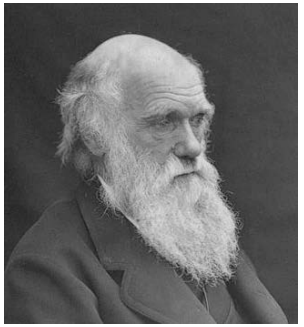
NATURAL SELECTION: Fundamentals

Duke UNIVERSITY

Natural selection

- “This preservation of favourable variations and the rejection of injurious variations, I call Natural Selection.”
  --Darwin (1859)
- Presented simultaneously with A. R. Wallace
- Emphases differed, though both correct–
  - Darwin: emphasized *competition within species*

    Wallace: emphasized *environmental pressures*



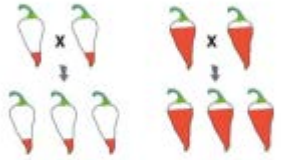
Is evolution by natural selection "just a theory"?

- Let's imagine that you're working with a population of squirrels.

	Type A: run randomly	Type B: fear asphalt	
Average:	1 offspring	2 offspring	
Start:	A: 100	B: 100	50% B
Gen 1:			
Gen 2:			
Gen 3:			

Requirements for evolution by natural selection

- Variation in traits
- Heritability of traits
- Trait variants affect survival/ reproduction



Quantitative Traits vs. Single Locus

- Already discussed selection in the context of heritability: **Heritability = Response/Selection**
  - Genetic component of variation dictates selection's response
  - Response often from change in allele frequencies at **multiple loci**
- Can also be studied at *single locus/ gene*
  - We'll come back to phenotypes shortly

What does selection do to alleles at individual loci?

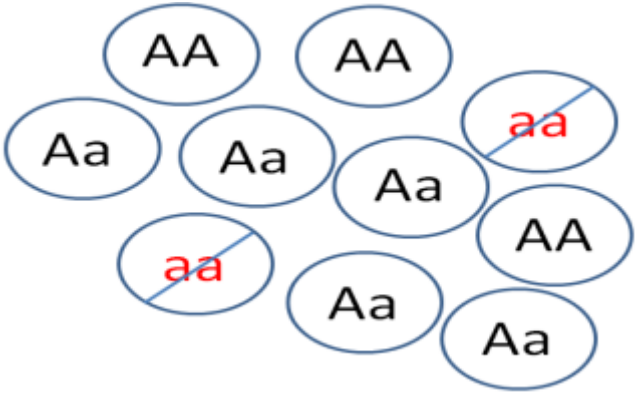
- Affects abundance of particular genotypes

  e.g., AA: good, Aa: good, aa: "less good" (dead?)

- Affects frequency of alleles in population

  –In example above, fewer "a" alleles remain in population

- DOMINANCE OF ALLELES MATTERS FOR SELECTION



Strong selection in humans: Single loci

- Spontaneous bad mutations are *common*
- Half of pregnancies never detected because spontaneously abort very early
- Half of spontaneous abortions result from genetic problems
  - ~25% of all human fertilizations immediately eliminated by natural selection!

Weak(er) selection in humans: Single loci

- Historically, all humans adult lactose intolerant
- Estimate ~5% fewer kids if lactose intolerant
- New mutation arose– now most people “lactase persistent” (lactose tolerant) as adults
  - What is effect of 5% more kids???

Can simulate with AlleleA1

- Fitness of “AA” (intolerant) is 0.95
- Fitness of “Aa” and “aa” (tolerant) is 1.00
- Time: 5000 years
- All were “AA” and then new mutation (a) arose in Africa ~5000 years ago

http://faculty.washington.edu/herronjc/SoftwareFolder/AlleleA1.html

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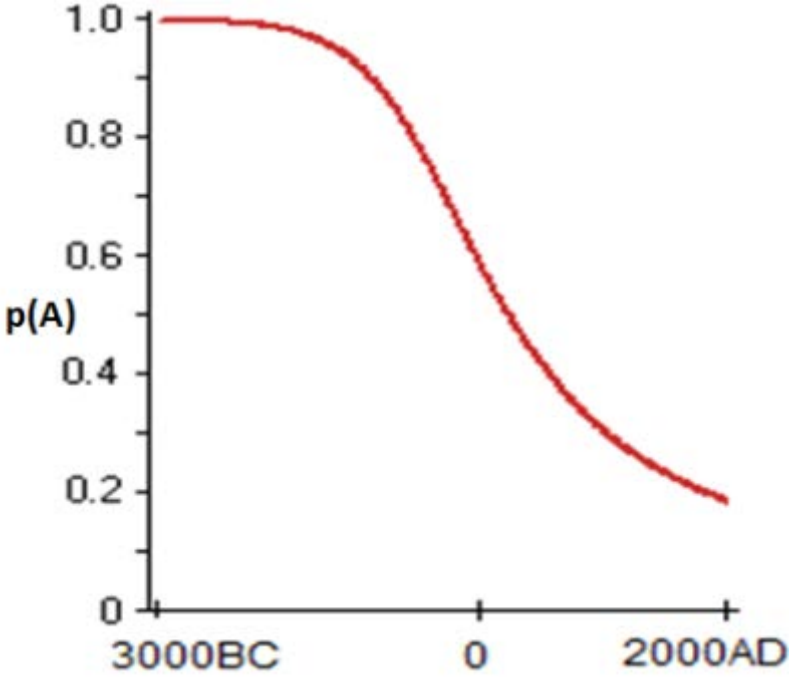

Selection uses "*relative* fitness" of genotypes

- In lactase example:
  - AA: 0.95 Aa: 1.00 aa: 1.00
  - AA has "5% fewer kids" successfully on average than Aa or aa
- Because something is "selected against", doesn't mean it's "bad" by itself, just not as good as the alternative...
  - Humans survived for a long time as AA (lactose intolerant)...

Analogy…

"I love rock & roll"

Forgotten original is by the Arrows, 1975

- A new mutation is like a released cover of a previously released song
  - Original song was popular/ successful
  - Cover may be more successful
    - Spreads (sells), and everyone forgets the original
  - Cover may be less successful
    - Around briefly but then dies off

1982

Joan Jett

vs

Britney Spears

2002

What is relative fitness? *Example.*

- BB genotypes produces on average 3.2 surviving offspring
- Bb genotypes produce on average 3.0 offspring
- bb genotypes produce on average 2.4 offspring

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- Most fit genotype: BB
  - Call it "100% of maximum", fitness = w (BB) = 1.00
  - Others are percentage of *maximum*
    - w (Bb) = 3.0 / 3.2 = 0.94 (~6% less fit than BB)
    - w (bb) = 2.4 / 3.2 = 0.75 (~25% less fit than BB)

Effects on Hardy-Weinberg

- Assume all “aa” individuals die **at age 10**
- At age 8:
  - AA: 490 Aa: 420 aa: 90
  - Is this 8-year-old population at HW?

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Effects on Hardy-Weinberg

- Assume all “aa” individuals die **at age 10**
- At age 8:
  - AA: 490 Aa: 420 aa: 90 p(A) = 0.70
- At age 25:
  - AA: 490 Aa: 420 aa: --dead--

Effects on Hardy-Weinberg

- Assume all “aa” individuals die **at age 10**
- At age 8:
  - AA: 490 Aa: 420 aa: 90 p(A) = 0.70
- At age 25:
  - AA: 490 Aa: 420 aa: 0 p(A) = 490/910 + ½ (420/910) = 0.769

Effects on Hardy-Weinberg

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- At age 8:
  - AA: 490 Aa: 420 aa: 90 p(A) = 0.70
- At age 25:
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- Deviation from Hardy-Weinberg
  - Selection altered genotype frequencies
- Selection also altered allele frequencies

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- Deviation from Hardy-Weinberg
  - Selection altered genotype frequencies
- Selection also altered allele frequencies
- Are aa’s gone for good? What happens next?

What happens next?

AA: 490 Aa: 420 aa: 0

Total number of survivors: 910

freq(AA) = 490 / 910 = 0.538

freq(Aa) = 420 / 910 = 0.462

p(A) = 0.538 + ½ 0.462 = 0.769 (was 0.70)

q(a) = 0.000 + ½ 0.462 = 0.231 (was 0.30)

Babies in next generation (assuming random mating):

AA: 0.591 Aa: 0.355 aa: 0.054

They're back!

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