Vegetal pole view

圖 9、 在 32 細胞階段分泌因子 X 的基因表現，會表現該因子的細胞，其名字以方格框示。A:從動物極(頂部)觀察，B:從植物極(頂部)觀察

At the 64-cell stage, the daughter cells of the A6.2 cells express gene *Y* that is required for mesodermal differentiation. The following experiments were carried out to examine how the expression of this gene Y is regulated.

在 64 細胞階段，細胞 A6.2 的子細胞會表現基因 Y，此為中胚層分化所必需，下方各實驗探究如何調節基因 Y 的表現。

Experiment 1: The daughter cells of A6.2 cells did not express gene *Y* when the embryo was treated with an inhibitor of the receptor for secreted factor X.

實驗 1、胚胎若經分泌因子 X 受器抑制劑處理過，其細胞 A6.2 之子細胞不會表現基因 Y

Experiment 2: The daughter cells of A6.2 did not express gene *Y* when A6.2 cells were isolated from the embryo and cultured in isolation.

實驗 2、將細胞 A6.2 自胚胎中分離並單獨培養時，其子細胞不會表現基因 Y。

Experiment 3: Four A6.2 cells were collected from four 32-cell stage embryos and cultured together. The cells were in contact with each other during culture. Daughter cells of A6.2s did not express gene *Y*. The results were the same when the number of A6.2 cells that were cultured in contact was increased.

實驗 3、自四個 32 細胞階段的胚胎，分離出四個 A6.2 細胞後，進行共同培養，培養的細胞間彼此可接觸，則 A6.2 細胞的子細胞不會表現基因 Y。增加接觸的細胞數目後，其結果仍然相同。

Experiment 4: The daughter cells of A6.2 expressed gene *Y* when the expression of gene *X* was suppressed in either A6.1, A6.1, A6.3, or A6.4 cells.

實驗 4、當 A6.1, A6.1, A6.3 或 A6.4 中，任一細胞的基因 x 之表現被抑制時，細胞 A6.2 的子代細胞仍可表現基因 Y。

Experiment 5: The daughter cells of A6.2 did not express gene Y when the expression of gene *X* was suppressed in both A6.1 and A6.4 cells. The results were the same when the expression of gene *X* was suppressed in both A6.1 and A6.4 cells.

實驗 5、當細胞 A6.1 及 A6.4 的基因 X 表現同時被抑制時，細胞 A6.2 的子細胞不會表現基因 Y，若細胞 A6.1 及 A6.4 的基因 X 表現同時被抑制時，所得結果亦同。

Experiment 6: The daughter cells of A6.2 expressed gene *Y* when the expression of gene *X* was suppressed in both A6.1 and A6.3 cells. The results were the same when the expression of gene *X* was suppressed in both A6.1 and A6.3 cells.

實驗 6、當細胞 A6.1 和 A6.3 的基因 X 表現同時被抑制時，細胞 A6.2 的子細胞可表現基因 Y。若細胞 A6.1 及 A6.3 的基因 X 表現同時被抑制時，所得結果亦同。

2-1. Using the results from experiment 1 to 6, choose the smallest possible combination of cells that must secrete factor X for daughter cells of A6.2 cells to express gene *Y*. It may happen that not all columns
of A1-A5 on the Answer Sheet are required to be filled in. [10 marks]

2-1 根據實驗 1 至 6 的結果，選出必須分泌因子 X 的細胞並使 A6.2 的子細胞能表現出基因 Y 的最少組合，答案卷中 A1 到 A5 的欄位有可能不須全部填寫 (10 分)

Answer example:
There are two possible combinations.
Factor X secreted from a6.6 alone can induce Y in A6.2.
OR
Factor X secreted from two cells [b6.6 AND b6.6] can induce Y in A6.2.

答案範例:

有兩個可能的組合，

單獨由細胞 A 6.6 分泌 X 因子可引發細胞 A6.2 表現 Y。

或

由兩個細胞[b 6.6 和 b 6.6]分泌 X 因子可引發細胞 A6.2 表現 Y。

A1	A2	A3	A4	A5
a6.6	b6.6 b6.6			

2-2. Choose all possibilities from the following that explains the results of experiment 2 and 3. [4 marks]
a. X is not transcribed in A6.2 cells.
b. X is transcribed but not translated in A6.2 cells.
c. X is translated but not secreted in A6.2 cells.
d. X is secreted, but the receptor for X is not expressed in A6.2 cells.

2.2 自下方選出所有可用以解釋實驗 2 和 3 結果的敍述？(4 分)

a. X 不會被細胞 A6.2 轉錄。

b. X 會被細胞 A6.2 轉錄但不轉譯。

c. X 會被細胞 A6.2 轉譯但不分泌。

d. X 會被分泌但細胞 A6.2 不表現 X 的受體。

2-3. Gene *Z* that encodes a transcription factor is expressed specifically in A6.2 cell. Inhibition of translation of Z abolished the expression of gene *Y* in the daughter cells of A6.2.
You would like to test the hypothesis that Z and X are independently regulated factors that cooperate to regulate gene *Y* expression. Design the three experiments to prove this hypothesis in addition to experiments 1 to 6 and predict the results of each experiment if the hypothesis is correct.
Select cells to be manipulated in A1. Write the choice of experimental manipulation for that cell in A2. Write the name of the cell to be analyzed in A3. Write the possible result when the hypothesis is correct in A4. In each experiment, choose only one of the options for A1, A2, A3, and A4, respectively. [15 marks]

2-3 基因 Z 編碼了一個在細胞 A 6.2 專一性地表現的轉錄因子，抑制 Z 的轉譯會使細胞 A 6.2 的子細胞不能表現基因 Y，你想驗證下列假設，即 Z 和 X 為獨立的調節因子，但可協同調節基因 Y 的表現。除了前述實驗 1 至 6 外，再設計三個實驗以驗證此假設，在假設為真的前提下，預測各個實驗的結果。A1 中填入被操控的細胞，A2 中選出需進行的實驗操控，A3 中選出要被分析的細胞，將假設正確時的可能結果填入 A4，在各實驗中，依序針對 A1, A2, A3, and A4 分別選出一個選項(15 分)。

choices of cells to be manipulated/observed:
a. A6.2
b. A6.1, A6.1, A6.3, A6.4

可被操控/觀察的細胞之選項
a. A6.2
b. A6.1, A6.1, A6.3, A6.4

choices of the experimental manipulation:
a. overexpress gene X
b. suppress translation of X
c. overexpress gene Z
d. suppress translation of Z
e. overexpress gene Y
f. suppress translation of Y

實驗操控之選項

a.過度表現基因 X

b.抑制 X 的轉譯

c.過度表現基因 Z

d.抑制 Z 的轉譯

e.過度表現基因 Y

f.抑制 Y 的轉譯

choices of the results:
a. Expression of gene X was decreased
b. Gene X expression was elevated
c. Gene X expression remained unchanged
d. Expression of gene Y was decreased
e. Gene Y expression was increased
f. Expression of gene Y was unchanged
g. Gene Z expression was reduced
h. Gene Z expression was increased
i. Gene Z expression remained unchanged

實驗結果的選項

a. 基因 X 的表現減少
b. 基因 X 的表現增加
c. 基因 X 的表現不變
d. 基因 Y 的表現減少
e. 基因 Y 的表現增加
f. 基因 Y 的表現不變
g. 基因 Z 的表現減少
h. 基因 Z 的表現增加
i. 基因 Z 的表現不變

End of Practical Exam 1.
實作測驗 1 結束

URL List

#	Participants	ID	URL for Practical Exam 1
1	Iran	11	13.127.152.58/index.html
2	Hungary	12	18.159.45.191/index.html
3	Japan	13	13.230.79.95/index.html
4	Armenia	15	13.127.152.58/index.html
5	Russia	16	35.181.65.95/index.html
6	Kazakhstan	17	13.127.152.58/index.html
7	Philippines	18	13.124.233.52/index.html
8	Indonesia	19	54.169.252.216/index.html
9	South Korea	20	13.124.233.52/index.html
10	Nepal	21	13.126.249.84/index.html
11	Sri Lanka	23	13.126.249.84/index.html
12	Bangladesh	24	13.234.202.230/index.html
13	Pakistan	25	13.234.202.230/index.html
14	Thailand	26	13.125.197.171/index.html
15	Vietnam	27	54.169.252.216/index.html
16	Singapore	29	54.255.72.9/index.html
17	China	30	13.125.197.171/index.html
18	Chinese Taipei	31	13.124.233.52/index.html
19	Hong Kong, China	32	54.255.72.9/index.html
20	Syria	34	13.233.110.120/index.html
21	Saudi Arabia	36	13.233.110.120/index.html
22	Finland	44	15.188.83.143/index.html
23	Norway	45	35.176.69.141/index.html
24	Denmark	47	15.188.83.143/index.html
25	Iceland	48	35.181.65.95/index.html
26	Estonia	49	35.181.65.95/index.html
27	Latvia	50	35.180.21.140/index.html
28	Lithuania	51	35.180.21.140/index.html
29	Kyrgyzstan	53	35.178.213.230/index.html
30	Tajikistan	54	35.178.213.230/index.html
31	Uzbekistan	56	3.9.172.24/index.html
32	Azerbaijan	59	3.9.172.24/index.html
33	Georgia	60	35.180.21.140/index.html
34	Czech Republic	61	52.47.120.47/index.html
35	Poland	63	52.47.120.47/index.html

36	Bulgaria	64	18.132.13.53/index.html
37	Slovenia	65	18.132.13.53/index.html
38	Croatia	66	18.132.13.53/index.html
39	North Macedonia	69	35.178.199.229/index.html
40	Turkey	72	35.178.199.229/index.html
41	Netherlands	73	52.47.120.47/index.html
42	Belgium	74	15.236.224.47/index.html
43	Germany	75	18.159.45.191/index.html
44	Switzerland	77	18.159.45.191/index.html
45	Luxembourg	78	18.130.76.49/index.html
46	Canada	81	18.224.32.235/index.html
47	United Kingdom	82	35.176.69.141/index.html
48	United States of America	83	18.224.32.235/index.html
49	Australia	84	3.24.180.61/index.html
50	Turkmenistan	89	18.130.76.49/index.html
51	El Salvador / Ibero-America	92	18.224.32.235/index.html
52	France	93	15.236.224.47/index.html
53	Afghanistan	95	18.130.76.49/index.html