Purpose:

Demonstrate understanding of disequilibrium and the consequences of drift, selection, migration, mutation

Keywords: Hardy Weinberg Equilibrium, Disequilibrium

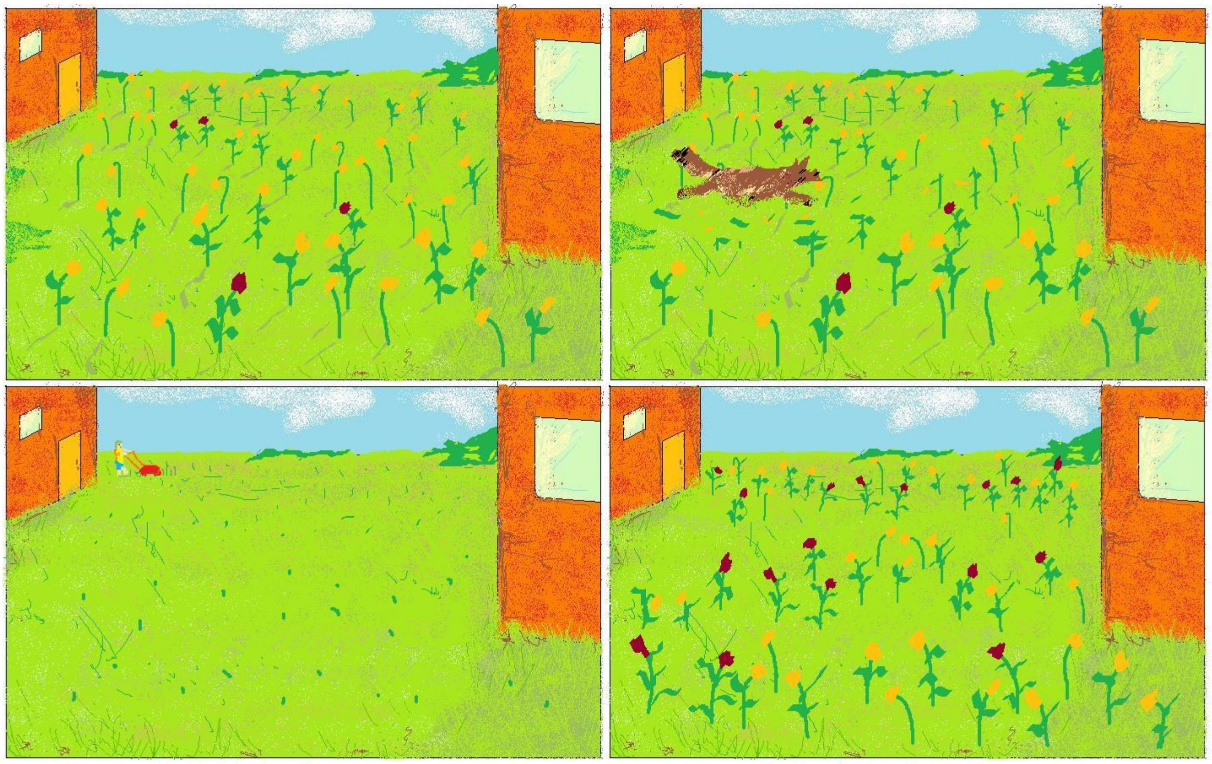
References:

Captivate: Population Genetics Foundations

Chapter 2, Bernardo

ALA: Populations in disequilibrium.

a. Imagine before pollen sheds from the flowers in our yard, a dog runs through the yard randomly killing plants. The remaining plants may not represent the initial frequencies of the initial population. Starting with an original population of 50 plants, imagine the dog leaves only 20 plants: 4 brown ones, 12 leafy and 4 barren yellow ones. In such case a dramatic change in frequencies will lead to an increase of brown flowers in the population, because their fraction of the surviving plants was much higher than before the dog. After some generations the population has stabilized again at 50 individuals but now with new frequencies.



Based on the three informative panels (upper left, upper right and lower right) fill out three tables that can be used to assess disequilibrium in the population. What mechanism has affected the change to the original population? Provide evidence to support your answer.

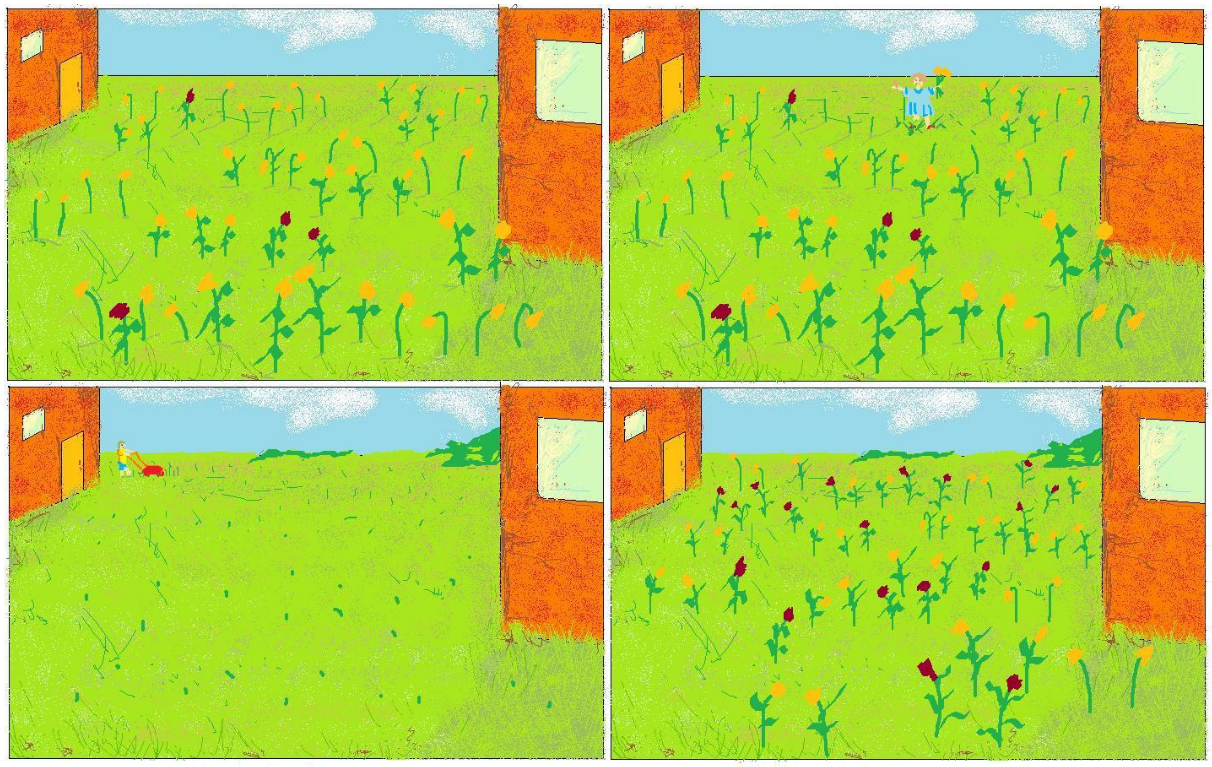
2a) initial population			
50 plants	p = 0.29	q = 0.71	
genotypes	AbAb	AbaB	aBaB
count:	4	21	25
Gametes	Ab	aB	
count:	29	71	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	4	21	25

Drift is the mechanism that altered the allele frequencies. The dog randomly reduced the number of plants that provided alleles to future generations.

genotypes	AbAb	AbaB	aBaB
count	4	12	4
Frequency	0.2000	0.6000	0.2000
	p^2	2pq	q^2
gametes	Ab	aB	
40	20	20	
Phenotypes	leafy brown	leafy yellow	barren yellow
count	4	12	4

genotypes	AbAb	AbaB	aBaB
count	17	24	9
Frequency	0.3400	0.2400	0.1800
	p2	2pq	q2
gametes	Ab	aB	
100	58	42	
Phenotypes	leafy brown	leafy yellow	barren yellow
count	17	24	9

b. Imagine a little girl walks into our meadow to pick flowers for her mother, she knows her mother will remove the leaves for a vase, so she decides to pick only yellow plants that do not have leaves. If she does this before pollen sheds clearly those plants do not contribute to the next generation and selection against barren stalk and yellow flower occurs resulting in new frequencies for alleles and genotypes. In the next generation only 25 seeds germinate with the new distribution under HWE.



After several years without any other further interference 50 plants cover the meadow again but now 18 plants flower brown. Use a table to quantify the allelic changes. What mechanism is responsible for the changes?

Table 3 a, b, c) Genotypes are denoted A and B for leaf phenotype and flower phenotype, respectively for convenience.
Note that Ab and aB are the only two alleles because no recombination is possible within in pleiotropic genes. p = frequency of Ab, q = frequency of aB gamete. All others are counts for genotype, phenotype and gamete classes.

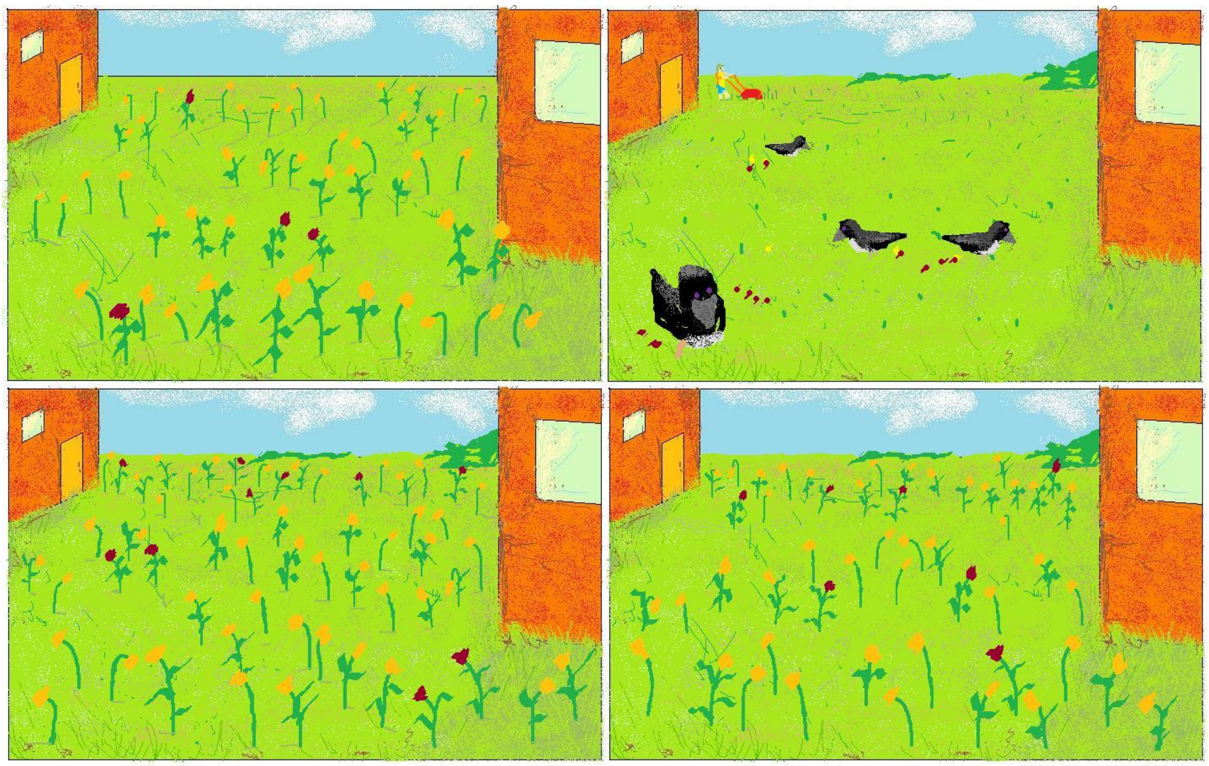
3 a) initial population			
50 plants	p = 0.29	q = 0.71	
genotypes	AbAb	AbaB	aBaB
count:	4	21	25
Gametes	Ab	aB	
count:	29	71	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	4	21	25

genotypes	AbAb	AbaB	aBaB
Count:	4	21	0
freq:	0.1600	0.8400	0
	p^2	2pq	q^2
Gametes	Ab	aB	
50	29	21	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	4	21	0

3 c) at stable population size			
50 plants	p = 0.6	q = 0.4	
genotypes	AbAb	AbaB	aBaB
count:	18	24	8
Gametes	Ab	aB	
count:	60	40	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	9	12	4

Selection is the mechanism that has altered the allelic frequencies and resulted initially in a deviation from HWE.

c. Imagine that after the meadow is cut the plants in our meadow mated and seed has formed and ripened on the plants, crows enter the meadow. The crows have been feeding in a meadow behind the mountains where many brown flowers grow. After their break some seeds are left behind and eight additional seeds are still alive and will germinate next season. After stabilizing to 50 individuals some generations later the number of brown flowers has almost doubled compared to the initial population.



After several generations, the population stabilizes to 50 individuals, but the number of brown flowers has almost doubled compared to the initial population. What mechanisms could be responsible for the changes?

Table 4 a, b, c) Genotypes are denoted A and B for leaf phenotype and flower phenotype, respectively for convenience.
Note that Ab and aB are the only two alleles because no recombination is possible within in pleiotropic genes. p = frequency of Ab, q = frequency of aB gamete. All others are counts for genotype, phenotype and gamete classes.

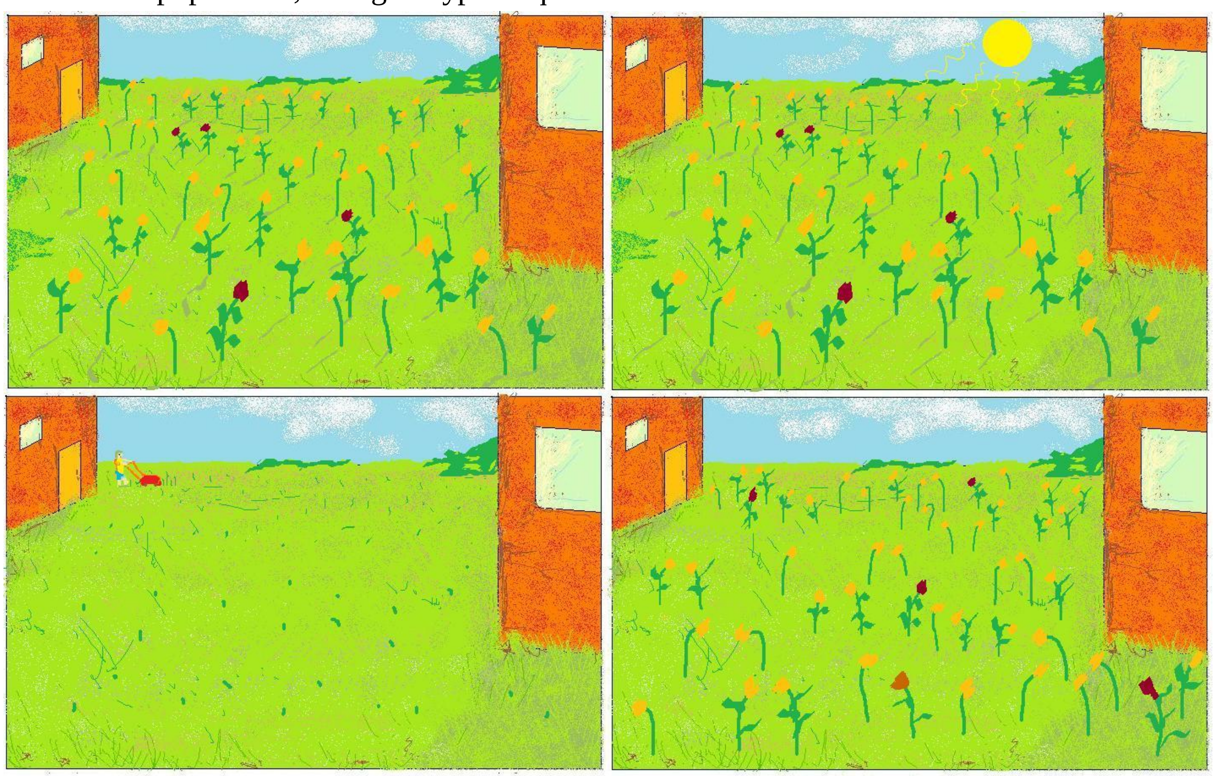
4 a) initial population			
50 plants	p = 0.29	q = 0.71	
genotypes	AbAb	AbaB	aBaB
count:	4	21	25
Gametes	Ab	aB	
count:	29	71	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	4	21	25

4 b) after migration of 8 seeds			
58 plants	p = 0.37	q = 0.63	
genotypes	AbAb	AbaB	aBaB
count:	10	23	25
Gametes	Ab	aB	
count:	43	73	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	10	25	25

4 c) at stable population size			
50 plants	p = 0.37	q = 0.63	
genotypes	AbAb	AbaB	aBaB
count:	7	23	20
Gametes	Ab	aB	
count:	37	63	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	7	23	20

The primary mechanism for changing the allele frequencies is migration.

d. Imagine strong sun radiation changes a base on one of the egg cells in one of the plants before pollination. A new allele has been created. In most cases such new alleles will cause nothing exciting for example when they don't affect gene expression. In other cases they lead to death. In this case a new phenotype results because the mutation enchances the color depending on color of the other allele at the same locus in this diploid organisms. In other words, the resulting phenotype can be a dark yellow or dark brown color. However, if the mutation is not lost and two mutant alleles are combined the flower will be white. For the leafs the mutation results in a recessive null allele combined with barren allele or homozygous mutant showing a barren phenotype and combined with the other leafy allele resulting in a leafy phenotype. In this case the mutant combines as expected with the most abundant allele for yellow flower and the recessive barren stalk, so that the heterozygous mutant shows a dark yellow flower and barren stalk. With a new allele in the population, new genotype frequencies can be observed.



What has been the impact of the mutation on allelic frequencies after the population is again stabilized at 50 plants?

5 a) initial population			
50 plants	p = 0.29	q = 0.71	
genotypes	AbAb	AbaB	aBaB
count:	4	21	25
Gametes	Ab	aB	
count:	29	71	
phenotypes	leafy brown	leafy yellow	barren yellow
count:	4	21	25

5 b) after mutation					
50 plants	p = 0.28	q = 0.71	r = 0.01		
genotypes	AbAb	AbaB	aBaB	A*b*aB	A*b*Ab
count:	4	20	25	1	0
Gametes	Ab	aB	A*b*		
count:	28	71	1		
phenotypes	leafy brown	leafy yellow	barren yellow	barren dark yellow	
count:	4	20	25	1	

Table 5 a, b) Genotypes are denoted A and B for leaf phenotype and flower phenotype, respectively for convinience. Note that Ab and aB are the only two alleles because no recombination is possible within in pleiotropic genes. p = frequency of Ab, q = frequency of aB gamete. All others are counts for genotype, phenotype and gamete classes.