Evolution: Constant Change and Common Threads
2005 Holiday Lectures on Science
Chapter List

Lecture One
Endless Forms Most Beautiful
Sean B. Carroll, Ph.D.

Lecture Two
Selection in Action
David M. Kingsley, Ph.D.

1. Start of Lecture 2
2. Introduction by HHMI Vice President Dr. Peter Bruns
3. Introductory interview with Dr. David Kingsley
4. Natural selection and artificial selection
5. Artificial selection created corn (maize)
6. Video: Corn and ancestral teosinte
7. Ancient breeders selected seed and stalk traits
8. Genetic archaeology: How corn was bred
9. Mendelian inheritance pattern: A one-gene trait
10. How many genes result in maize/teosinte differences?
11. Only 4 to 5 genes changed to make corn from teosinte
12. Single genes can radically change an organism
13. Video: Dogs and selective breeding
14. Breeding has generated many dog varieties
15. The genetic basis of different dog skeletons
16. A German shepherd – basset hound cross
17. Genetic control of muzzle shape in dogs
18. Summary of dog genetics
19. Q&A: How much does modern genetics guide breeders?
20. Q&A: Why different genes for upper/lower jaw formation?
21. Q&A: How did corn breeders know what genes to change?
22. Q&A: What problems arise from inbreeding dogs?
23. Can natural selection create variation as breeders do?
24. Video: The stickleback on “Jeopardy!”
25. Ancestral sticklebacks spawned in freshwater streams
26. Video: Environmental pressures led to stickleback evolution
27. Adaptive radiation from ancestral form
28. Adaptive changes in freshwater sticklebacks
29. Crosses between stickleback forms reveal underlying genes
30. Important varieties in wild stickleback populations
31. Genetic basis for reduction in stickleback armor plating
32. Genetic archaeology locates the plate-number gene
33. Modifier genes also influence plate number
34. Genetic engineering adds armor to a plateless stickleback
35. Genetic control of stickleback hindfins
36. Limb reduction has occurred in many vertebrates
37. Animation: 3-D CT scan of stickleback skeleton
38. Hindfin reduction controlled by major and modifier genes
39. Artificial and natural selection give rise to variety
40. Review of how quickly selection can act
41. Q&A: Would domesticated dogs go extinct in the wild?
42. Q&A: Are there inbreeding effects with F1 crosses?
43. Q&A: Has artificial selection helped improve other crops?
44. Q&A: What fish are used with the stickleback crosses?
45. Q&A: Are dogs still closely related to wolves?
46. Closing remarks from HHMI Vice President Dr. Peter Bruns

Lecture Three
Fossils, Genes, and Embryos
David M. Kingsley, Ph.D.

1. Start of Lecture Three
2. Welcome by HHMI President Dr. Thomas Cech
3. Introductory interview with Dr. David Kingsley
4. Laws of nature lead to natural selection
5. Descent with modification explained conundrums
6. Major questions resulting from Darwin's theories
7. Is the earth too young for descent from a single ancestor?
8. Modern physics shows that the earth is 4.6 billion years old
9. Where are the transitional forms in the fossil record?
10. Billion-year-old fossils of early lifeforms
11. The reinvasion of water by land mammals
12. Traits suggest manatees evolved from land mammals
13. Transitional manatee ancestors
14. The dolphin and its transitional forms
15. Fossils of transitional forms in stickleback fish
16. Video: Fossils show 25,000 years of stickleback evolution
17. Transitional fossils are everywhere
18. Q&A: What caused rapid replacement in the fossil record?
19. Q&A: What were the first common ancestors?
20. Q&A: Does evolution address how life started?
21. Q&A: Can the evolution rate change over time?
22. Can rare forms be swamped out?
23. Mendelian genetics: Variants are not lost by blending
24. Pocket mouse simulation and real stickleback data
25. Are animals too different to share an ancestor?
26. Organisms share molecular pathways and enzymes
27. Organisms share DNA as the basis for heredity
28. Different animals share developmental pathways
29. *Hox* "toolkit" genes guide development in mice and flies
30. Eye development in humans, flies, and mice uses *pax6* gene
31. Overexpressing *pax6* in flies creates eyes in wrong places
32. *Pax6* is a toolkit gene that turns other genes on or off
33. Animation: How regulatory switches work
34. Forelimb vs. hindlimb development in vertebrates
35. Master regulators are expressed in one limb or other
36. *Pitx1:* master regulator for stickleback hindfin reduction
37. *Pitx1* plays multiple roles in development
38. Variants have changes in switch regions, not in *Pitx1*
39. Animation: *Pitx1* switching in two types of sticklebacks
40. Genetic basis of evolutionary change in species
41. Darwin's predictions supported by multiple sciences
42. Q&A: How do major changes in gene structure occur?
43. Q&A: Are the extra eyes on the *pax6* flies functional?
44. Q&A: Why are some religions and evolution in conflict?
45. Q&A: How do you look for single-celled fossils?
46. Q&A: Has evolution of viruses been traced?
47. Closing remarks by HHMI President Dr. Thomas Cech

Lecture Four
From Butterflies to Humans
Sean B. Carroll, Ph.D.

1. Start of Lecture Four
2. Welcome by HHMI Program Officer Dr. Dennis Liu
3. Introductory interview with Dr. Sean Carroll
4. Darwin's theory helped in understanding new discoveries
5. Henry Walter Bates and his trip to the Amazon
6. Bates returned with 8,000 new species
7. Batesian mimicry in butterfly markings
8. Bates's book, *The Naturalist on the River Amazons*
9. Data from butterflies offers insight into our own evolution
10. How did fruit flies and butterflies get their spots?
11. Video: Fruit fly courtship behavior
12. Sexual selection and courtship behavior
13. Video: Courtship dance of a different species
14. Spots evolved via new use of old toolkit gene
15. Butterfly wing spots: An adaptation for survival
16. Reuse of a toolkit gene creates the wing spots
17. Animation: Toolkit gene expression at center of wing spots
18. Much of diversity is due to new uses of existing genes
19. Genes are reused in different ways via genetic switches
20. Animation: Paintbrush gene switch in the fruit fly
21. Evolution acts by gain and loss due to chance mutations
22. Q&A: Are the switch regions turned off or deleted?
23. Q&A: Spots the only difference between fruit fly species?
24. T.H. Huxley in 1863 on human evolution
25. First Neanderthal fossil supported Huxley's ideas
26. 3-million-year-old bipedal hominid: Lucy
27. Older evidence of bipedal hominids: Laetoli footprints
28. Fossil record of *Homo sapiens*
29. The evolutionary tree of hominids
30. Problems with finding hominid fossils
31. *Homo sapiens* are a very new species
32. Hominid skull evolution
33. Evolution of larger brain size in hominids
34. Traits that distinguish humans from other apes
35. What can we learn about human evolution?
36. Comparing the chimp and human genomes
37. Loss of jaw-muscle gene could allow a larger skull
38. Modern genetics tries to find key evolutionary changes
39. Resistance to the theory of evolution
40. Darwin's "endless forms" are endangered
41. The alternative to thinking in evolutionary terms
42. Q&A: Why did some hominids last longer than others?
43. Q&A: Could some hominid species just be variants?
44. Q&A: Gene control region mutations more likely?
45. Closing remarks by HHMI President Dr. Thomas Cech