

## Lecture 13

Mutation - Source of Variation  
Intro to Drift - A Game of Chance

•See Article 13. Mutation

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## Hardy Weinberg Review

- The H-W Law predicts genotype frequencies (t+1) from allele frequencies (t)
- Combined with the relationship between allele and genotype frequencies within generations, we can solve ALL H-W problems.

Time t                      Time t+1

Allele Frequency      Allele Frequency

Genotype Frequency      Genotype Frequency

Hardy-Weinberg Law

(1)  $p = F_{11} + 1/2 F_{12}$   
 $q = F_{22} + 1/2 F_{12}$

(2)  $F_{11} = p^2$   
 $F_{12} = 2pq$   
 $F_{22} = q^2$

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## Factors That Drive Change in Allele Frequency

- 1
- 2
- 3
- 4
- 5

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### Fun Facts About Mutation in Us!

- Each of us is born with 300 new mutations that make us different from our parents
- At least 4500 human genetic defects have been found that cause inherited disease
- In 500,000 humans, there will be 800,000 mutations each generation

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### Mutation

- New alleles arise by mutation
- Mutation is change in the nucleotide sequence of DNA

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### Mutation

- Mutation may involve alteration of
  - 1 base pair
  - Several bases
  - Part of the chromosome
  - Whole chromosomes

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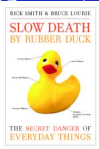
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## Causes of Mutations

- Errors in DNA replication
- Physical chromosome damage
- Insertion of transposable element
- UV radiation
- Radiation at other wavelengths (gamma, x-ray)
- Chemicals of various sorts



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Source of Exposure	Dose
Dental X-ray	0.005 mSv*
135g bag of Brazil nuts	0.005 mSv
Chest X-ray	0.02 mSv
Transatlantic flight	0.07 mSv
Nuclear power station worker average annual occupational exposure	0.18 mSv
UK annual average radon dose	1.3 mSv
CT scan of the head	1.4 mSv
UK average annual radiation dose	2.7 mSv
USA average annual radiation dose	6.2 mSv
CT scan of the chest	6.6 mSv
Average annual radon dose to people in Cornwall	7.8 mSv
Whole body CT scan	10 mSv
Annual exposure limit for nuclear industry employees	20 mSv
Level at which changes in blood cells can be readily observed	100 mSv
Acute radiation effects including nausea and a reduction in white blood cell count	1000 mSv
Dose of radiation which would kill about half of those receiving it in a month	5000 mSv

\*unit = millisieverts

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## Definitions

- Haplotype - a particular DNA sequence that differs from homologous sequences by one or more mutations
- Genetic markers - specific mutations geneticists use to recognize certain genes or genetic 'lines'

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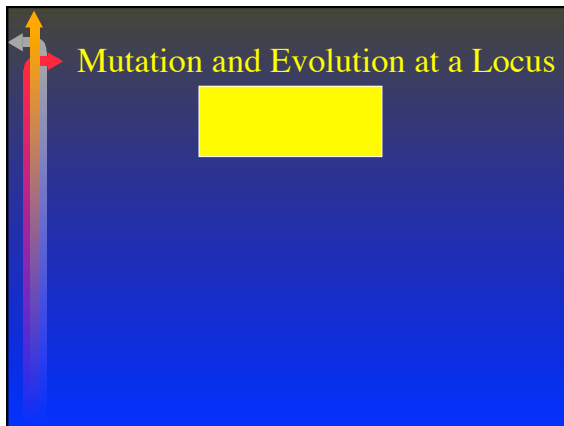
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## Mutation and Evolution at a Locus

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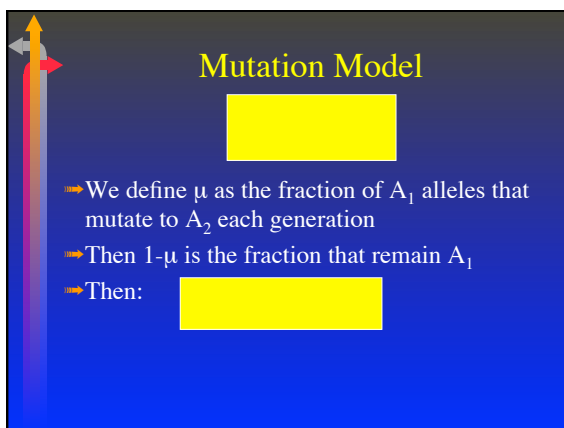
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## Mutation Model

- We define  $\mu$  as the fraction of  $A_1$  alleles that mutate to  $A_2$  each generation
- Then  $1-\mu$  is the fraction that remain  $A_1$
- Then:

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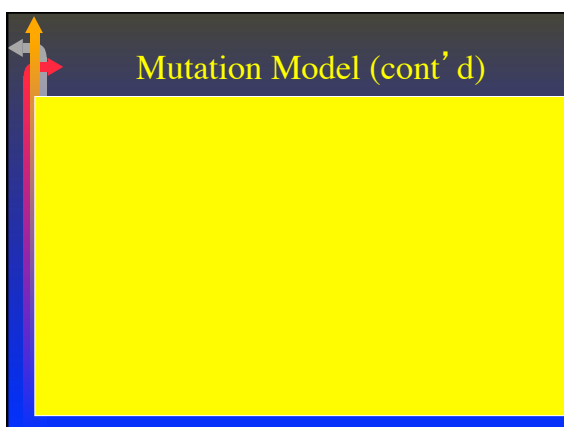
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## Mutation Model (cont' d)

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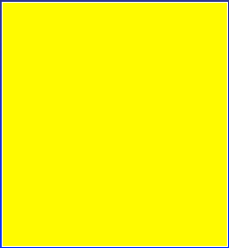
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**Prediction of Mutation Model**

→ How long will it take to change  $p$  from 0.9 to 0.1 (=a substantial evolutionary change)?



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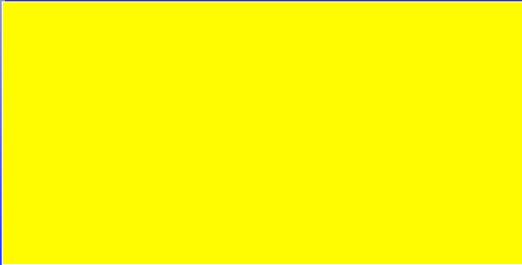
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**Mutation Model Prediction**



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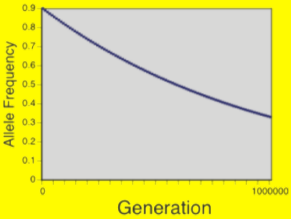
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**Evolution by Mutation**

Effect of Mutation on Allele Frequency



Generation	Allele Frequency
0	0.9
1,000,000	0.3

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## Molecular Clocks

- Slow accumulation of neutral mutations allows us to establish a biological clock.
- Knowing the rate of substitution of DNA base pairs within genes, we can estimate times since two lineages diverged, and reconstruct phylogenies.

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## Mutation and Migration History

- Accumulation of mutations in maternally inherited DNA (e.g., mitochondrial) or paternally inherited DNA (Y-chromosome) can help us understand past migration.

<https://www3.nationalgeographic.com/genographic/index.html>



The Genographic Project  
National Geographic Society

“Millions of Men May Be Descended From Irish King, Study Says”

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## 23 & me!



[HOME](#)
[MY RESULTS](#)
[FAMILY & FRIENDS](#)
[RESEARCH & COMMUNITY](#)

JAMES

RECOMMENDED FOR YOU

MORE RESULTS!

4 OF 4 STEPS TO YOUR RESULTS

James, all of your ancestry features are now available. Have fun exploring your genome!

54.6%

BRITISH & IRISH

ANCESTRY COMPOSITION

CLOSE FAMILY 0

2nd & 3rd 4

4th 573

DISTANT COUSINS 343

DNA RELATIVES

REFER FAMILY AND FRIENDS

FEATURED CONTENT

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## 23&me (I just learned this!)

### Sleep Movement

Occasional movement of the arms and legs during sleep is normal, but more frequent movement can be disruptive to sleep. Genetic factors appear to influence how much people move while sleeping.

Result About Test Stories Inheritance What You Can Do

James, people with your genetic result tend to have more than 10 limb movements per hour of sleep.

Likely more movement during sleep

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## Effect of Mutation

- Constant level of mutation produces very slow change in allele frequency, assuming these changes are neutral (do not affect fitness)
- Mutation is evolutionarily important as a **SOURCE OF VARIATION**.

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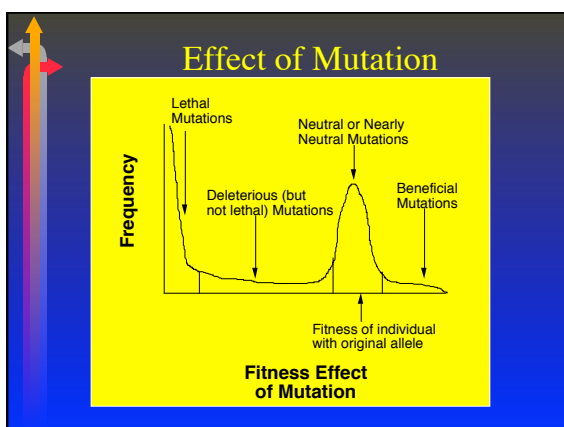
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## Mutation Summary

- Mutation produces slow evolutionary change
- Mutations are largely neutral or detrimental
- Mutation is a source of variation
- Steady mutational forces allow us to gauge time since divergence of lineages with a “molecular clock”
- Mutational legacies allow us to trace migration pathways by using unique marker genes

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## Next Lecture

- Genetic drift - random genetic change in small populations

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