Lecture 10: Mutation, Migration, Non-random mating

- **Mutation**
  - Neutral, advantageous, deleterious
  - Mutation-selection balance

- **Migration**: model and equilibrium condition

- **Non-random mating**: inbreeding, inbreeding depression
Exam #1 (Bio 405)

October 2
Covers lectures 1-10 (readings too!)
Bring calculator

Lecture notes: on web

Study guide: on web Tues 26 Sept
Mutation and polymorphism

- Introduces new alleles: $\mu \sim 10^{-4}$ to $10^{-8}$
- Weak evolutionary force: Small changes in allele frequencies

Fig 5.23

Initial allele frequencies:
- $A$: 0.9
- $a$: 0.1

Final allele frequencies:
- $A$: 0.89991
- $a$: 0.10009

Mutation converts copies of $A$ into new copies of $a$ at the rate of 1 per 10,000.

Number of zygotes:
- $AA$: 0.81
- $Aa$: 0.18
- $aa$: 0.01

Number of adults:
- $AA$: 0.81
- $Aa$: 0.18
- $aa$: 0.01

Number of juveniles:
- $AA$: 0.81
- $Aa$: 0.18
- $aa$: 0.01
Neutral Mutation

• Mutation rate \( \mu \) from A to a (Box 5.9)

\[
p' = p - \mu p \\
\Delta p = p' - p \\
\Delta p = -\mu p
\]

✓ Change in \( p \) depends on \( \mu \)

\[
\mu = 1 \times 10^{-4}, \ p = 0.9 \\
p' = 0.9 - (0.0001 \times 0.9) = 0.89991
\]
Box 5.9

Mutation rate $\mu$ from $A$ to $a$

\[
p' = p - \mu p \\
p' = (1 - \mu) p \\
p_t = (1 - \mu)^t p_0 \quad (t = \text{generations})
\]
After 160 generations

\[ p_{t} = (1-0.0001)^{160} \times 0.9 = 0.8857 \]
Advantageous mutations

- Mutation to advantageous alleles
- Selection increases frequency: fixation
- Fig 5.25
- *E. coli*
- Limiting conditions
Deleterious Mutation

- Mutation to deleterious alleles
- Selection reduces their frequency

"mutation-selection balance"
Deleterious Mutation

mutation    allele    selection
frequency

“mutation-selection balance”

Fitness:

\[ w_{11} \quad w_{12} \quad w_{22} \]
\[ \begin{array}{ccc} 1 & 1 & 1-S \end{array} \]

\[ \hat{q} = \sqrt{\frac{\mu}{s}} \quad \hat{q} = \text{equilibrium freq} \]
Migration and polymorphisms

• Transfer of alleles from one population into the gene pool of another
• Maintains polymorphism within populations
• Fig 6.4
• **HW conclusions violated:**
  - **Allele frequency changes**
  - **Genotype frequencies:** deficit of heterozygotes
Migration and polymorphisms

- Continent-Island model
- $Fr(A_{\text{continent}}) = p_C$
- $Fr(A_{\text{island}}) = p_I$
- $p'_I = (1-m)p_I + (m)p_C$
- $\Delta p = m(p_C - p_I)$
Migration homogenizes frequencies

- Continent-Island model
  \[ \Delta p = m(p_C - p_I) \]

- No Evolution?
  \[ \Delta p = 0 \]
  \[ p_C = p_I \]
Non-random mating

Assortative mating: mating between phenotypically similar individuals

Disassortative mating: the opposite!

Inbreeding:

Outbreeding:
Non-random mating

**Inbreeding:** mating between genetic relatives. High probability that alleles in a zygote are Identical by Descent (IBD).

**Outbreeding:** opposite of inbreeding

What are the evolutionary consequences of inbreeding?
Inbreeding Coefficients

\[ F = \text{probability of autozygosity} = \text{probability that 2 alleles are identical by descent (IBD)}. \]

\[ \Pr(\text{red}) = \left(\frac{1}{2}\right)^4 = 1/16 \]
Inbreeding Coefficients

\[
\Pr(\text{red}) = \left(\frac{1}{2}\right)^4 = \frac{1}{16}
\]

\[
\Pr(\text{green}) = \left(\frac{1}{2}\right)^4 = \frac{1}{16}
\]

\[
F = \frac{1}{16} + \frac{1}{16} = \frac{1}{8}
\]

\[
F = 2 \times \left(\frac{1}{2}\right)^N
\]
Consequences: Genotype frequencies

Autozygotes \( (F) \)

\[ \text{Fr}(A) = p \]
\[ \text{Fr}(a) = q \]
\[ p = q = 0.5 \]

Gene pool

Not autozygous \( (1 - F) \)
What is probability of creating an AA individual?

Pr(A) = p
Pr(autozygote) = F
Pr(autozygote for A) = pF

Pr(A) = p
Pr(A not autozygous) = p(1-F)
P(AA not autozygous) = p^2(1-F)
What is the probability of creating an AA individual?

\[ Fr(AA) = p^2(1 - F) + pF \]

\[ Fr(AA) = p^2 + pqF \]
Consequences of Inbreeding

<table>
<thead>
<tr>
<th>$F$</th>
<th>$Fr(AA)$</th>
<th>$Fr(Aa)$</th>
<th>$Fr(aa)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$p^2 + pqF$</td>
<td>$2pq - 2pqF$</td>
<td>$q^2 + pqF$</td>
</tr>
<tr>
<td>1</td>
<td>$p^2$</td>
<td>$2pq$</td>
<td>$q^2$</td>
</tr>
</tbody>
</table>

Inbreeding leads to a **deficiency of heterozygotes** and an excess of homozygotes.

Inbreeding does not affect allele frequencies.
• Scoobymiz@aol.com
• **Mutation is a slow force, but**
  - mutation and selection can lead to rapid evolution
  - maintenance of polymorphism
• **Migration maintains polymorphism, homogenizes frequencies among populations**
• **Inbreeding (Non-random mating) increases homozygosity, decreases heterozygosity**
  - Affect evolution through inbreeding depression
    • Unmasking deleterious recessives
    • The absence of heterozygotes under overdominance