- Empirical foundations
  - change & time
- How and Why?
  - Charles Darwin (1809–1882)
- Darwin’s three postulates
  1. “struggle for existence”
  2. variation and natural selection
  3. inheritance

- Unanswered questions
  - genetics =
  - mutation =
- What about behavior?
  - culture =
  - cultural variation =
  - innovation =
- adaptation =
  - biological adaptation
  - cultural adaptation
- cultural uniformitarianism

recap to this point

<table>
<thead>
<tr>
<th>Linnaeus</th>
<th>life is changeable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyell</td>
<td>enough time for change</td>
</tr>
<tr>
<td>Boucher</td>
<td>enough time for change in human life-ways</td>
</tr>
<tr>
<td>Thomsen &amp; Worsaae</td>
<td>change was big &amp; occurred in regular sequence</td>
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</tbody>
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How and Why does life change?

Charles Darwin in 1880
Theory of Evolution
Darwin’s Three Postulates

1. More offspring are produced than can survive
2. Organisms are variable in the traits that affect their survival
3. Traits that affect survival are inherited by offspring

• populations grow to carrying capacity (K)
  – K = the number of individuals that an environment can support

Calculus of Survival

• K = 100 individual
• 50 offspring are produced
• 25 adults die at end of generation
• 25 offspring in excess of K must die
• Which 25?
Theory of Evolution
Darwin’s Three Postulates

1. More offspring are produced than can survive

2. Organisms are variable in the traits that affect their survival

3. Traits that affect survival are inherited by offspring

How variation affects survival
(natural selection = …)

The number of individuals varies with the change in environment.

Survivors are those with traits that are better adapted to the new environment.
Variation and reproduction

For evolution to occur, new offspring **MUST** inherit the traits that allowed their parents to survive.

What if trait is inherited randomly, or is not heritable at all?

- Survivors produce new offspring

- What if trait is inherited randomly, or is not heritable at all?

- Survivors produce new offspring

- Offspring well-fit (adapted) to new environment

- Equilibrium

- Fluctuating Environment
Darwin’s Unanswered Questions

• How are biological traits inherited?
  – genetics = inheritance of biological information

• How does new biological variability arise?
  – mutation = generation of new biological variability

What about behavior?

• Most behaviors are non-genetic!!!

behavior = preference for EMINEM

Behavior is Variable!

different social learning opportunities

number of individuals

Eminem Fan Factor
• How is new culture generated?
  – Innovation = “a change in the way of doing something”
  – Innovation by accident = Errors
    • analogous to genetic mutation
  – Innovation by design = Intentional change
    • often called “Invention”
    • no close analogy in biology (in a pre-bioengineering world) except perhaps immune system

• Adaptation
  = characteristics of an organism that evolved through natural selection and which result in a “good fit” between the organism and the environment

• Biological adaptation
  = genetically-based characteristics of an organism…

• Cultural adaptation
  = behaviorally-based (non-genetic) characteristics of an organism…

• cultural adaptation =

  biological adaptation in *Gazella subgutturosa* (goitered gazelle)

  Inuit seal hole hunting

  Aztec human sacrifice
• cultural/biological uniformitarianism?
  – biological, behavioral and cultural processes observed today also operated in the past

• cultural uniformitarian calculations?
  – minor cultural process x long time = BIG RESULT
  – minor innovations applied to existing systems x … = …