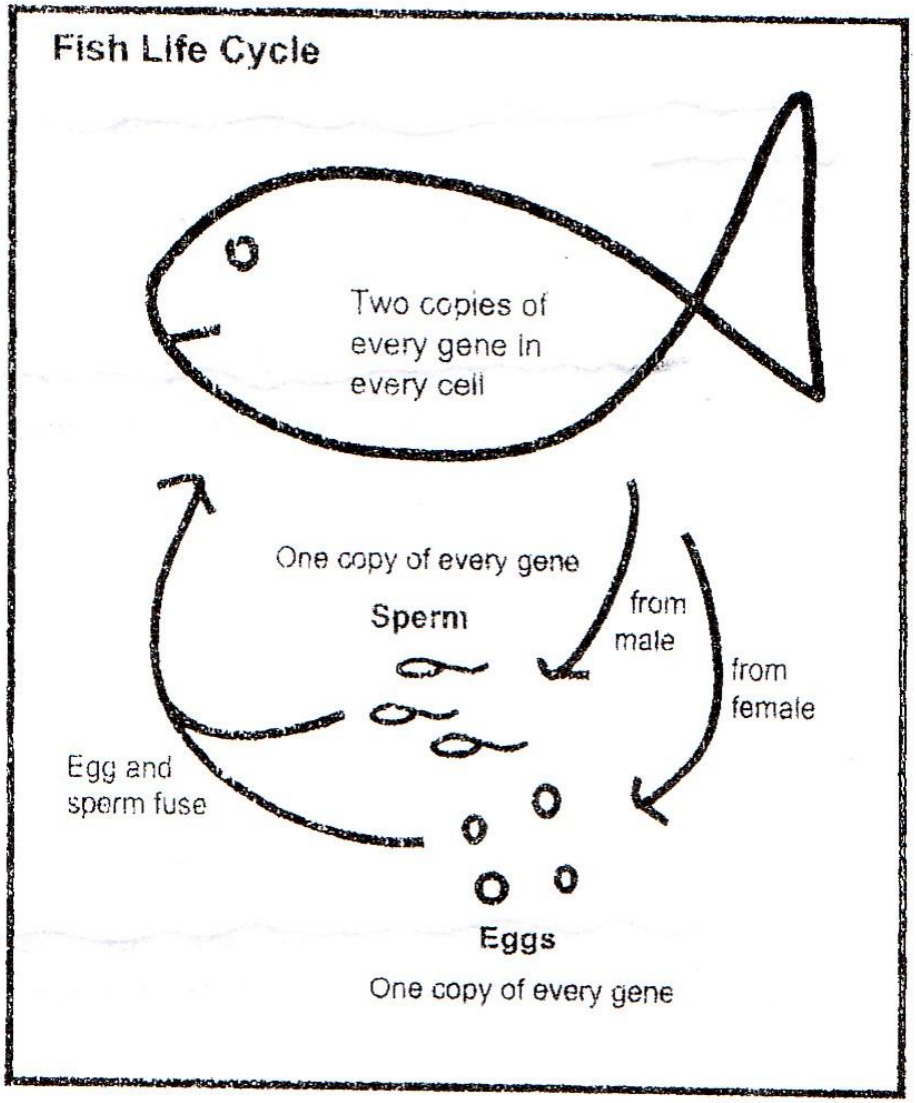
QUESTION 1: The Toothpick fish in its Environment

Aim:

Learners will investigate the **impact that the environment** (habitat) of a population has **on the genes (alleles)** of that population. Learners will learn about the relationships / interactions between different aspects of a fish's life e.g. genes, gene pools, characteristics, inheritance, variation, survival and reproduction. Even though this practical activity is a simulation, it illustrates the way in which fish and other organisms survive in nature.

Materials needed:

1 "gene pool" container / small plastic bag / petri dish
8 green marked toothpicks
8 red marked toothpicks
8 yellow marked toothpicks



Introduction

The coloured toothpicks represent 3 different forms of a gene (green, red and yellow) that determines the skin colour of the fish. The table below indicates which forms (alleles) of the gene are dominant and which are recessive and which are equal (co-dominant):

The green gene (**G**) is …..	dominant over all the other colour genes
The red gene (**R**) is …..	recessive against green, but equal (incomplete dominance) to yellow. *****
The yellow gene (**Y**) is …..	recessive against green, but equal (incomplete dominance) to red. *****

***** Combined red and yellow genes create a fish with an **orange skin colour**.

REMEMBER: Each toothpick represents a gene and not a fish

Instructions

1. Count your number of sticks to ensure that you have **8 of each colour** (altogether 24 toothpicks).

2. Determine **which gene combinations** give rise to **which colour** fish and fill the answers in on the table below:

Phenotype **(*Colour of the fish*)**	**Genotype** **(*Gene combinations*)**
Green	
Red	
Yellow	
Orange	

(6)

3. Use your genotypes in the previous table to answer the following questions. In each case use a complete **Punnet square** to illustrate your answer and give a **short explanation**. You don't need to give the detail of each cross.

(a) Will **two red fish** ever produce **green offspring**?

(3)

(b) Will **two orange fish** ever reproduce to create **red offspring**?

(3)

(c) Will **two green fish** ever reproduce to create **orange offspring**?

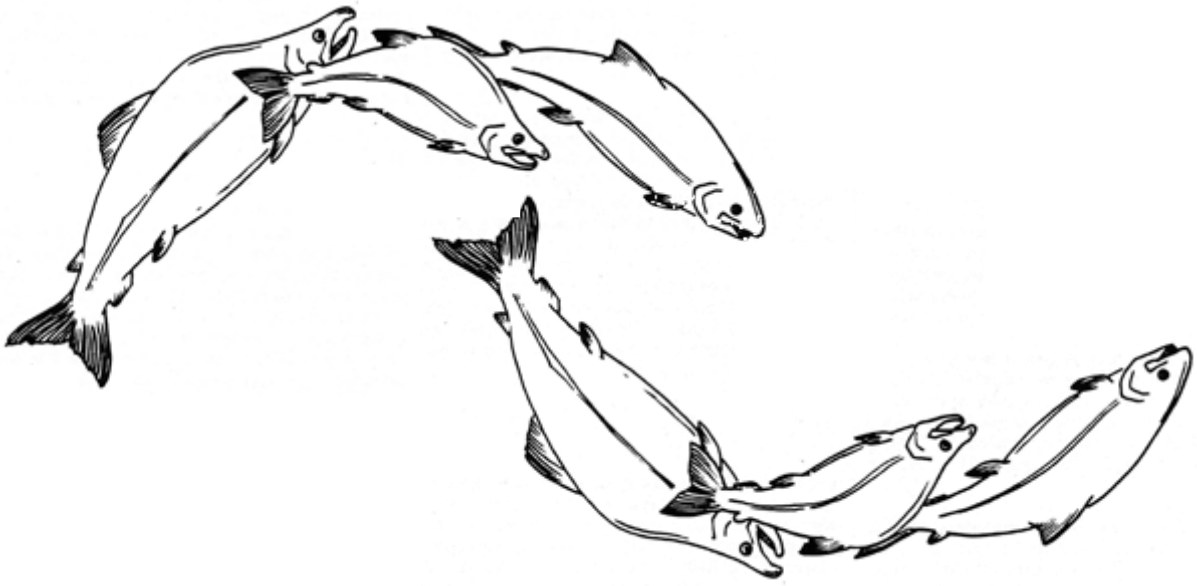
(3)

4. Illustrate the **FIRST FISH GENERATION.**
   - Throw all the toothpicks into one small plastic bag. Mix them well.
   - Without looking, draw genes (toothpicks) in pairs and put them aside (they must remain in their pairs).
   - This represents how the sperm of the male fish fuse independently with the eggs of the female fish.
   - After you have drawn all twelve genes, indicate the results (genotype and phenotype of the first generation) in **TABLE A** below.

TABEL A

	Genotype (First Gene / Second Gene)				**Phenotype (Appearance of fish colour)**			
	GENERATION							
Offspring	**1st**	**2 nd**	**3 rd**	**4 th**	**1 st**	**2 nd**	**3 rd**	**4 th**
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

(4)



5. Count the number of fish offspring of each colour in **TABLE A** and fill it in on **TABLE B** where it says "first generation". (Summary of the phenotypes)

TABEL B

Environment	Generation	Green	Red	Orange	Yellow
Green algae is growing everywhere	First				
	Second				
	Third				
The algae die and leave the rocks and sand bare	Fourth				
	Fourth (survivors)				

(5)

The stream in which the fish live, contains many green algae. The green fish are effectively camouflaged from the predators in their environment. The red and orange fish are camouflaged relatively well, but the yellow fish are very visible in between the green algae. The result is that none of the yellow fish survive and reproduce, because the predators see them very quickly and eat them.

THUS: If you have any yellow fish (fish of which both toothpicks are yellow), put them aside.

6. Illustrate the **SECOND FISH GENERATION**

- Put all the genes / toothpicks you have left back into the gene pool (in the small plastic bag) **(remember that you put the yellow fish aside.)**
- Draw a **SECOND GENERATION** of fish, again without looking.
- Put any yellow fish aside again (if both sticks are yellow) and place the surviving fish back in the gene pool.
- Complete your gene pairs in **TABLE A.**
- Count the total amount of fish of each colour and complete the numbers in the second generation row in **TABLE B.**

7. Illustrate the **THIRD FISH GENERATION**

- The fish that camouflage well, live longer and produce more offspring, thus their numbers increase.
- Draw a **THIRD GENERATION** of fish, again without looking.
- Put any yellow fish aside again and place the surviving fish back in the gene pool.
- Complete your gene pairs in **TABLE A.**
- Count the total amount of fish of each colour and complete the numbers in the third generation row in **TABEL B.**

STOP HERE!
DO NOT CONTINUE TO STEP 7. FIRST ANSWER THE FOLLOWING THREE QUESTIONS.

(a) Have all the **yellow genes** disappeared? Provide a reason for your answer.

_____

_____

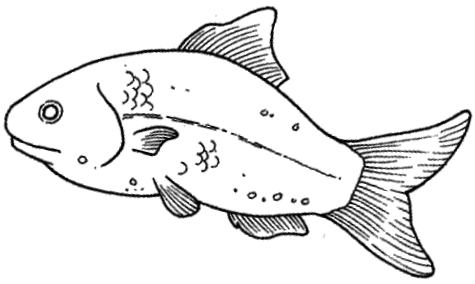
(2)

(b) Has the population size and genetic composition changed in the 3rd generation? How does it compare to the composition of the previous generations?

_____

_____

(2)



8. Illustrate the **FOURTH GENERATION**

- Draw gene pairs again to show the **fourth generation** as you did it in steps 6 and 7. Complete the data in **TABLES A and B**.
  DO NOT REMOVE YELLOW FISH.

STOP!
AN ENVIRONMENTAL DISASTER STRIKES!

Industrial waste, that's bad for the algae, is poured into the stream. All the algae die. The remaining rocks and sand act as a good camouflage for yellow, red and orange fish, but the green fish are easily visible. Predators easily eat them all and they DO NOT survive and reproduce.

9. No **green fish** survive, **put them aside.**

- Complete the surviving offspring (everyone except green) in the last row of **TABLE B** (*in the fourth generation-surviving row*).
- Share your final data with the class on the blackboard. Your teacher will write all the data of the learners down.
- After studying the data of the whole class, answer the following questions:

(a) Did the population in the **4th generation** change in comparison with the previous generations? How?

_____

_____

(2)

(b) Which gene disappeared completely?

_____

(1)

(c) Yellow genes are recessive against green, green genes are dominant for both red and yellow. Which colour gene will disappear faster if the environment causes the green algae to die out? Why?

_____

_____

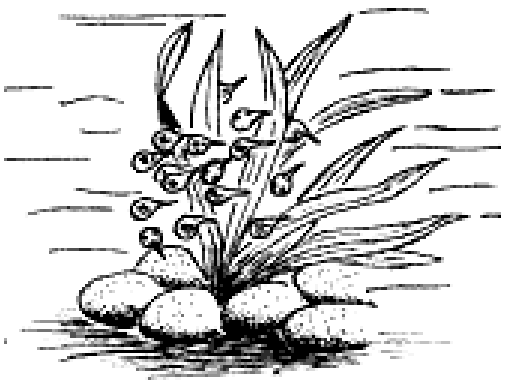
(2)

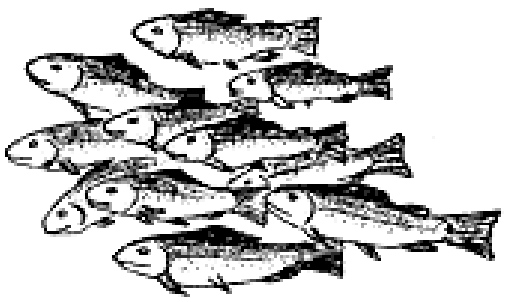
(d) If the fish from a specific stream are genetically adapted to their home stream over many generations, what could happen if their fertilized eggs are used to breed in a stream where other fish have become extinct?

_____

_____

(2)





10. Draw a **COLOMN GRAPH** to show the information in **Table B**. (Only the 1st, 3rd and 4th surviving generations)

(7)

10. What would the initial ……

(a) … hypothesis for this investigation be?

_____

_____

(1)

(b) … independent variable be?

_____

_____

(1)

(c) … dependent variable be?

_____

_____

(1)

(d) … constant variables be? Name **TWO**.

_____

_____

(2)

TOTAL: [47]

QUESTION 2

Brown eyes are dominant over blue eyes. Anrie (brown eyes) and Johan (brown eyes) have four children, Susan (brown eyes), Rory (brown eyes), Janet (blue eyes) and Liam (brown eyes). Liam died in a car accident at the age of 15. Susan married Martin (brown eye) that has no family history of blue eyes. They have two daughters that both have brown eyes. Rory married Lelani (brown eyes). They have two sons (both have brown eyes) and one daughter (blue eyes). Janet moved to England with her husband Dean (blue eyes). They have one child on which the sex is unknown.

Use the information given to draw a complete **pedigree diagram** using the correct symbols. Ensure that all genotypes and phenotypes (use a key for the phenotypes) are included on your diagram. Also ensure that you include the possible genotype of Janet and Dean's child. Use the space provided below to draw your diagram:

Mark allocation for pedigree diagram		
Correct symbol for Liam	1	0
Correct symbol for unknown child	1	0
Genotypes included	1	0
Genotype of unknown child	1	0
Phenotypes included with a key	2	0
Pedigree diagram correctly drawn (lines, levels etc.)	1	0
All sexes included and correct	2	0
All genotypes correct 1 – 2 genotypes incorrect 3 – 4 genotypes incorrect 5 – 6 genotypes incorrect More than 6 genotypes incorrect	4 3 2 1 0	
TOTAL	**13 marks**	

SUM TOTAL: [60]

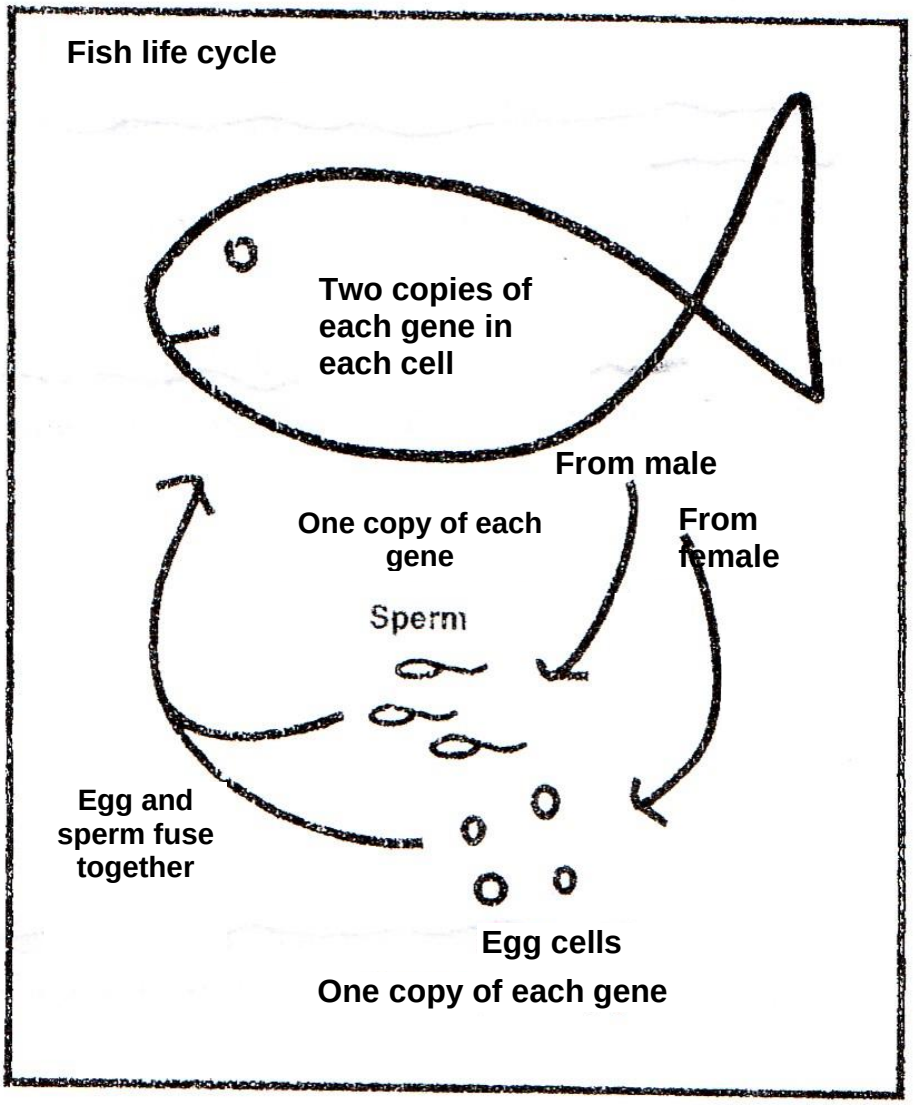
QUESTION 1: The Toothpick Fish in its Environment

Purpose:

Learners will investigate the impact that the environment (habitat) of a population has on the genes (alleles) of that population. Learners will learn about the relationship / interaction between many different aspects of a fish's life, e.g. genes, gene pool, traits, inheritance, variation, survival and reproduction. Although the practical activity is a simulation, it illustrates the ways in which the fish and other organisms survive in nature.

Materials needed:

1 "gene pool" container / bank bag / petri dish
8 green marked toothpicks
8 red marked toothpicks
8 yellow marked toothpicks



Introduction

The colored toothpicks represent 3 different forms of a gene (green, red and yellow) that determine the fish's skin colour. The table below indicates which forms (alleles) of the genes are dominant and which are recessive and which are equal (co-dominant):

The green genes (G) are …..	dominant over the other color genes
The red genes (R) are …..	recessive to green, but equal (incomplete dominance) to yellow. *
The yellow genes (Y) are …..	recessive to green, but equal to red. *

*Combined red and yellow genes result in a fish with an orange skin color.

REMEMBER: Each toothpick represents a gene and not a fish

Instructions

1. Count your number of sticks to make sure you have 8 of each color for a total of 24 sticks.

2. Determine which gene combination gives rise to which color of fish and fill in the answers in the table below:

Phenotype (Color of fish)	Genotype (Gene combinations)
Green	GG✓, GR✓, GY✓
Red	RR✓
Yellow	YY✓
Orange	RY / YR✓

Learners may indicate recessive genes with small letters(6)

3. Use your genotypes in the table above to answer the questions below. In each case, use a complete Punnet square to illustrate your answers and give a brief explanation. You don't have to give the detail of every cross.

(a) Will two red fish ever be able to produce a green offspring?

no✓, red is recessive and the fish must have both alleles for red to be red

Gametes	R	R
R	RR	RR
R	RR	RR

✓

✓ **Genotype: 100% RR**

Phenotype: 100% RED

(3)

(b) Will two orange fish ever mate to produce red offspring?

yes, 25%✓of offspring will be red, because orange fish carry the red allele

Gametes	R	Y
R	RR	ROW
Y	ROW	YY

✓

✓ **Genotype: 50% RY, 25% YY AND 25% RR**

Phenotype: 50% ORANGE, 25% RED AND 25% YELLOW

(3)

(c) Will two green fish ever mate to produce orange offspring?

Yes, 25% CHANCE because green is dominant over all the other colors, unless there are recessive yellow / red genes in the fish.

Gametes	G	R
G	GG	GR
Y	GY	ROW

✓

✓ **Genotype: 25% RY, 25% GY, 25% GG AND 25% GR**

Phenotype: 75% GREEN AND 25% RED

(3)

4. Illustrates the FIRST FISH GENERATION.
   - Put all the toothpicks in one bank bag. Mix it well.
   - Without looking, draw genes (sticks) in pairs and put them aside (they must stay in their pairs).
   - It represents how sperm from the male fish independently fuse with the egg cells of the female fish.
   - After you have drawn all twelve pairs of genes, indicate the results (genotype and phenotype of the first generation) in TABLE A, below.

TABLE A

	Genotype (First None / Second None)				Phenotype (Appearance of fish color)			
	GENERATION							
Offspring	1st	2 th	3rd	4 th	1 st	2 th	3rd	4 th
1	GG	GG	ROW	GR	GREEN	GREEN	ORANGE	GREEN
2	ROW	GR	RR	RR	ORANGE	GREEN	RED	RED
3	GR	ROW	GR	GG	GREEN	ORANGE	GREEN	GREEN
4	YY	RR	GR	RR	YELLOW	RED	GREEN	RED
5	RR	GG	GR	GR	RED	GREEN	GREEN	GREEN
6	GY	GY	GY	GR	GREEN	GREEN	GREEN	GREEN
7	GR	GR	GG	GG	GREEN	GREEN	GREEN	GREEN
8	GY	GR	GR	YY	GREEN	GREEN	GREEN	YELLOW
9	GY	RR	GR	GR	GREEN	RED	GREEN	GREEN
10	GR	GG			GREEN	GREEN		
11	RR				RED			
12	YY✓	✓	✓	✓	YELLOW			

(4)

- NO YELLOW FISH IN 2ND AND 3RD GENERATION (YY REMOVED), OTHERWISE -1
- YELLOW FISH COME BACK AGAIN IN THE 4TH GENERATION
- POPULATIONS PER GENERATION CAN ONLY DECREASE / STAY CONSTANT, IT CANNOT INCREASE! OTHER -1
- MAKE SURE PHENOTYPES ARE TRANSLATED CORRECTLY IF NOT -1 POINT FOR WRONG PHENOTYPES

Count the number of fish offspring of each color in TABLE A and fill it in on TABLE B where it says "first generation". (Summary of the phenotypes)

TABLE B

Environment	Generation	Green	Red	Orange	Yellow
Lots of green algae growing everywhere.	First	7	2	1	2✓
	Second	7	2	1	0 ✓
	Third	7	1	1	0 ✓
The algae die and leave rocks and sand stripped (bare).	Fourth	6	2	0	1✓
	Fourth (Survivors)	0 ✓	2	0	1

CHECK IF LEARNER HAS REQUESTED RIGHTS(5)

The stream in which the fish lives has a lot of green algae. The green fish are very well camouflaged from their predators in the area. The red and orange fish are also quite well camouflaged, but the yellow fish are very visible among the green algae. The result is that none of the yellow fish survive or reproduce, because the predators easily spot and eat them.

THEREFORE: If you have any yellow fish (fish with both sticks yellow), set them aside.

5. Illustrates the SECOND FISH GENERATION

- Put all the genes / toothpicks you have left back into the gene pool (in the bank bag) (remember, you put the yellow fish aside.)
- Pull a SECOND GENERATION of fish, again without looking.
- Complete your gene pairs in TABLE A.
- Count the total number of fish of each color and complete the numbers in the second generation row in TABLE B.
- Set any yellow fish aside again (if both spikes are yellow) and return the surviving fish to the gene pool.

6. Illustrates the THIRD FISH GENERATION

- The fish that are well camouflaged live longer and produce more offspring, so their numbers increase.
- Pull a THIRD GENERATION of fish, again without looking.
- Complete your gene pairs in TABLE A.

- Count the total number of fish of each color and complete the numbers in the third generation row
  TABLE B.
- Set any yellow fish aside and return the surviving fish to the gene pool.

STOP HERE!
DO NOT PROCEED TO STEP 7. ANSWER THE FOLLOWING THREE QUESTIONS FIRST.

(a) Have all the yellow genes disappeared? Provide a reason for your answer.

NO✓, THERE ARE STILL YELLOW GENES / ALLELES LEFT✓(BECAUSE THEY ARE RECESSIVE). HETEROSYGOTES STILL CARRY THE GENE

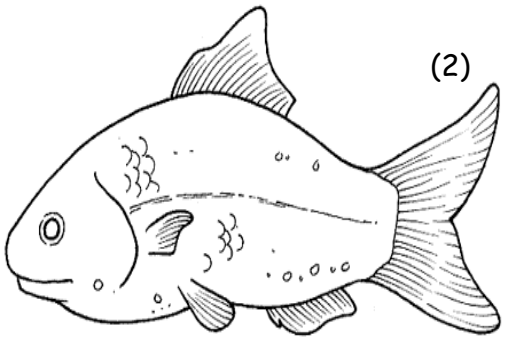
(2)

(b) Did the population size and genetic composition change in the 3rd generation? How does it compare to previous generations?

SMALLER✓AND NO YELLOW FISH APPEARS ANYMORE✓. THERE IS AN INCREASE IN GREEN FISH AND LESS ORANGE / RED FISH

(2)

7. Illustrates the FOURTH FISH GENERATION



- Draw gene pairs again to show the fourth generation as you did in steps 6 and 7. Complete the data in TABLE A and B. DO NOT REMOVE YELLOW FISH.

STOP!
AN ENVIRONMENTAL DISASTER HAPPENS!

Factory waste that is harmful to algae is dumped into the stream. All the algae will die. The remaining rocks and sand serve as good camouflage for the yellow, red and orange fish, but the green fish are easy to spot. Predators eat them easily and therefore they do NOT survive and cannot reproduce.

8. No green fish survive, put them aside.

- Complete the surviving offspring (all but green) in the last row of TABLE B (in the fourth generation surviving row).
- Share your final data with the class on the blackboard. Your teacher will record the total data of all the learners.
- After studying the data from the whole class, answer the following questions:

(a) Has the population changed in the 4th generation compared to the previous generations? How?

YES, DRASTICALLY REDUCED✓, GREEN FISH EXTINCT✓, RECESSIVE AND CO-DOMINANT GENES ARE MORE OBSERVED

(2)

(b) Which genes have completely disappeared?

GREEN✓

(1)

(c) Yellow genes are recessive to green, green genes are dominant to both red and yellow. Which color genes will disappear sooner if the environment causes green algae to die? Why?

GREEN✓BECAUSE IT IS THE DOMINANT NONE✓

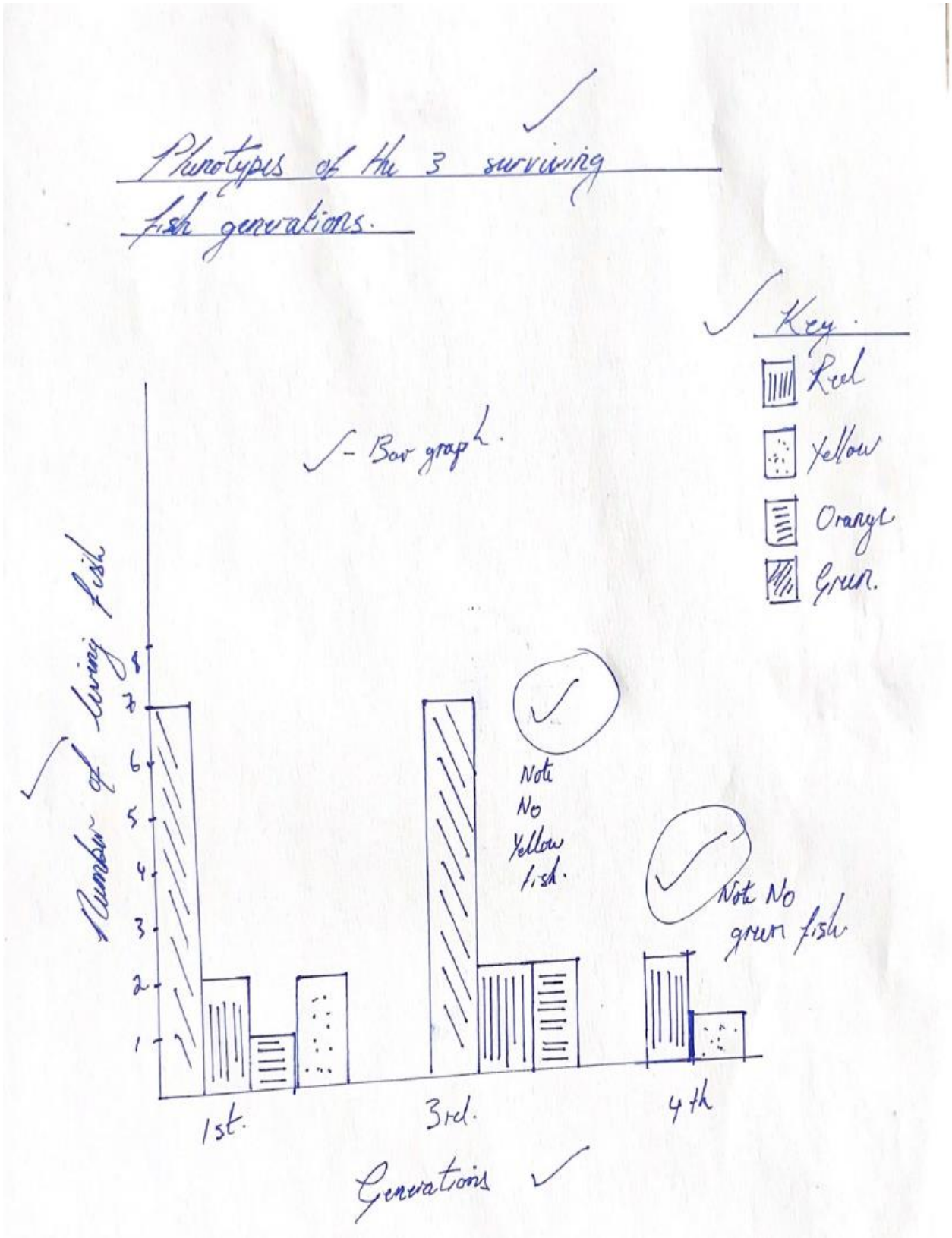
(2)

(d) If fish from a particular stream are genetically adapted to their home stream over many generations, what might happen if their fertilized eggs are used to breed in another stream where fish have become extinct?

NOT GENETICALLY ADAPTED TO THE ENVIRONMENT✓
FISH IN DIFFERENT STREAMS WILL GENETICALLY CHANGE TO ADAPT TO THE NEW ENVIRONMENT✓
BEST FIT WILL SURVIVE✓
NATURAL SELECTION THROUGH MUTATIONS✓
IF NOT ADAPTED IT WILL EXTINCT
EGGS WILL NOT HATCH✓
NOT USED TO ENVIRONMENT✓

(2)

9. Draw a COLUMN GRAPH to show the information in Table B. (Only 1st, 3rd and 4th surviving generations)



10. What would the initial ……

(a) … hypothesis for this investigation be?

THE ENVIRONMENT IN WHICH FISH SUPPORT DETERMINES THE GENOTYPE AND PHENOTYPE OF THE POPULATION✓

(1)

(b) … independent variable be?

ENVIRONMENT✓,/ INITIAL AMOUNT OF GENES IN GENE POOL / AMOUNT OF EACH COLOR GENE PRESENT AT THE BEGINNING

(1)

(c) … dependent variable be?

GENOTYPE AND PHENOTYPE✓
REDUCTION / INCREASE OF THE TYPE / COLOR OF FISH

(1)

(d) … constant variables be? Name TWO.

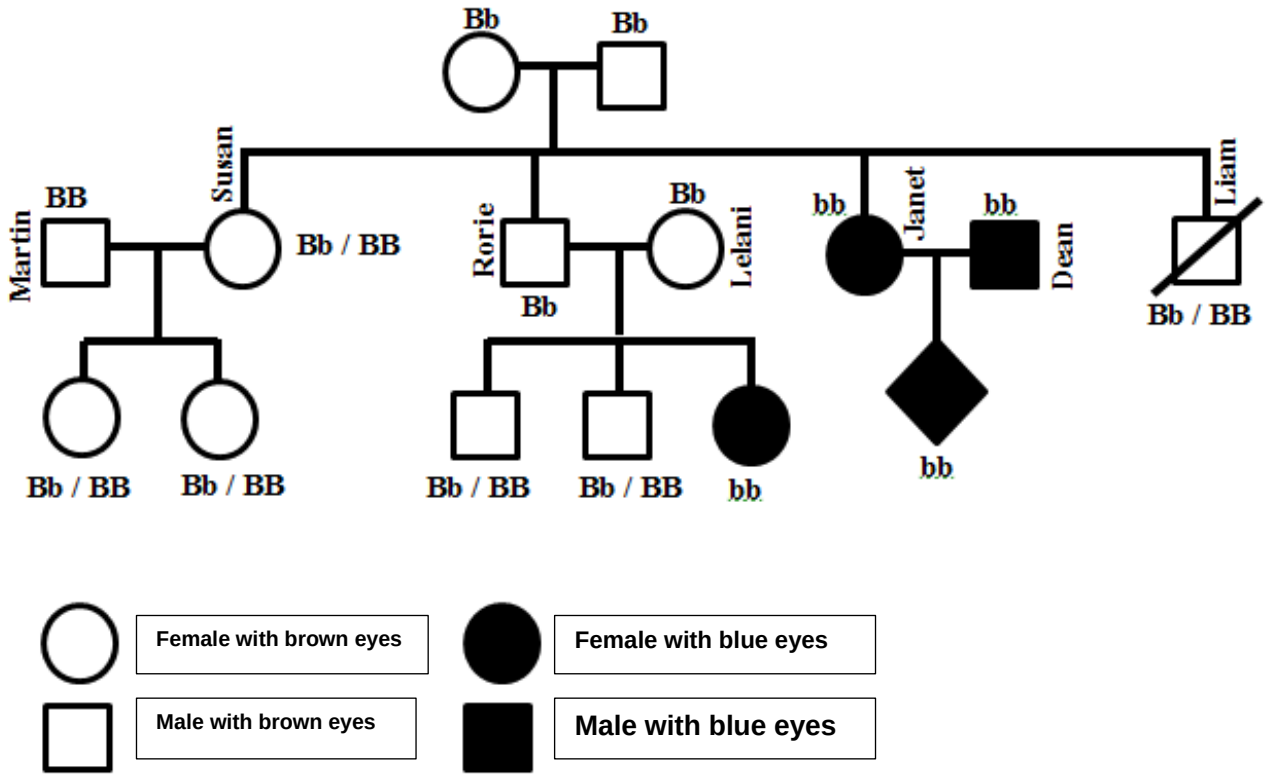
SAME…
FISH SPECIES
GENES
SIZE ENVIRONMENT
QUANTITY OF GENES (IF NOT MENTIONED WITH INDEPENDENTS)
PREDATORS
CURRENT
CONSTANT / UNCHANGED NO POOL (NO IMMIGRATION)

(2)

TOTAL: [47]

QUESTION 2

I.



Points awarded for family tree diagram		
Correct symbol for Liam	1	0
Correct symbol for unknown child	1	0
Genotypes included	1	0
Genotype of unknown child**(IS RIGHT)**	1	0
Phenotypes included with a key**(KEY MUST BE CORRECT)**	2	0
Pedigree diagram correctly drawn (lines, levels etc.)**(DRAWN WITH RULER)**	1	0
All genders included and correct	2	0
All genotypes correct 1 – 2 genotypes wrong 3 – 4 genotypes wrong 5 – 6 genotypes wrong More than 6 genotypes wrong	4 3 2 1 0	
TOTAL	**13 points**	

GRAND TOTAL: [60]