Bio1B Evolution 4

Last lecture:
- 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

Today
- Predicting genotype freq's: Hardy (Castle) Weinberg Equilibrium
  - Application: Predicting heterozygote frequencies for recessive traits

Evolutionary processes
- Sampling effects => "genetic drift"
  - Relevance in evolution - loss of variation, bottlenecks
- Mutation as the ultimate source of variation; effects on fitness
- Selection
  - fitness
  - Forms and consequences

1

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

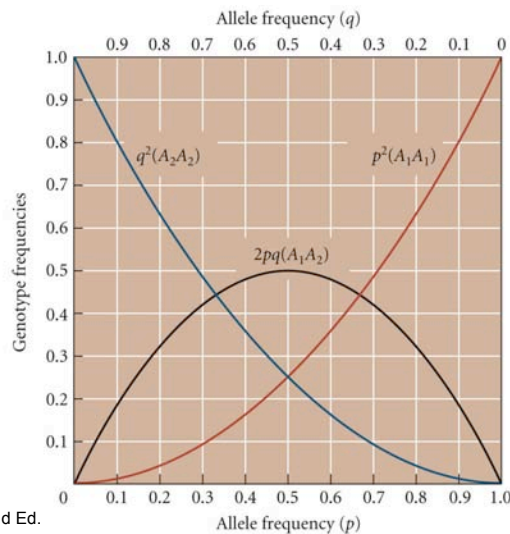Common mutation, ΔF508 is recessive and at p = 0.02 in caucasian population

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

F(hom) = p2 = 0.0004 (affected)
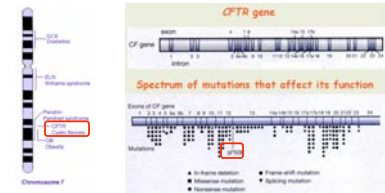
2

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

Futuyma, 2nd Ed.

EVOLUTION 2e, Figure 9.8

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Effect of small population size - "genetic drift"

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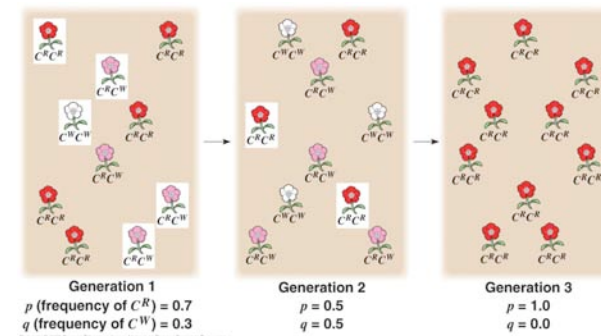=> reduced variation within populations

Fig. 23.8

4

Population bottlenecks

- Habitat loss or over-harvesting
- Colonization of new areas (eg. islands; humans "Out of Africa"
⇒ Loss of genetic diversity
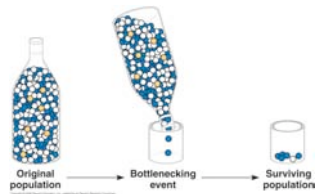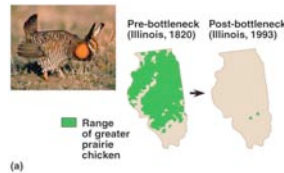⇒ Rapid change in allele frequencies => divergence

Fig. 23.9

Fig. 23.10   5

Mutations - forms

<u>Changes in</u>:

Coding sequence

Gene regulation

Gene copy number

Chromosome number & structure

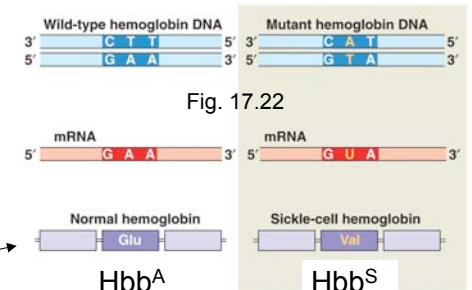Fig. 17.22
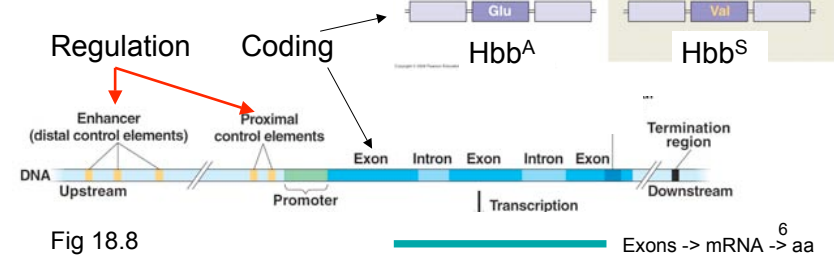
Regulation   Coding

Hbb^A Hbb^S

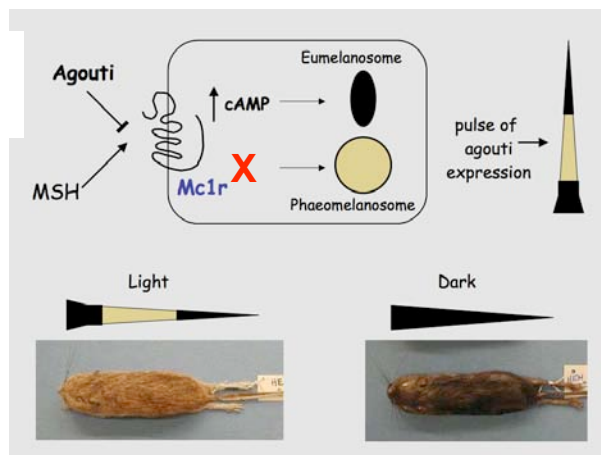Fig 18.8   Exons -> mRNA -> aa   6

Some key genes in melanin production pathway

Agouti melanistic mutations:

Recessive [regulatory & coding]

Mc1r Melanistic mutations

Dominant [structural]
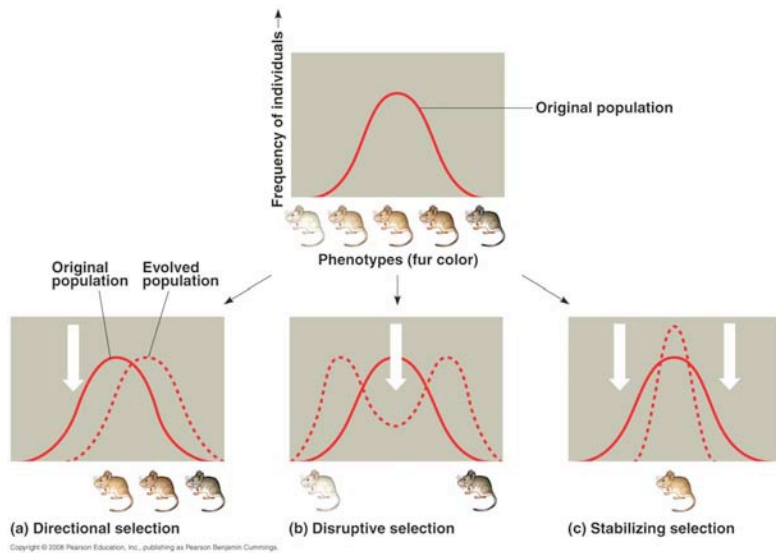
So what? … Mc1r & melanoma!   7

Genetic **fitness**

- Selection acts through the phenotype
- <u>Fitness</u> = Survival and reproduction relative to other phenotypes or genotypes in the population
- Relative fitness can be <u>environment dependent</u>

Sorry Arnie….   8

Forms of selection (Fig. 23.13)

(a) Directional selection
(b) Disruptive selection
(c) Stabilizing selection

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Example of Heterozygote advantage sickle-cell anaemia
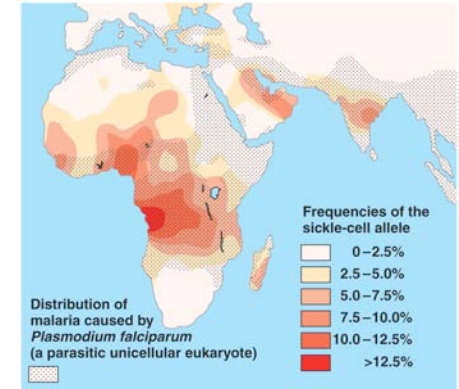
Relative fitnesses:

Without malaria:

$Hbb^{AA} > Hbb^{AS} > Hbb^{SS}$

→ anaemia

With malaria:

$Hbb^{AS} > Hbb^{AA} > Hbb^{SS}$

More resistant to malaria

Distribution of malaria caused by *Plasmodium falciparum* (a parasitic unicellular eukaryote)

Frequencies of the sickle-cell allele

	0–2.5%
	2.5–5.0%
	5.0–7.5%
	7.5–10.0%
	10.0–12.5%
	>12.5%

Note - fitness of Hbb^{AS} depends on environment (± malaria)

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Adaptive color polymorphism in rock pocket mice

mouse

habitat

O'Neill Hills ←— 2 miles —→ Pinacate Lava

Association between melanic phenotype and Mc1r allele in rock pocket mice from Pinacates lava flow
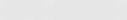

Hopi Hoekstra in the field..

Perfect association between genotype and phenotype

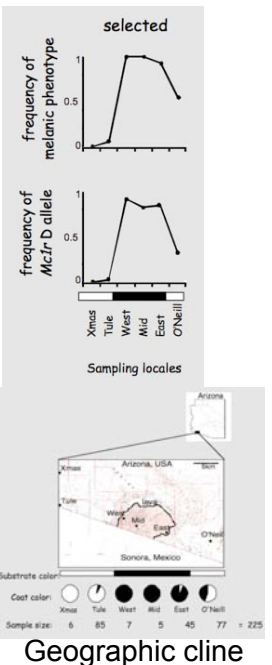| Genotype: *Mc1r* locus	Phenotype: coat color
	Dark
	Dark
	Light

N = 202 individuals (404 alleles)

selected

frequency of melanic phenotype

frequency of *Mc1r* D allele

Sampling locales

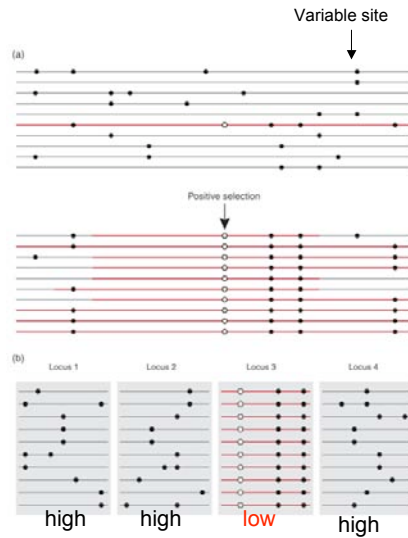Geographic cline

Genomic signatures of recent selection

New mutation arises
that increases fitness

Under directional selection
increases to p = 1; drags
<u>linked</u> sites with it

Results in a region of low
variation relative to others

Storz 2005

Variable site

(a)

Positive selection

(b) Locus 1   Locus 2   Locus 3   Locus 4

Variation   high   high   low   high

Genomic signatures of selection; localized reductions in diversity

The dog has its day

A Single *IGF1* Allele Is a Major
Determinant of Small Size in Dogs

What's
with my
crazy dog?

Sutter et al. 2007
Science 316:112