POPULATION GENETICS

GENETIC STRUCTURE OR CONSTITUTION OF POPULATIONS

GENETIC CONSTITUTION OF POPULATIONS

- **Genes** come in different variants **(alleles).**
- Individuals can have one or two alleles for any gene:

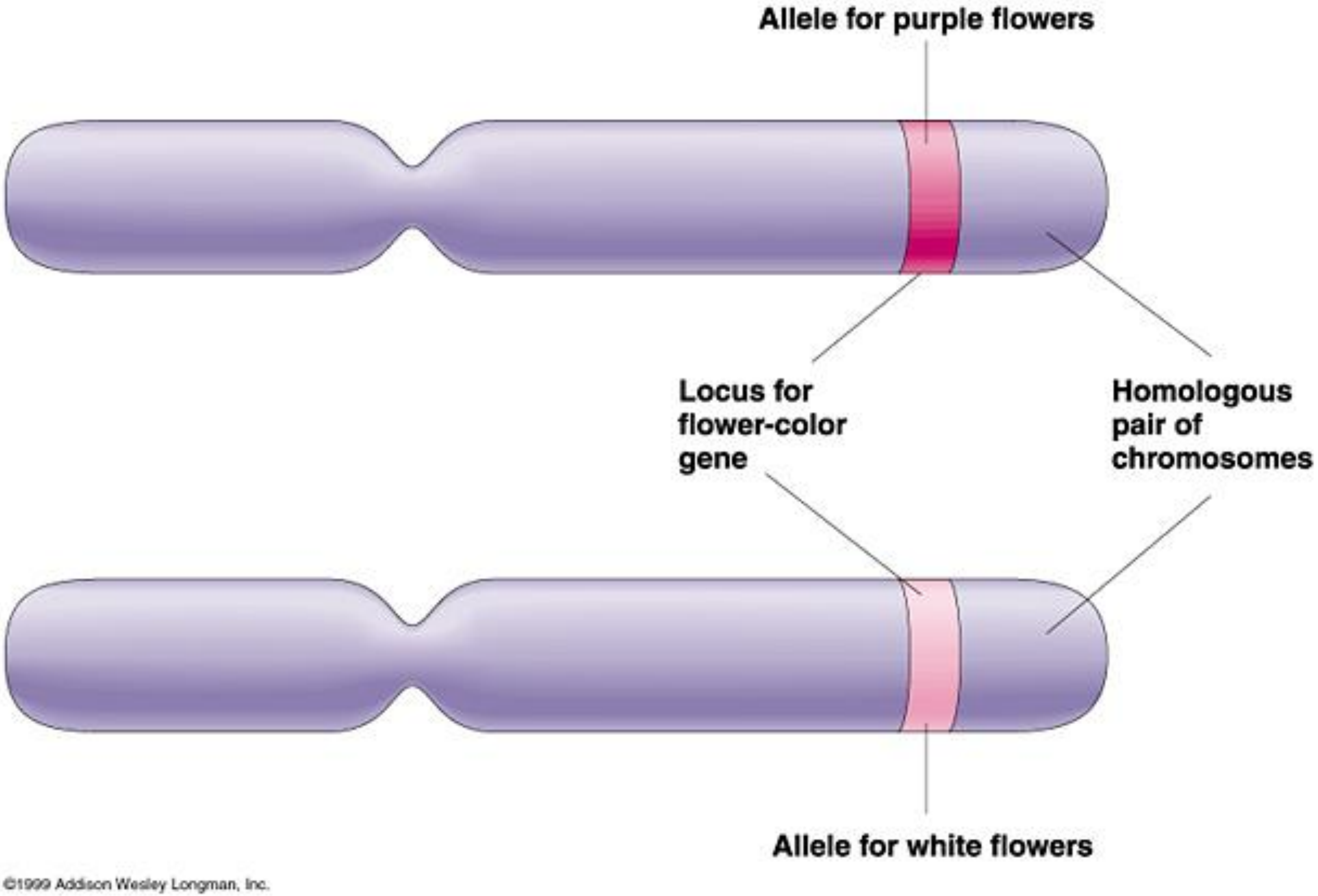
  Two different alleles = **heterozygous**

  Two of the same allele = **homozygous**
- **Dominant alleles** are expressed whether there is one copy or two.
- **Recessive alleles** must be present in two copies to be expressed.

GENETIC CONSTITUTION OF POPULATIONS

- **So if there are N individuals → Total number of genes or alleles at locus = 2N**
- **Allele : alternative forms of a gene.**
- **Two alleles at a locus → simple case or common.**
- **More than two alleles at locus → multiple alleles. Example. ABO blood group system in human.**

GENETIC CONSTITUTION OF POPULATIONS



Gene frequency or allelic frequency or gametic array

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Allele frequency is the proportion of that allele relative to all alleles at a locus in the population

- **Frequency of dominant allele** A ⇒ p
- **Frequency of recessive allele** a ⇒ q
- **$p + q = 1$**
- **$P = 1 - q$**
- **$q = 1 - p$**
- **$p+q+r = 1$ (if there are three different alleles at a locus).**

Calculation of allele frequency

Suppose that there are N individuals having the following genotypes

Phenotype	Red	Roan	White	Total
Genotype	AA	Aa	aa	
No. of individuals	K	L	M	N
No. of alleles A	2K	L	-	2K+L
No. of alleles a	-	L	2M	2M+L
Genotypic frequency	D	H	R	1

2K + L + 2M + L = 2 (K + L + M) = 2N

Methods of calculation

1. From number of phenotypes

$$\text{Freq. of a gene} = \frac{(\text{No. of indivi. homozygous for that allele}) + (\frac{1}{2}\text{No. of indivi. heterozygous for the same allele})}{\text{Total number of individals}}$$

$$\therefore \quad P(A) = \frac{K + \frac{1}{2}L}{N} \qquad also \qquad q(a) = \frac{M + \frac{1}{2}L}{N}$$

Methods of calculation

2. From genotypic frequency

$$\text{Freq. of a gene} = \text{freq. of indivi. homozyous for that allele} + \frac{1}{2}$$

Freq. of individual Heterozygous for the same allele

$$P_{(A)} = D + \frac{1}{2}H$$

$$q_{(a)} = R + \frac{1}{2}H$$

Methods of calculation

3. From number of alleles

$$\text{Freq. of a gene} = \frac{(2\text{No.of indivi. homozygous for that allele}) + (\text{No.of indivi. heterozygous for the same allele})}{2\text{Total number of individals}}$$

$$\therefore \quad P(A) = \frac{2K + L}{2N} \qquad \text{also} \qquad q(a) = \frac{2M + L}{2N}$$

Genotypic frequency or zygotic array or genotypic array

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Genotypic frequency: the relative frequency of a particular genotype in a population.

phenotype	Red	Roan	White	Total
Genotype	AA	Aa	aa	
No. of indivi.	K	L	M	N
Genotype Frequency	D	H	R	1

Calculation of genotypic frequency

$$Genotypic\ frequencies = \frac{The\ No.of\ individuals\ of\ a\ particular\ genotype}{The\ total\ No.of\ individuals\ in\ the\ population}$$

$$D = \frac{K}{N} \qquad H = \frac{L}{N} \qquad R = \frac{M}{N}$$

Example

- In shorthorn cattle, 3 coat colors are Red, Roan and White. In a sample of 1000 shorthorn assume the number of animals with each colour is:

phenotype	Red	Roan	White	Total
Genotype	RR	Rr	rr	
No. of indivi.	360	480	160	1000

a. What are the gene frequency.
b. What are the genotypic frequency.

Solution

a. Gene frequency

$$p_{(R)} = \frac{360 + \frac{1}{2}480}{1000} = 0.6$$

$$q_{(r)} = \frac{160 + \frac{1}{2}480}{1000} = 0.4$$

b. Genotype frequency

$$D_{(RR)} = \frac{360}{1000} = 0.36$$

$$H_{(Rr)} = \frac{480}{1000} = 0.48$$

$$R_{(rr)} = \frac{160}{1000} = 0.16$$

The Hardy-Weinberg Law

Table 24.1 Possible Combinations of *A* and *a* Gametes from Gametic Pools for a Population

Female gametes	Male gametes: $A(p)$	Male gametes: $a(q)$
$A(p)$	AA (p^2)	Aa (pq)
$a(q)$	Aa (pq)	aa (q^2)

In sum, $p^2\ AA + 2pq\ Aa + q^2\ aa = 1.00$

Test Hardy-Weinberg Law

Two equations can be used:

1 $$H = 2\sqrt{D.R}$$

H: frequency of heterozygote.
D: frequency of homozygous dominant.
R: frequency of homozygous recessive.

2 $$H = 2pq$$

p: frequency of dominant allele.

q: frequency of recessive allele.

Example

We sampled 2020 Guinea pigs that have one of three phenotypes. Long, Short, or Intermediate hair. The gene for hair length is governed by incomplete dominance, where Long hair is HH, Intermediate hair is Hh, and Short hair is hh. We find that 1322 Guinea pigs have long hair, 450 have Intermediate hair, and 248 have short hair.

1. Determine the genotypic frequencies
2. Determine the allelic frequencies
3. Decide if this population is in Hardy-Weinberg equilibrium or not?

Test Hardy-Weinberg Law

phenotype	Long	Intermediate	Short	Total
Genotype	HH	Hh	hh	
No. of indivi.	1322	450	248	2020

- **Genotypic frequencies**

$$D_{(HH)} = \frac{1322}{2020} = 0.65$$

$$H_{(Hr)} = \frac{450}{2020} = 0.22$$

$$R_{(hh)} = \frac{248}{2020} = 0.12$$

Test Hardy-Weinberg Law

- **Allelic frequencies**

$$p_{(H)} = 0.65 + \frac{1}{2} 0.22 = 0.76$$

$$q_{(h)} = 0.12 + \frac{1}{2} 0.22 = 0.23$$

- **Test of H &W law**

$$H = 2\sqrt{D.R}$$

$$0.22 = 2\sqrt{0.65 \times 0.12}$$

$$0.22 \neq 0.558$$

Population not in H &W law

Or $H = 2pq$

0.22 = 2 x 0.76 x 0.23

0.22 ≠ 0.34

Example

One hundred person from a small town in Egypt were tested for Mm blood types the genotypic data are: MM = 41 , MN= 38, and NN= 21. Is the population in Hardy-Weinberg proportions?

Solution:

A. $$\frac{H}{\sqrt{D.R}} = 2$$

Blood Types	MM	MN	NN	Total
Numbers	41	38	21	100
Genotype frequency	D	H	R	
	(0.41)	(0.38)	(0.21)	

Example

$$\therefore \frac{0.38}{\sqrt{(0.41)(0.21)}} = \frac{0.38}{0.29} = 1.30$$

The equation is not equal 2 , then the population is not in Hardy-Weinberg equilibrium.

B. H = 2pq

$$P(M) = [(41x2)+38]/200 = .06$$

$$q(N) = [(21x2)+38]/200 = 0.4$$

$$H = 2pq$$

$$0.38 = 2x0.6x0.4$$

$$\therefore H \neq 2pq$$

Then, the population is not in Hardy-Weinberg equilibrium.

Thanks for your attention