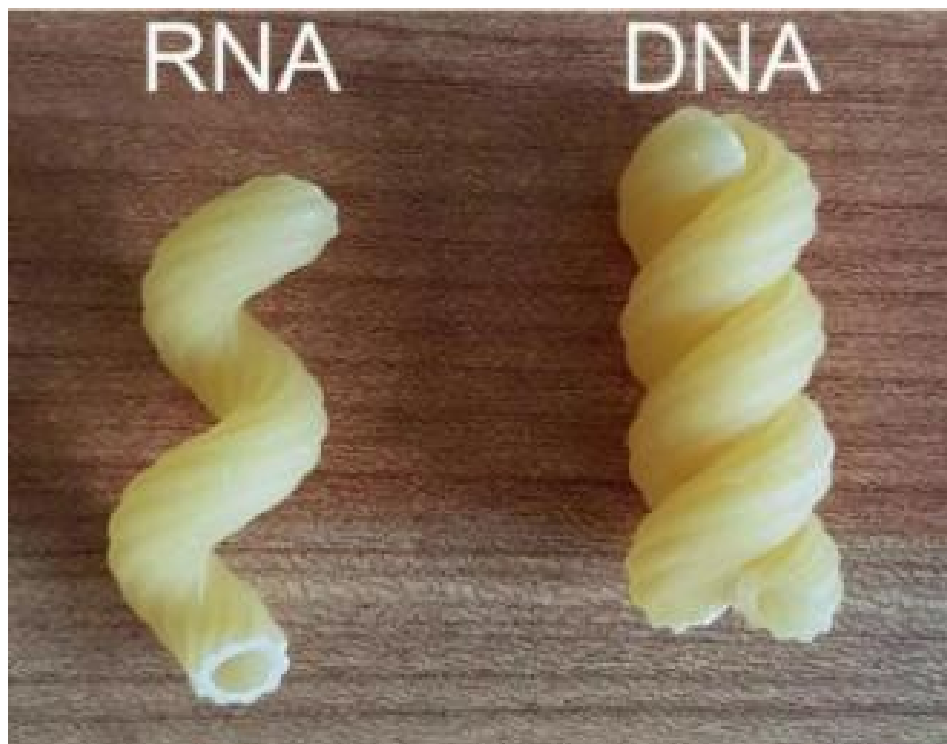


2021-2022 SciOly Summer Study Session

Bio-Process Lab

Division B

Exam Key



Total Score: ____/100

- I. Section 1: ____/25
- II. Section 2: ____/20
- III. Section 3: ____/25
- IV. Section 4: ____/30

Written by: Ninn

Instructions and Information

- 50 minutes will be given for the exam
- This test is divided into 4 sections:
 - 2 sections are shorter in length, and 2 are longer in length
 - There is no time limit as to how long a team can spend per sections
- All questions are worth 1 point unless otherwise specified.
 - Multiple select questions are graded as: (# of correct answers) - (# of incorrect answers)
 - ½ credit is awarded for correct work but incorrect answers on calculation questions
- This test requires use of **non-programmable calculators**

Good luck!

Section 1 - Microbiology lab

Suppose that the distance between the divisions on the stage micrometer (the larger lines) in **Figure A** is 0.1mm.

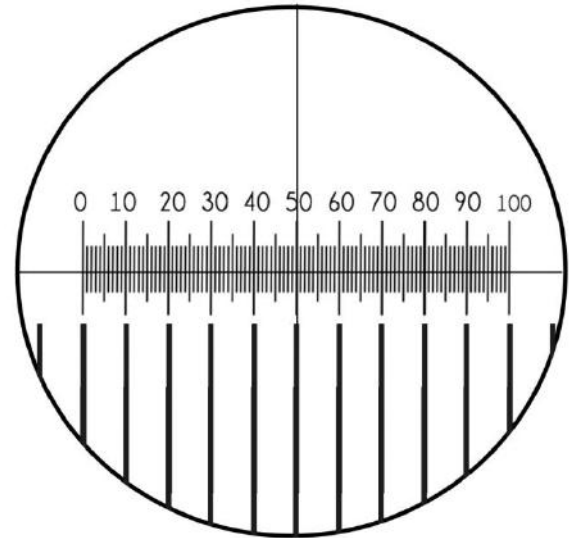


Figure A: 100X Total Magnification

1. If the eyepiece magnification is 10X, what is the objective magnification of the scope? **10X**
 $(100 \times \text{Total Magnification}) / (10X) = 10X$
2. Estimate the FOV of the scope in **figure A**. **Roughly 1.2mm (count divisions of the stage micrometer).**
3. [2 points] Calibrate the length of one smaller division on the ocular scale (the smaller lines) of **figure A**. State the answer in μm .
 $0.1\text{mm} \times 10$ (10 division of the bottom lines = length of ocular scale) = 1mm
 $1\text{mm} / 100 = 0.01\text{mm}$
 $0.01\text{mm} \times 1000 = 10\mu\text{m}$
4. [2 points] In μm , what would the length between two divisions of the ocular scale be if the same scope was at 40X power? **$25\mu\text{m}$**
 $100 / 40 = 2.5$
 $2.5 \times 10 = 25$

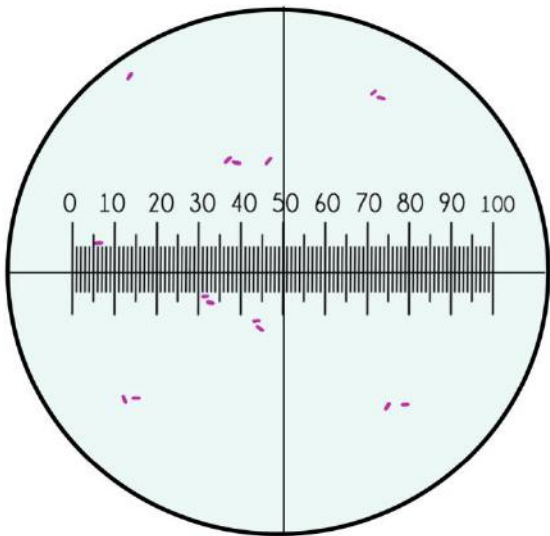


Figure B: 1000X Total Magnification

Figure B shows a diluted sample of *E. coli* bacteria under 1000X magnification.

5. [2 points] In μm , what would the length of the smaller division be on 1000X power? **$1\mu\text{m}$**
 $100 / 1000 = 0.1$
 $0.1 \times 10 = 1$
6. Estimate the size of a single *E. coli* cell. **$2\mu\text{m}$**
(From #5):
1 division of the ocular scale = $1\mu\text{m}$
Leftmost cell on scale can be used for reference

For fun, you take a scanning electron microscope picture of your *E. coli* shown in **figure C**.

7. What process is the cell indicated by the yellow arrow undergoing? **Binary fission**
(mitosis is an incorrect answer)

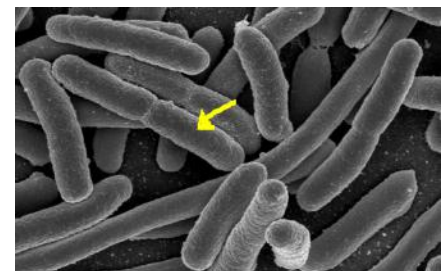


Figure C

Bacteria are able to take up foreign genetic material in a process known as transformation.

8. [2 points] Transformation is also possible in multicellular organisms, but transformation procedures are rarely carried out in said organisms. Briefly explain a complication that would prevent labs from transforming multicellular organisms. **For a multicellular organism to fully express a gene, either (1) many cells would have to be introduced to the gene or (2) a gene would have to be introduced to a single cell, which then grows into other cells. Both of these options are more difficult than only transforming one bacterial cell.**
***either (1) or (2) will be worth 2 points -- additional answers with proper justification may be accepted**

You want to insert a plasmid containing 3 genes into *E. coli*:

1. **pGLO** - expresses a green fluorescent protein.
2. **araC** - in the presence of arabinose, it recruits RNA polymerase to transcribe many mRNA copies of pGLO
3. **Amp** - codes for resistance to ampicillin, a common antibiotic.

You perform a transformation procedure that exposes some *E. coli* cells to your plasmid. You expect that the *E. coli* cells that pick up the plasmid to both floresce and be resistant to ampicillin. To evaluate your results, you make four plates, shown in **Figure D** below, on which you will grow your bacteria.

All bacteria are grown on the Luria-Bertani (**LB**) growth medium, which contains all nutrients needed for their survival. **AMP** denotes plates that contain ampicillin. **+plasmid** indicates that *E. coli* that have been exposed to the plasmid are growing on the medium, while **-plasmid** indicates that the bacteria growing on the medium have not been exposed to the plasmid. Arabinose sugar is present on plates denoted by **ARA**.

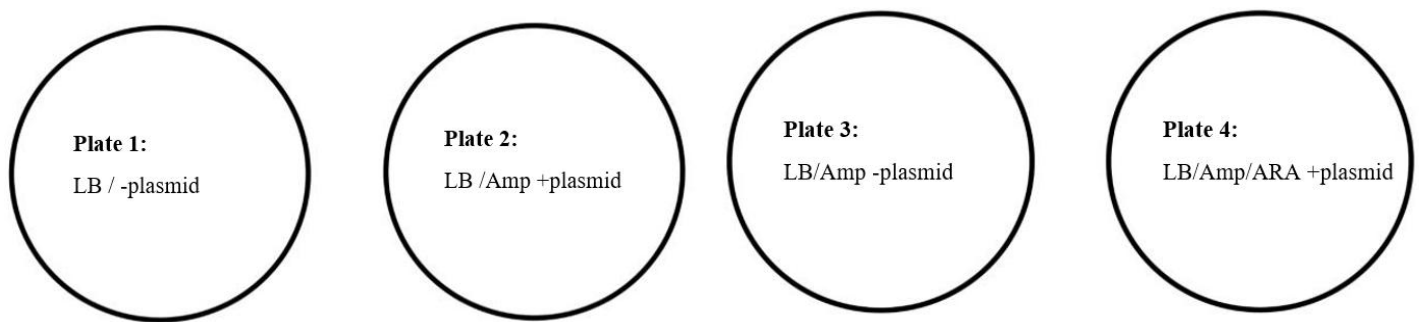


Figure D

9. What biological macromolecule is the plasmid composed of? **Nucleic acids**
10. [2 points] Which plate is the positive control? Explain. **(1) Plate 1: LB/-plasmid (2) a positive control is a condition where the effects of a treatment are known, you would expect *E. coli* to grow on the plate with LB and the plasmid since there are no antibiotics on the plate.**
11. [2 points] Which plate is the negative control? Explain. **(1) Plate 3: LB/AMP -plasmid (2) a negative control is a condition where your experimental treatment is expected to have no effect, you would expect no bacteria to grow on the plate with ampicillin without a plasmid since the antibiotic would kill off the *E. coli***
12. State an alternate hypothesis for your experiment. **The *E. coli* transformed by the plasmid will grow on the agar plate with ampicillin.**
13. [2 points] State a null hypothesis for your experiment. **There will be no difference in bacterial growth between the plates. (A null hypothesis is hypothesis that claims there is no statistical significance of a variable)**

After the plasmid is introduced to *E. coli*, the plates created are placed in an incubator at 37°C. After 24 hours, a picture of the complete experiment is taken as shown below in **Figure E**.

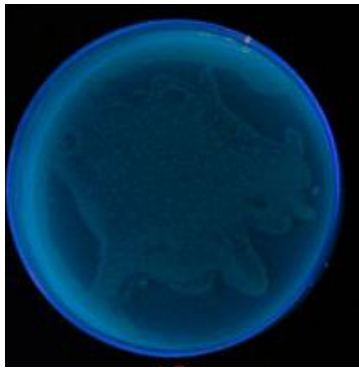


Plate 1: LB/-plasmid

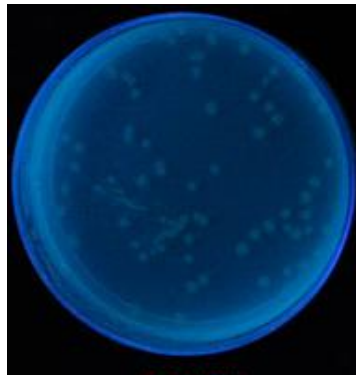


Plate 2: LB/Amp +plasmid

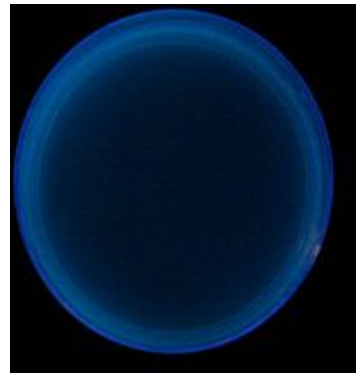


Plate 3: Lb/Amp -plasmid

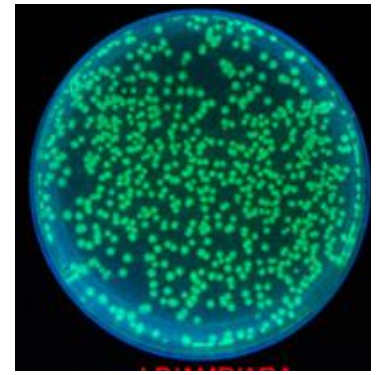


Plate 4: LB/Amp/ARA +plasmid

Figure E

14. [2 points] Predict how the growth on your plates would differ if you grew the plates at a significantly lower temperature (such as 20°C). Explain. (1) Growth would be reduced (2) since the rate of enzymatic reactions involved in metabolism would decrease
15. [2 points] Why does only plate 4 contain fluorescent bacteria? (1) Only bacteria that picked up the plasmid containing the fluorescence and ampicillin resistance would have survived here (2) the presence of arabinose sugar means the fluorescent protein is expressed in these colonies
16. [2 points] Compare the cell density of plate 1 with plates 2 and 4. What does this indicate? (1) Since plate 1 has less bacteria growth than plates 2/4 (2) not all the bacteria could take up the plasmid.

Section 2 - Food Web

Shown below is a simplified table of the dietary composition of various organisms in a particular forest environment.

Organism	Food Source (% of diet)				
	Cranberries	Aphids	Lacewings	Sparrows	Crows
Cranberries					
Crows	40		40	20	
Aphids	100				
Lacewings	10	90			
Sparrows	50	30	20		

The food web to the right is created using the organisms in the table above.

Identify the organisms that would fill the blanks denoted by the following letters:

17. Label A: _____ Aphids
18. Label B: _____ Lacewings
19. Label C: _____ Sparrows
20. Label D: _____ Crows

21. A food web shows the flow of _____ in an ecosystem. Energy
22. Which of the following are represented in the food web? (select all that apply)

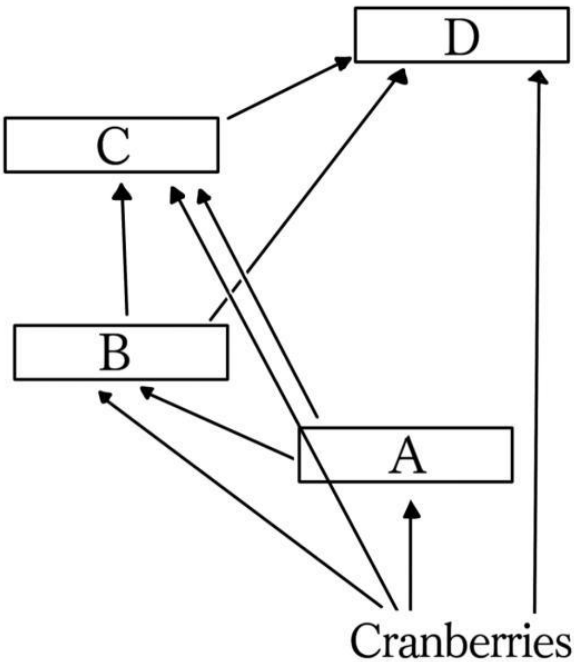
a. Herbivore

b. Carnivore

c. Omnivore

d. Detritivore

e. Decomposer



A survey of the sparrow and crow populations of this forest show the following:

Organism	Estimated Population Size
Sparrows	5,479
Crows	692

23. [3 points] Why are there a greater number of sparrows than crows? (1) crows are of a higher trophic level (2) energy is lost as one moves up the trophic levels due to heat production/other biological processes, this means that (3) less energy is available to crows at the top, so their population has to be less than that of sparrows for the ecosystem to remain in balance

A large portion of the forest is sprayed with a pesticide that kills off aphids.

24. In the short-term, which of the following organisms would be most affected by the sudden decrease in aphids?
- a. Crows
 - b. Lacewings
 - c. Sparrows
25. [3 points] Explain your answer above. (1) Aphids make up the largest portion of a lacewing's diet (90%). This (2) decrease in the lacewings' food source (2) in combination with predation by sparrows and crows results in its population being most affected
26. A student that has never visited the forest before states that, after a decrease in the population of aphids, consumption of cranberries by lacewings will increase. Is this an observation or inference? Inference
27. [2 points] Briefly define top-down and bottom-up population controls in an ecosystem.
- (1) Top-down (predator-controlled): lower trophic level populations are controlled by the population of organisms at the top.
- (1) Bottom-up (resource-controlled or food-limited): higher trophic level populations are controlled by the population of organisms at the bottom.

Oh no! The pesticide that kills aphids is also toxic to the other organisms in the ecosystem. In a process known as biomagnification, toxins begin to build up in the food web.

28. [3 points] Which level of the food chain would be most affected by this biomagnification? Explain. (1) The highest level/crows (2) lower trophic levels tend to have lower levels of contaminants, as these toxins travel up the food chain, they (3) become concentrated in the higher predators

Station 3 - Skinks!

You are raising some skinks in a lab. You mostly feed the skinks wet food, and are trying to decide which brand of food you should buy:

Nutrition Facts	
5 servings per container	
Serving size	2 oz (56g)
Amount Per Serving	
Calories	250
% Daily Value*	
Total Fat 30g	38%
Saturated Fat 3g	15%
Trans Fat 2g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 2g	1%
Dietary Fiber 6g	21%
Total Sugars 3g	
Includes 2g Added Sugars	4%
Protein 40g	80%
Not a significant source of vitamin D, calcium, iron, and potassium	
*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.	

Food X

Nutrition Facts	
8 servings per container	
Serving size	3 oz (85g)
Amount Per Serving	
Calories	170
% Daily Value*	
Total Fat 17g	22%
Saturated Fat 2g	10%
Trans Fat 3g	
Cholesterol 0mg	0%
Sodium 0mg	0%
Total Carbohydrate 1g	0%
Dietary Fiber 4g	14%
Total Sugars 1g	
Includes 0g Added Sugars	0%
Protein 35g	70%
Not a significant source of vitamin D, calcium, iron, and potassium	
*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.	

Food Y

29. Which food has the greatest number of calories per ounce? **Food Y**
30. How many grams of protein does 5 ounces of food X contain? **100g**
5 oz/2oz = 2.5 ratio
2.5*40g = 100g
31. A monomer of a protein is known as a: _____. **Amino acid**
32. [2 points] Skinks are healthiest when fed 600 calories a day. How many grams of food Y would you have to feed a skink to meet this calorie count exactly? **134.4g**
600 calories/250 calories = 2.4 servings
2.4 servings * 56g = 134.4g
33. [4 points] Ideally, you want to minimize the amount of sugar you feed your skinks. With this in mind, which food should you choose? **Food Y**

Food X: (from above) 2.4 servings of food to fulfill daily calorie intake
2.4 servings * 3g = 7.2g sugar per day for food X

Food Y: 600 calories/170 calories = 3.53 servings of food to fulfill daily calorie intake
3.53 servings * 1g = 3.53g sugar per day for food Y

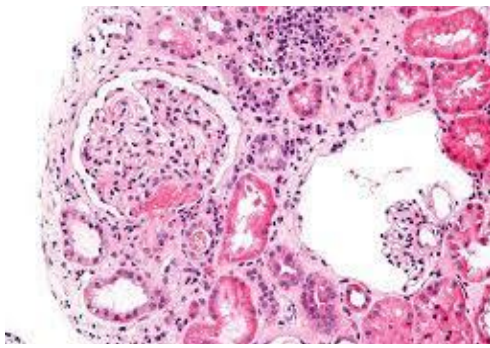


Figure F



Figure G

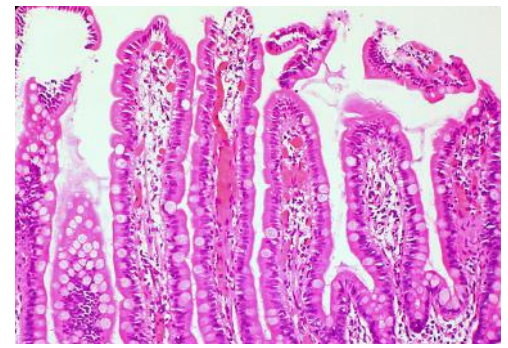


Figure H

Shown above are three histological sections of various parts of a skink.

34. [2 points] Which figure shows a section that would most likely originate from the intestines? Explain with reference to the structure and function of the image. (1) Figure H (2) villi are present, there's a larger surface area for absorption of nutrients.
35. Which organelle would most likely be in higher concentrations in the intestinal lining cells (enterocytes) as compared to other cells?
- Lysosome
 - Mitochondria
 - Nucleus
 - Ribosome

Your skinks drink roughly 30ml of water each. This water is mixed with 7mL of a vitamin D3 supplement.

36. Vitamin D3 supplements can be expensive -- which of the following measuring tools would most accurately measure out the required volume of calcium supplement?
- 10mL beaker
 - 10mL graduated cylinder
 - 10mL syringe
 - 10mL volumetric pipet
37. You also want to add exactly 5.65g of a calcium supplement powder to the water. Which of the following tools would you use to measure the mass of the powder?
- Scoopula
 - Micropipette
 - Triple beam balance
 - Analytical balance
38. You want to mix the supplements and the water. Which of the following measuring tools would you use for this?
- Graduated cylinder
 - Buret
 - Beaker
 - Watch glass

Gene A codes for a protein X that results in longer tails. There are two possible tail phenotypes: normal tails and long tails. Skinks with longer tails are blacked out in the pedigree below. The skinks have X and Y chromosomes in which females are XX and males are XY.

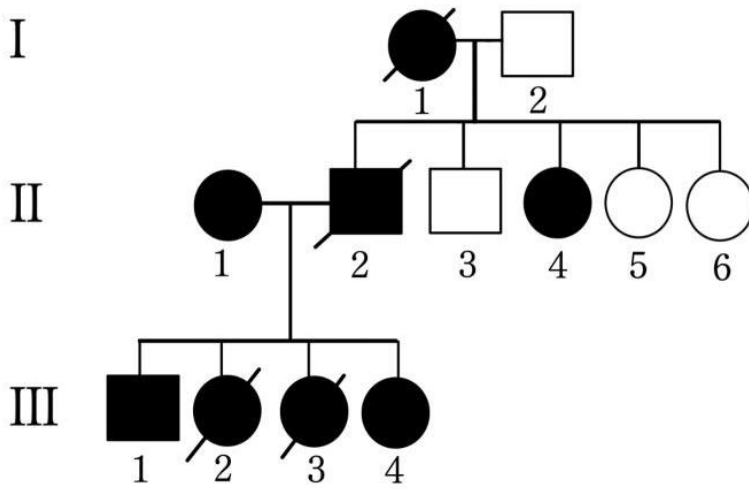


Figure I



A Skink :)

39. [2 points] The pattern of inheritance shown in **Figure I** is:
- Autosomal dominant
 - Autosomal recessive
 - X-linked dominant
 - X-linked recessive
 - Y-linked
40. [2 points] Based on **Figure I** alone, make an inference as to whether long-tailed skinks or short-tailed skinks are more genetically fit. Explain. (1) short-tailed skinks are more fit (2) of the sample population above, only the long-tailed skinks have died
41. [2 points] With the goal of establishing evolutionary relationships between different species of skink, you have the choice of either sequencing protein X or a mitochondrial protein for comparison. Which protein should you sequence? Explain. (1) The mitochondrial protein (2) this protein is conserved/involved in a key process and therefore would change less than proteins only responsible for phenotype

Unlike tail length, the length of a skink's body is determined by non-Mendelian inheritance. A sample of skink body lengths are measured and given in a set below.

Skink Body Length (in)
18.5, 19.0, 19.3, 19.8, 20.0, 20.0, 20.5, 21.0, 23.0

42. What is the mean of the data set? 20.12 inches
43. What is the median of the data set? 20.0 inches
44. What is the range of the data set? 4.5 inches
45. Based on the data and what you know about inheritance, what method below most likely dictates the size of the skinks?
- Codominance
 - Polygenic inheritance
 - Pleiotropic inheritance
 - Epistatic inheritance

Section 4 - Photosynthesis and Glucose

Plants, along with cyanobacteria and certain protists, are capable of synthesizing their own food using the energy of sunlight. Photosynthesis takes place in a series of reactions, starting with carbon dioxide and water and ending with glucose and oxygen. The oxygen is released as a byproduct, and glucose can be transported about the cell for use in polymers such as starch.



You obtain a mature pothos plant, which grows as a vine. To propagate it, you cut pieces of its stem into two equal sections and grow the stem in planters until they root. Afterwards, you place your new plants in the following conditions for 24 hours:

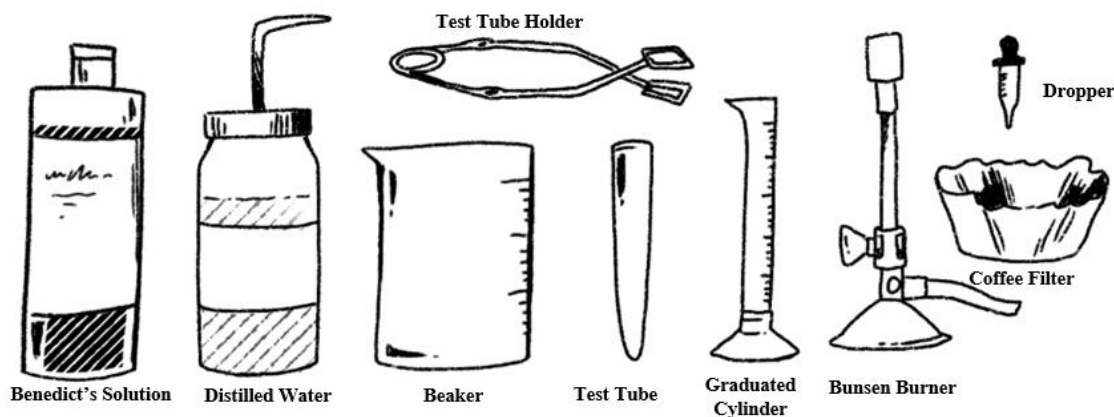


Condition 1: Under a LED lamp for 24 hours



Condition 2: Placed in a box for 24 hours

You want to test to see which plant cutting has produced more glucose. In addition to the plants, you have the following materials (item quantity may be greater than what is shown):



46. Write an alternative hypothesis for your experiment. **The plant grown under the LED lamp for 48 hours will have produced more glucose.**
47. [2 points] Identify the independent and dependent variables of the experiment. **Independent: amount of light the plants are exposed to;**
Dependent: Amount of glucose produced
48. [3 points] Identify/infer 3 possible controls in the experiment.
- **Plant origin (cut from the original plant)**
 - **Same species of plant**
 - **Same number of leaves in cutting**
 - **Same length of stem in cutting**
 - **Same soil**
 - **Same pot**
 - **Same temperature**

49. [22 points] Write a procedure describing how you would test for glucose in the two plants using the materials above (not all materials need to be used)

The procedure below is divided into general steps and smaller details.

1. [4 points] Tear/boil leaves from both plants in distilled water (any kind of mechanical disturbance of the cells)

a. Additional points:

- i. +1 specify that the leaves will be boiled in the test tubes over the bunsen burner
- ii. +1 specify that the test tube above is held using the test tube holder (prevent burns)
- iii. +1 filter the leaf solution using the coffee filters
- iv. +1 specify that the filter would be placed in the beaker

2. [3 points] Mix the leaf solution with Benedict's solution.

a. Additional points:

- i. +1 specify the vessel in which the solutions are transferred in (e.g. using the dropper to transfer the leaf solution or Benedict's solution)
- ii. +1 specify the vessel in which the solutions are mixed in (depends on previous steps)
- iii. +1 specify transfer of the solutions to a test tube for boiling (if the solution was mixed in a test tube, award points)

3. [4 points] Boil the mixture and evaluate colors.

a. Additional points:

- i. +1 specify that the test tube that the solution is boiling in is held with the test tube holder
- ii. +1 specify that the test tube is to be held above the inner blue cone of the bunsen burner flame

+2 additional points for neatness

You create an experimental control of only distilled water and benedict's solution.

50. [2 points] Explain what might cause your control solution to change color. If the distilled water was contaminated with reducing sugars.