Bio1B Evolution 2

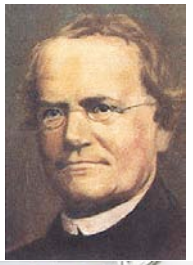
Last lecture:

- Natural selection - principles, lines of evidence in the "Origin"
- Descent with modification
- Estimation & interpretation of phylogeny
- Some major insights about the "Tree of Life"
  - 3 kingdoms: Archaea, Bacteria, Eukarya
  - Metazoan origins & relationships

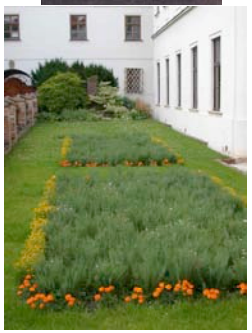
Today

- More history - Darwin+Mendel => the neodarwinian synthesis
- Mechanisms of evolution:
  - Evolution in populations - population genetics
  - Allele, genotype and phenotype frequencies
  - Predicting genotype freq's: Hardy (Castle) Weinberg Equilibrium
    - Application: Null model for evolution
    - Application: Predicting heterozygote frequencies for recessive traits

Mendel's principles of inheritance (1865) [see Ch 14]

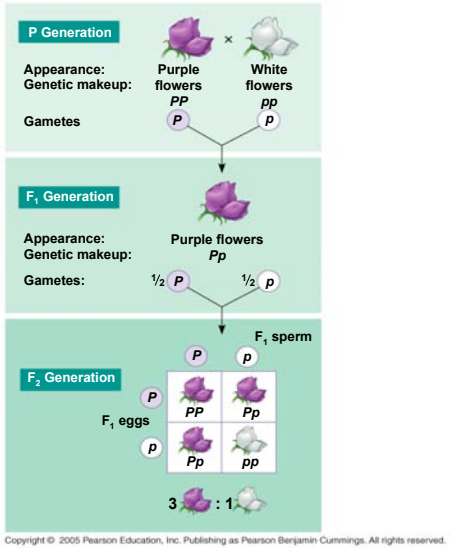


- Alternative versions of genes (alleles) account for variation in inherited characters
- For each character, an organism inherits 2 alleles, one from each parent
- If the 2 alleles at a locus differ, then the dominant allele determines phenotype
- The 2 alleles for a heritable character segregate during gamete formation (Law of Segregation)
- Each pair of alleles segregates independently of others during gamete formation [for unlinked genes]

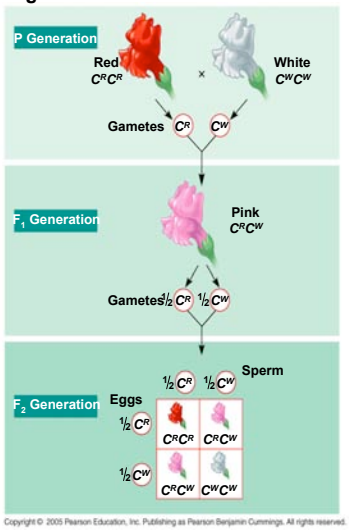


Mendel's garden; Brno

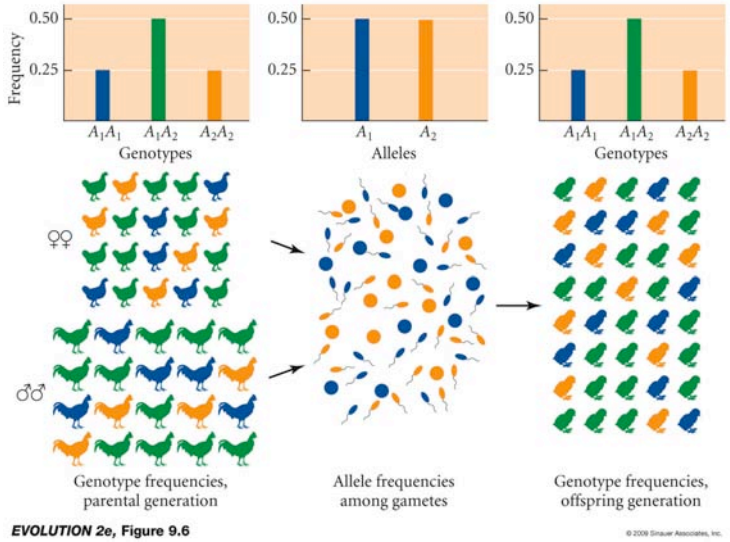
Dominance of purple (P) over white (p) flower color: Fig. 14-5



Co-dominance - heterozygote is intermediate (pink) in snapdragons: Fig. 14.10



Genotype and allele frequencies for a locus with two alleles



***EVOLUTION 2e*, Figure 9.6**

Futuyma, 2nd Ed.

Hardy-Weinberg Equilibrium

general case

male gametes

$f(A_1) = p$ $f(A_2) = q$

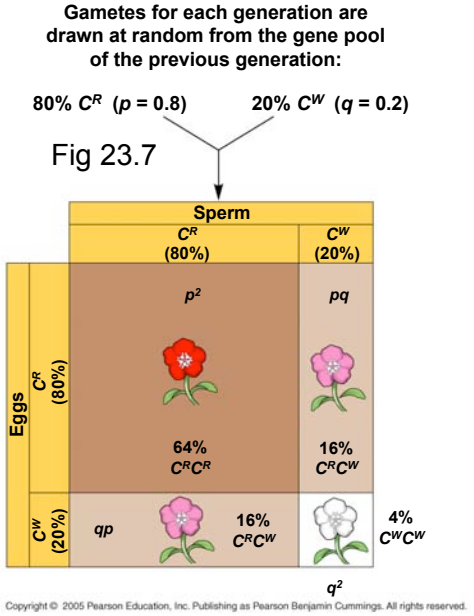
female gametes	$f(A_1) = p$	$f(A_2) = q$
	p^2 A_1A_1	pq A_1A_2
	qp A_2A_1	q^2 A_2A_2

Expected genotype frequencies

$A_1A_1 = p^2$

$A_1A_2 = 2pq$

$A_2A_2 = q^2$



Hardy-Weinberg Equilibrium

- Predicts genotype (& phenotype) frequencies from allele frequencies
- Genotype frequencies in expected proportions in a single generation
- Allele (& genotype) frequencies constant across generations => inheritance alone does not cause evolution
- Assumptions
  - Random mating (for this gene/trait)
  - No mutation, selection, migration
  - Large population (no drift)

Applications of HWE

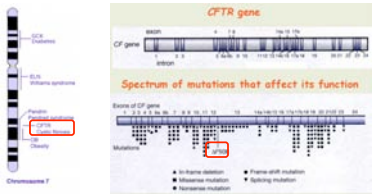
- A null model for evolution
  - Deviations from expected proportions indicate something interesting - but what?
- Predicting frequency of heterozygotes for recessive alleles, e.g. cystic fibrosis

Cystic fibrosis: Mapped to chloride transport gene on chromosome 7

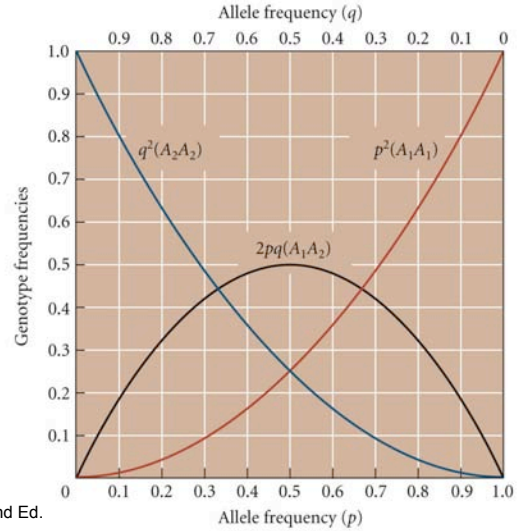
Common mutation, ΔF508 is recessive and at p = 0.02 in caucasian population

F(het) = 2pq = 0.04 (carriers)

F(hom) = p2 = 0.0004 (affected)



Hardy-Weinberg genotype frequencies as a function of allele frequencies at a locus with two alleles



Futuyma, 2nd Ed.

***EVOLUTION 2e*, Figure 9.8**

Effect of small population size - “genetic drift”

- Sampling gametes => zygotes
- Small population have greater sampling error => larger fluctuations in allele frequency

=> reduced variation within populations

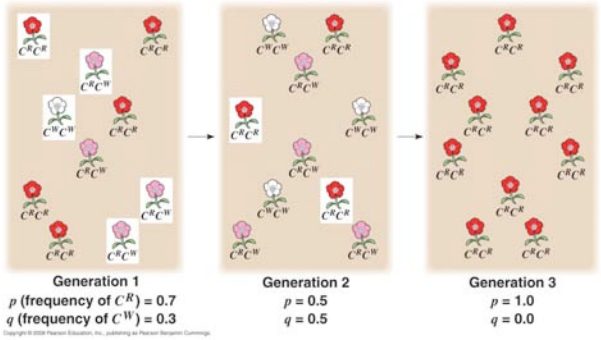


Fig. 23.8

Population bottlenecks

- Habitat loss or over-harvesting
- Colonization of new areas (eg. islands; humans “Out of Africa”

⇒ Loss of genetic diversity

⇒ Rapid change in allele frequencies => divergence

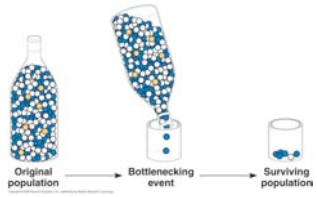
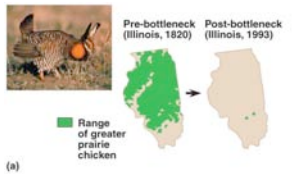


Fig. 23.9



Location	Population size	Number of alleles per locus	Percentage of eggs hatched
Illinois			
1930–1960s	1,000–25,000	5.2	93
1993	<50	3.7	<50
Kansas, 1998 (no bottleneck)	750,000	5.8	99
Nebraska, 1998 (no bottleneck)	75,000–200,000	5.8	96
Minnesota, 1998 (no bottleneck)	4,000	5.3	85

(b)

Fig. 23.10