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Using BioInteractive.org Resources to Teach:

Evolution

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From the Author

With the pace of current research, the biological sciences change incredibly fast, particularly in the field of evolutionary biology, making me keenly aware that I must keep myself and my students abreast of cutting-edge research. Therefore, as a veteran biology teacher, I am constantly looking for resources that include up-to-date research, help my students process material, reinforce textbook material, and stimulate discussions and explorations of current topics in biology. For these reasons, I routinely use the Howard Hughes Medical Institute's (HHMI's) BioInteractive.org website and Holiday Lectures on Science DVDs in my classroom to highlight and strengthen my day-to-day coverage of material.

The BioInteractive.org and Holiday Lectures on Science resources are accurate, user friendly, free, and easily accessible—all key elements for successful classroom implementation. The video clips, animations, and lecture chapters enhance formal classroom lecture material, increasing student understanding and assisting student visualization of the subject matter, particularly at the molecular level, where many students struggle. Furthermore, the interactive Click and Learn activities, virtual museum, and classroom activities are used to introduce or complement curricular objectives. Finally, the virtual lab series is an excellent set of computer laboratory simulations.

I highly recommend the Holiday Lectures on Science DVDs and the BioInteractive.org online resources. These resources have greatly enhanced my teaching methods, my students' ability to understand the material, and our shared knowledge about current findings in biology.

This curriculum guide assists in filtering through the vast resources and provides an evolution-specific organization of material regarding natural and artificial selection, speciation, population genetics, human adaptations and evolution, and phylogeny and classification. Please do not hesitate to contact me with any questions or suggestions.

Most sincerely,

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Introduction

The amount of resources accessible to teachers from various organizations and the Internet can be overwhelming. Furthermore, finding the time to process these resources and develop solid, classroom-ready activities and lessons is difficult. This guide provides teacher-ready curriculum ideas using Howard Hughes Medical Institute (HHMI) resources, including the BioInteractive.org website features and the Holiday Lectures on Science DVDs, to enhance classroom instruction of evolutionary biology.

This curriculum guide organizes HHMI resources into the following categories: evolution, natural selection, artificial selection, speciation, population genetics, human adaptations and evolution, and phylogeny and classification. The resources include animations, video clips, interactive Click and Learn activities, short films, and lecture chapters specific to evolution. The following is a brief overview of the material covered in each section.

"Evolution" includes a vast array of information pertaining to evolution in general, including evolutionary theory, genetic variation and lineage, specific examples of evolution, molecular evolutionary genetics, Y chromosome evolution, epidemics and antibiotic resistance, HIV evolution, stratigraphy, and radiocarbon dating. Numerous resources illustrate the importance of evolution in the study of biology.

"Natural and Artificial Selection" reviews the processes of natural and artificial selection, including examples of both natural selection and artificial selection as well as details of Charles Darwin's research.

"Speciation" includes resources that cover the concepts of speciation, mass extinctions, and great transition events during the history of life on Earth.

"Population Genetics" covers the Hardy-Weinberg principle! These resources help students understand the Hardy-Weinberg principle, the causes of evolution, examples of population genetics, and data collection and analysis.

"Human Adaptations" is devoted to specific examples of human adaptations, including lactose tolerance and lactase persistence, sickle cell disease, and bitter taste perception.

"Human Evolution" includes resources related to human evolution over geological time. These resources trace human migration, human genetic variation, and details of human evolution, behavior, and paleobiology.

"Phylogeny and Classification" provides several resources that pertain to phylogenetic trees, taxonomy, and biological classification.

Evolution

All of these resources can be accessed via www.BioInteractive.org and/or the Holiday Lectures on Science DVDs.

If you have downloaded this document from BioInteractive.org, simply click on the resource name to open the resource.

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Lecture	Evolution: Fossils, Genes, and Mousetraps, Chs. 3–9	Is evolution a theory? (6:04–20:42)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.C.3	5.1, 5.2, 10.3
Lecture	Evolution: Fossils, Genes, and Mousetraps, Chs. 10–12	Fossils and evolution. (20:42–26:46)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.2, 1.A.3, 1.A.4	5.1, 5.2
Lecture	Evolution: Fossils, Genes, and Mousetraps, Chs. 19–27	Dover, Pennsylvania, evolution trial. (40:46–65:35)	HS.LS.1, HS.LS4.B	1.A.1, 4.A.1	5.1, 5.2, 6.3
Lecture	Evolution: Fossils, Genes, and Mousetraps, Chs. 1–37	This is Dr. Kenneth Miller's entire lecture on evolution. (0:00–88:24)	HS.LS.1, HS.LS3.A, HS.LS4.A, HS.LS.4.B	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.B.2, 1.C.3, 3.A.1, 3.A.3	3.2, 5.1, 5.2, 6.3, 10.3
Print Article	How Did We Get Here?	From the inheritance of acquired traits to natural selection to evo-devo, evolutionary theory has itself evolved.	HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B	1.A.1, 1.A.2, 1.A.3, 1.A.4, 2.E.1, 3.C.1	1.1, 3.1, 3.4, 5.1, 5.2, 10.2
Lecture	Lecture 1: Human Evolution and the Nature of Science, Ch. 8	Relationship between medical science and evolution. (14:18–16:03)	HS.LS4.A	1.A.1	5.1, B.4
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 9–11	Using genetic variation to reconstruct lineage history. (11:51–18:01)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.3, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.4, 10.3, B.5
Short Film	The Making of the Fittest: Got Lactase? The Co-Evolution of Genes and Culture	Follow human geneticist Spencer Wells, director of the Genographic Project of the National Geographic Society, as he tracks down the genetic changes associated with the ability to digest lactose as adults, tracing the origin of the trait to less than 10,000 years ago, a time when some human populations started domesticating animals. (14 min. 52 sec.)	HS.LS1.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.A.1, 4.B.1, 4.C.2	2.1, 2.3, 2.5, 3.1, 5.1, 5.2
Click & Learn	Regulation of the Lactase Gene	Lactase persistence results from a mutation that changes how transcription factors interact, thereby affecting gene expression. (21 slides)	HS.LS1.A, HS.LS3.B, HS.LS4.A	1.A.1, 1.A.2, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.C.2	2.7, 5.1, 5.2, 7.2, 7.3
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 1–34	This is Dr. John Shea's entire lecture on the history of stone tool use, human behavior, and human evolution. (0:00–58:31)	HS.PS1.A, HS.ESS2.A, HS.ESS3.A, HS.LS4.A	1.A.4	5.1, 5.3, A.4

Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 5–6	Stratigraphic principles of superposition and association. (8:40–11:59)	HS.ESS2.A	1.A.4	5.1
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 7–8	Principles of radiocarbon and radiopotassium dating. (11:59–15:25)	HS.PS1.A, HS.LS4.A	1.A.4	5.1
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 28–34	Evolution in action: the rock pocket mouse. (44:35-50:49) *This segment of material shows how mutation rate is associated with selection and evolution.* Additional resources can be found in the "Natural and Artificial Selection" section of this guide.	MS.LS2.A, MS.LS4.B, MS.LS4.C, HS.LS2.A, HS.LS2.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.C.1, 3.C.2, 4.B.3, 4.C.2, 4.C.3	3.1, 5.1, 5.2, 10.3
Short Film	The Making of the Fittest: The Birth and Death of Genes	For life to survive, it must adapt and readapt to an ever-changing Earth. The discovery of the Antarctic icefish has provided a stunning example of adaptation in an environment both hostile and abundant, where the birth and death of genes have played crucial roles. (13 min. 14 sec.)	HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C, HS.ESS2.A	1.A.2, 1.C.3, 3.C.1, 3.C.2, 4.B.1, 4.C.1, 4.C.2	2.4, 3.1, 5.1, 5.2, D.6
Classroom Resource	Icefish Adaptations	A simple activity that investigates the importance of antifreeze proteins to icefish survival. It includes background information and analysis questions that reinforce the main ideas of the film. *Appropriate for:* middle school life science, high school biology (all levels).	MS.PS1-4, MS.LS1-5, MS.LS3-1, MS.LS4-4, HS.LS1-2, HS.LS3-2, HS.LS4-2, HS.LS4-4, PS1.A, HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C, ESS2.E	1.A.1, 1.A.2, 1.A.4, 2.D.2, 3.C.1, 4.C.1	2.4, 3.1, 5.1, 5.2, D.6
Classroom Resource	The Molecular Evolution of Gene Birth and Death	An advanced Click & Learn activity that describes how mutations are an important part of both the birth and death of genes. *Appropriate for:* high school biology (second year, AP, IB), advanced high school genetics elective, introductory college biology, college-level genetics.	HS.LS1-1, HS.LS3-1, HS.LS3-2, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 2.E.1, 3.A.3, 3.C.1, 3.C.2, 4.A.1, 4.B.1, 4.C.1	3.1, 3.2, 3.3, 3.4, 5.1, 5.2, 10.3, D.4
Classroom Demonstration	Viscosity of Icefish and Non-Icefish Blood	A simple demonstration that uses readily available materials to simulate how blood pumps through the circulatory system of icefish and other fish. *Appropriate for:* middle school life science, high school biology (all levels), and introductory college biology.	MS.LS4-4, MS.LS4.B, MS.LS4.C, MS.PS1.A, HS.LS4.2, HS.LS1.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 3.C.1, 4.C.1	3.1, 5.1, 5.2, D.6
Click & Learn	Natural and Artificial Selection *Resource title on DVD:* Selection	Learn about artificial and natural selection. Features multiple video clips from the lectures on evolution. (6 slides)	HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3	5.1, 5.2
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 1–40	This is Dr. Sean Carroll's entire lecture on Charles Darwin, natural selection, and evolution. (0:00–58:30)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.ESS2.A	1.A.1, 1.A.2, 1.A.4, 1.C.1, 1.C.3, 3.C.1, 3.C.2, 4.B.3, 4.C.2, 4.C.3	5.1, 5.2, 5.4, 10.3

Video Clip	Fossil Record of Stickleback Evolution	A quarry site in Nevada carries the evolutionary history of a population of stickleback fish that resided there when it was a freshwater lake. (2 min. 34 sec.)	HS.LS1.A, HS.LS3.B, HS.LS4.B	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Video Clip	Stickleback Environment	At the end of the ice age, the retreating ice sheet created many new lakes, some of which were colonized by sticklebacks. The presence of different predators in different lakes dictated the subsequent evolution of each isolated lake stickleback. (1 min. 27 sec.)	HS.LS1.A, HS.LS2.A, HS.LS3.B	1.A.1, 1.A.2, 1.A.4, 4.B.3	4.1, 5.1, 5.2
Lecture	Lecture 2: Selection in Action, Chs. 23–26	Can natural selection create variation as breeders do? (29:43–35:04)	HS.LS1.A, HS.LS2.A, HS.LS3.B	1.A.1, 1.A.2, 1.A.4, 4.B.3	4.1, 5.1, 5.2
Lecture	Lecture 2: Selection in Action, Chs. 27–36	Adaptive radiation from the ancestral form in sticklebacks. (35:04–44:08)	HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 3.A.1, 3.A.3, 3.C.1, 4.C.2	3.1, 3.2, 3.4, 5.1, 5.2, 10.3
Short Film	The Making of the Fittest: Evolving Switches, Evolving Bodies	After the end of the last ice age 10,000 years ago, populations of marine stickleback fish became stranded in freshwater lakes dotted throughout the Northern Hemisphere in places of natural beauty like Alaska and British Columbia. These remarkable little fish have adapted and thrive, living permanently in a freshwater environment drastically different from the ocean. (15 min. 27 sec.)	MS.LS1.B, MS.LS2.A, MS.LS3.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.C.2, 1.C.3, 2.D.1, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.A.1, 4.C.2, 4.C.3	2.7, 3.1, 3.4, 5.1, 5.2, 7.2, C.1
Virtual Lab	Stickleback Evolution Virtual Lab	This virtual lab teaches skills of data collection and analysis to study evolutionary processes using stickleback fish and fossil specimens.	HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 2.D.1, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.A.1, 4.C.2	2.7, 3.1, 3.4, 5.1, 5.2, 7.2
Virtual Lab Worksheet	Stickleback Evolution Virtual Lab	A worksheet that guides students through “Stickleback Evolution Virtual Lab.” The virtual lab lets students learn firsthand the methods for analyzing body structure in stickleback collected from lakes and fossils recovered from a quarry. Students measure, record, and graph their results to discover evolutionary patterns.	HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 2.D.1, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.A.1, 4.C.2	2.7, 3.1, 3.4, 5.1, 5.2, 7.2
Lecture	Lecture 3: Fossils, Genes, and Embryos, Ch. 24	Pocket mouse simulation and real stickleback data. (32:31–34:07)	HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.1	5.1, 5.2
Lecture	Lecture 3: Fossils, Genes, and Embryos, Chs. 28–33	Different animals share developmental pathways. (36:06–43:37) *This segment also discusses the* Hox *toolkit and* pax6 *genes and the expression of these genes in development.*	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1, 3.A.3, 3.B.1, 3.C.1	1.1, 3.1, 5.1
Lecture	Lecture 3: Fossils, Genes, and Embryos, Chs. 34–39	Forelimb versus hind limb development in vertebrates. (43:51–48:39)	HS.LS1.A, HS.LS1.B, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 2.E.1, 3.A.4, 3.B.1, 3.C.1	2.7, 3.1, 3.2, 5.1, 7.2

Animation	Gene Switch	Regulatory "switches" are found upstream from a gene. Regulatory molecules bind to the switches and recruit RNA polymerase to bind to the gene's promoter region, increasing the transcription of the gene into messenger RNA. (1 min. 15 sec.)	HS.LS1.A, HS.LS3.A	3.A.1, 3.B.1, 3.C.1, 4.A.3	2.6, 2.7, 3.1, 7.2
Animation	*Pitx 1* Expression	In the stickleback fish, pelvic-fin reduction resulted from changes in the regulatory switch elements of the *Pitx1* gene. (55 sec.)	HS.LS1.A, HS.LS3.A	3.A.1, 3.B.1, 3.C.1, 4.A.3	2.6, 2.7, 3.1, 7.2
Animation	Paintbrush Gene	In two related *Drosophila* species, a so-called paintbrush gene is activated to "paint" the pigment on the body. In one species, an extra switch activates the gene, resulting in spotted wings. (49 sec.)	HS.LS1.A, HS.LS3.A	3.A.1, 3.B.1, 3.C.1, 4.A.3	2.6, 2.7, 3.1, 7.2
Click & Learn	Genetic Switches	Learn about how gene switches can control expression of genes in different tissues. (2 slides)	HS.LS1.A, HS.LS3.A	3.A.1, 3.B.1, 3.C.1, 4.A.3	2.6, 2.7, 3.1, 7.2
Lecture	Lecture 3: Fossils, Genes, and Embryos, Chs. 1–47	This is Dr. David Kingsley's entire lecture on natural selection, genetics, and evolution. (0:00–58:30)	MS.LS1.A, MS.LS4.A, MS. ESS1.C, HS.LS1.A, HS.LS1.B, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.ESS1.A, HS.ESS1.C	1.A.1, 1.A.2, 1.A.4, 1.C.1, 1.C.2, 1.C.3, 2.E.1, 3.A.1, 3.A.3, 3.A.4, 3.B.1, 3.C.1, 4.A.3	1.1, 2.6, 2.7, 3.1, 3.2, 5.1, 5.2,7.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 4–8	Charles Darwin's theory helped in understanding new discoveries. (5:04–11:10)	HS.LS4.B, HS.LS4.C	1.A.1, 3.E.1	5.1, 5.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 9–13	Data from butterflies offers insight into our own evolution. (11:10–16:01)	HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 2.E.1, 3.E.1	1.1, 5.1, 5.2, 7.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 14–18	Spots evolved via new use of an old toolkit gene. (16:01–21:23) *These chapters include material on toolkit gene expression as related to wing spots.*	HS.LS1.A, HS.LS3.B, HS.LS4.C	1.A.1, 2.E.1, 3.B.1, 3.C.1	1.1, 5.1, 5.2, 7.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 19–22	Genes are reused in different ways via genetic switches. (21:23–25:41) *These four chapters discuss the significance of genetic switches and the role of evolution in the gain and loss of control.*	HS.LS1.A, HS.LS3.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.B.1, 2.E.1, 3.B.1, 3.C.1	2.6, 2.7, 3.1, 5.1, 5.2, 7.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 39	Resistance to the theory of evolution. (46:31–48:46)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.4	5.1
Lecture	Lecture 4: From Butterflies to Humans, Chs. 40	Darwin's "endless forms" are endangered. (48:46–51:49)	HS.LS2.C, HS.LS4.C, HS.LS4.D	1.C.3, 4.A.5, 4.C.4	4.1, 5.1, C.3
Lecture	Lecture 4: From Butterflies to Humans, Chs. 1–45	This is Dr. Sean Carroll's entire lecture on natural selection, genetics, and evolution. (0:00–58:30)	HS.LS1.A, HS.LS2.C, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.B.2, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 3.E.1, 4.A.1, 4.A.5, 4.C.4	1.1, 2.6, 2.7, 3.1, 4.1, 5.1, 5.2, 5.4, 7.2, A.2, C.3
Discussion/ Lecture	Reconciling Religion and Science, Chs. 1–17	This is the entire discussion regarding religion and evolution. (0:00–70:57)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.4, 1.C.3, 1.D.2	5.1, 5.2

Poster	Fossil Evidence and Evolution	A poster (JPEG format) created for the 2005 Holiday Lectures on Science, Evolution: Constant Change and Common Threads. Click on the hyperlink and save the image to print a copy.	MS.LS4.A, MS.ESS1.C, HS.LS4.C	1.A.4, 1.C.1	5.1
Classroom Resource	Biodiversity and Evolutionary Trees	This is an activity on biological classification, and it accompanies the 2009 Holiday Lectures on Science, Exploring Biodiversity: The Search for New Medicines. Students construct evolutionary trees by sorting seashells. (Click on the link and scroll down to the activity.)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.B.1, 1.B.2, 3.A.1	3.1, 5.1, 5.3, 5.4
Click & Learn	Sorting Seashells	Students explore principles of taxonomy by sorting seashells according to their morphological characteristics and constructing an evolutionary tree.	HS.LS1.A, HS.LS1.B, HS.LS3.B	1.B.1, 1.B.2	5.3, 5.4
Classroom Resource	Comparing DNA Sequences to Determine Evolutionary Relationships of Molluscs	In this exercise, students revisit "Biodiversity and Evolutionary Trees: An Activity on Biological Classification" activity and reconstruct the phylogenetic tree using ClustalX, software that aligns and compares DNA sequences. They use a simple viewer program called NJplot to view the tree. (Click on the link and scroll down to the activity.)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.B.1, 1.B.2, 3.A.1	3.1, 5.1, 5.3, 5.4
Lecture	Lecture 1: Deconstructing Obesity, Chs. 18–26	Adoption and twin studies show that obesity is highly heritable. (33:31–52:37) *This section of lecture discusses the role of leptin in obesity.*	HS.LS3.A, HS.LS3.B	2.C.1, 3.C.1, 3.D.2	3.1, 3.4, 6.6, A.2
Animation	PPAR-Gamma Activation in the Fat Cell	The PPAR-gamma receptor activates certain genes in a fat cell, resulting in the storage of fat and changes in hormone levels. (2 min. 49 sec.)	HS.LS1.A	1.A.1, 1.A.2, 3.B.1, 3.C.3, 3.D.1	1.2, 6.6, 7.2
Video Clip	Pima Indians	A video clip about the Pima Indian tribe and how environment has affected them. (2 min. 36 sec.)	HS.LS1.A, HS.LS3.B	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.B.2, 4.C.2	2.3, 7.2
Lecture	Lecture 4: Exploring Obesity: From the Depths of the Brain to the Far Pacific, Chs. 20–27	How does variation in genes lead to obesity? (31:14–47:47) *This illustrates a genetic variation study using an isolated population on a Pacific island. It traces inheritance of single nucleotide polymorphisms and the use of DNA chips to analyze the data.*	HS.LS1.A, HS.LS3.B, HS.LS4.B	1.A.1, 1.A.2, 1.A.4, 3.A.1, 4.C.2	5.1, 5.2, 2.3, 3.1, B.5
Animation	Evolution of the Y Chromosome	How did the human Y chromosome become so small relative to its X counterpart? This animation depicts the 300-million-year odyssey of the sex chromosomes that began when the proto X and Y were an identical pair. (5 min. 39 sec.)	HS.LS.1.A, HS.LS4.A	1.A.4, 3.A.4, 3.B.2	3.1, 3.2, 3.3, 5.1
Animation	The Y Chromosome	The Y chromosome has been likened to a hall of mirrors because its sequence contains many sections that appear to be palindromes, which provide a clue to some interesting events that may have occurred during the course of its evolution. (2 min. 46 sec.)	HS.LS.1.A, HS.LS4.A	1.A.4, 3.A.4, 3.B.2	3.1, 3.2, 3.3, 5.1
Lecture	Lecture 4: Sexual Evolution: From X to Y, Chs. 11–15	Overview of 300 million years of Y chromosome evolution. (19:27–28:54)	HS.LS.1.A, HS.LS4.A	1.A.4, 3.A.4, 3.B.2	3.1, 3.2, 3.3, 5.1

Animation	Bacterial Conjugation	Bacteria can transfer genetic material, and thus drug resistance, to other bacteria via conjugation. (23 sec.)	HS.LS1.A, HS.LS3.A, (HS.LS4.B)	1.A.2, 1.C.3, 3.A.1, 3.C.1, 3.C.2	2.6, 5.2, 6.3
Animation	Recombination of Viral Genome	When two different strains of influenza infect a single cell, their genetic material can mix freely, resulting in a new strain of influenza. (3 min. 5 sec.)	HS.LS1.A	3.C.3	6.3
Lecture	Lecture 2: The Microbes Strike Back, Chs. 27–31	Bacteria can develop antibiotic resistance. (29:20–35:18)	HS.LS1.A, HS.LS3.A, HS.LS4.B	1.A.2, 1.C.3, 3.A.1, 3.C.1, 3.C.2	2.6, 5.2, 6.3
Lecture	Lecture 4: Emerging Infections: How Epidemics Arise, Chs. 4-5	How do new epidemics arise? (6:47–9:26)	HS.LS2.A	1.C.3, 4.B.4, 4.B.4	C.1, C.5
Lecture	Lecture 4: Emerging Infections: How Epidemics Arise, Chs. 6–11	Genetics changes in viruses: mutation and recombination. (9:26–15:23)	HS.LS1.A, HS.LS3.A	1.C.3, 3.A.1, 3.C.1, 3.C.2, 4.B.1	2.6, 2.7, 3.1, 6.3
Lecture	Lecture 4: Emerging Infections: How Epidemics Arise, Chs. 12–19	Influenza epidemics and pandemics. (15:23–25:52)	HS.LS1.A, HS.LS3.A	1.C.3, 2.D.4, 3.C.2, 4.A.1, 4.B.3	2.4, 5.1, 6.3, C.1, C.5
Lecture	Lecture 3: Drugs and HIV Evolution, Chs. 11–13	HIV evolves to become resistant to a drug. (13:13–16:26)	HS.LS1.A, HS.LS3.A	1.A.2, 2.D.3, 2.D.4, 3.C.3, 4.B.1	2.5, 5.1, 6.3, 11.1
Lecture	Lecture 4: Vaccines and HIV Evolution, Chs. 13–16	HIV mutation leads to staggering diversity in the HIV genome. (14:36–19:22)	HS.LS3.B, HS.LS4.A	2.D.3, 2.D.4, 3.C.3	1.3, 5.4, 6.3
Lecture	Lecture 1: Research Mechanics: Putting the Brakes on Cancer, Ch. 23	Why has evolution not made DNA replication perfect? (38:15–39:07)	HS.LS3.B	3.C.1	3.1
Lecture	Lecture 2: RNA as an Enzyme: Discovery, Origins of Life, and Medical Possibilities, Chs. 13–15	RNA enzymes and the origin of life. (28:33–40:22)	HS.LS1.A, HS.LS4.A	1.A.4, 1.D.1, 1.D.2, 3.A.1, 4.B.1	2.5, 3.1, 5.1
Short Film	The Day the Mesozoic Died	The disappearance of the dinosaurs at the end of the Cretaceous period posed one of the greatest, long-standing scientific mysteries. This three-act film tells the story of the extraordinary detective work that solved it. (33 min. 43 sec.)	MS.ESS1.C, MS.ESS2.A, MS.LS2.C, MS.LS4.A, MS.LS4.C, MS.PS3.C, HS.ESS1.C, HS.ESS2.A, HS.ESS2.E, HS.LS2.B, HS.LS2.C, HS.LS4.C, HS.LS4.D, HS.PS1.C	1.A.1, 1.C.1, 4.B.4	4.1, 5.1, C.2
Classroom Resource	Finding the Crater	This hands-on activity requires students to “visit” different K-T boundary sites, evaluate the evidence at each site, find these sites on a map, and predict where the crater is located. It tests a diverse set of skills, including mapping, mathematical scaling, and interpretation of mixed visual, graphic, and textual evidence.	MS.ESS1-4, MS.ESS1.C, MS.ESS2-2, HS.ESS1.B, HS.ESS1.C, HS.ESS2-2, HS.ESS2.A	—	—

Classroom Resource	Following the Trail of Evidence	This worksheet supports the HHMI short film *The Day the Mesozoic Died*. As students watch the film, they write down the evidence that led to the discovery that an asteroid struck Earth about 66 million years ago, causing a mass extinction. Through this exercise, students gain an appreciation for the scientific process, which consists of asking questions, making observations, formulating hypotheses, and gathering and evaluating evidence.	MS.PS3.C, MS.LS2.C, MS.LS4.A, MS.LS4.C, MS.ESS1.C, MS.ESS2.A, HS.LS2.B, HS.LS2.C, HS.LS4.C, HS.LS4.D, HS.ESS1.C, HS.ESS2.A, HS.ESS2.E, HS.PS1.C	4.B.4, 1.C.1, SP5	4.1, 5.1, C.2
Classroom Resource	Weighing the Evidence of a Mass Extinction—on Land	This lesson supports the HHMI short film *The Day the Mesozoic Died*. Students analyze graphs and data on pollen grains and fern spores to form a picture of the living landscape before and after the K-T event. This activity complements the hands-on activity "Weighing the Evidence for a Mass Extinction, Part 1: In the Ocean," in which students examine data on fossils of foraminifera, microorganisms that are abundant in the ocean.	MS.LS2-1, MS.LS2-4, MS.LS4-1, MS.ESS2-2, MS.LS2.A, MS.LS2.C, MS.LS4.A, MS.LS4.B, MS.LS4.C, MS.ESS1.C, HS.LS2-1, HS.LS2-2, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS4.B, HS.LS4.C, HS.ESS1.C	1.3.A, 1.A.4, 1.C.1, 2.D.1, 4.A.6, 4.B.3, 4.B.4	5.1, 10.3, C.1, C.2
Classroom Resource	Weighing the Evidence of a Mass Extinction—in the Ocean	This hands-on activity supports the HHMI short film *The Day the Mesozoic Died*, and in particular "Act 1: An Earth-Shattering Hypothesis." Students make observations and measurements on photomicrographs of research samples of fossilized protists called foraminifera (or forams). Their observations mirror those made by researchers documenting a mass extinction event at the end of the Cretaceous period about 66 million years ago.	MS.LS2-1, MS.LS2-4, MS.LS4-1, MS.ESS2-2, MS.LS2.A, MS.LS2.C, MS.LS4.A, MS.LS4.B, MS.LS4.C, MS.ESS1.C, HS.LS2-1, HS.LS2-2, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS4.B, HS.LS4.C, HS.ESS1.C	1.3.A, 1.A.4, 1.C.1, 2.D.1, 4.A.6, 4.B.3, 4.B.4	5.1, 10.3, C.1, C.2
Print Article	The Day the Mesozoic Died	A short article by Dr. Sean Carroll, which serves as both a supplement to the film of the same title and a great nonfiction reading for the Common Core standards.	MS.ESS1.C, MS.ESS2.A, MS.LS2.C, MS.LS4.A, MS.LS4.C, MS.PS3.C, HS.ESS1.C, HS.ESS2.A, HS.ESS2.E, HS.LS2.B, HS.LS2.C, HS.LS4.C, HS.LS4.D, HS.PS1.C	1.A.1, 1.C.1, 4.B.4	4.1, 5.1, C.2
Click & Learn	Geological History of Oxygen	Today, oxygen, or O_2, makes up about 21% of Earth's atmosphere, but for most of our planet's long history, O_2 levels in the atmosphere and dissolved in the ocean were much less than they are today. In this Click and Learn, students learn the complex biological and geological factors that have influenced the changes in O_2 levels.	HS.ESS1.C, HS.ESS2.A, HS.ESS2.D, MS.LS4.A, HS.LS4.C	1.A.4, 1.C.1, 2.A.2, 4.A.6	4.4, 5.1, 5.3

Click & Learn	Deep History of Life on Earth	The record of life on Earth stretches over 3 billion years, with evidence ranging from chemical signatures in rocks and ancient biological molecules to fossils of colossal dinosaurs and early humans. Developed in support of the 2012 HHMI Holiday Lectures on Science, Changing Planet: Past, Present, Future.	HS.ESS1.C, HS.ESS2.A, MS.LS4.A, HS.LS4.C	1.A.4, 1.C.1, 2.A.2, 4.B.3	5.1, 5.3, 5.4
Click & Learn	Paleoclimate: A History of Change	Earth's climate is a complex system controlled by many factors. This Click and Learn activity examines the two most important factors: solar radiation and the composition of Earth's atmosphere.	MS.ESS3.D, HS.ESS2.A, HS.ESS2.D, HS.ESS3.D, HS.LS4.D	1.A.4, 1.C.1, 4.A.5, 4.A.6, 4.B.4	4.4, C.2
Poster	Earth Evolution—the Intersection of Geology and Biology	The Earth is approximately 4.6 billion years old. Over this vast span of time, the planet has changed dramatically from an inhospitable sphere of molten rock to a diverse world rich with life. The world we live in today is the product of complex interactions between life and the environment. This poster (JPEG format) summarizes these interactions, including discussions of plate tectonics, chemical cycles, oxygenation of the planet, and the effect that oxygenation had on animal size. It was created for the 2012 Holiday Lectures on Science, Changing Planet: Past, Present, Future. Click on the hyperlink and save the image to print a copy.	HS.ESS1.C, HS.ESS2.A, MS.LS4.A, HS.LS4.C	1.A.4, 1.C.1, 2.A.2, 4.B.3	5.1, 5.3, 5.4
Poster	Fossil Evidence and Evolution	In this poster (JPEG format), students are challenged to place seven types of fossils into the proper geological era. Includes a timeline ranging from 1.5 million to 540 million years ago. Click on the hyperlink and save the image to print a copy.	MS.LS4.A, HS.LS4.C	1.A.4, 1.C.1	5.1

Natural Selection and Artificial Selection

All of these resources can be accessed via www.BioInteractive.org and/or the Holiday Lectures on Science DVDs.

If you have downloaded this document from BioInteractive.org, simply click on the resource name to open the resource.

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Short Film	The Origin of Species: The Making of a Theory	The epic voyages of Charles Darwin and Alfred Russel Wallace led each to independently discover the natural origin of species and to formulate the theory of evolution by natural selection. (30 min. 51 sec.)	MS.ESS1.C, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Classroom Resource	Making of a Theory—Fact or Fiction	This activity supports the viewing of the film *The Origin of Species: The Making of a Theory*. Before and after watching the film, students discuss and evaluate several statements about Charles Darwin, Alfred Russel Wallace, and the specific evidence that led each of them to the theory of evolution by natural selection.	MS.ESS1.C, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1, 5.2

Classroom Resource	Discovering the Wallace Line	This activity supports the HHMI short film *The Origin of Species: The Making of a Theory*. Students are presented with a map of the Malay Archipelago and some field notebooks with observations of animals. By plotting which animals are found on which island, the students discover the Wallace Line—a sharp boundary that separates distinct Asian and Australian fauna.	MS.LS2-4, MS.LS4-1, MS.LS4.A, MS.LS4.B, MS.LS4.C, MS.ESS1.C, HS.LS4-1, HS.LS4-2, HS.LS4-5, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.4	5.1, 5.2
Classroom Resource	Fact Patterns: A Film Guide	Students are challenged to identify "fact patterns," or patterns that emerge from a collection of different facts and observations, and draw conclusions about what they suggest.	MS.LS2-2, MS.LS2-4, MS.LS4-1, MS.LS4-2, MS.ESS2-3, MS.LS2.A, MS.LS2.C, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4-1, HS.LS4-5, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Classroom Resource	Reading Primary Sources: Darwin and Wallace	This activity serves as a supplement to the HHMI short film *The Origin of Species: The Making of a Theory*. Students read and analyze excerpts from texts written by Charles Darwin and Alfred Russel Wallace and answer questions about the information presented, developing their nonfiction reading comprehension.	HS.LS4-1, HS.LS4-2, HS.LS4-4, HS.LS2.A, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Animated Short	The Animated Life of A. R. Wallace	This animated short video tells the story of Alfred Russel Wallace, who independently formulated the theory of evolution by natural selection at the same time as Charles Darwin. The video tracks A. R. Wallace's life from growing up in England to his voyages with Henry Walter Bates and later adventures in the Malay Archipelago. The video ends with an examination of the naturalist's legacy. (The video is presented here with permission from Sweet Fern Productions; 7 min. 45 sec.)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Animation	Natural Selection of Lactose Tolerance	Environmental and cultural factors can affect whether a new human mutation becomes common in a population. (46 sec.)	MS.LS4.B, MS.LS4.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.C.1, 4.C.2	3.1, 5.1, 5.2
Short Film	The Making of the Fittest: Natural Selection and Adaptation	In a complete story, from ecosystem to molecules, pocket mice show us how random changes in the genome can take many paths to the same adaptation. (10 min. 25 sec.)	MS.LS2.A, MS.LS2.C, MS.LS3.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS2.A, HS.LS3.A, HS.LS3.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.C.1, 3.C.2, 4.B.3, 4.C.2, 4.C.3	3.1, 4.1, 5.1, 5.2, 10.3
Classroom Resource	Lactose Intolerance: Fact or Fiction	Students evaluate and discuss several statements about lactose intolerance and evolution before and after watching the film.	MS.PS1.B, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS2.A, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 2.A.2, 2.D.2, 2.E.1, 3.B.1, 3.C.1, 3.C.2	2.1, 2.3, 2.5, 3.1, 5.1, 6.1
Animation	Pocket Mouse and Predation	The rock pocket mouse is found in two color variants, or morphs: light and dark. The dark morph is more vulnerable to predators on light sandy desert, and the light morph on dark lava rock. (20 sec.)	MS.LS2.A, MS.LS4.B, MS.LS4.C, HS.LS2.A, HS.LS2.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2	5.1, 5.2, C.1

Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 28–34	Evolution in action: the rock pocket mouse. (44:35–50:49)	MS.LS2.A, MS.LS4.B, MS.LS4.C, HS.LS2.A, HS.LS2.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 4.B.3, 4.C.3	3.1, 5.1, 5.2, 10.3
Classroom Resource	Color Variation Over Time in Rock Pocket Mouse Populations	A data collection and analysis activity that examines selection for coat color in pocket mouse populations on different color substrates over time. *Appropriate for:* middle school life science, high school biology (all levels).	MS.LS2-1, MS.LS2-2, MS.LS4-4, MS.LS4-6, MS.ESS2-2, MS.LS2.C, MS.LS4.B, MS.LS4.C, HS.LS2-2, HS.LS2-6, HS.LS3-3, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS2.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 4.B.3, 4.C.3	5.1, 10.3, C.1, C.5
Classroom Resource	Allele and Phenotype Frequencies in Rock Pocket Mouse Populations	This activity uses real rock pocket mouse data collected by Dr. Michael Nachman and his colleagues to illustrate the Hardy-Weinberg principle. *Appropriate for:* high school biology (all levels), introductory college biology.	MS.LS2.A, MS.LS2.C, MS.LS3.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.C.1, 3.C.2, 4.B.1, 4.C.2, 4.C.3	3.1, 5.1, 10.3
Classroom Resource	Molecular Genetics of Color Mutations in Rock Pocket Mice	An activity requiring students to transcribe and translate portions of the wild-type and mutant rock pocket mouse *Mc1r* genes and compare sequences to identify the locations and types of mutations responsible for the coat color variation described in the film *The Making of the Fittest: Natural Selection and Adaptation*. *Appropriate for:* high school biology (all levels), introductory college biology.	HS.LS1-1, HS.LS3-1, HS.LS3-2, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS1.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 3.A.1, 3.C.1, 4.B.1	2.7, 3.1, 5.1, 5.2, 7.2, 7.3, 10.3
Classroom Resource	Biochemistry and Cell Signaling Pathway of the *Mc1r* Gene	An advanced activity that requires students to analyze partial DNA sequences of the *Mc1r* gene and identify the effects altered amino acid chemistry has on the functionality of the mutated MC1R protein pathway. *Appropriate for:* high school biology (AP, IB), introductory college biology.	HS.LS1-1, HS.LS3-1, HS.LS1.A, HS.LS4.B, HS.LS4.C	3.D.1, 3.D.3, 4.A.1, 4.B.1	1.3, 2.4, 2.7, 3.1, 5.1, 5.2, 7.2, 7.3, 10.3
Classroom Resource	Natural Selection and Evolution of Rock Pocket Mouse Populations	An activity in which students analyze amino acid data and draw conclusions about the evolution of coat color phenotypes in different rock pocket mouse populations. *Appropriate for:* high school biology (all levels), introductory college biology.	HS.LS1-1, HS.LS3-1, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS1.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.C.1, 4.A.1, 4.B.1	3.1, 5.1, 5.2, 5.3, 10.3
Short Film	The Making of the Fittest: Natural Selection in Humans	In some parts of the world, there is an intimate connection between the infectious parasitic disease malaria and the genetic disease sickle cell anemia. The protection against malaria by the sickle cell mutation shows how evolution does not necessarily result in the best solution imaginable but proceeds by whatever means are available. (14 min. 3 sec.)	HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.B.1, 4.C.1, 4.C.2	3.1, 3.4, 5.1, 5.2

Classroom Resource	A Lesson on the Nature of Science	The activity, when coupled with the film *The Making of the Fittest: Natural Selection in Humans*, asks students to describe how Dr. Tony Allison's discovery was made possible through the work of others. Students are also asked to examine Dr. Allison's data and to use these data to support his findings. *Appropriate for*: high school biology (all levels), introductory college biology.	HS.LS3-1, HS.LS3-2, HS.LS4-2, HS.LS4-4, HS.LS1.A, HS.LS2.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.3, 3.C.1, 4.C.1	3.1, 3.4, 5.1, 5.2
Classroom Resource	Testing a Hypothesis	A worksheet designed to actively engage students as they watch the film *The Making of the Fittest: Natural Selection in Humans*. Students are asked to answer questions pertaining to the information provided in the film. Follow-up questions probe student understanding of how Dr. Tony Allison found the link between sickle cell disease and malaria, and why this finding is important in understanding human evolution. *Appropriate for*: middle school life science, high school biology (all levels).	MS.LS1-5, MS.LS4-4, MS.LS1.A, MS.LS2.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS4-2, HS.LS4-4, HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.C.1	3.1, 3.4, 5.1, 5.2
Click & Learn	Natural and Artificial Selection *Resource title on DVD:* Selection	Learn about artificial and natural selection. This Click & Learn activity features multiple video clips from the lectures on evolution. (6 slides)	HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3	5.1, 5.2
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 4–16	Charles Darwin. (6:51–28:44)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.ESS2.A	1.A.1, 1.A.2, 1.A.4, 1.C.3	5.1, 5.2
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 19–25	Darwin's first big idea: descent with modification. (31:08–41:35)	MS.LS4.A, MS.LS4.B, HS.LS4.A	1.A.1, 1.A.2, 1.A.4, 1.C.1, 1.C.3	5.1, 5.2, 5.4
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 26-28	Darwin's second big idea: natural selection. (41:35–44:35)	MS.LS4.B, MS.LS4.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.1, 1.C.3	5.1, 5.2, 5.4
Lecture	Lecture 1: Endless Forms Most Beautiful, Chs. 1–40	This is Dr. Sean Carroll's entire lecture on Darwin, natural selection, and evolution. (0:00–58:30)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.ESS2.A	1.A.1, 1.A.2, 1.A.4, 1.C.1, 1.C.3, 3.C.1, 3.C.2, 4.B.3, 4.C.2, 4.C.3	5.1, 5.2, 5.4, 10.3
Lecture	Lecture 3: Fossils, Genes, and Embryos, Chs. 4–17	Laws of nature lead to natural selection. (4:53–26:17)	MS.LS1.A, MS.LS4.A, MS.ESS1.C, HS.LS1.A, HS.LS4.A, HS.LS4.C, HS.ESS1.A, HS.ESS1.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 1.D.2	5.1, 5.2
Video Clip	Galápagos Creatures	These are some of the animal species Charles Darwin would have seen when he visited the Galápagos Islands. (24 sec.)	HS.LS4.B	1.A.1	5.1
Classroom Resource	Survival of the Fittest—Battling Beetles	The overall goal of the "Battling Beetles" guided inquiry activity is to engage students in thinking about the mechanism of natural selection through data collection and pattern recognition. *Appropriate for*: high school biology (all levels), introductory college biology.	HS.LS3-3, HS.LS4-3, HS.LS4-4, HS.LS2.A, HS.LS2.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 4.C.3	5.1, 5.2, 10.3

Classroom Resource	Survival of the Fittest—Variations in the Clam Species *Clamys sweetus*	This guided inquiry activity has been designed to engage students in thinking about the mechanism of natural selection by encouraging them to formulate questions that can be answered through scientific investigation, data collection, and pattern recognition. *Appropriate for*: middle school life science and high school biology (all levels).	HS.LS3-3, HS.LS4-3, HS.LS4-4, HS.LS2.A, HS.LS2.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 4.C.3	5.1, 5.2, 10.3
Short Film	The Making of the Fittest: Evolving Switches, Evolving Bodies	After the end of the last ice age 10,000 years ago, populations of marine stickleback fish became stranded in freshwater lakes dotted throughout the Northern Hemisphere in places of natural beauty like Alaska and British Columbia. These remarkable little fish have adapted and thrive, living permanently in a freshwater environment drastically different from the ocean. (15 min. 27 sec.)	MS.LS1.B, MS.LS2.A, MS.LS3.A, MS.LS3.B, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS1.B, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.C.2, 1.C.3, 2.D.1, 2.E.1, 3.A.4, 3.B.1, 3.C.1, 3.C.2	2.7, 3.1, 3.4, 5.1, 7.2, 10.3
Virtual Lab	Stickleback Evolution Virtual Lab	This virtual lab teaches skills of data collection and analysis to study evolutionary processes using stickleback fish and fossil specimens.	HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 1.C.3, 2.D.1, 3.C.1	3.4, 5.1, 5.2, 10.3
Virtual Lab Worksheet	Stickleback Evolution Virtual Lab	A worksheet that guides students through "Stickleback Evolution Virtual Lab." The virtual lab lets students learn firsthand the methods for analyzing body structure in stickleback collected from lakes and fossils recovered from a quarry. Students measure, record, and graph their results to discover evolutionary patterns.	HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 1.C.3, 2.D.1, 3.C.1	3.4, 5.1, 5.2, 10.3
Classroom Resource	Modeling the Regulatory Switches of the *Pitx1* Gene in Stickleback Fish	A hands-on activity in which students interpret molecular diagrams and build physical models of eukaryotic gene regulation. Students review eukaryotic gene transcription, explore how changes in gene expression can affect body development, and learn how those changes, with the appropriate selective pressure, play a role in the evolution of a population. *Appropriate for:* high school biology (all levels), introductory college biology.	HS.LS1.A, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 2.D.1, 2.E.1, 3.A.1, 3.A.4, 3.B.1, 3.C.1, 4.A.3	2.7, 3.2, 5.1, 5.2, 5.3, 7.2, 10.3
Video Clip	Breeding Corn from Teosinte	Corn was originally bred from the teosinte plant by native Mexican farmers. The morphologies of modern-day corn and teosinte plants are compared to illustrate how artificial selection can bring about dramatic changes in plants. (52 sec.)	MS.LS4.B, HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4	5.1
Lecture	Lecture 2: Selection in Action, Chs. 4–8	Natural selection and artificial selection. (5:03–10:44)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1
Video Clip	Dog Breeding	The many forms of dogs that exist today were all created through selective (artificial) breeding from the dog's ancestor, the wolf. (1 min. 53 sec.)	MS.LS4.B, HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1

Classroom Resource	Mapping Genes to Traits in Dogs Using SNPs	In this hands-on genetic mapping activity, students identify single nucleotide polymorphisms (SNPs) correlated with different traits in dogs.	HS.LS-1, HS.LS3-3, HS.LS1.A, HS.LS3.B	3.A.1, 3.C.1	3.1, 3.5
Lecture	Lecture 2: Selection in Action, Chs. 13–18	Dogs and selective breeding. (16:24–25:01)	MS.LS4.B, HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4	5.1
Lecture	Lecture 2: Selection in Action, Chs. 1–46	This is Dr. David Kingsley's entire lecture on natural and artificial selection. (0:00–58:29)	HS.LS1.A, HS.LS2.A, HS.LS3.A, HS.LS3.B, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 3.A.1, 3.A.3, 3.C.1, 4.B.3, 4.C.2	3.1, 3.2, 3.4, 4.1, 5.1, 5.2, 10.3
Lecture	Lecture 4: From Butterflies to Humans, Chs. 4–8	Darwin's theory helped in understanding new discoveries. (5:04–11:10)	HS.LS4.B, HS.LS4.C	1.A.1, 3.E.1	5.1, 5.2

Speciation

All of these resources can be accessed via www.BioInteractive.org and/or the Holiday Lectures on Science DVDs.

If you have downloaded this document from BioInteractive.org, simply click on the resource name to open the resource.

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Short Film	The Origin of Species: The Beak of the Finch	Four decades of research on finch species that live only on the Galápagos Islands illuminate how species form and multiply. (15 min. 54 sec.)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3, 4.C.2, 4.C.3	5.1, 5.2, 10.3, C.1
Click & Learn	Sorting Finch Species	Finches discriminate between members of their own species and those of a closely related species based on song and appearance.	HS.LS3.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.2, 1.C.3	5.1, 5.2, A.4
Classroom Resource	Beaks as Tools: Selective Advantage in a Changing Environment	This classroom experiment supports the film *The Origin of Species: The Beak of the Finch*. Students collect and analyze data to learn why even slight variations in beak size can make the difference between life and death.	HS.LS2-1, HS.LS2-2, HS.LS4-2, HS.LS4-4, HS.LS4-5, HS.LS2.A, HS.LS2.C, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 4.B.3	5.1, 5.2, C.1
Classroom Resource	Evolution in Action: Data Analysis	These *two* activities support the film *The Origin of Species: The Beak of the Finch*. They provide students with the opportunity to analyze data collected by Princeton University evolutionary biologists Peter and Rosemary Grant. In one activity, "Evolution in Action: Graphing and Statistics," students are guided through the analysis of this sample of the Grants' data by constructing and interpreting graphs and by calculating and interpreting descriptive statistics. The second activity, "Evolution in Action: Statistical Analysis," provides an example of how the data set can be analyzed using statistical tests, in particular the Student's *t*-test for independent samples, to help draw conclusions about the role of natural selection on morphological traits based on measurements.	HS.LS4-2, HS.LS4-3, HS.LS4-4, HS.LS4-5, HS.LS4.B, HS.LS4.C, SEP4-7	1.A.1, 1.A.4, 1.C.1, 1.C.2, SP5	5.1, 5.2, 10.3

Short Film	The Origin of Species: Lizards in an Evolutionary Tree	In the Caribbean islands, adaptation to several common habitats has led to a large adaptive radiation with interesting examples of convergent evolution. (17 min. 45 sec.)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3	5.1, 5.2, 10.3, C.1
Animation	Anole Lizards: An Example of Speciation	The anole lizards of the Caribbean islands represent a group of about 150 closely related species, most of which evolved within the past 50 million years from a single colonizing species. Different processes, including geographic isolation, adaptation to different environments, and reproductive isolation, play a role in anole speciation. (2 min. 38 sec.)	MS.LS2.A, MS.LS4.B, MS.LS4.C, HS.LS2.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.1, 1.C.2, 1.C.3, 4.C.2	5.1, 5.2, 10.3, C.1
Classroom Resource	Using DNA to Explore Lizard Phylogeny	This activity supports the film *The Origin of Species: Lizards in an Evolutionary Tree*. Students are guided to sort the lizard species by appearance, then generate a phylogenetic tree using the lizards' DNA sequences to evaluate whether species that appear similar are closely related to each other.	MS.LS4-2, MS.LS4-4, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4-1, HS.LS4-4, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3	4,1, 5.1, 5.2, 5.4, C.1
Virtual Lab	Lizard Evolution Virtual Lab	The virtual lab includes four modules that investigate different concepts in evolutionary biology, including adaptation, convergent evolution, phylogenetic analysis, reproductive isolation, and speciation. Each module involves data collection, calculations, analysis, and answering questions. The Educators tab includes lists of key concepts and learning objectives and detailed suggestions for incorporating the lab in your instruction.	MS.LS1-5, MS.LS4-2, MS.LS4-4, MS.LS4.A, MS.LS4.B, MA.LS4.C, HS.LS4-1, HS.LS4-2, HS.LS4-3, HS.LS4-4, HS.LS4-5, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3, SP1, SP2, SP4, SP5, SP6	4.1, 5.1, 5.2, 5.4, 10.3, C.1
Short Film	Great Transitions: The Origin of Tetrapods	One of the most exciting discoveries in the long history of fossil exploration is *Tiktaalik*, a creature with a mix of features common to fish and four-legged animals, or tetrapods. (17 min. 11 sec.)	MS.LS4.A, MS.LS4.C, MS.ESS1.C, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.C.1, 1.C.3, 4.B.4	5.1, 5.2, 10.3, C.2
Click & Learn	Great Transitions Interactive	The fossils of transitional creatures were key evidence for Charles Darwin's evolutionary theory, but none had been found when he published *On the Origin of Species*. Now, there are many examples of such fossils, which clearly show that big evolutionary leaps consist of many smaller steps.	MS.LS4.A, MS.LS4.C, MS.ESS1.C, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.C.1, 1.C.3	5.1
Video Clip	Young Students Recognize a Transitional Fossil	Neil Shubin brought the fossil of *Tiktaalik* to his daughter's first grade class to see what the students would make of it. The students immediately recognized that the fossil has characteristics of both a fish and a four-legged land animal. This short video, inspired by Neil Shubin's book *Your Inner Fish*, illustrates the power of fossil evidence. (4 min. 44 sec.)	MS.LS4.A, MS.LS4.C, MS.ESS1.C, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.C.1, 1.C.3	5.1
Print Article	"It's a Fishapod!"	This article by Dr. Sean Carroll tells the story of the search for and discovery of *Tiktaalik*, an animal with a mix of fish and tetrapod features—a fishapod! It supplements the short film *Great Transitions: The Origin of Tetrapods*, starring Neil Shubin.	MS.LS4.A, MS.LS4.C, MS.ESS1.C, HS.LS4.A, HS.LS4.C, HS.ESS2.B	1.A.1, 1.A.4, 1.B.1, 1.C.1, 1.C.3, 1.D.2, 4.B.3, 4.B.4	5.1, 5.2, 10.3

Short Film	Great Transitions: The Origin of Humans	Paleontologists have studied the fossil record of human evolution just as they have done for other major transitions, including the evolution of tetrapods from fish and the evolution of birds from dinosaurs. In this film, Dr. Sean Carroll and Dr. Tim White discuss the most important human fossils and how they illuminate key phases of human evolution, focusing in particular on three traits: larger brains, tool use, and bipedality. (19 min. 44 sec.)	HS.LS1.A, HS.LS2.A, HS.LS4.C, HS.ESS2.A, HS.ESS3.A, MS.ESS1.C, MS.LS1.A, MS.LS4.A, MS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.B.2, 4.A.5	4.1, 5.1, 5.2, 5.3, 5.4
Click & Learn	Explore Your Inner Animals	This interactive explores different anatomical features of the human body and what they reveal about the evolutionary history we share with other organisms, including earlier, long-extinct species.	MS.LS1.A, MS.LS4.A, HS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.C.3, 3.A.1, 3.C.1, 3.E.2, 4.C.1	3.1, 5.1, A.2, A.3, D.2
App	EarthViewer	What did Earth look like 250 million years ago? Or 1 billion years ago? Or 4.5 billion years ago? EarthViewer is an interactive tool for tablet computers that allows you to explore the science of Earth's deep history. Watch this 30-second tour of how EarthViewer works and how to use the interface: EarthViewer Video Tour.	MS.ESS1.C, MS.ESS2.A, MS.ESS2.B, MS.ESS2.D, MS.ESS3.D, MS.LS2.B, MS.LS2.C, HS.ESS1.C, HS.ESS2.A, HS.ESS2.B, HS.ESS2.D, HS.ESS3.D, HS.LS2.B, MS.LS2.C, HS.LS4.C	1.A.4, 1.C.1, 2.A.3, 4.B.3, 4.B.4	4.1, 4.2, 4.3, 4.4, 5.1, 5.3
Poster	The Making of Mass Extinctions	Extinction is a normal part of the evolutionary process, but at certain times in Earth's history the rate of extinction has greatly exceeded that of normal, or background, species loss. Scientists have identified five such events. What caused these five big mass extinction events? What did they have in common, and how did they differ? And are we headed for a sixth one? Explore the answers to these questions in this data-rich poster (JPEG format) for the classroom. Click on the hyperlink and save the image to print a copy.	HS.ESS1.C, HS.ESS2.A, MS.LS4.A, HS.LS4.C	1.A.1, 1.A.4, 1.C.1	5.1

Population Genetics

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If you have downloaded this document from BioInteractive.org, simply click on the resource name to open the resource.

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Short Film	The Making of the Fittest: Natural Selection and Adaptation	In a complete story, from ecosystem to molecules, pocket mice show us how random changes in the genome can take many paths to the same adaptation. (10 min. 25 sec.)	MS.LS2.A, MS.LS2.C, MS.LS3.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS2.A, HS.LS3.A, HS.LS3.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.C.1, 3.C.2, 4.B.3, 4.C.2, 4.C.3	3.1, 4.1, 5.1, 5.2, 10.3

Animation	Pocket Mouse Evolution	This simulation shows the spread of a favorable mutation through a population of pocket mice. Even a small selective advantage can lead to a rapid evolution of the population. (1 min. 5 sec.)	HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.1	5.1, 5.2
Classroom Resource	Allele and Phenotype Frequencies in Rock Pocket Mouse Populations	This activity uses real rock pocket mouse data collected by Dr. Michael Nachman and his colleagues to illustrate the Hardy-Weinberg principle. *Appropriate for:* high school biology (all levels), introductory college biology.	MS.LS2.A, MS.LS2.C, MS.LS3.A, MS.LS3.B, MS.LS4.B, MS.LS4.C HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.C.1, 3.C.2, 4.B.1, 4.C.2, 4.C.3	3.1, 5.1, 10.3
Classroom Resource	Survival of the Fittest—Battling Beetles	The overall goal of the "Battling Beetles" guided inquiry activity is to engage students in thinking about the mechanism of natural selection through data collection and pattern recognition. *Appropriate for*: high school biology (all levels), introductory college biology. (Click on the link and scroll down to activity.)	HS.LS3-3, HS.LS4-3, HS.LS4-4, HS.LS2.A, HS.LS2.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 4.C.3	5.1, 5.2, 10.3
Short Film	The Making of the Fittest: Natural Selection in Humans	In some parts of the world, there is an intimate connection between the infectious parasitic disease malaria and the genetic disease sickle cell anemia. The protection against malaria by the sickle cell mutation shows how evolution does not necessarily result in the best solution imaginable but proceeds by whatever means are available. (14 min. 3 sec.)	HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.B.1, 4.C.1, 4.C.2	3.1, 3.4, 5.1, 5.2
Classroom Resource	Population Genetics, Selection, and Evolution	This hands-on activity, in conjunction with the information presented in the short film *The Making of the Fittest: Natural Selection in Humans*, teaches students about population genetics, the Hardy-Weinberg principle, and the various modes of natural selection. It uses simple simulations to guide students through these concepts. *Appropriate for*: high school biology (all levels), introductory college biology.	HS.LS2-1, HS.LS2-6, HS.LS3-1, HS.LS3-2, HS.LS3-3, HS.LS4-2, HS.LS4-3, HS.LS4-4, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.C.1, 4.C.3	3.1, 5.1, 5.2, 10.3

Human Adaptations

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If you have downloaded this document from BioInteractive.org, simply click on the resource name to open the resource.

Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Click & Learn	Recent Adaptations in Humans	Lactose tolerance, sickle cell disease, and bitter taste perception are three examples of recently evolved human traits. (53 slides)	HS.LS1.A, HS.LS1.C, HS.LS2.A, HS.LS2.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.A.1, 3.B.1, 3.C.1, 4.A.1, 4.B.1, 4.C.2	2.1, 2.3, 3.5, 3.1, 3.4, 5.1, 5.2, 10.2, 10.3, A.3

Lecture/ Discussion	Genetics of Bitter Taste Perception	Dr. Michael Campbell discusses how humans perceive the taste of the chemical PTC. With Dr. Sarah Tishkoff, he fields questions about the evolution of taste perception and scientific career choices. (50 min. 39 sec.)	HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 2.E.1, 3.A.3, 3.B.1, 3.C.1, 3.C.2, 4.C.1, 4.C.2	3.1, 5.1, 5.2, 10.2, 10.3, A.3
Short Film	The Making of the Fittest: Got Lactase? The Co-Evolution of Genes and Culture	Follow human geneticist Spencer Wells, director of the Genographic Project of the National Geographic Society, as he tracks down the genetic changes associated with the ability to digest lactose as adults, tracing the origin of the trait to less than 10,000 years ago, a time when some human populations started domesticating animals. (14 min. 52 sec.)	HS.LS1.C, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.1, 3.B.1, 3.C.1, 3.C.2, 4.A.1, 4.B.1, 4.C.2	2.1, 2.3, 2.5, 3.1, 5.1, 5.2
Animation	Natural Selection of Lactose Tolerance	Environmental and cultural factors can affect whether a new human mutation becomes common in a population. (46 sec.)	HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2	5.1, 5.2
Click & Learn	Regulation of the Lactase Gene	Lactase persistence results from a mutation that changes how transcription factors interact, thereby affecting gene expression. (21 slides)	HS.LS1.A, HS.LS3.B, HS.LS4.C	1.A.1, 1.A.2, 2.E.1, 3.A.3, 3.B.1, 3.C.1, 3.C.2, 4.C.2	2.7, 3.1, 5.1, 5.2, 7.2
Classroom Resource	Lactose Intolerance: Fact or Fiction	Students evaluate and discuss several statements about lactose intolerance and evolution before and after watching the film.	MS.PS1.B, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS2.A, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 2.A.2, 2.D.2, 2.E.1, 3.B.1, 3.C.1, 3.C.2	2.3, 2.5, 3.1, 5.1, 6.1
Classroom Resource	Pedigrees and the Inheritance of Lactose Intolerance	In this classroom activity, students analyze the same Finnish family pedigrees that researchers studied to understand the pattern of inheritance of lactose tolerance/intolerance. They also examine portions of DNA sequence near the lactase gene to identify specific mutations associated with lactose tolerance.	HS.LS3-1, HS.LS2.A, HS.LS1.A, HS.LS3.A	3.A.3, 3.B.1, 3.C.1, 4.A.1, LO 3.14, LO 3.18, LO 3.19	2.3, 2.7, 5.1, 5.3
Classroom Resource	Diet and the Evolution of Salivary Amylase	In this classroom activity, students analyze data obtained from a research study to draw conclusions about the relationship between the number of copies of the salivary amylase (*AMY1*) gene and production of salivary amylase, which is the enzyme in saliva that digests starch. They also analyze the relationship between *AMY1* gene copy number and dietary starch consumption among different populations.	HS.LS1-3, HS.LS3-1, HS.LS3-3, HS.LS4-2, HS.LS4-3, HS.LS4-4, HS.LS1.A, HS.LS.2A, HS.LS.3A, HS.LS.3B, HS.LS.4B, HS.LS.4C	1.A.1, 1.A.2, 3.A.1, 3.C.1, 4.A.1, 4.C.1	2.3, 2.7, 5.1, 5.2, 10.3
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 27-28	Lactase persistence as an example of human adaptation. (42:42–46:26)	HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.4, 2.E.1, 3.A.1 3.B.1, 3.C.1, 4.B.1	2.5, 2.6, 3.1, 5.1

Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Ch. 30	The genetic basis of lactase persistence in Europe and Africa. (47:39–50:38)	HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 4.B.1	2.5, 2.6, 3.1, 3.2, 5.1, 5.2
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Ch. 31	The genetic footprint of recent natural selection. (50:39–52:55)	HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 3.A.1, 3.B.1, 3.C.1, 4.B.1	2.5, 2.6, 3.1, 3.2, 5.1, 5.2
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Ch. 33	Other examples of natural selection in humans. (53:52–55:00)	HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3	5.1, 5.2
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 1–35	This is Dr. Sarah Tishkoff's entire lecture on human adaptations. (0:00–58:31)	HS.LS1.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.B.1, 1.B.2, 1.C.3, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 4.B.1	2.5, 2.6, 3.1, 3.2, 5.1, 5.2, 5.3, 5.4, 10.3, B.5
Short Film	The Making of the Fittest: Natural Selection in Humans	In some parts of the world, there is an intimate connection between the infectious parasitic disease malaria and the genetic disease sickle cell anemia. The protection against malaria by the sickle cell mutation shows how evolution does not necessarily result in the best solution imaginable but proceeds by whatever means are available. (14 min. 3 sec.)	HS.LS1.A, HS.LS2.A, HS.LS2.C, HS.LS3.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.B.1, 4.C.1, 4.C.2	3.1, 3.4, 5.1, 5.2
Classroom Resource	Testing a Hypothesis	A worksheet designed to actively engage students as they watch the film. Students are asked to answer questions pertaining to the information provided in the film. Follow-up questions probe student understanding of how Dr. Tony Allison found the link between sickle cell disease and malaria, and why this finding is important in understanding human evolution. *Appropriate for*: middle school life science, high school biology (all levels).	MS.LS1-5, MS.LS4-4, MS.LS1.A, MS.LS2.A, MS.LS3.B, MS.LS4.B, MS.LS4.C, HS.LS4-2, HS.LS4-4, HS.LS1.A, HS.LS3.B, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.C.3, 3.A.3, 3.C.1, 3.C.2, 4.C.1	3.1, 5.1, 10.2, 10.3

Human Evolution

All of these resources can be accessed via www.BioInteractive.org and/or the Holiday Lectures on Science DVDs.

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Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Short Film	Great Transitions: The Origin of Humans	Paleontologists have studied the fossil record of human evolution just as they have done for other major transitions, including the evolution of tetrapods from fish and the evolution of birds from dinosaurs. In this film, Dr. Sean Carroll and Dr. Tim White discuss the most important human fossils and how they illuminate key phases of human evolution, focusing in particular on three traits: larger brains, tool use, and bipedality. (19 min. 44 sec.)	HS.LS1.A, HS.LS2.A, HS.LS4.C, HS.ESS2.A, HS.ESS3.A, MS.ESS1.C, MS.LS1.A, MS.LS4.A, MS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.B.2, 4.A.5	4.1, 5.1, 5.2, 5.3, 5.4

Click & Learn	Explore Your Inner Animals	This interactive explores different anatomical features of the human body and what they reveal about the evolutionary history we share with other organisms, including earlier, long-extinct species.	MS.LS1.A, MS.LS4.A, HS.LS4.B, MS.LS4.C, HS.LS1.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.C.3, 3.A.1, 3.C.1, 3.E.2, 4.C.1	3.1, 5.1, A.2, A.3, D.2
Click & Learn	Using the Scientific Process to Study Human Evolution	Researchers, including those scientists who study human evolution, use a scientific process in which testing ideas with evidence is a critical component. (23 slides)	HS.ESS2.A, HS.ESS1.C, HS.PS1.A, HS.LS4.A, SEP, Analyzing and Interpreting Data	1.A.4, 1.B.1	5.1
Click & Learn	Using DNA to Trace Human Migration *Resource title on DVD:* Origins of Modern Humans	All living humans originated from populations of ancestors who migrated out of Africa less than 100,000 years ago. Learn how genetic markers have been used to trace the migration routes. (18 slides)	HS.LS1.A, HS.LS3.B	1.A.4, 1.B.1, 3.A.1	2.6, 3.1
Lecture	Lecture 1: Reading Genes and Genomes, Chs. 4–6	Geneticists are interested in human variation. (6:18–11:46)	MS.LS3.A, HS.LS1.A, HS.LS3.A, HS.LS3.B	1.A.4, 1.B.1, 3.A.1, 4.C.2	3.1, 3.4, 5.1
Lecture	Lecture 1: Reading Genes and Genomes, Chs. 29–31	Human and mouse comparisons: the mouse as a model for humans. (45:55–50:03)	HS.LS1.A, HS.LS4.A	1.A.4, 3.A.1, 3.A.3, 3.B.1, 3.C.1	3.1, 3.2, 5.1
Lecture	Lecture 3: Human Genomics: A New Guide for Medicine, Chs. 7–9	Human origins and why we have little genetic variation. (10:04–14:45)	HS.LS1.A, HS.LS3.B, HS.LS4.A	1.A.4, 1.B.2, 3.A.1	3.1, 5.1
Lecture	Lecture 3: Human Genomics: A New Guide for Medicine, Chs. 14–16	Filling in life's matrix: genes, phenotypes, and SNPs. (22:44–29:03) *This section includes examples of genetic bases of human phenotype variation.*	HS.LS3.B, HS.LS4.A	1.A.4, 1.B.1, 3.A.1, 3.B.1, 3.C.1, 3.C.2	3.1, 5.1
Lecture	Evolution: Fossils, Genes, and Mousetraps, Ch. 13	Molecular evolution: chimps and humans. (26:46–32:37)	HS.LS.1, HS.LS3.A	1.A.3, 1.A.4, 1.B.1, 1.B.2, 1.C.3, 3.A.3	3.2, 5.1
Lecture	Lecture 2: Unwinding Clock Genetics, Ch. 8	Similarity of cellular structures and genomes between humans and *Drosophila*. (11:40–13:39)	HS.LS1.A	1.B.1	5.1, 6.5
Lecture	Lecture 1: Human Evolution and the Nature of Science, Ch. 5	Where do we come from? (5:26–8:40)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.2	5.1, 5.2
Lecture	Lecture 1: Human Evolution and the Nature of Science, Chs. 10 and 11	Basic classification of great apes and human origins. (18:23–25:00)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.3, 5.4
Lecture	Lecture 1: Human Evolution and the Nature of Science, Ch. 13	Phases of human evolution. (27:15–29:01)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.3, 5.4
Lecture	Lecture 1: Human Evolution and the Nature of Science, Chs. 1–13	This is Dr. Tim White's entire lecture on human evolution. (0:00–29:01)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.2, 5.3, 5.4
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 4 and 5	What is our place in the tree of life? (4:57–7:14)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1, 1.B.2, 3.A.1	5.1, 5.3, 5.4, 10.3
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 6–8	Fossil and genetic evidence inform us about human history. (7:14–11:49)	HS.LS1.A, HS.LS3.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1, 3.A.1	1.2, 5.1, 5.2, 10.2
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 12–14	Other species of *Homo* left Africa earlier than *Homo sapiens*. (18:01–24:54)	HS.LS1.A, HS.LS3.B, HS.LS4.A	1.A.1, 1.A.3, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.2, 5.4, B.5

Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 19–20	Short tandem repeats (STRs) are highly variable genetic markers. (31:00–33:15)	HS.LS1.A, HS.LS3.A	1.A.1, 1.A.4, 1.B.1, 3.A.1	3.1, 5.1, 5.4
Lecture	Lecture 2: Genetics of Human Origins and Adaptation, Chs. 1–35	This is Dr. Sarah Tishkoff's entire lecture on human adaptations. (0:00–58:31)	HS.LS1.A, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.3, 1.A.4, 1.B.1, 1.B.2, 1.C.3, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 4.B.1	2.5, 2.6, 3.1, 3.2, 5.1, 5.2, 5.3, 5.4, 10.3, B.5
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 5 and 6	Stratigraphic principles of superposition and association. (8:40–11:59)	HS.ESS2.A	1.A.4	5.1
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 7 and 8	Principles of radiocarbon and radiopotassium dating. (11:59–15:25)	HS.PS1.A, HS.LS4.A	1.A.4	5.1
Video Clip	Stratigraphic Principles	Dr. John Shea demonstrates the two main principles in the study of rock layers: superposition and association. (2 min. 21 sec.)	HS.ESS2.A	1.A.4	5.1
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 18–23	Archaeological evidence of complex human behavior. (33:20–45:15)	HS.ESS3.A, SEP.Analyzing and Interpreting Data	1.A.4	5.1, 5.3
Video Clip	Classifying Stone Tools	Prehistoric stone tools are classified into six broad technological modes by the level of sophistication and method of fabrication. (3 min. 4 sec.)	HS.ESS3.A, SEP.Analyzing and Interpreting Data	1.A.4	5.1
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 24 and 25	Origin of distinctly hominin behavior. (45:15–46:44)	SEP.Analyzing and Interpreting Data	1.A.4	5.1, A.4
Video Clip	Comparing Human and Chimpanzee Tool Use	Chimpanzees are capable of using rocks as tools to crack nuts for eating. But they don't appear to use sharp-edged tools. (29 sec.)	SEP.Analyzing and Interpreting Data	1.A.4	5.1
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 28 and 29	Hypotheses for the evolution of human behavioral complexity. (49:30–53:22)	SEP.Analyzing and Interpreting Data	1.A.4	5.1, 5.3, A.4
Lecture	Lecture 3: Stone Tools and the Evolution of Human Behavior, Chs. 1–34	This is Dr. John Shea's entire lecture on the history of stone tool use and human evolution. (0:00–58:31)	HS.PS1.A, HS.ESS2.A, HS.ESS3.A, HS.LS4.A, SEP.Analyzing and Interpreting Data	1.A.4	5.1, 5.3, A.4
Lecture	Lecture 4: Hominid Paleobiology, Ch. 16	Earliest *Homo sapiens*: Herto. (29:10–30:32)	HS.LS4.A	1.A.1, 1.A.4, 1.B.1	5.1
Video Clip	Rift Valleys of Africa and Plate Tectonics	African rift valleys were formed by the separation of tectonic plates. Water flows down to the valley floors, creating rivers and lakes. (2 min. 14 sec.)	HS.ESS2.B	—	—
Video Clip	Floods Supply Sediments for Fossil Formation	The floor of a rift valley is prone to periodic floods that carry in fine silt—the sedimentary matter responsible for fossil formation. (2 min. 42 sec.)	MS.ESS2.C, HS.ESS2.C, HS.ESS3.B	—	—

Video Clip	The Delicate Process of Excavating and Cleaning Fossils	Fossils are extremely fragile. Scientists remove them in a protective layer of plaster and clean sand away one grain at a time. (1 min. 27 sec.)	MS.ESS1.C, HS.ESS1.C	—	—
Lecture	Lecture 4: Hominid Paleobiology, Chs. 17 and 18	The delicate process of excavating and cleaning fossils: the Herto skull. (30:33–32:45)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1	5.1
Lecture	Lecture 4: Hominid Paleobiology, Chs. 20–23	Stone tools and human evolution. (33:38–37:50)	HS.LS1.A, HS.LS4.A, MS.ESS1.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 24–26	*Australopithecus* lineage, 4.2–2 Myr. (37:51–40:39)	HS.LS1.A, HS.LS4.A, MS.ESS1.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 27–28	Neanderthal lineage in Europe, 0.6–0.03 Myr. (40:40–42:14)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 29–31	How many species are in the human family tree? (42:15–47:10)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 36 and 37	*Ardipithecus* and our place in nature. (51:35–53:47)	HS.LS4.B, MS.ESS1.C	1.A.1, 1.A.4, 1.B.1	5.1
Lecture	Lecture 4: Hominid Paleobiology, Chs. 38–39	Darwin knew chimpanzees did not evolve into humans. (53:48–56:45)	HS.LS4.B	1.A.1, 1.A.4, 1.B.1, 1.B.2	5.1, 5.4
Click & Learn	Skeletons Reveal Human and Chimpanzee Evolution	Comparing features of a 4.4-million-year-old fossil skeleton to those of human and chimpanzee skeletons sheds light on our evolutionary history. (39 slides)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1, 1.B.2	5.1, 5.3, 5.4
Lecture	Lecture 4: Hominid Paleobiology, Chs. 41 and 42	Dung beetles and their fossilized evidence. (57:51–59:20)	HS.ESS2.A, HS.ESS3.A, MS.ESS1.C	1.A.1, 1.A.4	5.1
Lecture	Lecture 4: Hominid Paleobiology, Chs. 43–52	Discovery of hominid bones from 4.4 Myr. (Includes the discovery of "Ardi.") (59:21–73:12)	HS.LS1.A, HS.ESS2.A, HS.ESS3.A, MS.ESS1.C, HS.LS2.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1, 4.A.5	4.1, 5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Ch. 46	Reconstructing past environment from fossil evidence. (62:59–66:16)	HS.ESS2.A, HS.ESS3.A, MS.ESS1.C, HS.LS2.A	1.A.1, 1.A.4, 4.A.5	4.1, 5.1
Lecture	Lecture 4: Hominid Paleobiology, Ch. 47	Early hominid skeletons. (66:16–67:16)	HS.LS1.A	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 48–52	Comparing "Ardi" and "Lucy." (67:16–73:14)	HS.LS1.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Ch. 52	Comparing feet: "Ardi" and primates. (71:58–73:15)	HS.LS1.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 53 and 54	Making sense of "Ardi's" characteristics. (73:14–77:58)	HS.LS1.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 55 and 56	Chimpanzee-human common ancestor was not a chimpanzee. (77:58–80:59)	HS.LS1.A, HS.LS4.C	1.A.1, 1.A.4, 1.B.1	5.1, 5.3, 11.1, B.4

Lecture	Lecture 4: Hominid Paleobiology, Ch. 57	Evolution's perspective: geographic range and preferred habitat. (80:59–82:44)	HS.LS4.D	1.A.1, 1.A.4, 1.C.1, 4.B.3	4.1, 5.1, C.3
Lecture	Lecture 4: Hominid Paleobiology, Chs. 1–61	This is Dr. Tim White's entire lecture on human paleobiology and evolution. (0:00–93:25)	HS.LS1.A, HS.ESS2.A, HS.ESS3.A, MS.ESS1.C, HS.LS2.A, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.4, 1.B.1, 1.B.2, 4.A.5, 4.B.3	4.1, 5.1, 5.3, B.4, C.3
Lecture	Lecture 4: From Butterflies to Humans, Chs. 24–31	T. H. Huxley in 1863 on human evolution and fossil evolution in humans. (27:05–35:55)	HS.LS4.A	1.A.1, 1.A.4, 1.B.2	5.1, 5.4
Lecture	Lecture 4: From Butterflies to Humans, Chs. 32–33	Hominid skull evolution. (35:55–38:32)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.2, 1.A.4	5.1, 5.2
Lecture	Lecture 4: From Butterflies to Humans, Chs. 34–36	Traits that distinguish humans from other apes. (38:32–42:35)	HS.LS1.A, HS.LS4.A	1.A.1, 1.A.4, 1.B.2	5.1
Lecture	Lecture 4: From Butterflies to Humans, Chs. 35–37	What can we learn about human evolution? (40:10–45:07) *These three chapters illustrate how we use DNA to study human evolution and our relatedness to chimps.*	HS.LS1.A, HS.LS3.B, HS.LS4.A	1.A.1, 1.B.1, 3.A.1, 4.A.1	3.1, 5.1, A.2
Lecture	Lecture 4: From Butterflies to Human, Chs. 1–45	This is Dr. Sean Carroll's entire lecture on natural selection, genetics, and evolution. (0:00–58:30)	HS.LS1.A, HS.LS2.C, HS.LS3.B, HS.LS4.A, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.1, 1.B.2, 2.E.1, 3.A.1, 3.B.1, 3.C.1, 3.E.1, 4.A.1, 4.A.5, 4.C.4	1.1, 2.6, 2.7, 3.1, 4.1,5.1, 5.2, 5.4, 7.2, A.2, C.3
Lecture	Lecture 3: Fossils, Genes, and Embryos, Chs. 26 and 27	Organisms share molecular pathways and enzymes. (34:55–36:06). *This portion of material explains that organisms also share DNA as a basis for heredity.*	MS.LS4.A, HS.LS1.A, HS.LS4.A	1.A.4, 3.A.1	3.1, 5.1
Poster	Human Evolution within the Tree of Life	A poster (JPEG format) created for the 2011 Holiday Lectures on Science, Human Evolution and the Nature of Science. Click on the hyperlink and save the image to print a copy.	HS.LS4.A	1.A.1, 1.B.1, 1.B.2	5.1, 5.4

Phylogeny and Classification

All of these resources can be accessed via www.BioInteractive.org and/or the Holiday Lectures on Science DVDs.

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Resource Type	Resource Name	Resource Summary	NGSS (April 2013)	AP Biology (2012–13)	IB Biology (2016)
Click & Learn	Creating Phylogenetic Trees from DNA Sequences	This Click and Learn activity explains how DNA sequences can be used to generate phylogenetic trees and how to interpret them. (26 slides)	HS.LS1.A, HS.LS3.B, HS.LS4.A	1.A.1, 1.A.4, 1.B.1, 1.B.2, 3.A.1	5.1, 5.3, 5.4
Lecture	Lecture 1: Human Evolution and the Nature of Science, Chs. 10 and 11	Basic classification of great apes and human origins. (18:23–25:02)	HS.LS4.A, HS.LS4.B	1.A.1, 1.A.4, 1.B.1, 1.B.2, 1.C.3	5.1, 5.3, 5.4

Classroom Resource	Biodiversity and Evolutionary Trees	This is an activity on biological classification, and it accompanies the 2009 Holiday Lectures on Science, Exploring Biodiversity: The Search for New Medicines. Students construct evolutionary trees by sorting seashells. (Click on the link and scroll down to the activity.)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.B.1, 1.B.2, 3.A.1	3.1, 5.1, 5.3, 5.4
Click & Learn	Sorting Seashells	Students explore principles of taxonomy by sorting seashells according to their morphological characteristics and constructing an evolutionary tree.	HS.LS1.A, HS.LS1.B, HS.LS3.B	1.B.1, 1.B.2	5.3, 5.4
Classroom Resource	Comparing DNA Sequences to Determine Evolutionary Relationships of Molluscs	In this exercise, students revisit the “Biodiversity and Evolutionary Trees: An Activity on Biological Classification” activity and reconstruct the phylogenetic tree using ClustalX, software that aligns and compares DNA sequences. They use a simple viewer program called NJplot to view the tree. (Click on the link and scroll down to the activity.)	HS.LS1.A, HS.LS4.A, HS.LS4.C	1.A.1, 1.B.1, 1.B.2, 3.A.1	3.1, 5.1, 5.3, 5.4
Short Film	The Origin of Species: Lizards in an Evolutionary Tree	In the Caribbean islands, adaptation to several common habitats has led to a large adaptive radiation with interesting examples of convergent evolution. (17 min. 45 sec.)	MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3	5.1, 5.2, 10.3, C.1
Classroom Resource	Using DNA to Explore Lizard Phylogeny	This activity supports the film *The Origin of Species: Lizards in an Evolutionary Tree*. Students are guided to sort the lizard species by appearance, then generate a phylogenetic tree using the lizards’ DNA sequences to evaluate whether species that appear similar are closely related to each other.	MS.LS4-2, MS.LS4-4, MS.LS4.A, MS.LS4.B, MS.LS4.C, HS.LS4-1, HS.LS4-4, HS.LS4.A, HS.LS4.B, HS.LS4.C	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3	4,1, 5.1, 5.2, 5.4, C.1
Virtual Lab	Lizard Evolution Virtual Lab	The virtual lab includes four modules that investigate different concepts in evolutionary biology, including adaptation, convergent evolution, phylogenetic analysis, reproductive isolation, and speciation. Each module involves data collection, calculations, analysis, and answering questions. The Educators tab includes lists of key concepts and learning objectives and detailed suggestions for incorporating the lab in your instruction.	MS.LS1-5, MS.LS4-2, MS.LS4-4, MS.LS4.A, MS.LS4.B, MA.LS4.C, HS.LS4-1, HS.LS4-2, HS.LS4-3, HS.LS4-4, HS.LS4-5, HS.LS4.B, HS.LS4.C, HS.LS4.D	1.A.1, 1.A.2, 1.A.4, 1.B.2, 1.C.1, 1.C.2, 1.C.3, SP1, SP2, SP4, SP5, SP6	4.1, 5.1, 5.2, 5.4, 10.3, C.1
Lecture	Lecture 2: Shedding Light on an Invisible World, Chs. 4–6	Hidden biodiversity: the microbes. (4:59–8:06)	HS.LS4.A	1.A.4, 1.B.2	5.1, 5.4
Lecture	Lecture 2: Shedding Light on an Invisible World, Chs. 7 and 8	Three main branches of life. (8:06–10:01)	HS.LS4.A	1.A.4, 1.B.1, 1.B.2	5.1, 5.3, 5.4
Lecture	Lecture 1: From Venoms to Drugs, Ch. 14	Phylogenetic tree of cone snails. (19:32–21:42)	HS.LS4.A	1.A.4, 1.B.2	5.1, 5.4
Lecture	Lecture 1: From Venoms to Drugs, Ch. 17	Hunting specialization and phylogenetic tree. (22:56–24:20)	HS.LS4.A	1.A.4, 1.B.2	5.1, 5.4