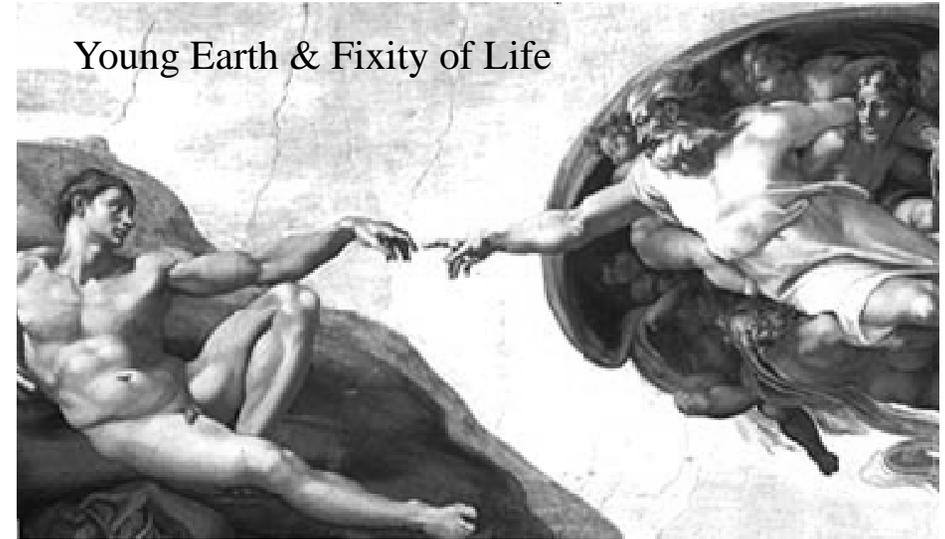


- Empirical foundations
 - change & time
- How and Why?
 - Charles Darwin (1809–1882)
- Darwin's three postulates
 1. "struggle for existence"
 2. variation and natural selection
 3. inheritance
- Unanswered questions
 - genetics =
 - mutation =
- What about behavior?
 - culture =
 - cultural variation =
 - innovation =
- adaptation =
 - biological adaptation
 - cultural adaptation
- cultural uniformitarianism

1

recap to this point

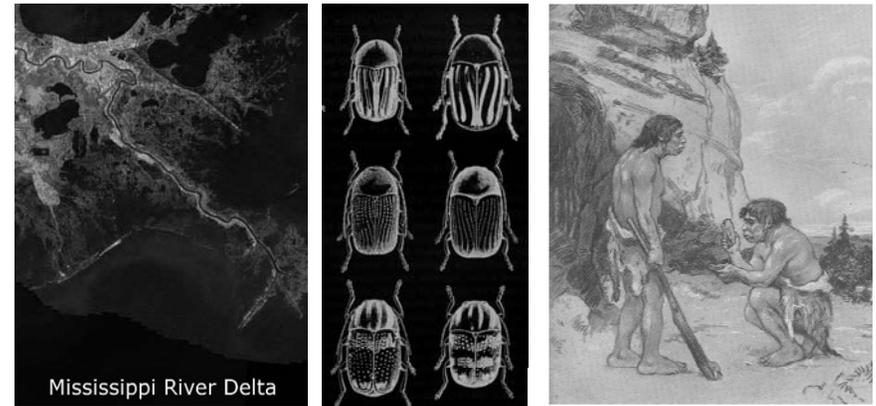


2

recap to this point

Lyell	enough time for change
Linnaeus	life is changeable
Boucher	enough time for change in human life-ways
Thomsen & Worsaae	change was big & occurred in regular sequence

3



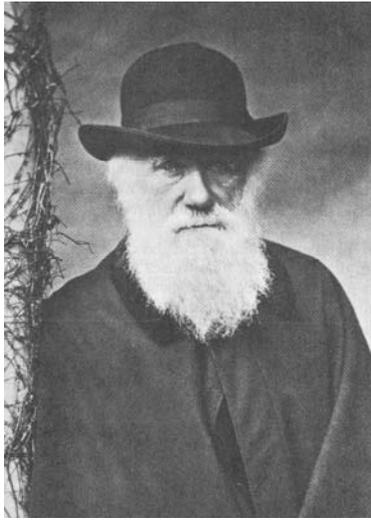
Lyell

Linnaeus

Boucher, Thomsen & Worsaae

How and Why does life change?

4



**Charles Darwin in 1880
(1809-1882)**

5



On the Origins of Species by Means of Natural Selection

- published in 1859
- first comprehensive theory of evolution
- very controversial
- proven largely correct

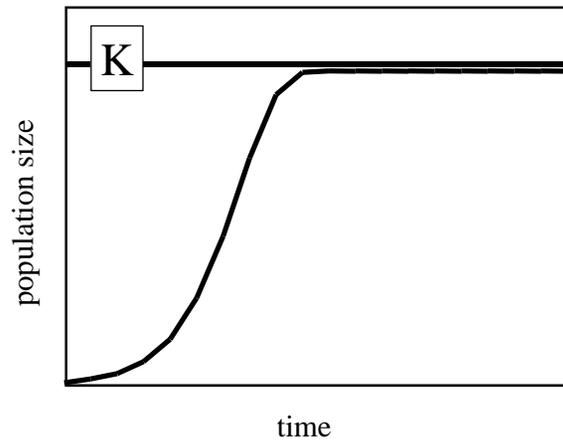


7

Theory of Evolution Darwin's Three Postulates

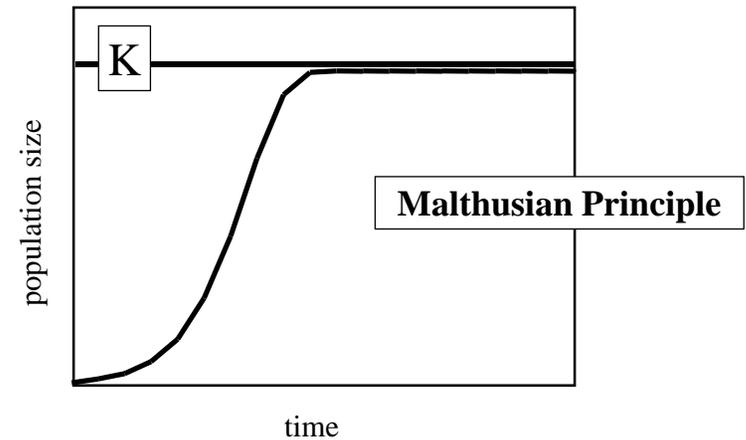
1. More offspring are produced than can survive
2. Organisms are variable in the traits that affect their survival
3. Traits that affect survival are inherited by offspring

8



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

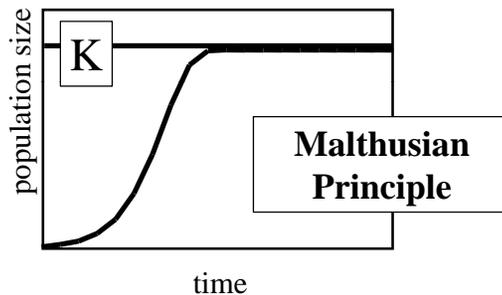
9



- more offspring produced than can survive
 - offspring produced in excess of K must die to bring the population back into equilibrium

10

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?

11

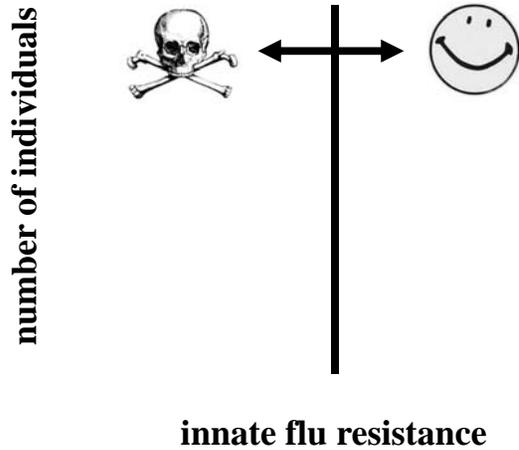
Theory of Evolution

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

12

Populations are variable!



13

How variation affects survival dynamically (natural selection → of survivors)

change in environment



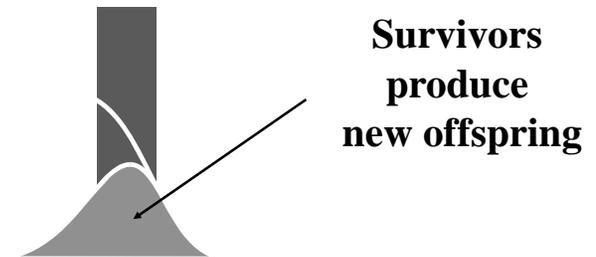
14

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

15

Variation and reproduction



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

16

number of individuals

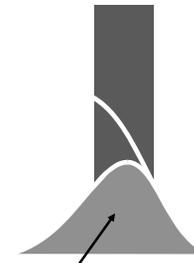
offspring well-fit (adapted) to new environment



flu resistance

17

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



Survivors



offspring poorly fit to environment (adapted) and most will die

18

IS THIS PROGRESS?
DIRECTIONAL CHANGE TOWARDS
A PERFECT ORGANISM?

number of individuals

offspring well-fit (adapted) to new environment



flu resistance

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Equilibrium



generation 1



generation 2

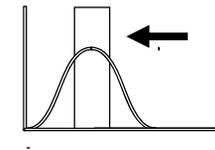


generation 3

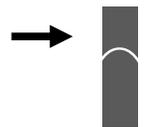
Fluctuating Environment



generation 1



generation 2

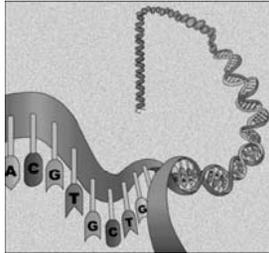


generation 3

20

Darwin's Unanswered Questions

- How are biological traits inherited?
 - genetics – system for the inheritance of biological information
- How does new biological variability arise?
 - mutation = generation of new biological variability



21

What about behavior?

- Most behaviors are largely non-genetic!!!



Music Preferences?

22

- How is behavioral information inherited?

- Culture = system for inheritance of behavioral (non-genetic) information
 - = social learning
 - = learned behavior
- Cultural Variation = differences in the behaviors expressed by individuals as a result of different social learning opportunities

23

Behavior is Variable & May Influence Survival

number of individuals

different social learning opportunities



Eminem Fan Factor

24

dietary preferences



25

- How is new culture generated?
 - Innovation = “a change in the way of doing something”
 - Innovation by accident = Errors
 - analogous to genetic mutation
 - the 3-M Post-It Factor
 - Innovation by design = Intentional change
 - often called “Invention”
 - no close analogy in biology (in a pre-bioengineering world)

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- 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...

27



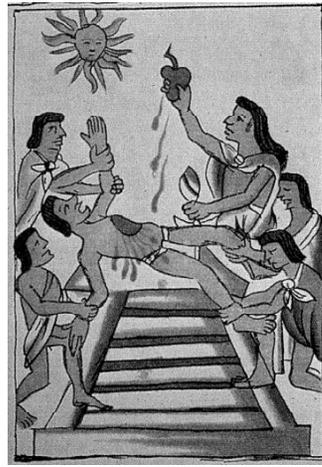
biological adaptation in
Gazella subgutturosa
(goitered gazelle)

28

■ cultural adaptation =



Inuit seal hole hunting



Aztec human sacrifice

29

■ cultural uniformitarianism?

■ cultural processes (innovation with social learning)
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 ... = ...



Wight Bros., December 17, 1903



Boeing 747, December 17, 2003

30