OUTLINE 22

- Forces that disrupt HW equilibrium

  A. Effects of chance in small populations - genetic drift

     1. Bottlenecks

     2. Founder effects

  B. Mutation

  C. Migration and gene flow

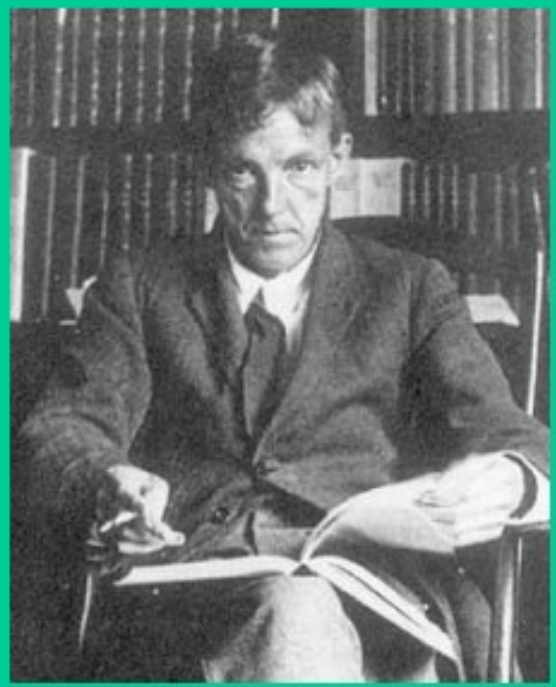
  D. Non-random mating

  E. Natural selection

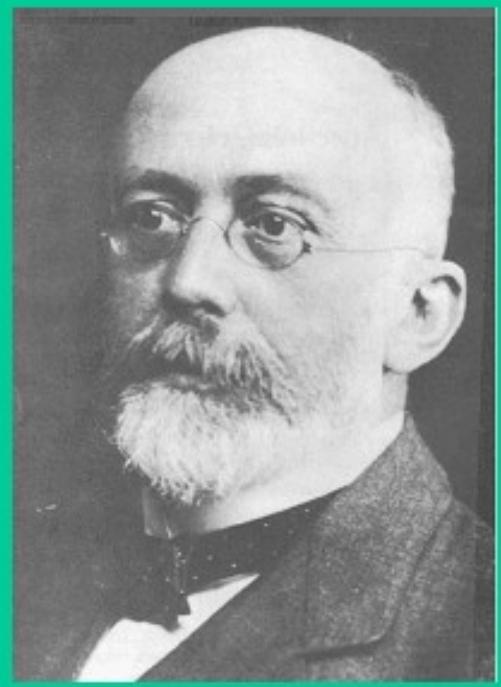
     1. Example: the peppered moth

The Hardy-Weinberg equilibrium

"A fundamental principle in population genetics stating that the genotype frequencies and gene frequencies of a large, randomly mating population remain constant provided immigration, mutation, and selection do not take place." *American Heritage Dictionary*



Godfrey Harold Hardy
1877-1947



Wilhelm Weinberg
1862-1937

Fig 23.3a

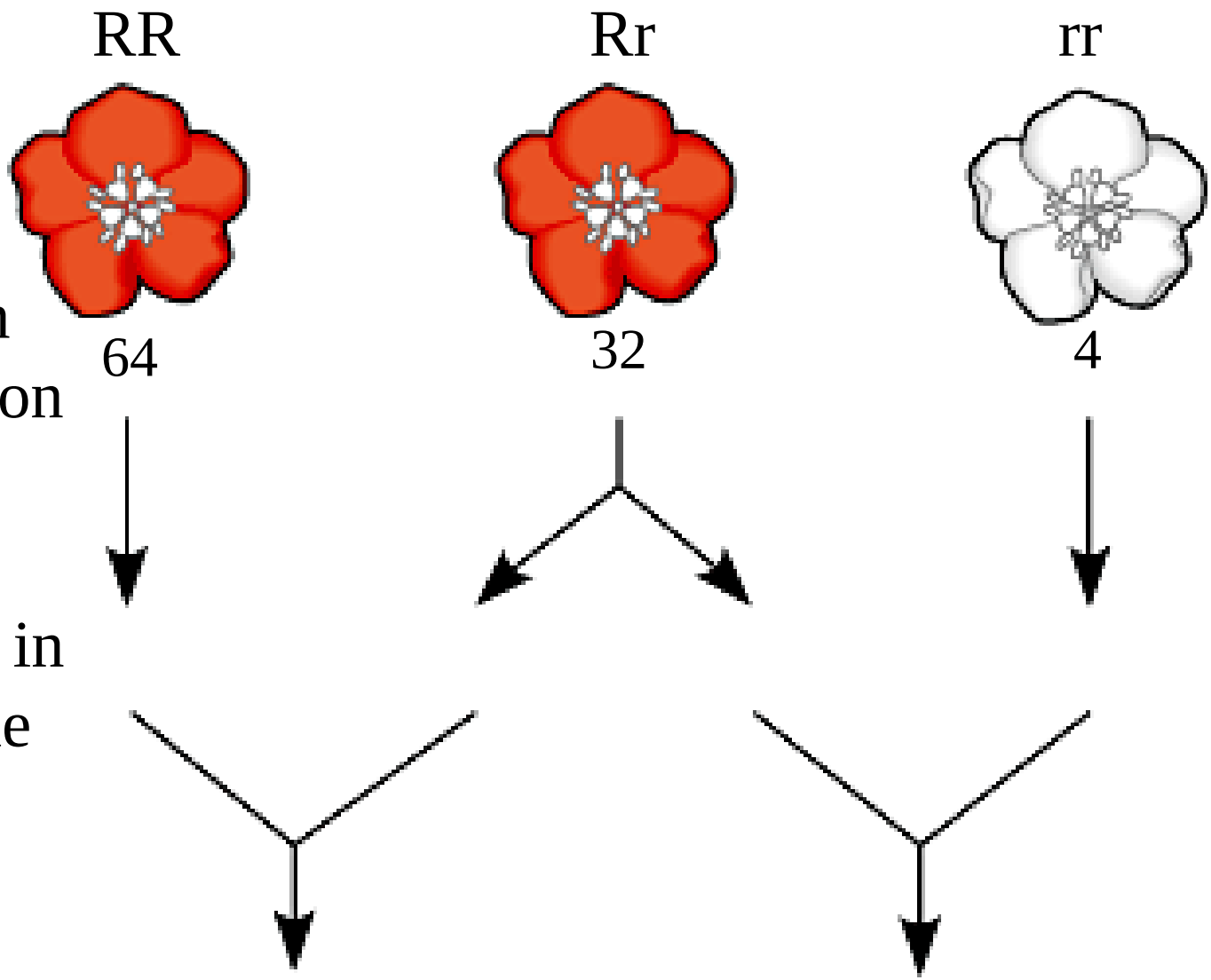


Fig 23.3a

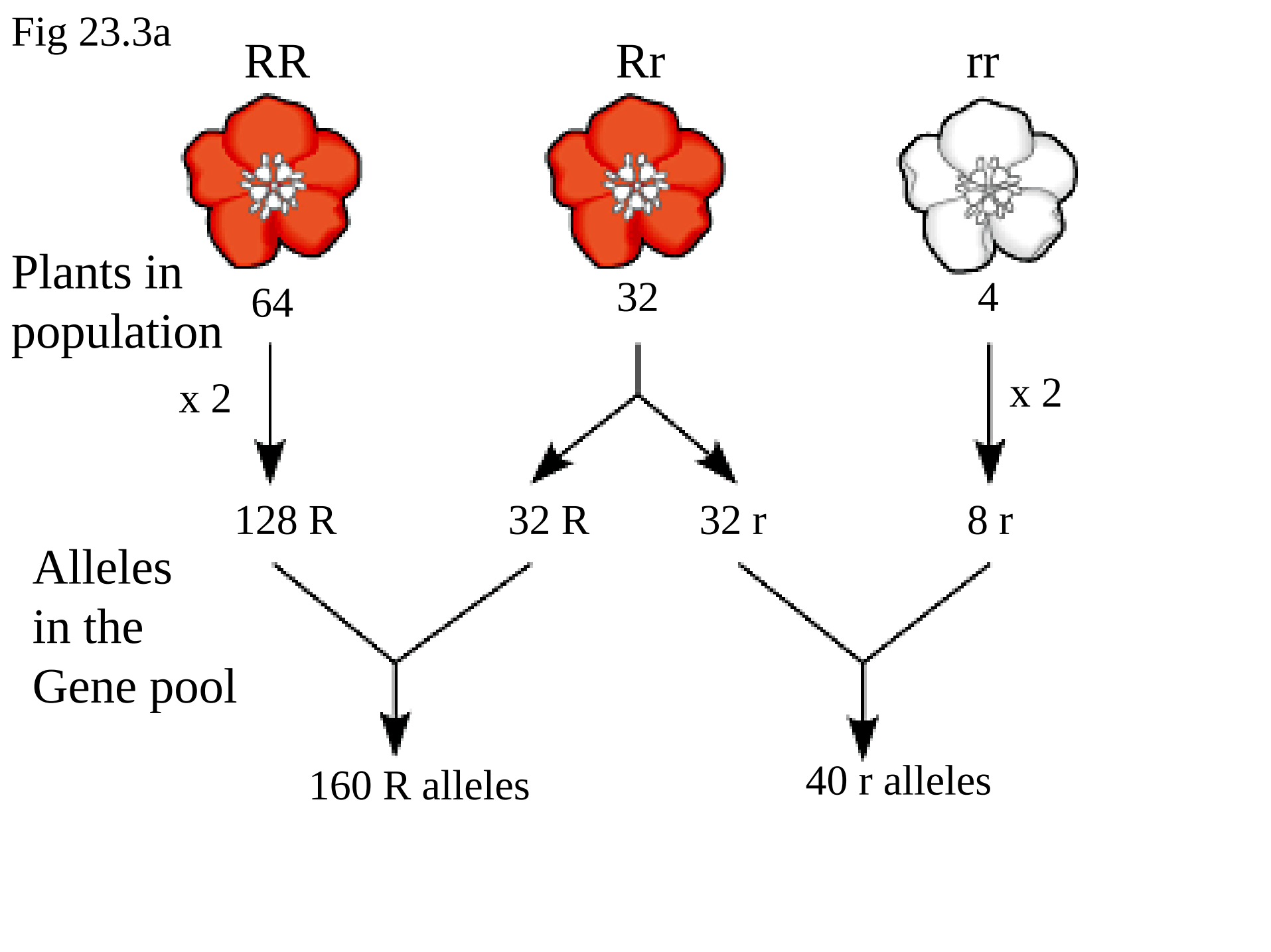
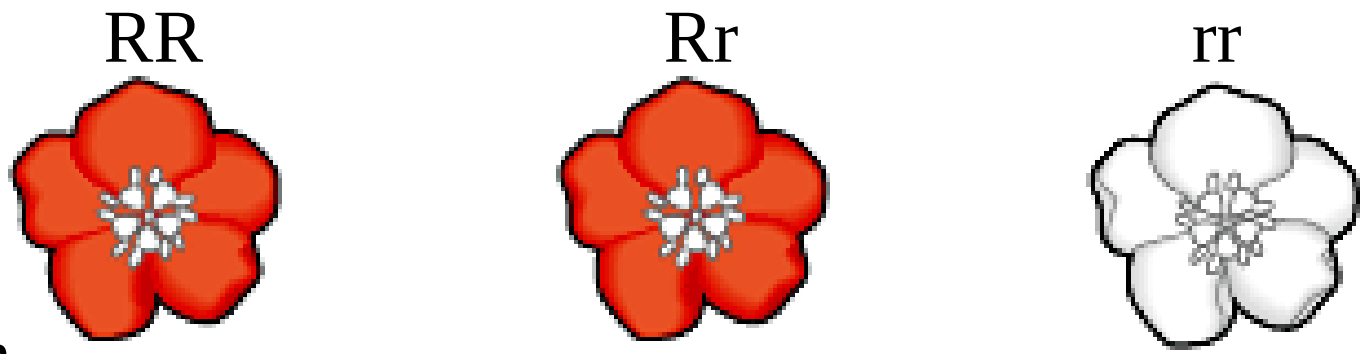

RR
Rr
rr
Plants in population
64
32
4
x 2
x 2
128 R
32 R
32 r
8 r
Alleles in the Gene pool
160 R alleles
40 r alleles

Fig 23.3a



Plants in population

64

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x 2

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Alleles in the Gene pool

128 R

32 R

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8 r

160 R alleles

40 r alleles

160 / 200 = .8 = p

40 / 200 = .2 = q

What is the probability of an offspring with the genotype RR In the next generation?

Probability of observing event 1 AND event 2 = the product of their probabilities.

160 / 200 = .8 = p

40 / 200 = .2 = q

P[2 R alleles from 2 gametes]?

Probability of each R = .8
Probability of RR = .8 x .8 = .64

= p x p = $\mathbf{p^2}$

What is the probability of an offspring with the genotype rr In the next generation?

Probability of observing event 1 AND event 2 = the product of their probabilities.

160 / 200 = .8 = p

40 / 200 = .2 = q

Pr: 2 r alleles from 2 gametes?

Probability of each r = .2

Probability of rr = .2 x .2 = .04

= q x q = $\mathbf{q^2}$

What is the probability of an offspring with the genotype Rr In the next generation?

160 / 200 = .8 = p

40 / 200 = .2 = q

Pr: one r and one R from 2 gametes?

P[r and R] or P[R and r]
= (.2 x .8) + (.8 x .2) = .32
= (p x q) + (p x q) = **2pq**

$$p^2 + 2pq + q^2 = 1$$

Frequency of RR

Frequency of Rr

Frequency of rr

Fig 23.3b

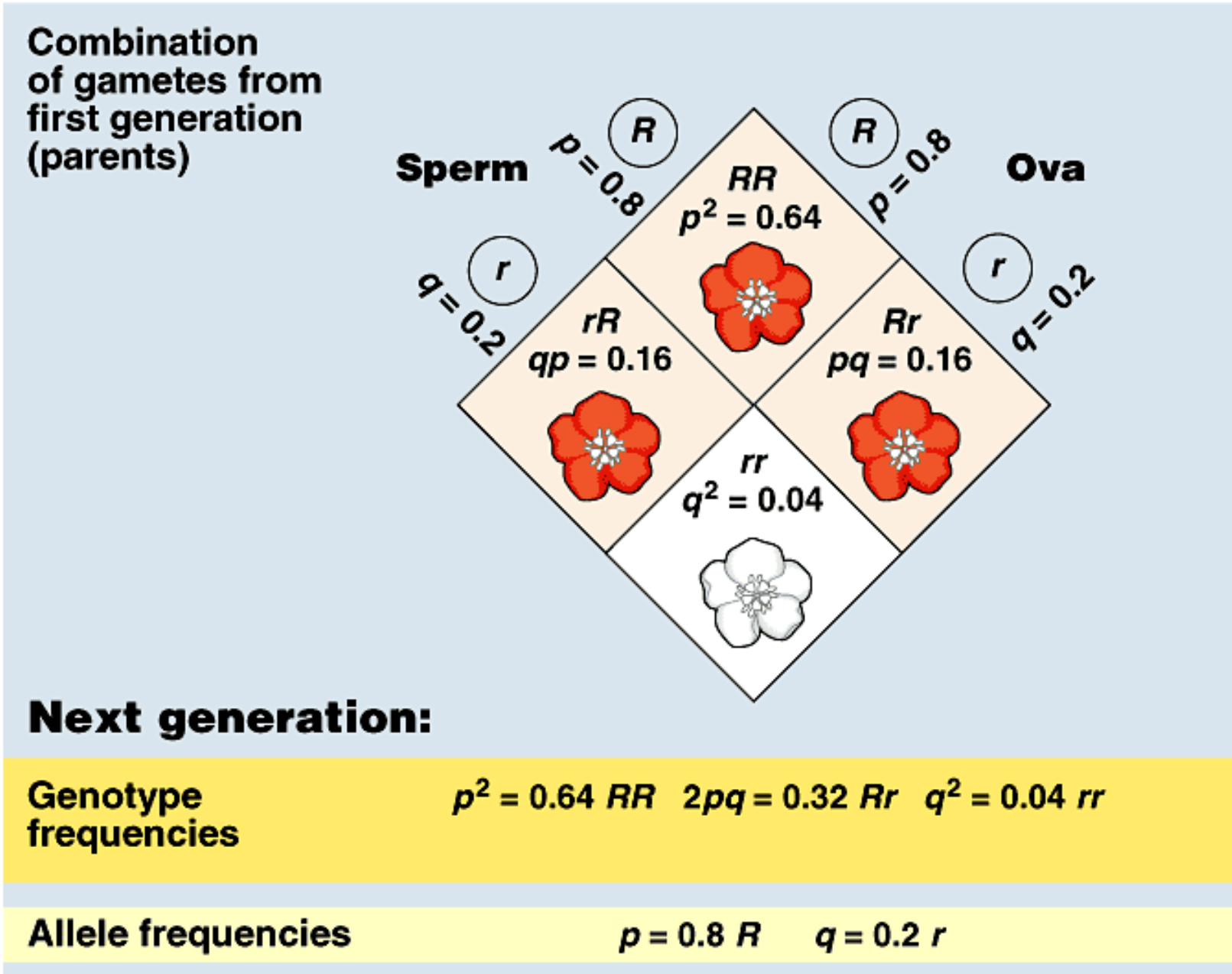
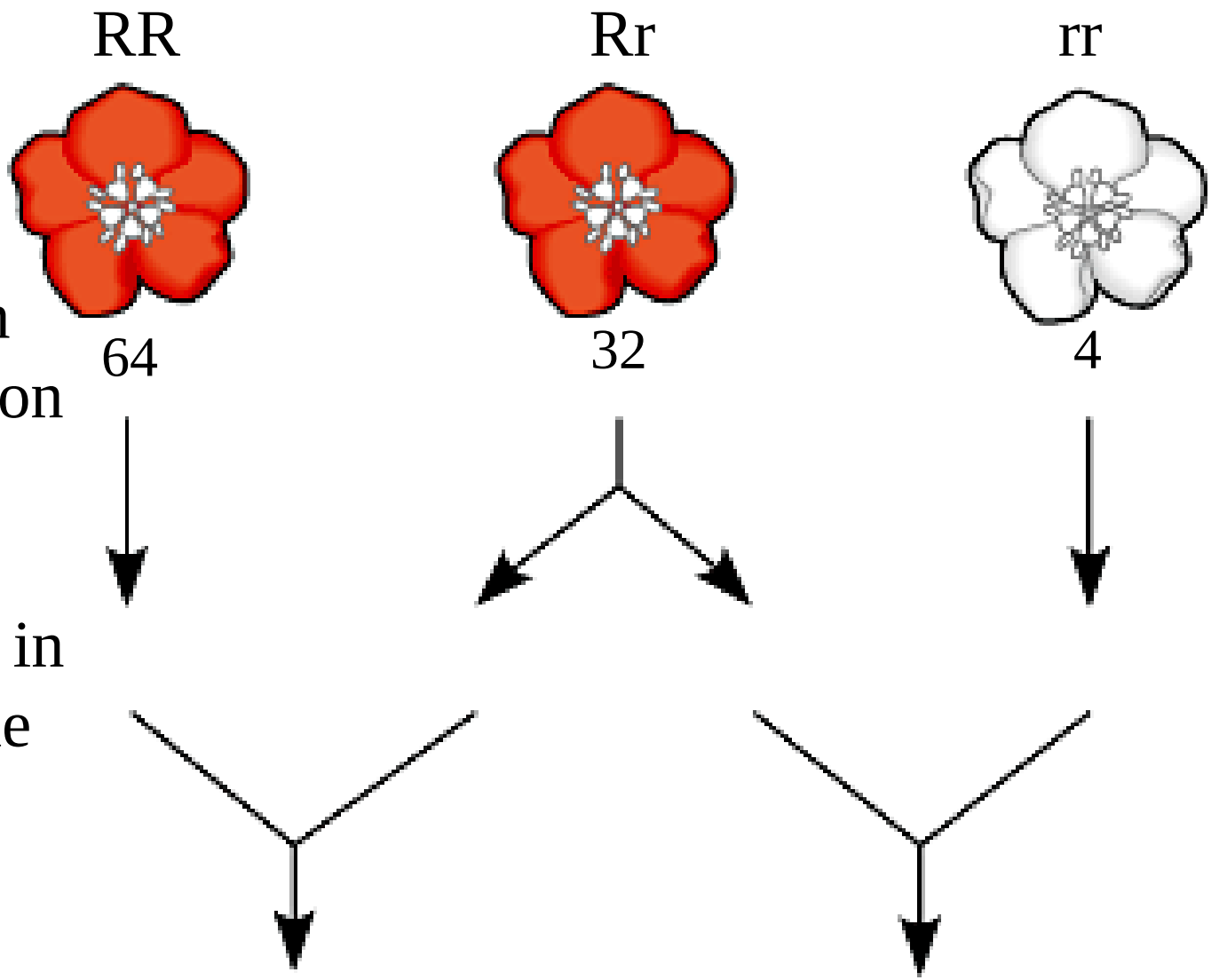

Combination of gametes from first generation (parents)
Sperm
Ova
R
r
p = 0.8
q = 0.2
RR
p² = 0.64
rR
qp = 0.16
Rr
pq = 0.16
rr
q² = 0.04
Next generation:
Genotype frequencies
p² = 0.64 RR 2pq = 0.32 Rr q² = 0.04 rr
Allele frequencies
p = 0.8 R q = 0.2 r

Fig 23.3a



The Hardy-Weinberg equilibrium

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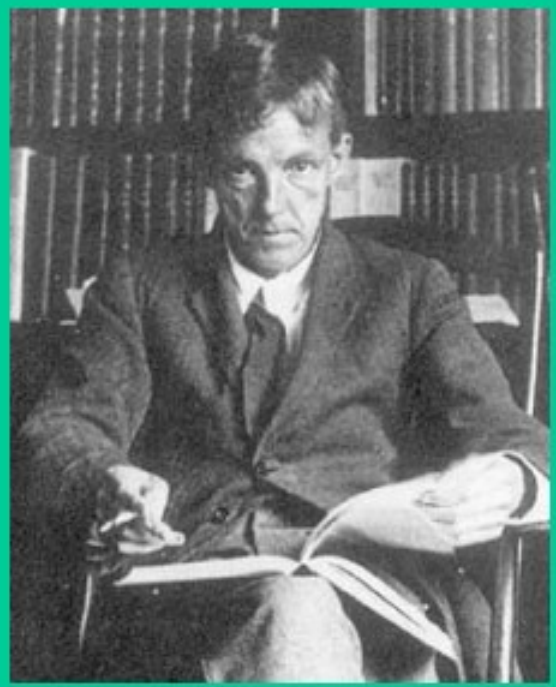

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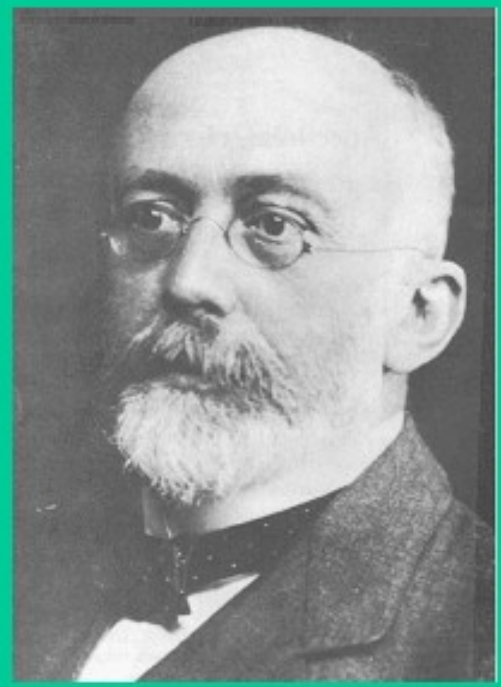


Wilhelm Weinberg
1862-1937

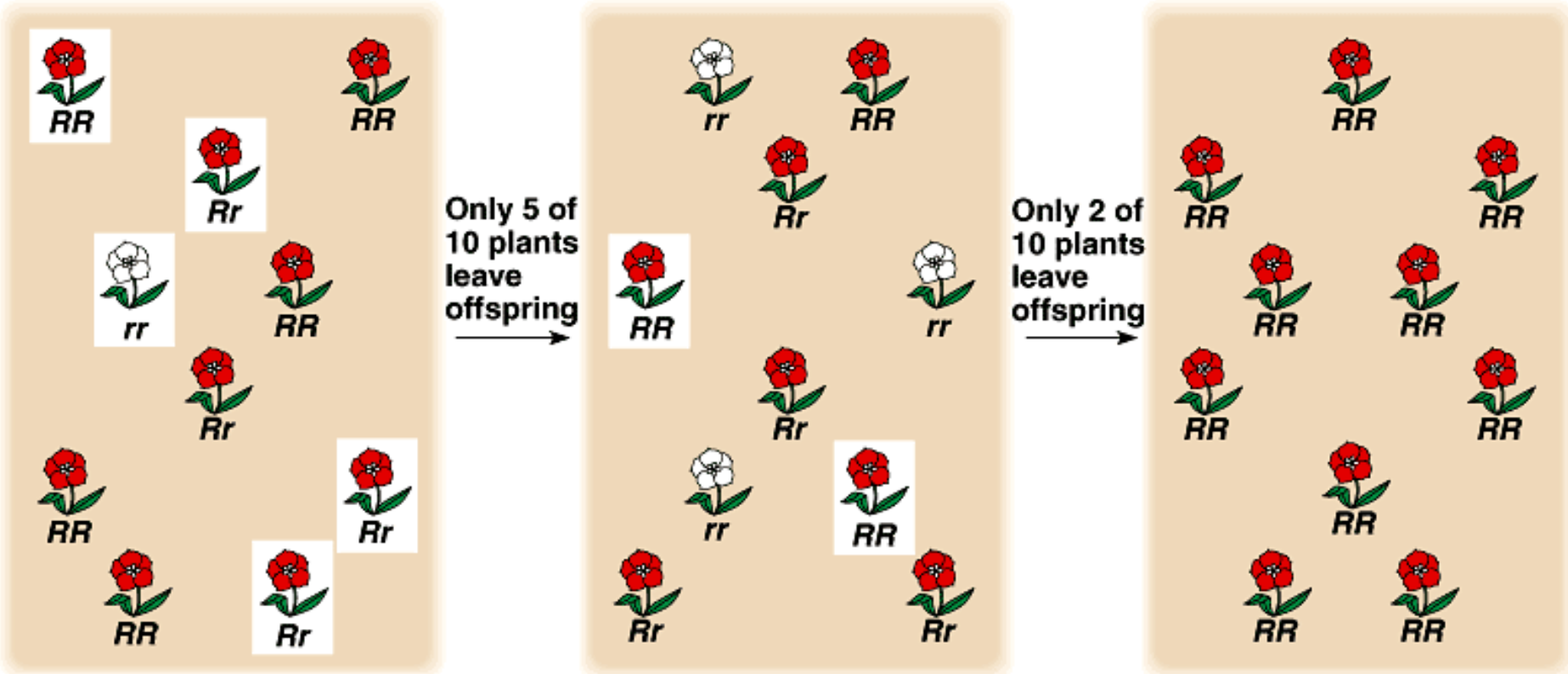
Hardy-Weinberg equilibrium is maintained as long as:

1. The population is large
2. There is no mutation
3. There is no immigration or emigration
4. Mating is random
5. All individual survive and reproduce equally well

   (i.e. no natural selection)

Fig 23.4

Genetic Drift in a small population of 10 individuals



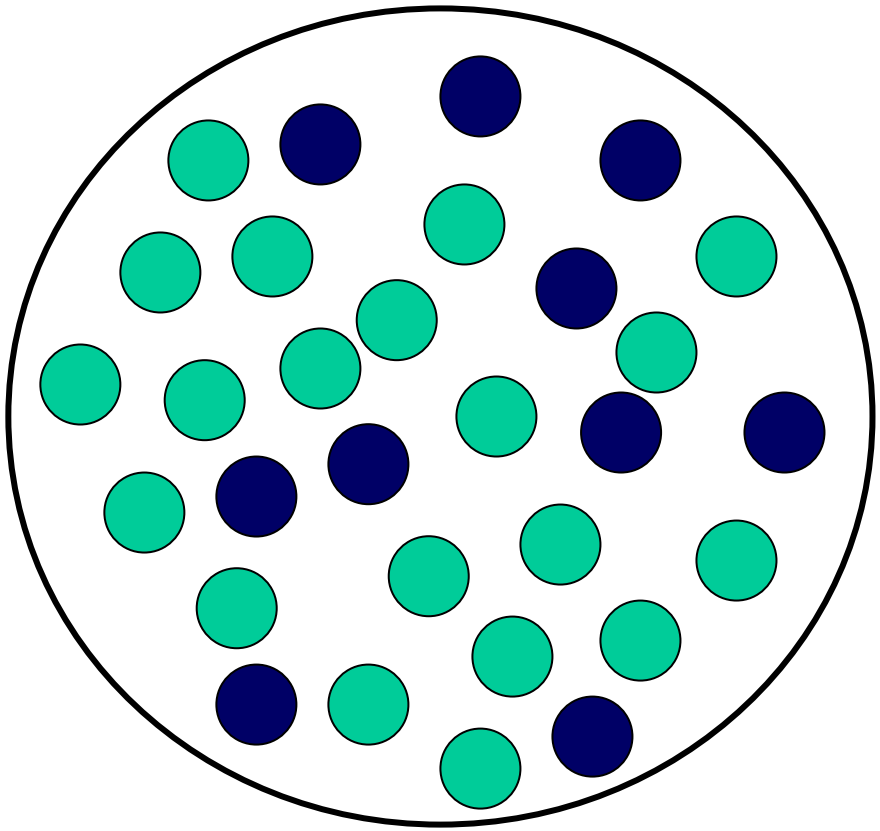
Generation 1
p (frequency of *R*) = 0.7
q (frequency of *r*) = 0.3

Generation 2
p = 0.5
q = 0.5

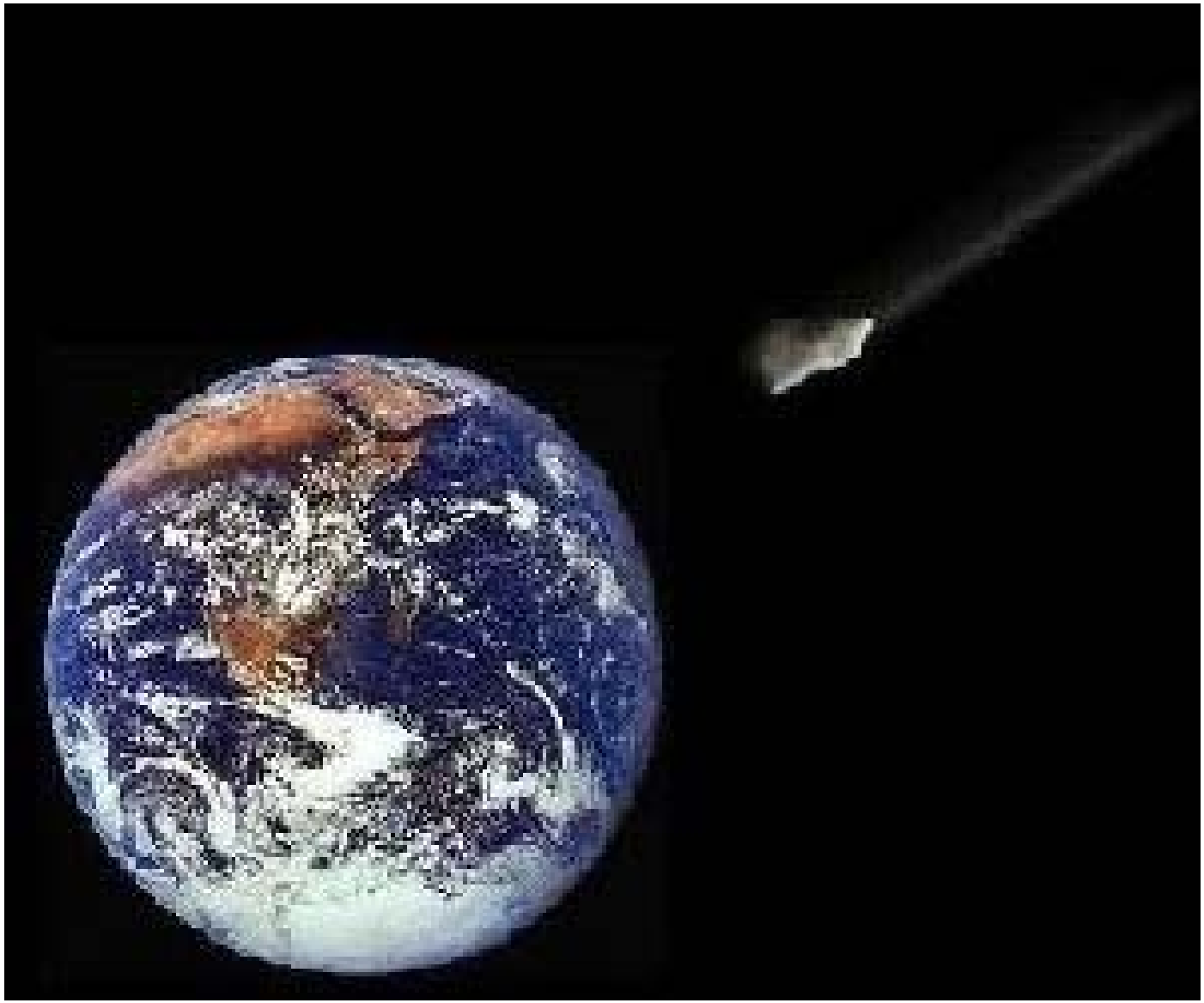
Generation 3
p = 1.0
q = 0.0

Bottleneck - **effect of a temporary period of small population size on allele frequencies**

Original population

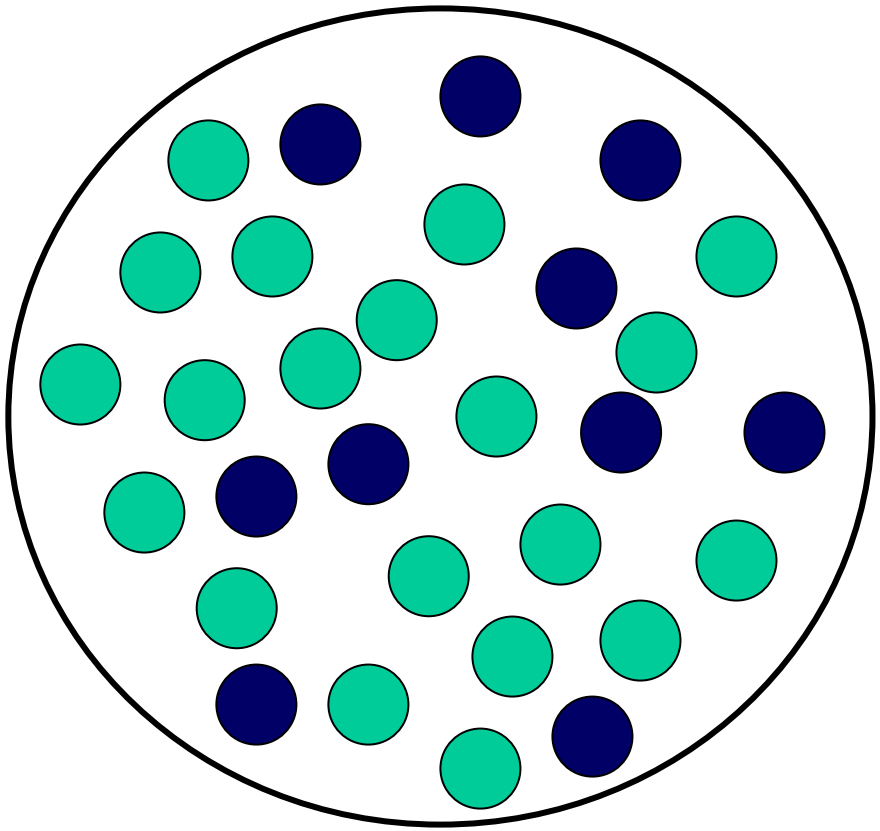


Some disaster strikes the original population ……

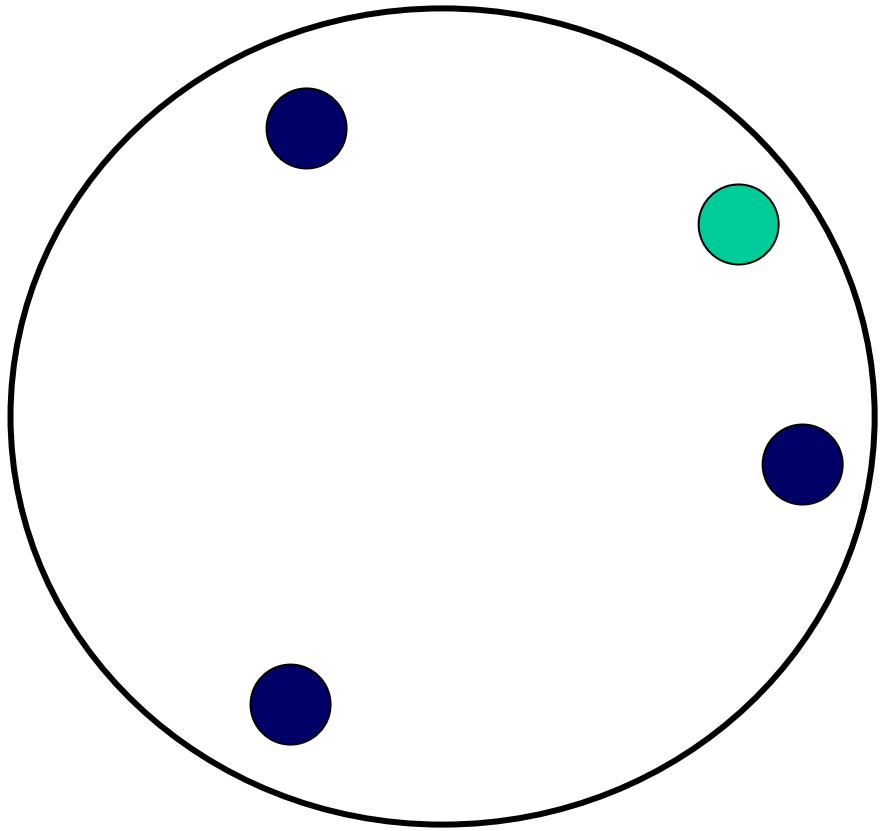


Bottleneck effect

Original population



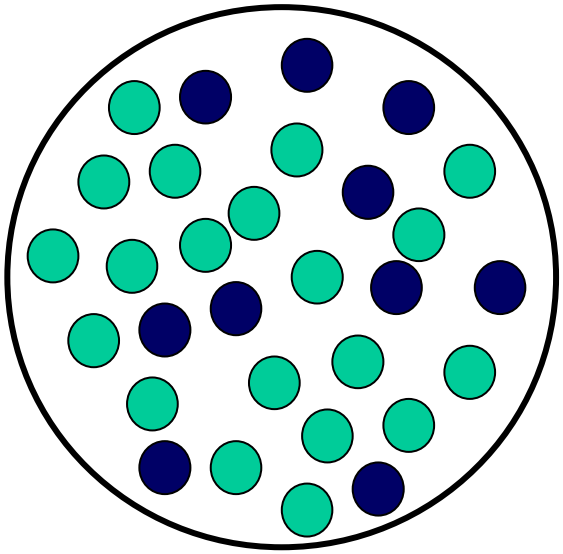
Disaster strikes



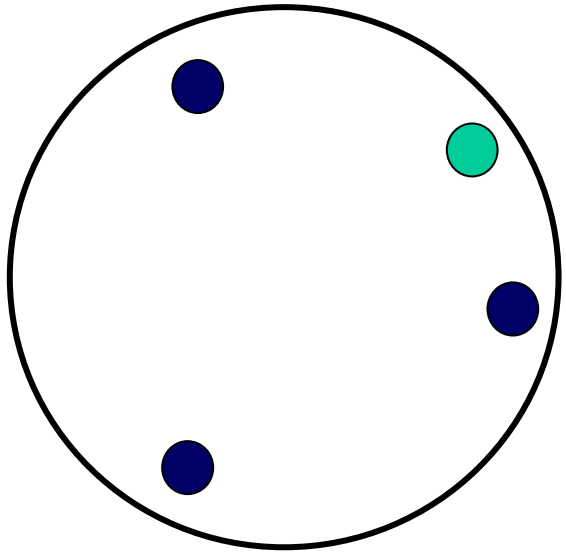
Allele frequency has changed

Bottleneck effect

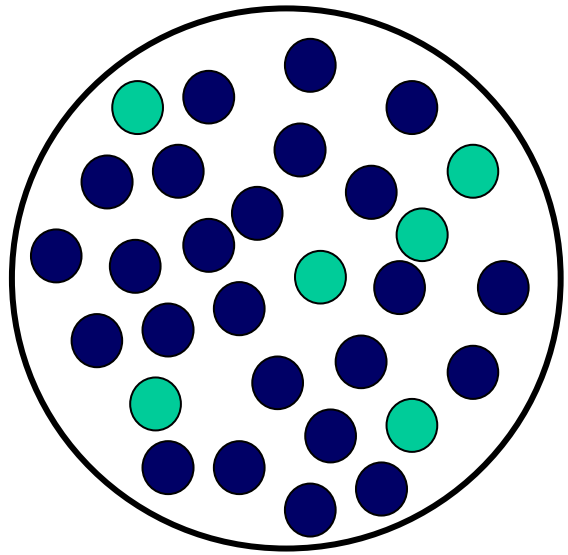
Original population



Disaster strikes

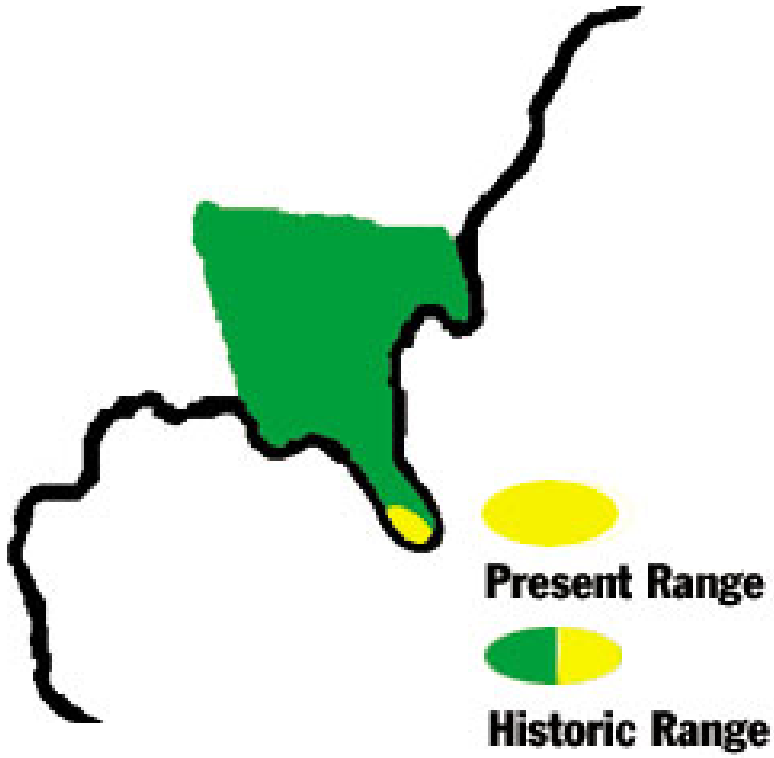


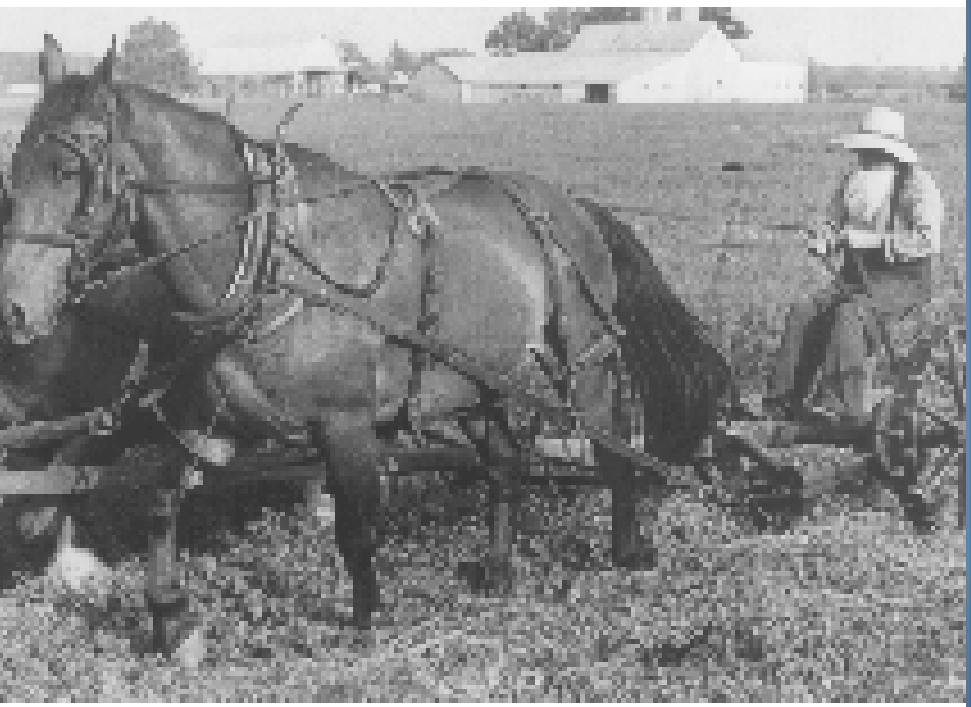
After the disaster



Allele frequency has changed

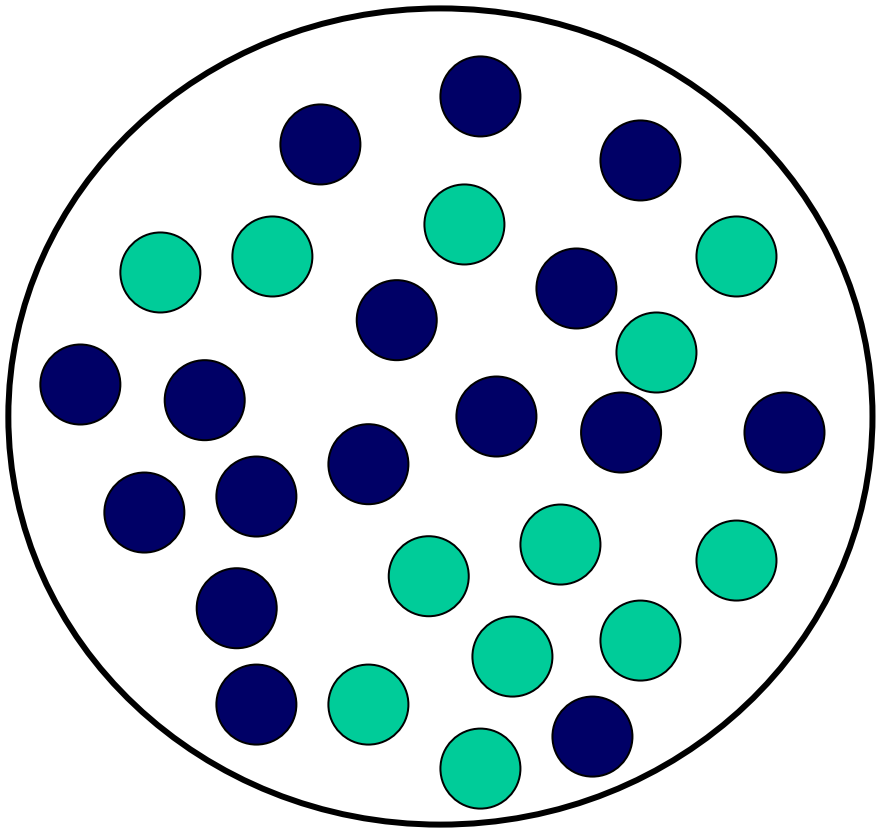
Florida Panther Range



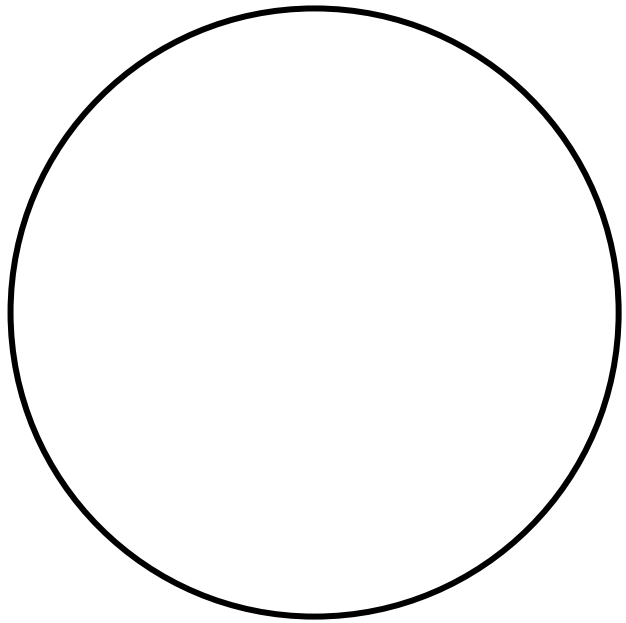


Founder effect: the small initial number of Amish colonists included an individual carrying the recessive allele for six-fingered dwarfism

Founder effect

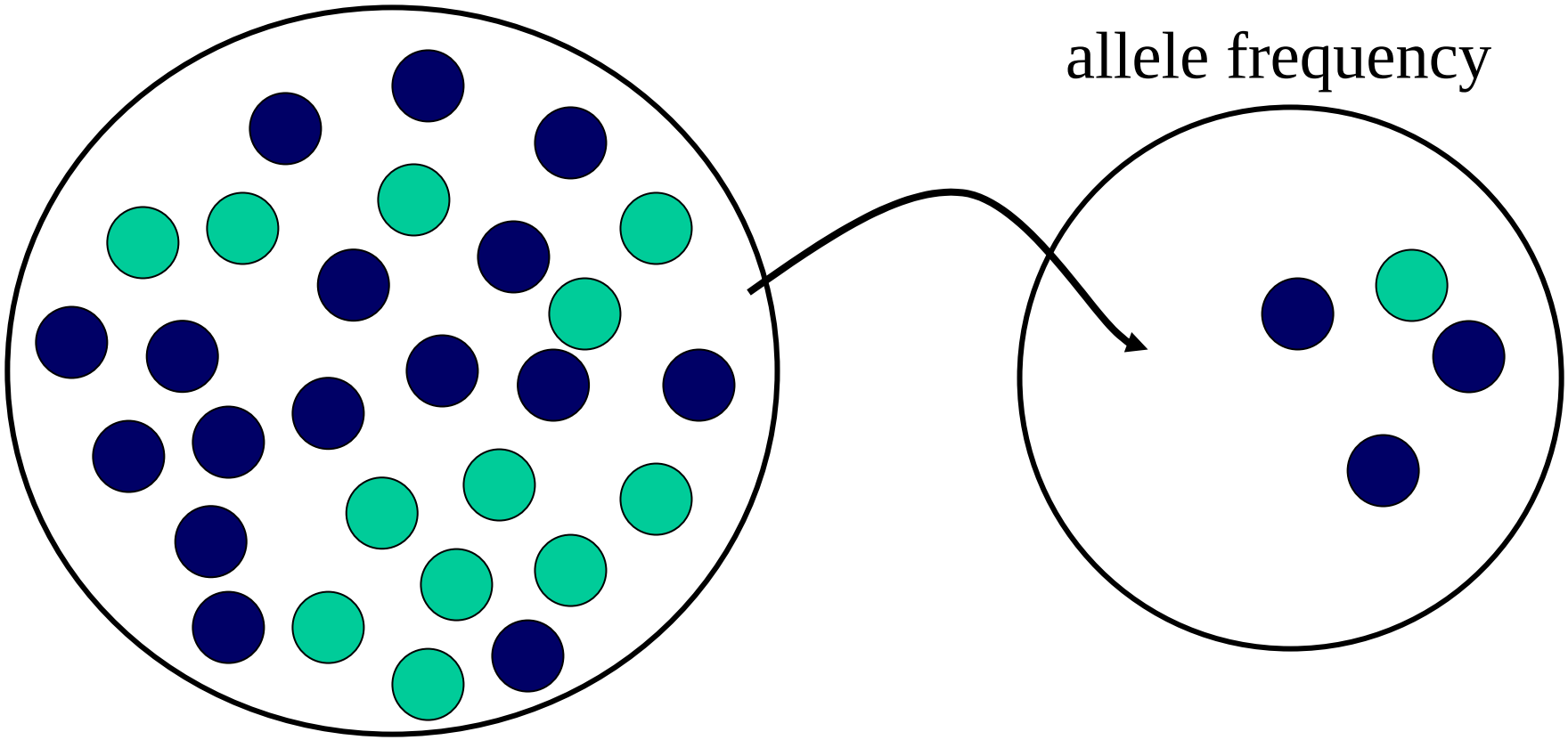


New habitat



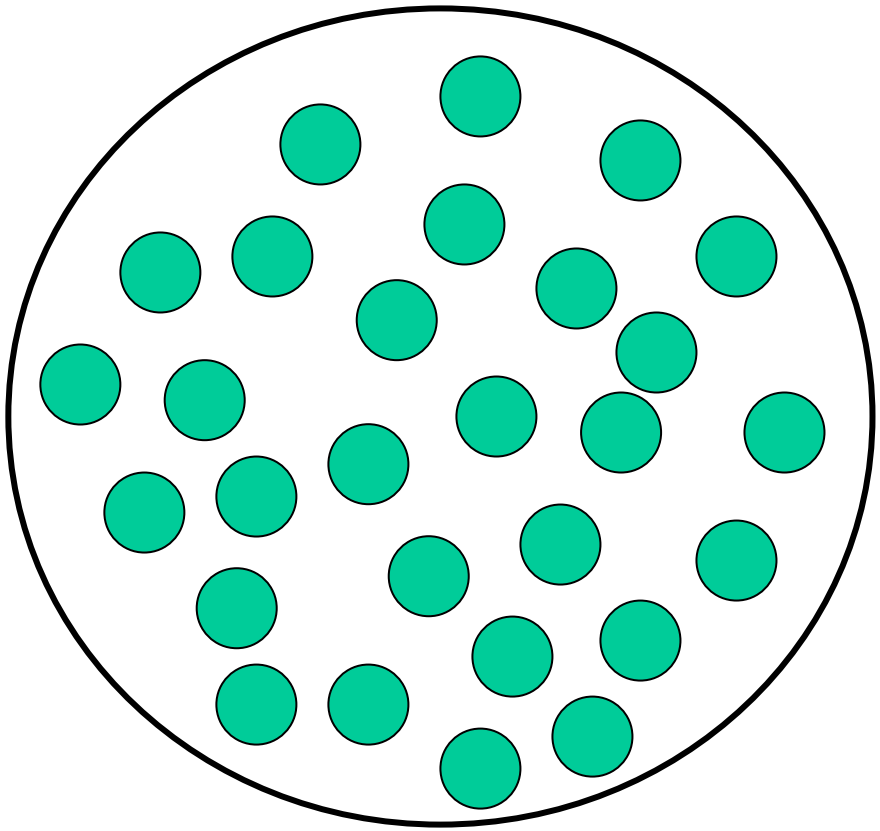
Founder effect

The founders of the new population have a different allele frequency

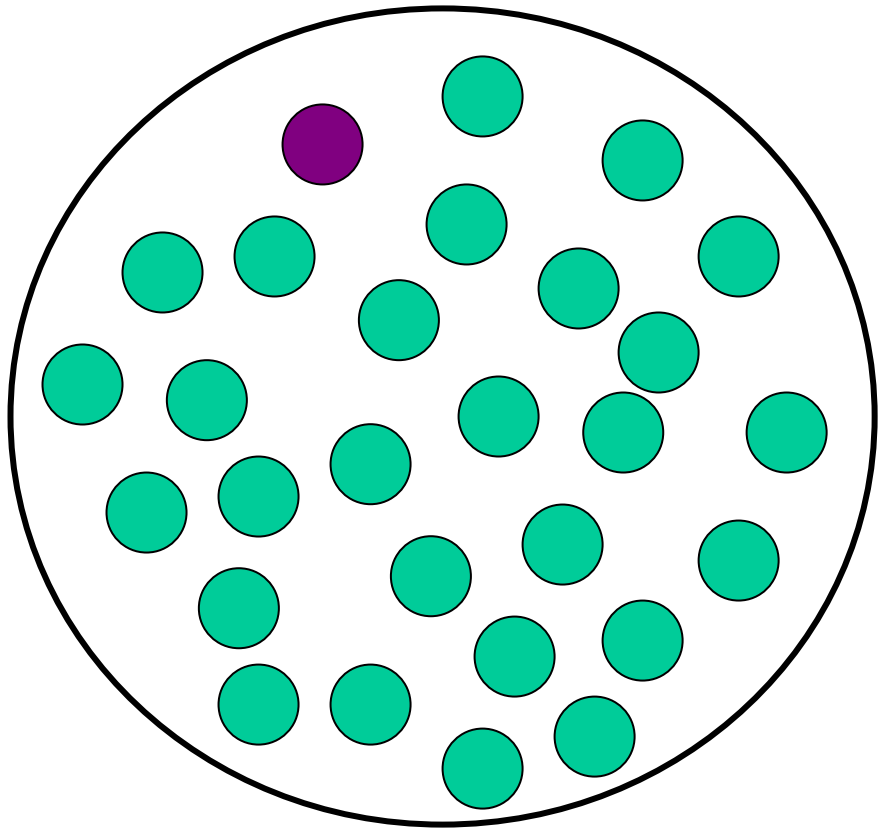


Mutation

Original population is fixed for the green allele



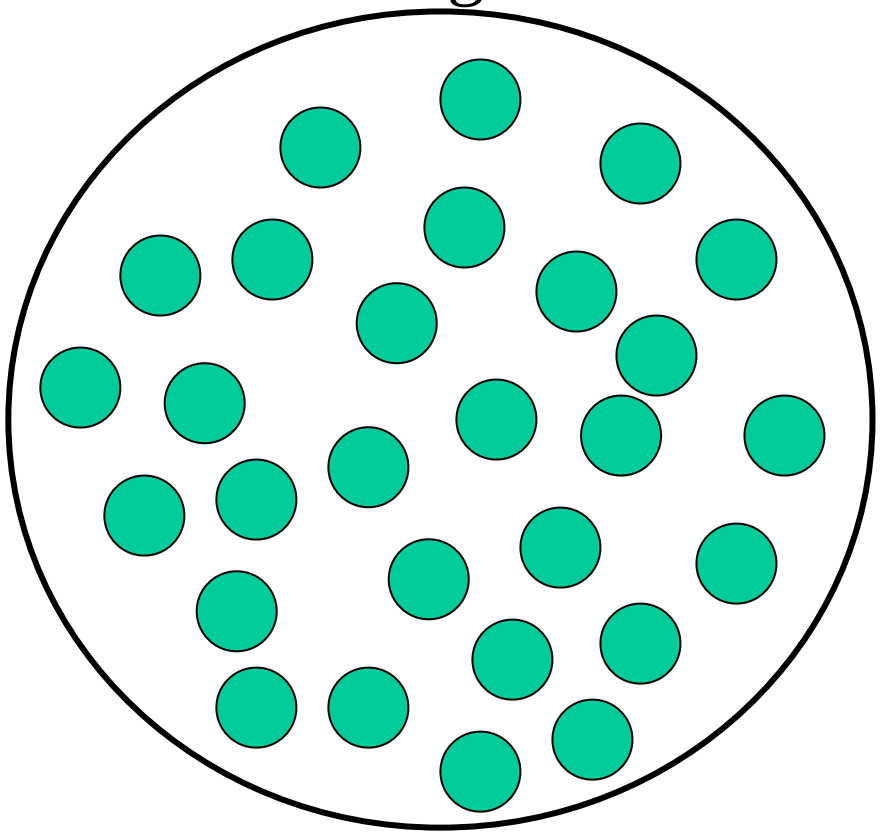
Mutation creates new alleles



Mutation

But recall that mutations are rare – about 1 in 100,000 per generation, and some of those mutations are lethal or deleterious

Original population is fixed for the green allele



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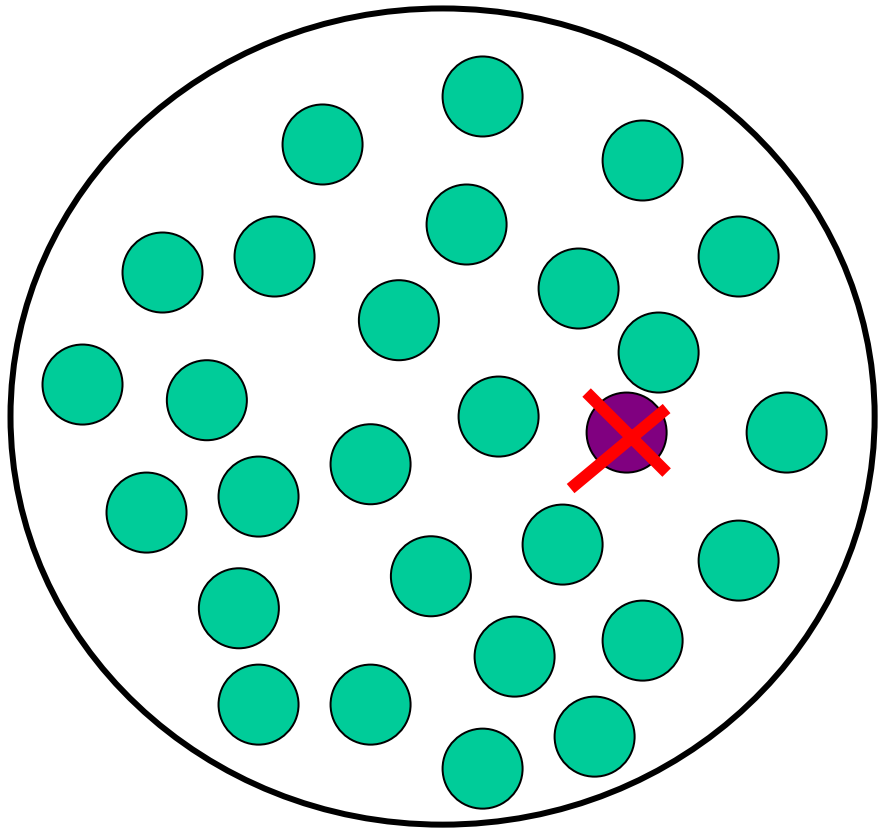
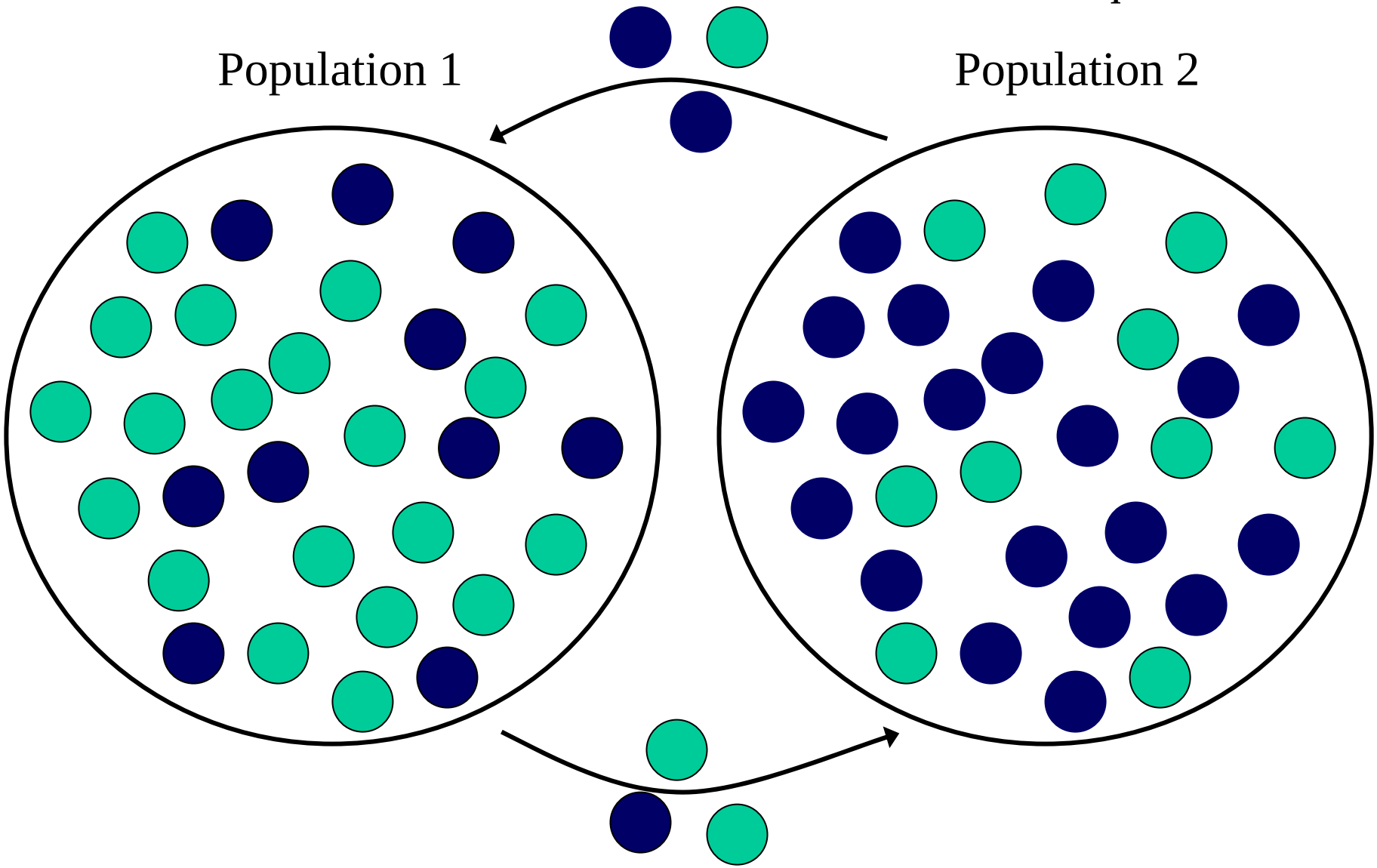


Gene flow – movement between populations can change their allele frequencies



Gene flow - exchange of alleles among population changes gene frequencies