
Dear Participants!
參賽者請注意

In the laboratory **"GENETICS"** you will be given the following two tasks:
本遺傳實驗題中，你必須完成兩項實作。

Task 1. Genetic analysis of inheritance of seed coat colour in *Phaseolus vulgaris L.*
實作一、對菜豆種皮顏色的遺傳性狀進行分析。

Task 2. Identification of the *trp* mutations in the yeast *Saccharomyces cerevisiae.*
實作二、辨認酵母菌的 *trp* 基因突變。

Duration of the lab work is **60 minutes.**
本部分時間為 **60 分鐘。**

Maximum number of points – **61**.
滿分為 **61 分。**

You have to write down your results and answers on the **ANSWER SHEET**
你必須把實驗結果及答案填寫於**答案卷。**
which will be collected by an assistant when the time elapses. It is not necessary to
實驗時間結束時，助教會回收答案卷，你無需
write anything on the task sheets.
在題本上作答。

Good luck!
祝 好運

Country_____
國家
First name_____ Family name _____
名 姓
Code_____
考生編號

<u>Task 1. (30.5 points)</u> Genetic analysis of inheritance of seed coat colour in
實作一 (30.5 分)　　對菜豆種皮顏色的遺傳性狀進行分析。
Phaseolus vulgaris L.

Time for carrying out this task must not exceed 25 minutes
本部分做時間不可超過 25 分鐘

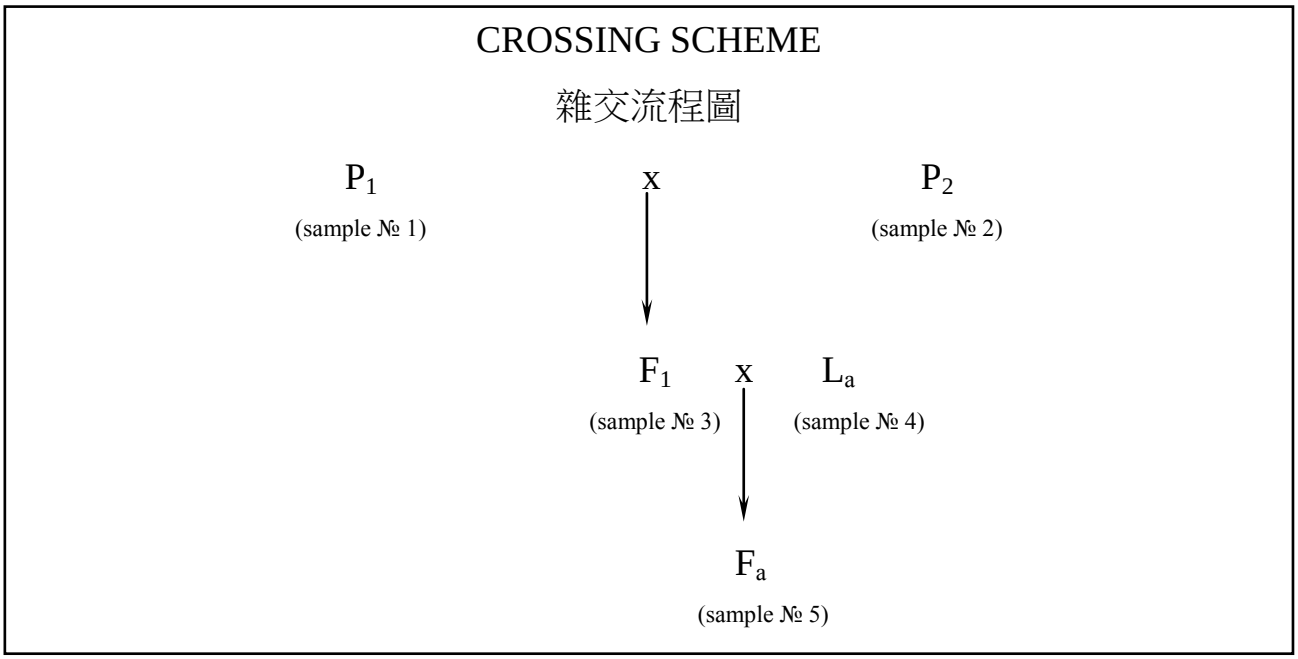
Materials and equipment
實驗材料及設備

1.	Parental sample seeds (P_1). 親代種子樣本 (P_1)	sample № 1 樣本編號 1
2.	Parental sample seeds (P_2). 親代種子樣本(P_2)	sample № 2 樣本編號 2
3.	Hybrid seeds (F_1). 雜交種子 (F_1)	sample № 3 樣本編號 3
4.	Test cross line seeds (L_a). 試交種子 (L_a)	sample № 4 樣本編號 4
5.	Seeds of F_a generation. F_a 代種子 (F_a)	sample № 5 樣本編號 5
6.	Petri dishes for seeds. 放置種子的培養皿	2
7.	Sheet of white paper. 白紙	1

The seed-coat colour of common beans (*Phaseolus vulgaris L.*) is controlled by a number
菜豆種皮的顏色由一群不同的基因所調控
of genes, which are responsible for the synthesis of pigments and distribution of the seed coat
這些基因可透過調控色素的合成、種皮顏色的分佈、
colour, as well as modifying genes, that can enhance, attenuate or change colour in another way.
以及其他基因的作用，來增強減弱或改變種皮的顏色。
In the preliminary experiments breeding of two types of common beans (P_1 and P_2)
初期實驗中將具有不同種皮顏色的菜豆予以雜交 (P_1 及 P_2)
differing in seed-coat colour was conducted. Seeds of F_1 plants were cultured. Plants (F_1)
把所得之子代種子 (F_1) 進行培植，成長後所得的種子
gave seeds of F_1 phenotype.
具有 F_1 的表現型。

On the next stage of the experiment test-crossing of F_1 plants with testcross line plants
在第二階段實驗中，利用 F_1 種子培植所得之植物與
(L_a) was conducted. Grown hybrids (F_a) gave seeds of F_a phenotype. For the next analysis, one
試交用之植物(L_a)進行試交，成長後所得的種子具有
seed from each F_a plant was taken.
F_1 表現型。

Scheme of the experiment.



Stages of the work:
本階段工作：

You are given parental sample seeds P_1 (sample № 1) and P_2 (sample № 2), hybrid seeds F_1 (sample № 3), testcross line seeds L_a (sample № 4) and seeds of F_a generation (sample № 5).
你獲得如下的種子樣本，包括親代 P_1 (樣本 № 1)、親代 P_2 (樣本 № 2)、子代 F_1 (樣本 № 3)、試交用種子(樣本 № 4)、F_a 子代種子(樣本 № 5)

Differences between parental samples are determined by different combinations of two pairs of non-allelic genes A and B (different gene loci). Gene A controls synthesis of pigment ("A" = dominant allele -pigment is present, "a" = recessive gene -pigment is absent). Gene B is a modifying gene, that influences colour intensity (B = dominant allele – modification is present, and b = recessive allele – modification is absent). Different combinations of two pairs of non-allelic genes A and B cause the development of three types of seed-coat colour (Table 1).
親代樣本的差異主要是由兩對非對偶基因 A 及 B，透過不同的組合而造成，基因 A 控制了色素的合成(A—代表顯性基因—會表現色素，a—代表隱性基因—不表現色素)；基因 B 調控基因的作用，會影響顏色的強度(B—代表顯性基因—會表現調控作用，b—代表隱性基因—不會表現調控作用)，兩對非對偶基因 A 及 B 的不同，會表現出三種不同的種皮顏色(表一)

Table 1
表一

Kind of seeds 種子的種類	Seed-coat colour 種皮的顏色	Code of the colour 顏色的代號
	White 白	**w**
	Yellow-brown 黃　棕	**y**
	Black 黑	**b**

You should accomplish the next problems:
你必須完成下一項題目

Determine if parental samples P_1 and P_2 are pure-breeding lines (homozygous at each gene locus).
辨別親代樣本 P_1 及 P_2 是否為純系交配(每一對對偶基因都是同型合子)。

- ❑ Determine the type of inheritance of seed-coat colour in common beans (presence of interaction of non-allelic genes A and B).
辨別菜豆種皮顏色的遺傳性狀種類(呈現非對偶基因 A 與 B 的交互作用)。

- ❑ Determine the genotypes of the parental forms of P_1 and P_2, hybrid seeds F_1, seeds of F_a generation and testcross line seeds L_a
辨別親代 P_1 及 P_2 、子代 F_1 、雜交種 F_a 、及試交種子 L_a 的基因型。

- ❑ Determine if the investigated non-allelic genes are linked.
辨別所分析的非對偶基因是否連鎖。

Attention! The differences in viability of zygotes or gametes of different types of analyzed common bean (*Phaseolus vulgaris L.*) samples were not detected. Genes A and B are localized in the nucleus.
注意！　分析的樣本中，合子或配子的存活率並無任何差異，基因 A 及 B 均位於細胞核內。

Problem 1.1. Determine if the parental samples P_1 and P_2 are pure-breeding lines (homozygous by every pair of non-allelic genes) by seed coat colour ? To answer this question you must analyze F_1 seeds.
問題 1.1　觀察樣本種皮的顏色，辨別親代樣本 P_1 及 P_2 是否為純系交配種？要回答此問題，你必須分析 F_1 種子。

1.1.1. (1.5 points) Look over samples № 1 and № 2. Specify the seed phenotypes of
題目 1.1.1(1.5 分) 觀察樣本 № 1 及 № 2，並利用前頁表一所列之符號標示親代
parental forms and F_1 using the symbols from Table 1 (Page 4). Fill in the table in the answer sheet: 及子代種子樣本的表現型。將答案填在答案卷所附之表中。

Plant seeds 植物種子	Sample 樣本	Seed phenotype 種子表現型
P_1	№ 1	
P_2	№ 2	
F_1	№ 3	

1.1.2. (2 points) Analyse the seed-coat phenotypes of parental samples and F_1
題目 1.1.2(2 分) 分析親代及 F_1 子代的表現型，並選擇
hybrids. Select the correct answer. On the answer sheet record in the symbols of correct answers:
正確的答案。在答案卷上填入代表正確答案的符號。

A. Both parental plants are homozygous.
兩個親代植物均為同型合子(同基因型)
B. Both parental plants are heterozygous.
兩個親代植物均為異型合子(異基因型)
C. Plant P_1 is homozygous, plant P_2 is heterozygous.
親代 P_1 為同型合子，親代 P_2 為異型合子
D. Plant P_2 is homozygous, plant P_1 is heterozygous.
親代 P_2 為同型合子，親代 P_1 為異型合子
E. Using the data presented it is impossible to determine, if the parental genotypes are pure-breeding lines.
若親代的基因型均為純系交配品系，以現有之資料無法進行判別。

1.1.2.:_____

Problem 1.2. Determine the type of inheritance of seed-coat colour in common beans.
問題 1.2 辨別菜豆種皮顏色遺傳性性狀的種類
You need to analyze the seeds of F_a plants, which were received after breeding of F_1 plants with L_a plants.
你需要分析 F_a 植物種子，這些種子是 F_1 植物與 L_a 植物交配之結果。

1.2.1. (1 point) Carefully place the seeds from sample № 5 (F_a plant seeds) on to the
題目 1.2.1(1 分) 小心將樣本 № 5 (F_a 植物種子)放在白紙上，
sheet of white paper. Identify the quantity of the phenotypic classes of F_a by seed-coat colour.
鑑定 F_a 種皮表現型類別的數目，利用培養皿把 F_a 種子按

Group the seeds of F_a by phenotypic classes by putting them into Petri dishes for seeds. Using
照表現型進行分類，利用表一所列的代號標明 F_a 的表現型，
the codes from Table 1 specify the phenotypes of F_a. Record in the table in the answer sheet.
請紀錄在答案紙所附的表中。

№ of class 類別之編號	**Seed phenotype** 種子之表現型
Total number of classes 類別之總數	

1.2.2. (3 points) Using your findings about the quantity of F_a classes, choose the type
1.2.2 (3 分) 利用你對 F_a 分類的結果，選擇非對偶基因 A、B
of interaction of non-allelic genes A and B, which control seed-coat colour in
交互作用的種類，二者中何者控制菜豆種皮的顏色？將正確答案之代號填在答
common beans. Record the symbols of correct answers on the answer sheet.
案紙上。

A. There is no interaction of non-allelic genes in the experiment conducted.
本實驗中，非對偶基因並無交互作用。
B. Incomplete dominance.
不完全顯性。
C. Duplicate genes
多重複基因。
D. Epistasis
上位基因。
E. Codominance.
等顯性或共同顯性。
F. Pleiotropic gene action.
基因多效性作用。

1.2.2:_____

Problem 1.3. Determine the genotypes of the parental samples P_1 and P_2, hybrid seeds
問題 1.3 辨別親代樣本 P_1, P_2、雜交子代 F_1、F_a 世代種子，及
F_1, seeds of F_a generation and testcross line seeds (L_a)
世交種子(L_a)的基因型。

1.3.1. (4 points) Specify all of the possible genotypes of P_1, P_2, F_1, F_a, and L_a plants
1.3.1 (4 分) 寫出 P_1, P_2, F_1, F_a, 及 L_a 植物之可能基因型，
using symbols "*A*" and "*B*" to mark the dominant alleles, symbols "*a*" and "*b*" to mark the
利用符號 A 及 B 表示顯性對偶基因，利用符號 a 及 b 代表隱性
recessive alleles of the investigated genes in the boxes of the table below. Fill in
對偶基因，寫在如下所附的表格中，但必須填在答案卷上。
the table in the answer sheet.

Plants 植物	Seed phenotype 種子表現型		
	Black 黑	**Yellow-brown** 黃棕	**White** 白
P_1			
P_2			
F_1			
L_a			
F_a			

Problem 4. Determine if the investigated non-allelic genes A and B are linked.
問題 4 辨別所分析的非對偶基因 A 及 B 是否聯鎖。

1.4.1. (1 point) Determine frequency of phenotypic classes in F_a by seed colour.
1.4.1(1 分) 利用種子的顏色辨別 F_a 不同表現型種類出現之
To answer this question calculate the number of seeds in each class. Use the codes from Table 1.
頻率。回答此問題必須計算不同表現型種類種子的數量。利用表一之代碼。
Fill in the table in the answer sheet.
答案必須填在答案紙所附之表格中。

№ of class 類別之編號	**Seed phenotype** 種子的表現型	**Number of seeds** 種子的數量
Total number of seeds 種子的總數		

1.4.2. (3 points) Determine the ratio of the different phenotype classes by the colour of the seeds in F_a. Fill in the answer sheet using the code of the correct answer:

1.4.2 (3 分) 利用 F_a 種皮之顏色判定不同種類表現型之比例，在答案紙上填入正確答案之代碼。

Code 代碼	**White** 白色	**Yellow-brown** 黃棕色	**Black** 黑色
A.	**0.50**	**0.25**	**0.25**
B.	**0.50**	**0.19**	**0.31**
C.	**0.56**	**0.16**	**0.28**
D.	**0.42**	**0.14**	**0.44**
E.	**0.44**	**0.15**	**0.41**
F.	**0.50**	**0.14**	**0.36**

1.4.2.:_____

1.4.3. (3 points) To determine whether there is linkage between the genes being investigated you must specify the **expected ratio** in F_a in the case of **no** linkage**.** You an receive the points for this task only if your answer for 1.2.2. is correct. Record in the table in the answer sheet:

1.4.3 (3 分) 欲辨別所分析基因的聯鎖性，你必須標示出 F_a 種子在不聯鎖時的期待比例，只有你在 1.2.2 中提供正確的答案，你才可在此題獲得分數，請將答案填入答案卷所附之表格中。

Phenotypic class 表現型的類別	Ratio (%) 比率(%)
White seeds **白種子**	
Yellow-brown seeds **黃棕種子**	
Black seeds **黑種子**	

1.4.4. (3 points) Specify the **expected ratio** by seed colour in F_a if the
1.4.4 (3 分) 假設所分析的基因 A 和 B 為完全聯鎖，請辨別
investigated genes *A* and *B* are linked completely. You can receive the points for this task only if F_a 種皮顏色比例的期待值，只有你在 1.2.2 中提供正確的答案時，你才可在此題獲得分數
your answer for 1.2.2. is correct. Record in the table in the answer sheet:
請將答案填入答案卷所附之表格中。

Phenotypic class 表現型的類別	Ratio (%) 比率(%)
White seeds **白種子**	
Yellow-brown seeds **黃棕種子**	
Black seeds **黑種子**	

1.4.5. (3 points) Using χ^2 method, determine whether to reject or not-reject (accept)
1.4.5 (3 分) 使用卡方分析來拒絕或接受"基因無聯鎖"的假設。
your hypothesis

Calculate the χ^2 value for H_0 (null hypothesis)being "No linkage" using the formula below:
利用下數公式計算虛無假設的卡方值，虛無假設為"基因無聯鎖"。

$$\chi^2 = \Sigma((E_i - O_i)^2 / E_i),$$

where E_i is the expected frequency of the phenotype class i. O_i is the
公式中，E_i 代表虛無假設中某表現型出現頻率的期待值，O_i 是
practically observed frequency of the same class. Use two decimal places during your
所觀察到某表現型實際出現的頻率。請把計算所得的結果以
calculations. Record in the answer sheet by the χ^2 value (with two decimal places).
小數點後兩位方式表示。把計算所得的卡方值填入答案卷中(以小數點後兩位方式表示)。

1.4.5._____

1.4.6. (3 points) Use the table of χ^2 distribution to determine what is the maximum
1.4.6 (3 分) 利用下頁所附的卡方分配表，找出虛無假設之最大
probability (p) of your H_0 (null hypothesis)not being rejected (being accepted). Write the codes
可能機率(p)，藉以判別虛無假設是否正確。將下頁代表正確答案的代碼填入答案卷中。
of the answers on your answer sheet.

Table of χ^2 distribution 卡方分配表

df	Value (p) of a significance level χ^2 卡方值(p)的顯著水準									
	0.99	**0.95**	**0.90**	**0.75**	**0.50**	**0.25**	**0.10**	**0.05**	**0.025**	**0.01**
1	-	-	0.02	0.10	0.45	1.32	2.71	3.84	5.02	6.63
2	0.02	0.10	0.21	0.58	1.39	2.77	4.61	5.99	7.38	9.21
3	0.11	0.35	0.58	1.21	2.37	4.11	6.25	7.81	9.35	11.34
4	0.30	0.71	1.06	1.92	3.36	5.39	7.78	9.49	11.14	13.28
5	0.55	1.15	1.61	2.67	4.35	6.63	9.24	11.07	12.83	15.09
6	0.87	1.64	2.20	3.45	5.35	7.84	10.64	12.59	14.45	16.81
7	1.24	2.17	2.83	4.25	6.35	9.04	12.02	14.07	16.01	18.48
8	1.65	2.73	3.49	5.07	7.34	10.22	13.36	15.51	17.53	20.09
9	2.09	3.33	4.17	5.90	8.34	11.39	14.68	16.92	19.02	21.67
10	2.56	3.94	4.87	6.74	9.34	12.55	15.99	18.31	20.48	23.21

A. < 0.01
B. > 0.01
C. < 0.05
D. > 0.05
E. 0.01
F. 0.05

1.4.6. _____

1.4.7. (3 points) Using your value of p, determine if genes A and B are linked
1.4.7 (3 分) 使用你的 p 值，判別基因 A 和 B 是否聯鎖

. Calculate the distance between genes A and B (in cM) if they linked. Record in the
假如基因 A 和 B 為聯鎖，請計算兩者間的距離，以圖單位(cM)來表示。
answer sheet the code of correct answer.
請在答案卷中填入代表正確答案的代碼。

A. There is complete linkage between genes A and B. The distance between the genes is 6.94 cM.
基因 A 和 B 為完全聯鎖，兩者的距離為 6.94cM

B. There is complete linkage between genes A and B. The distance between the genes is 12.36 cM.
基因 A 和 B 為完全聯鎖，兩者的距離為 12.36cM

C. There is complete linkage between genes A and B. The distance between the genes is 27.78 cM.
基因 A 和 B 為完全聯鎖，兩者的距離為 27.78cM

D. There is incomplete linkage between genes A and B. The distance between the genes is 6.94 cM.
基因 A 和 B 為不完全聯鎖，兩者的距離為 6.94cM

E. There is incomplete linkage between genes A and B. The distance between the genes is 12.36 cM.

基因 A 和 B 為不完全聯鎖，兩者的距離為 12.36cM

F. There is incomplete linkage between genes A and B. The distance between the genes is 27.78 cM.

基因 A 和 B 為不完全聯鎖，兩者的距離為 27.78cM

G. Genes A and B are not linked. The distance between the genes is 6.94 cM.

基因 A 和 B 並無聯鎖，兩者的距離為 6.94cM

H. Genes A and B are not linked. The distance between the genes is 12.,36 cM.

基因 A 和 B 並無聯鎖，兩者的距離為 12.36cM

I. Genes A and B are not linked. The distance between the genes is 27.78 cM

基因 A 和 B 並無聯鎖，兩者的距離為 27.78cM

J. Genes A and B are not linked

基因 A 和 B 並無聯鎖

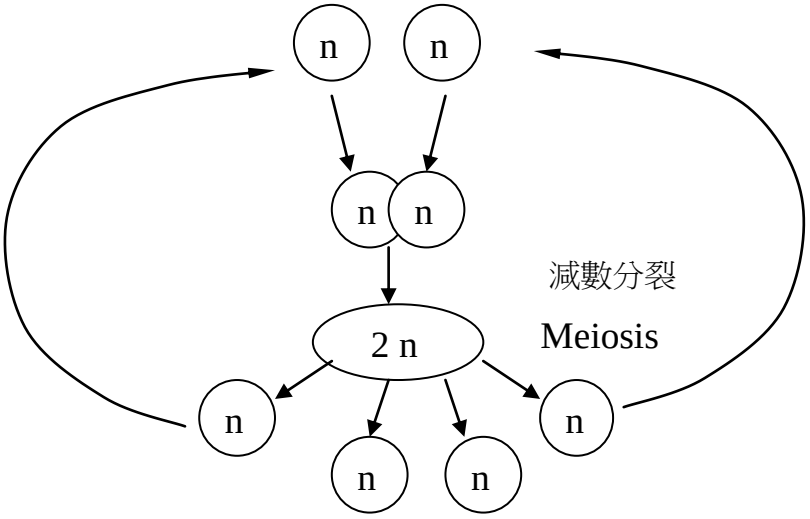
1.4.7:

Task 2: (30.5 points) Identification of *trp* mutations in yeast *Saccharomyces cerevisiae*
實作 2 (30.5 分)　　鑑別酵母菌的 *trp* 突變

Materials and equipment
實驗材料及設備

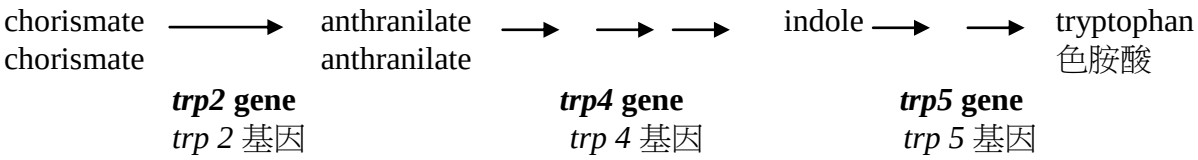
1.	Tubes with culture liquid. 含有培養液的試管	12
2.	A plate with 12 wells. 12 孔的培養皿	1
3.	A tube with Erlich reagent. 含有 Erlich 試劑的試管	1
4.	A tube with indole solution. 含有　　溶液的試管	1
5.	A tube with anthranilate solution. 含有 anthranilate 溶液的試管	1
6.	A tube with water. 含有清水的試管	1
7.	1 ml pipette. 1 ml 的吸管	13
8.	A sheet of white paper. 白紙一張	1
9.	A container for used pipettes. 放置使用過的吸管的容器	1
10.	Paper towels. 紙巾	1

You are given the yeast *Saccharomyces cerevisiae* as an experimental organism. The
本實驗將使用酵母菌作為實驗材料，下圖為酵母菌生活史的簡圖。
scheme of life cycle of this organism is presented below.



These yeasts have alternating haploid and diploid phases during their life cycle. The fusion
在酵母菌的生活史中分別存在單倍體及雙倍體世代。單倍體可融合成雙倍體，
of haploid cells gives rise to a diploid cell which through meiosis can produce four haploid cells
在透過減數分裂形成四個單倍體細胞，且各自具有不同的基因型。
with different genotypes.

The scheme below shows the pathway of tryptophan biosynthesis in the yeast
下列式子表示的是酵母菌體內色胺酸的合成過程。
Saccharomyces cerevisiae. The scheme shows some intermediate products and genes responsible
式子中還列出一些中間產物以及決定特定酵素的基因。
for the synthesis of enzymes of this pathway.



Mutations in the ***trp*** genes lead to the accumulation of the intermediates in the culture
trp 基因的突變將導致培養液內中間產物的累積。
liquid. Two intermediates of this biosynthetic pathway, anthranilate and indole, can be detected
在此生化反應中的 2 個中間產物 anthranilate 與 ，可以用加入 Erlich 試劑
in the culture liquid of the corresponding mutants through colour reactions with the Erlich
至培養液中並觀察其顏色變化的方式，來檢測是否有相對應的突變。
reagent.

2.1. (1.5 points) Using a special pipette, add 0.5 ml of Erlich reagent to the control
2.1 (1.5 分) 使用一特殊的吸管(pipette)，將 0.5ml 的 Erlich 試劑分別加入
tubes with standard solutions of anthranilate, indole and to the tube with water (with no
含有 anthranilate、 以及水(沒有 anthranilate 也沒有)的標準溶液中。觀察顏色變
anthranilate and indole). Observe the colour change and record it in the table in the answer sheet
化，並以代號紀錄在答案卷的表格內。
using single letter colour code.

Compound 化合物	**Colour after Erlich reagent addition** 加入 **Erlich** 試劑後的顏色
Water 水	
Anthranilate **Anthranilate**	
Indole	
Colour code: 顏色代號：	**Y – yellow** **Y - 黃色** **R – red** **R – 紅色** **N – no colour change** **N – 無顏色變化**

2.2. (1.5 points) Which compounds will accumulate in the culture liquid if the
2.2 (1.5 分) 如果突變種生長在營養充裕的培養基內，何種化合物會累積在培養
mutants are grown in the rich medium? Fill in the table below in the answer sheet using one
液裡？用代號在答案卷的表格內作答。
letter code.

Mutant **突變種**	**Accumulated intermediate** **累積的中間產物**
trp 2 $^{-}$	
trp 4 $^{-}$	
trp 5 $^{-}$	
Code: 代號：	**A – anthranilate** **A - anthranilate**
	I – indole **I –**
	O – neither anthranilate nor indole **O – 既無 anthranilate** 也無

2.3. (6 points) Three classes of double mutants have been constructed in haploid *S.*
2.3 (6 分) 三種雙突變的酵母菌單倍體被標示成 *trpX* $^{-}$ *trpY* $^{-}$ *trpZ* $^{+}$
cerevisiae named as ***trpX*** $^{-}$ ***trpY*** $^{-}$ ***trpZ*** $^{+}$***; trpX*** $^{-}$ ***trpY*** $^{+}$ ***trpZ*** $^{-}$***; trpX*** $^{+}$ ***trpY*** $^{-}$ ***trpZ*** $^{-}$(sign «– »
trpX $^{-}$ *trpY* $^{+}$ *trpZ* $^{-}$*; trpX* $^{+}$ *trpY* $^{-}$ *trpZ* $^{-}$ (符號"-"表示突變基因，"+"表示野生型基因，
denotes mutant genes, sign « + » denotes wild type genes; all ***trp*** genes are located on different
所有 *trp* 基因都位於不同染色體上)
chromosomes).

Three matings between these mutants have been performed as shown in the table below.
三個突變種之間的三種配對方式如下表所示。
Each mating has generated all possible types of haploid progeny.
每種配對都產生出所有可能單倍體子代。
Please write down in the answer sheet the genotypes of all possible progeny from each
請在答案卷上寫出各種配對所能產生出所有子代的基因型。
cross.

№	Mating 配對	Possible progeny genotypes 可能的子代基因型
I	***trpX*** $^-$ ***trpY*** $^-$ ***trpZ*** $^+$ × ***trpX*** $^-$ ***trpY*** $^+$ ***trpZ*** $^-$	
II	***trpX*** $^-$ ***trpY*** $^-$ ***trpZ*** $^+$ × ***trpX*** $^+$ ***trpY*** $^-$ ***trpZ*** $^-$	
III	***trpX*** $^-$ ***trpY*** $^+$ ***trpZ*** $^-$ × ***trpX*** $^+$ ***trpY*** $^-$ ***trpZ*** $^-$	

2.4. (12 points) Clones produced by these matings have then been grown in liquid
2.4 (12 分) 這些配對所產生出的株落被培養在液態培養基內，離心去除
medium, cells removed by centrifugation and supernatant collected for analysis. You now
細胞，取上清液用以鑑定。現在你必須鑑定這些株落。
need to identify these clones.

Please test each of the 12 culture liquid samples for the presence of the tryptophan
請檢測這 12 管培養液是否有色胺酸代謝時的中間產物，並使用這些數據來鑑定
metabolic intermediates and use these data for the identification of the ***trpX*** $^-$***, trpY*** $^-$ and ***trpZ*** $^-$
trpX $^-$*, trpY* $^-$ 以及 *trpZ* $^-$ 等突變。
mutations. You are given tubes with supernatants from 12 cultures of *S. cerevisiae.* The tubes are
你將會拿到 12 管酵母菌的上清液，這些管子將以前述的配對方式(I, II 與 III)
labelled according to the mating (I, II and III) and clone number (1-4).
以及株落別(1~4)來標示。

To test the accumulation of particular compounds, transfer 1 ml of liquid from each tube to
為了要檢測特殊化合物的累積，將每管內的液體取 1ml 並置入 12 孔培養皿的孔內。
the wells of the 12-well plate. **Use a new pipette for each transfer!**
每次的吸取都要用新的吸管(pipette)。

Add 0.5 ml of the Erlich reagent (using a special pipette) to each well containing the 1 ml
加入 0.5ml Erlich 試劑(使用特殊的吸管)到已經有 1ml 上清液的孔(well)內，
of supernatant. Record the colour changes (using a single letter code) in the table in the
將顏色變化紀錄在答案卷的表內(用代號作答)。
answer sheet.

Determine which compound has accumulated in each culture and record this in the same table in the answer sheet using a single letter code.

鑑別各試管中培養液內累積的化合物種類，並以代號作答在答案卷的同一表格內。

№	Mating 配對	Tube № 編號	Colour after Erlich reagent addition 加入 Erlich 後的顏色	Accumulated intermediate 累積的中間產物
I	***trpX*⁻ *trpY*⁻ *trpZ*⁺ × *trpX*⁻ *trpY*⁺ *trpZ*⁻**	**I.1**		
		I.2		
		I.3		
		I.4		
II	***trpX*⁻ *trpY*⁻ *trpZ*⁺ × *trpX*⁺ *trpY*⁻ *trpZ*⁻**	**II.1**		
		II.2		
		II.3		
		II.4		
III	***trpX*⁻ *trpY*⁺ *trpZ*⁻ × *trpX*⁺ *trpY*⁻ *trpZ*⁻**	**III.1**		
		III.2		
		III.3		
		III.4		
Code: 代號：			**У – yellow** **Y – 黃色** **R – red** **R – 紅色** **N – no colour change** **N – 無顏色變化**	**A – anthranilate** **A – anthranilate** **I – indole** **I –** **O – neither anthranilate nor indole** **O – 不是 anthranilate 也不是**

2.5. (3 points) Identify the ***trpX*⁻, *trpY*⁻** and ***trpZ*⁻** mutations. Write down names of the genes in which the ***trpX*⁻, *trpY*⁻** and ***trpZ*⁻** mutations are located in the table in the answer sheet.

2.5 (3 分) 鑑定 *trpX*⁻, *trpY*⁻ 與 *trpZ*⁻ 突變，在答案卷的表格內填入 *trpX*⁻, *trpY*⁻ 與 *trpZ*⁻ 突變基因分別對應至 *trp2*、*trp4* 或 *trp5* 的何者。

Gene 基因	Mutation 突變
trp 2	
trp 4	
trp 5	

2.6. (3 points) How would the experimental results change if the
2.6 (3 分) 如果 ***trpX*** $^{-}$ 與 ***trpY*** $^{-}$ 突變基因為完全聯鎖，
trpX $^{-}$ and ***trpY*** $^{-}$ genes were completely linked? Record in the answer sheet
實驗結果將會變成如何？將正確答案答案的代號填於答案卷內。
the letter corresponding to the correct answer:

A. The number of different progeny genotypes would be reduced.
子代基因型的種類將會減少。
B. The results would not be changed.
結果不會改變。
C. Phenotypically wild type yeast may be produced.
有可能產生野生種表現型的酵母菌。
D. The number of single and triple mutants would increase.
單突變及三突變的數量將會增加。

2.6.:_____

2.7. (1.5 points) How many genotype classes would be obtained if the three genes
2.7 (1.5 分) 如果 *trpX* $^{-}$, *trpY* $^{-}$ 與 *trpZ* $^{-}$ 突變基因都位於同一染色體上且
were located on the same chromosome and were 100 per cent linked? Write the number for each
完全聯鎖，則會產生幾種基因型種類？在答案卷填入每種配對的數量。
mating in the answer sheet.

2.7.: I_____

II_____

III_____

2.8. (0.5 points) Which mating will give the single mutant accumulating
2.8 (0.5 分) 哪種配對會產生累積 anthranilate 的單一突變？
anthranilate? Write the mating number (I, II or III) in the answer sheet.
在答案卷內填入配對代號(I, II 或 III)。

2.8.:_____

2.9. (0.5 point) Write the genotype of this mutant in the answer sheet using the actual gene names (***trp 2***, ***trp 4*** or ***trp 5***).
2.9 (0.5 分) 用實際的基因名稱(*trp2*、*trp4* 或 *trp5*)在答案卷內寫下這個突變種的基因型。

2.9.: _____

2.10. (1 point) Which of the double mutants has to be mated with this anthranilate-accumulating single mutant to get progeny with wild type genotype? Write the genotype of this double mutant in the answer sheet using the actual gene names (***trp 2***, ***trp 4*** or ***trp 5***).
2.10 (1 分) 如果要產生野生種表現型的子代，必須要以何種雙突變的個體與此一會累積 anthranilate 的單突變個體交配？以實際的基因名稱(*trp2*、*trp4* 或 *trp5*)於答案欄中寫出此一雙突變種的基因型。

2.10.: _____