BIOLOGY

Monohybrid, Dihybrid & Test Crosses

Date: 11/08/09

Aim:

The aim of this experiment was to collect our own data of corn endosperm characteristics (colour and texture) from F2 generations of corn and determine if Mendel's postulates involving Monohybrid and Dihybrid crosses were valid and can be applied to other organisms other than the pea plant.

Apparatus:

- One of the 4 types of ears of corn
- F2 of monohybrid cross A
- F2 of monohybrid cross B
- F2 of dihybrid cross (A and B traits)
- Test cross offspring
- Rubber bands
- A recording sheet
- Sample window

Method:

Part A: Monohybrid Cross A

1. Place the sample window upon the ear of the corn of the F2 generation of the monohybrid cross involving parents showing two colours of endosperm (purple and yellow).
2. Secure the sample window with the rubber bands.
3. Count all the kernels within the sample window, noting the number of kernels of each colour.
4. Record in table as shown on worksheet "Mendelian Genetics – Monohybrid, Dihybrid and Test Crosses".

Part B: Monohybrid Cross B

1. Place the sample window upon the ear of the corn of the F2 generation of the monohybrid cross involving parents showing two textures of endosperm (smooth [starchy] and wrinkled [sugary]).
2. Secure the sample window with the rubber bands.
3. Count all the kernels within the sample window, noting the number of kernels of each texture.
4. Record in table as shown on worksheet "Mendelian Genetics – Monohybrid

Dihybrid Cross

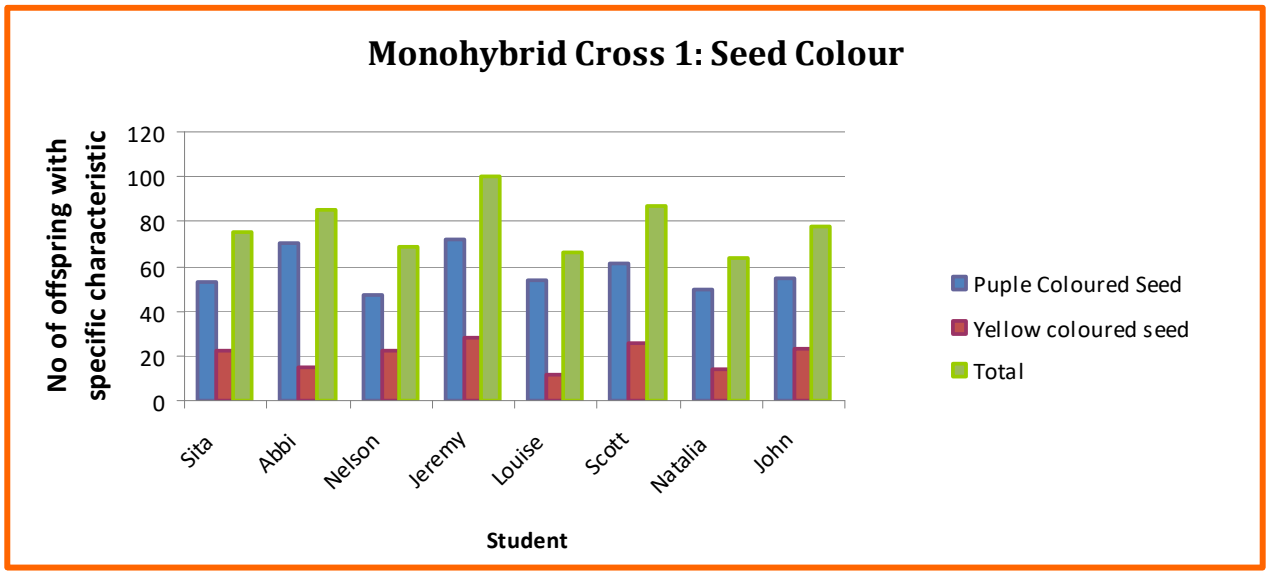
1. Place the sample window upon the ear of the corn of the F2 generation of the monohybrid cross involving parents showing two textures of endosperm (smooth [starchy] or wrinkled [sugary]) and two colours (purple or yellow).
2. Secure the sample window with the rubber bands.
3. Count all the kernels within the sample window, noting the number of kernels of each of the following sub-categories:
    a. Purple/Smooth
    b. Purple/Wrinkled
    c. Yellow/Smooth
    d. Yellow/Wrinkled
4. Record in table as shown on worksheet “Mendelian Genetics- Monohybrid, Dihybrid and Test Crosses”

Results:

Data Table 1: Monohybrid Cross A:

Student:	**Purple Coloured Kernel:**	**Yellow Coloured Kernel:**	**Total:**
Sita:	53	22	75
Abbi:	70	15	85
Nelson:	47	22	69
Jeremy:	72	28	100
Louise:	54	12	66
Scott:	61	26	87
Natalia:	50	14	64
John:	55	23	78
Total:	462	162	624

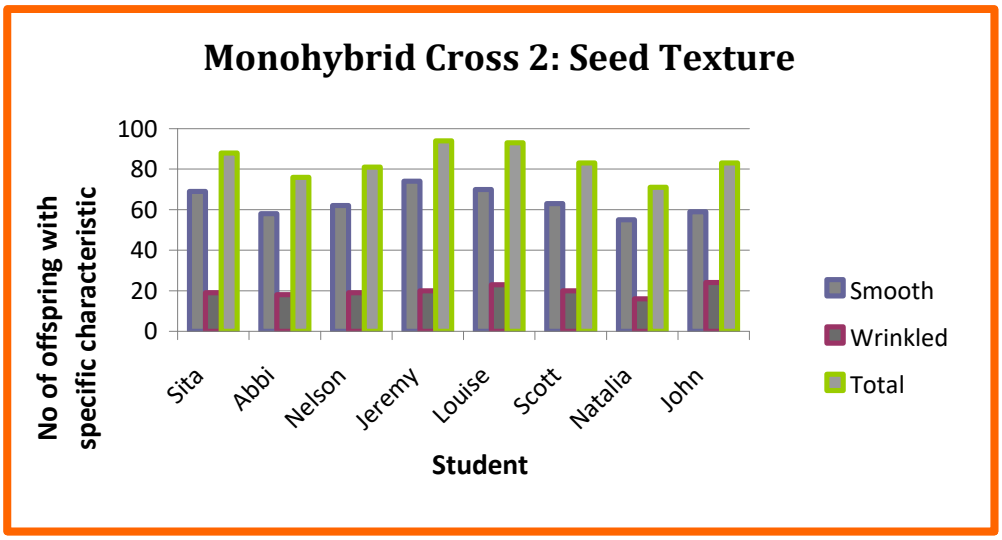
Graph 1: Monohybrid Cross 1 - Seed Colour



Data Table 2: Monohybrid Cross B:

Student:	Smooth Kernel:	Wrinkled Kernel:	Total:
Sita:	69	19	88
Abbi:	58	18	76
Nelson:	62	19	81
Jeremy:	74	20	94
Louise:	70	23	93
Scott:	63	20	83
Natalia:	55	16	71
John:	59	24	83
Total:	510	159	669

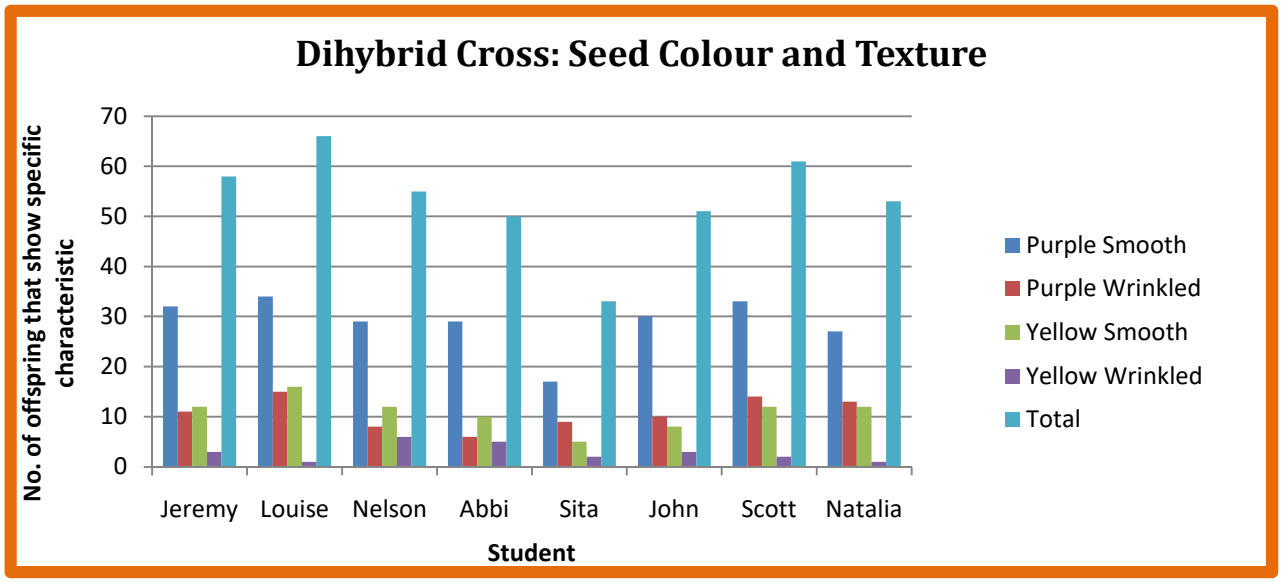
Graph 2: Monohybrid Cross 1- Seed Texture



Dihybrid Cross:

Student	Purple Smooth	Purple Wrinkled	Yellow Smooth	Yellow Wrinkled	Total
Jeremy	32	11	12	3	58
Louise	34	15	16	1	66
Nelson	29	8	12	6	55
Abbi	29	6	10	5	50
Sita	17	9	5	2	33
John	30	10	8	3	51
Scott	33	14	12	2	61
Natalia	27	13	12	1	53
Total	231	86	87	23	427

Graph 3: Dihybrid Cross - Seed Colour and Texture



Discussion:

Monohybrid Crosses A and B:

1.

There are two possible phenotypes for each gene:

Gene 1: Seed Colour

- Purple colouring of seed
- Yellow colouring of seed

Gene 2: Seed Texture

- Smooth (starchy)
- Wrinkled (sugary)

The dominant trait only requires one copy of the dominant allele to show up phenotypically in offspring; meanwhile the recessive trait requires two copies of the recessive allele to show up. This means that there are two possible genotypes for the dominant trait; meanwhile the recessive trait only has one possible genotype. Thus the probability of a dominant trait coming up is greater than a recessive trait.

Thus from our results it can be seen that there is a greater F2 population that is purple than yellow and also that there is a greater F2 population that is smooth (starchy) than wrinkled (sugary). Therefore it can be concluded that the purple is the dominant phenotype for seed colour and yellow is the recessive phenotype for seed colour. Meanwhile smooth is the dominant phenotype for seed texture and wrinkled is the recessive phenotype.

Thus the alleles:

P – Purple Coloured seed (dominant)
P – Yellow coloured seed (recessive)
S – Smooth texture (dominant)
S – Wrinkled texture (recessive)

2.

Monohybrid Cross A:

Assigned symbols for alleles of Gene 1- Seed Colour:

P – Purple Coloured seed (dominant)
p – Yellow coloured seed (recessive)

F2 Phenotype:	Purple	Yellow
Phenotypic Ratio:	462 : 2.85 : Approx 3 : 1	162 : 1

From the raw data of Data Table 1 it can be seen that the ratio of purple to yellow kernels is approximately 3:1

In order to have two heterozygote offspring the parents could have the following genotypes:
PP x pp Or Pp x pp
This can be verified by the following punnet squares:

	P	P
p	Pp	Pp
p	Pp	Pp

F2 Genotype:	Pp 100%
Genotypic Ratio:	1
F2 Phenotype:	Purple 100%
Phenotypic Ratio:	1

	p	P
P	Pp	Pp
P	pp	Pp

F2 Genotype:	Pp 50%	pp 50%
Genotypic Ratio:	1:1	
F2 Phenotype:	Purple 50%	Yellow 50%
Phenotypic Ratio:	1:1	

Thus it can be seen that the parent generation are most likely to be homozygous for the two different alleles with genotypes PP and pp.
Thus the phenotypes would be one purple parent and one yellow parent.

The F2 offspring had a phenotypic ratio of 3:1 which can be obtained only between the breeding of two heterozygote parents. This is because when fertilisation occurs, the offspring must obtain one chromosome from its mother and one from its father. Thus in order for it to have two outcomes phenotypically, the parents must have one copy of each allele. This can be verified by the following punnet square:

	P	p
P	PP	Pp
P	Pp	pp

F2 Genotype:	PP (25%)	Pp (50%)	pp (25%)
Genotypic Ratio:	1 : 2 : 1		
F2 Phenotype:	Purple (75%)		Yellow (25%)
Phenotypic Ratio:	3 : 1		

Monohybrid Cross B:

Assigned symbols for alleles of Gene 1- Seed Colour:

S – Smooth texture (dominant)
S – Wrinkled texture (recessive)

F2 Phenotype:	Smooth	Wrinkled
Phenotypic Ratio:	510 : 159 3.21 : 1 Approx 3 : 1	

From the raw data of Data Table 2 it can be seen that the ratio of smooth to wrinkled kernels is approximately 3:1

In order to have two heterozygote offspring (F1) the parents could have the following genotypes:

SS (smooth)x ss (wrinkled)
Or
Ss (smooth)x ss(wrinkled)

This can be verified by the following punnet squares:

	S	S
s	Ss	Ss
s	Ss	Ss

F2 Genotype:	Ss 100%
Genotypic Ratio:	1
F2 Phenotype:	Smooth 100%
Phenotypic Ratio:	1

	S	S
s	Ss	Ss
s	Ss	Ss

F2 Genotype:	Ss 50%	ss 50%
Genotypic Ratio:	1:1	
F2 Phenotype:	Smooth 50%	Wrinkled 50%
Phenotypic Ratio:	1:1	

Thus it can be seen that the parent generation are most likely to be homozygous for the two different alleles with genotypes SS and ss.
Thus the phenotypes would be one smooth parent and one wrinkled parent.

Since F2 offspring have a phenotypic ratio of 3:1 it can be inferred that both parents of F1 are heterozygous. This is because when fertilisation occurs, the offspring must obtain one chromosome from its mother and one from its father. Thus in order for it to have two outcomes phenotypically, the parents must have one copy of each allele. This can be verified by the following punnet square:
Ss (smooth) x Ss(smooth)

	S	s
S	SS	Ss
s	Ss	ss

S: Smooth s: wrinkled

F2 Genotype:	SS (25%)	Ss (50%)	ss (25%)
Genotypic Ratio:	1 : 2 : 1		
F2 Phenotype:	Smooth 75%		Wrinkled 25%
Phenotypic Ratio:	3 : 1		

3.

Alleles can either be dominant or recessive. When two homozygous parents with different phenotypic traits mate, the child (F1) is heterozygous and displays the dominant trait, despite having one copy of the recessive allele. If this child (F1) was to mate with another heterozygous F1 offspring, there is a 25% chance that the characteristic not seen in F1 but in P can reappear as seen in this punnet square:

Parents: PP (purple seed colour) X pp (yellow seed colour)
Produce F1 Offspring: Pp (purple seed colour)

F1: Pp (purple seed colour) X Pp(purple seed colour)

	P	P
P	PP	Pp
P	Pp	Pp

They may produce F2:

F2 Genotype:	PP (25%)	Pp (50%)	pp (25%)
Genotypic Ratio:	1 :	2 :	1
F2 Phenotype:	Purple		Yellow
Phenotypic Ratio:	3	:	1

The highlighted trait once found in the parent generation has reappeared in the F2, when seemingly hidden in F1 generation.

4.

The phenotypic expression of a gene can be affected by the environment, in the form of temperature (eg: pigments), diet (eg: can cause individual to suffer from PKU), pH of soil (eg: colour of certain plants) etc.

5.

If a parent has a smooth endosperm texture then we can determine if they are homozygous or heterozygous by doing a testcross/backcross. This involves a cross between the parent in question of being either a heterozygote or homozygous and a homozygous recessive parent (shows the recessive trait).

Gene: Seed texture
Alleles:

S- Smooth texture (dominant)
s- wrinkled texture (recessive)

(refer to next page for continuation of answer)

If parent (smooth) is a homozygous:

SS (smooth) x ss (wrinkled)

Gametes:	S	S
S	Ss	Ss
S	Ss	Ss

F1Genotype:	Ss 100%
Genotypic Ratio:	1
F1Phenotype:	Smooth
Phenotypic Ratio:	1

If parent (smooth) is a heterozygous:

Ss (smooth) X ss (wrinkled)

Gametes:	S	S
S	Ss	Ss
S	Ss	Ss

F1Genotype:	Ss 50%	ss 50%
Genotypic Ratio:	1:1	
F1Phenotype:	Smooth	Wrinkled
Phenotypic Ratio:	1:1	

6.

From the results of both Monohybrid cross A and Monohybrid Cross B, it can be seen that the 3:1 ratio was obtained from the data collected. (Refer to Question 2 for more working out).To improve accuracy of results, Monohybrid B should actually be conducted instead of making up false data in future, the same number of kernels should be counted by each student/participant, the experiment should be repeated to see if same results occur, and the sample size should be increased (both corn and students).

Dihybrid Cross:
7.

F2 Phenotype:	Purple Smooth	Purple Wrinkled	Yellow Smooth	Yellow Wrinkled
Phenotypic Ratio:	231 : 86 : 87 : 23			
	10.04 : 3.74 : 3.78 : 1			
	Approx 9:3:3:1			
From the raw data of Data Table 3 it can be seen that the phenotypic ratio is approximately 9:3:3:1				

Since F2 offspring have a phenotypic ratio of 9:3:3:1 it can be inferred that both parents of F1 are heterozygous. This is because when fertilisation occurs, the offspring must obtain two chromosomes from its mother and two from its father. It is two as the two genes for colour and seed texture are not located on the same chromosome. Thus in order for it to have two outcomes phenotypically, the parents must have one copy of each allele. This can be verified by the following punnet square:

S: Smooth s: wrinkled
P: Purple p: Yellow
F1 X F1
PpSs (purple smooth) x PpSs (purple smooth)

Gametes	PS	Ps	pS	ps
PS	PPSS	PPSs	PpSS	PpSs
Ps	PPSs	PPss	PpSs	Ppss
pS	PpSS	PpSs	ppSS	ppSs
ps	PpSs	Ppss	ppSs	ppss

F2 Genotype:	PPSS (6.25%)	PPSs (12.5%)	PpSS (12.5%)	PpSs (25%)	Ppss (12.5%)	PPss (6.25%)	ppSS (6.25%)	ppSs (12.5%)	Ppss (6.25%)
F2 Genotypic Ratio:	1 : 2 : 2 : 4 : 2 : 1 : 1 : 2 : 1								
F2 Phenotype:	Purple Smooth (56.25%)				Purple Wrinkled (18.75%)		Yellow Smooth (18.75%)		Yellow Wrinkled (6.25%)
F2 Phenotypic Ratio:	9				: 3		: 3		: 1

In order to have to have heterozygote F1 offspring, the parents must have been homozygous for different traits.
So they must have been
PPSS X ppss
Purple smooth X Yellow wrinkled

As the gametes they would have produced could only be PS and ps. Thus all offspring would have a heterozygous genotype and display the dominant traits, in this case purple and smooth.

8.

The expected ratio of 9:3:3:1 was approximated from 10.04:3.74:3.74:1, however results were not accurate due to many errors such as differences in number of kernels counted, small sample sizes (both corn and students) and experiment was not repeated multiple times.

General Questions:

9.

GENE: The unit of heredity. It is a sequence of nucleotides that encodes a protein, tRNA, mRNA or rRNA molecule.

ALLELE: Is a variant form of a gene.

RECESSIVE ALLELE: Is an allele which requires two copies in order to be observed phenotypically, and when there is only one copy (heterozygote) it remains hidden phenotypically.

DOMINANT ALLELE: Is an allele which requires only one copy but can also have two copies in order to be observed phenotypically.

CARRIER: A heterozygous organism that does not show a particular trait but can transmit to its offspring the allele responsible for that trait.

HOMOZYGOUS: Individual who has two identical alleles at a particular genetic locus, for example BB or bb

HETEROZYGOUS: Individual who has two different alleles at a particular gene locus, for example Bb

MONOHYBRID CROSS: A monohybrid cross is a cross involving the segregation of alleles of a single gene.

DIHYBRID CROSS: Cross involving the segregation of alleles of two genes.

Conclusion:

Conclusively it can be seen that Mendel's postulates of the monohybrid and dihybrid crosses were valid in not only peas but also other organisms such as corn. It was seen that the genotypes of parents affected their offspring as alleles of gametes from parents were inherited by the offspring of next generation. The phenotype however is not only based upon the genotype, but is affected also by environmental conditions.

The results obtained from this experiment however were not completely accurate due to many errors that must be rectified in future by conducting the counting of kernels in Monohybrid cross B and not making up results, having a larger sample size for both corn and students, repeating the experiment more than once and counting the same amount of kernels.