OUTLINE 21
POPULATION GENETICS
I. The New Synthesis
A. Challenge
   1. Brachydactyly
   2. The Hardy-Weinberg rule
B. Populations and Gene Pools
   1. Definitions
   2. Illustration of Hardy-Weinberg Equilibrium
C. Conditions for Hardy-Weinberg equilibrium
D. Significance of Hardy-Weinberg for the study of Evolution
E. How to recognize Hardy-Weinberg equilibrium
More offspring are born than can survive to reproduce
Individuals within a species vary
Traits are heritable

Parent  →  Offspring

Parent  →  Offspring
Individuals with some traits reproduce more than others
Traits that enhance reproduction become more common each generation.
Artificial selection has produced different, true-breeding varieties of “fancy” pigeons from a single ancestral form.
Fossils - preserved evidence of previously living things
Homology - similarity caused by common ancestry

Human
Cat
Whale
Bat

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Early embryos of diverse groups share many features. As development proceeds, embryonic forms diverge and become more similar to adults of their own species (von Baer’s law)
The Paradox of Variation:

Evolution requires natural selection, but natural selection eliminates variation.
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
A population: Phenotype frequencies 1/3 red and 2/3 green
A population has a frequency of genotypes
Total number = 15, frequency of AA = 8/15 (53%)
Aa = 4/15 (27%)
aa = 3/15 (20%)
Individuals have 2 alleles for each gene

Total number of alleles in the gene pool = 2 x # individuals
A population has a frequency of alleles
Total number of alleles = 30, frequency of $A = 20/30$ (67%)

$a = 10/30$ (33%)
A population fixed for the “a” allele
A population with genetic variation
Fig 23.3a

Plants in population:
- RR: 64
- Rr: 32
- rr: 4

Alleles in the gene pool
Plants in population

RR: 64 plants
Rr: 32 plants
rr: 4 plants

Alleles

RR: 128 R alleles
Rr: 32 R alleles, 32 r alleles
rr: 8 r alleles

160 R alleles
40 r alleles
Fig 23.3a

Plants in population

<table>
<thead>
<tr>
<th>RR</th>
<th>Rr</th>
<th>rr</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>32</td>
<td>4</td>
</tr>
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</table>

x 2

Alles in the Gene pool

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x 2

160 R alleles

160 / 200 = .8 = p

40 R alleles

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.

\[
\frac{160}{200} = .8 = p \\
\frac{40}{200} = .2 = q
\]

P[2 R alleles from 2 gametes]?

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

\[= p \times p = p^2\]
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.

\[
\frac{160}{200} = .8 = p \\
\frac{40}{200} = .2 = q
\]

Pr: 2 r alleles from 2 gametes?

Probability of each r = .2
Probability of rr = .2 \times .2 = .04
\[= q \times q = q^2\]
What is the probability of an offspring with the genotype Rr in the next generation?

\[ \frac{160}{200} = .8 = p \]
\[ \frac{40}{200} = .2 = q \]

Pr: one r and one R from 2 gametes?

\[ P[ \text{r and R} \text{ or R and r} ] = (p \times q) + (p \times q) = 2pq \]
\[ p^2 + 2pq + q^2 = 1 \]

- Frequency of RR
- Frequency of Rr
- Frequency of rr
Combination of gametes from first generation (parents)

Next generation:

<table>
<thead>
<tr>
<th>Genotype frequencies</th>
<th>$p^2 = 0.64$</th>
<th>$2pq = 0.32$</th>
<th>$q^2 = 0.04$</th>
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<tr>
<td>Allele frequencies</td>
<td>$p = 0.8$</td>
<td>$q = 0.2$</td>
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Fig 23.3a

Plants in population

Alleles in the gene pool

RR   64

Rr   32

rr   4
The Hardy-Weinberg equilibrium

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