

the Jane Goodall Institute

http://www.jane-goodall.org



Dear Teacher,

As a naturalist, conservationist, and scientist, I am deeply committed to fostering an appreciation for both the natural world and science, particularly among young people. That's one of the reasons I founded "Roots & Shoots," a global environmental and humanitarian program for young people that combines classroom learning with local projects that benefit people, animals, and the environment.

That's also why I am delighted to lend my support to the *Evolution* project, one of the most comprehensive public television science initiatives ever undertaken. In addition to an outstanding eight-hour broadcast series, the *Evolution* team has put together an extraordinary set of multimedia resources for high school teachers across the country to help them expand and strengthen students' understanding of evolution.

I believe that teaching evolution is critical to nurturing a community that is not only scientifically literate, but also compassionate and caring and that values the natural world. I hope you'll take advantage of the *Evolution* project's many resources for years to come.

Sincerely,

Dr. Jane Goodall, CBE

P.O. Box 14809 Silver Spring, Maryland 20911-4809

evolution

a journey into where we're from
and where we're going

Dear Teacher,

Evolution is one of the most powerful ideas ever to emerge from science. It is the very foundation of biology and the key to understanding our own human origins. The mechanism of evolution helps determine who lives, who dies, and who gets the opportunity to pass on traits to the next generation. At the same time, evolution ranks as one of the most widely misunderstood scientific principles in America today.

To address this, leading public broadcaster WGBH Boston (producer of the award-winning science series *NOVA*TM) and acclaimed documentary and feature film production company Clear Blue Sky Productions have joined together to bring you *Evolution*. This groundbreaking project includes a PBS series, content-rich Web site, and extensive educational resources—including this teacher's guide—for classrooms nationwide. The guide is packed with activities to help you enhance and deepen your students' understanding of evolution and its relevance today.

We salute you, America's high school biology teachers, for your dedication and commitment to teaching evolution. We hope you'll use this guide and all our *Evolution* resources to illuminate what many regard as the single greatest scientific idea ever conceived.

Sincerely,

Richard Hutton
Executive Producer, *Evolution*
WGBH

Jody Patton
Executive-in-Charge
Clear Blue Sky Productions

Evolution is a co-production of the WGBH/NOVA Science Unit
and Clear Blue Sky Productions.



STARRING JANE GOODALL
PRODUCTION

WGBH
125 Western Avenue
Boston, MA 02134
617-300-2000



CONTENTS

ABOUT THE <i>EVOLUTION</i> PROJECT	2
ORDERING <i>EVOLUTION</i> PROJECT VIDEOS AND MATERIALS	3
USING THIS GUIDE	4
CURRICULUM LINKS AND ACTIVITY PLANNING GRID	5
UNIT 1: WHAT IS THE NATURE OF SCIENCE?	6
Introduces the nature of science and the scientific process, the difference between scientific and everyday meanings of words, and the importance of inference and interpretation	
UNIT 2: WHO WAS CHARLES DARWIN?	10
Offers a close-up look at Darwin, his adherence to the scientific process, the development of the theory of natural selection, and his contributions to science	
UNIT 3: WHAT IS THE EVIDENCE FOR EVOLUTION?	14
Examines evidence for evolution across many scientific disciplines—paleontology, molecular biology, anatomy, and physiology—and how this evidence is helping to determine evolutionary relationships between species	
UNIT 4: HOW DOES EVOLUTION WORK?	18
Explores how natural selection produces adaptations in populations over time and the importance of sexual reproduction in organisms' variability	
UNIT 5: HOW DID HUMANS EVOLVE?	22
Reviews the fossil and molecular evidence for early hominid evolution and the adaptations of bipedalism and larger brains	
UNIT 6: WHY DOES EVOLUTION MATTER NOW?	26
Looks at natural selection's role in the development of antibiotic resistance, and the applications and implications of evolutionary principles in modern medicine, agriculture, conservation, and society at large	
UNIT 7: DEALING WITH CONTROVERSY	30
Offers effective strategies for respectfully addressing controversies around evolution	
ASSESSMENT RUBRICS	34
GLOSSARY	36
<i>EVOLUTION</i> SERIES INDEX	38
NATIONAL SCIENCE EDUCATION STANDARDS	40

ABOUT THE *EVOLUTION* PROJECT



“ If I were to give an award for the single best idea anyone has ever had, I’d give it to Darwin, ahead of Newton and Einstein and everyone else. In a single stroke, the idea of evolution by natural selection unifies the realm of life, meaning, and purpose with the realm of space and time, cause and effect, mechanism and physical law. But it is not just a wonderful idea. It is a dangerous idea.”

—Daniel Dennett,
Darwin’s Dangerous Idea, p. 21

Programs can be videotaped and used for up to one year after broadcast. Check your TV listings or call your local public television station to confirm broadcast dates and times.

The *Evolution* project—a groundbreaking public television series, content-rich and easy-to-navigate Web site, and extensive educational resources—explores a simple yet remarkable theory that ranks as one of the greatest breakthroughs in the annals of science, and one of the most misunderstood scientific principles in America today.

Produced by public broadcaster WGBH Boston and documentary and feature film producer Clear Blue Sky Productions, the *Evolution* project aims to help biology teachers nationwide enhance and deepen their students’ understanding of evolution and the nature of science.

TELEVISION SERIES

This seven-part, eight-hour PBS series premiering fall 2001 travels around the world to examine evolutionary science and its profound effect on our lives and our planet.



Darwin’s Dangerous Idea (two hours)

Why does Charles Darwin’s “dangerous idea” matter more today than ever, and how does it explain the past and predict the future of life on Earth? This show combines drama and documentary filmmaking to explore Darwin’s life and the key concepts of evolution.



Great Transformations (one hour)

What underlies the incredible diversity of life on Earth? How have complex organisms evolved? The journey from water to land, the return of marine mammals to the sea, and the emergence of humans suggest that species, past and present, are all members of a single tree of life.



Extinction! (one hour)

Five mass extinctions have occurred over the life of the planet. Are we humans causing the next one? And what does evolutionary theory predict for the world we will leave to our descendants?



The Evolutionary Arms Race (one hour)

“Survival of the fittest” —is raw competition or a level of cooperation indispensable to life? Interactions between species are among the most powerful evolutionary forces on Earth, and understanding them may well be the key to our own survival.



Why Sex? (one hour)

In evolutionary terms, sex is more important than life itself. Sex fuels evolutionary change by adding variation to the gene pool. The drive to pass on our genes has shaped not only our bodies, minds, and lives, but the rich and complex fabric of human culture.



The Mind’s Big Bang (one hour)

Fifty thousand years ago, something happened—the modern human mind emerged, triggering a creative, technological, and social explosion. What forces contributed to this breakthrough and where might the power of the human mind ultimately lead us?



What About God? (one hour)

Of all species on Earth, humans alone attempt to explain who we are and how we came to be. This final show explores the struggle between science and religion. The personal stories of scientists, teachers, and students support the view that the two are compatible.

EVOLUTION WEB SITE

Visit pbs.org/evolution for an engaging, comprehensive educational experience. The site is packed with interactive features that allow users to test evolutionary principles in action.

RESOURCES FOR TEACHERS AND STUDENTS

Evolution Library

Direct Web access to hundreds of multimedia evolution resources, including video, photographs, interviews, articles, and annotated Web links. Available at pbs.org/evolution.

Online Lessons for Students: Learning Evolution

Produced in tandem with the *Evolution Teacher's Guide*, these inquiry-based, teacher-assigned lessons provide students with online activities to enhance their understanding of the nature of science and evolution. Available at pbs.org/evolution.

Videos for Students: Evolving Ideas

Seven short videos (streamed online at pbs.org/evolution and available for purchase through WGBH Boston Video) combine storytelling and science to explore the concepts of evolution and spark students' interest.

Teaching Evolution Case Studies

Four 15-minute videos (streamed online at pbs.org/evolution and available for purchase through WGBH Boston Video) highlight a range of strategies for teaching evolution in classrooms across the country.

Online Course for Teachers: Teaching Evolution

This eight-session course for high school teachers draws on the broadcast series, Web features, case study videos, and the *Evolution* Library to provide a vibrant learning experience. The course will deepen your understanding of evolutionary concepts and help you address obstacles to teaching evolution. Available at pbs.org/evolution. Explore the sessions for your own enrichment or take the whole course for credit through a local college (contact local institutions for availability).

Companion Book

Award-winning journalist Carl Zimmer tells the compelling story of the theory of evolution—from Charles Darwin to 21st century science—in *Evolution: The Triumph of an Idea*. Published by HarperCollins, this companion book to the *Evolution* series features an introduction by renowned paleontologist Stephen Jay Gould and a forward by *Evolution* Executive Producer Richard Hutton.

ORDER TODAY

Free *Evolution Teacher's Guide*

WGBH
Educational Programming & Outreach
125 Western Avenue
Boston, MA 02134
Order online at pbs.org/evolution

Series Videos, Videos for Students, Case Study Videos

1. The entire seven-part *Evolution* series is available for \$99.95 (WG1158)

2. Single program videos are available for \$19.95

“Darwin’s Dangerous Idea” (WG1219)

“Great Transformations” (WG1220)

“Extinction!” (WG1221)

“The Evolutionary Arms Race” (WG1222)

“Why Sex?” (WG1223)

“The Mind’s Big Bang” (WG1224)

“What About God?” (WG1225)

3. *Learning and Teaching Evolution*, a compilation of the videos for students and case study videos, is available for \$19.95 (WG1302)

Contact WGBH Boston Video at 1-800-949-8670 to place an order, or to request more information about other videos and DVDs.

USING THIS GUIDE



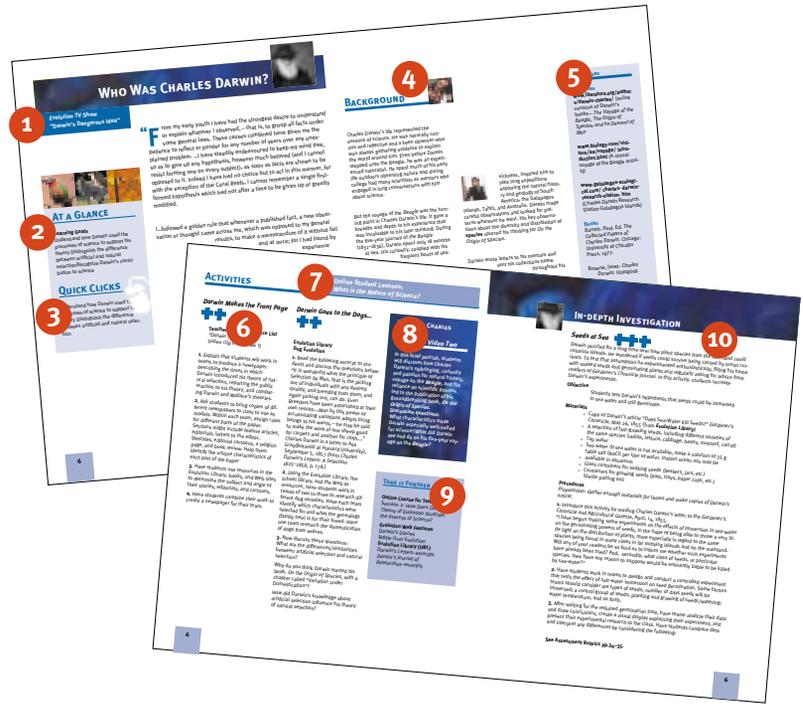
This guide is designed to help you take full advantage of the *Evolution* project's vast multimedia resources. Many of the lessons and activities are built around dynamic video segments, *Evolution* Web features, articles, images, and more...all easily accessible by going to **pbs.org/evolution** and clicking on Teachers and Students. Then go to the *Evolution Teacher's Guide*, where you'll find the Teacher's Guide Web Resources organized by unit. Teaching high school biology will never be the same!

Do You AVOID THE "E" WORD?

Are you committed to teaching evolution, but nervous about the controversy that might arise? Did you know that nearly every major religion doctrinally supports the teaching of evolution? Turn to p. 30 for "Dealing with Controversy," a special section created to help you successfully and respectfully address the controversy surrounding the teaching of evolution.

OVERVIEW

The guide is divided into six four-page units, each one framed by an essential question designed to spur inquiry-based learning and to meet National Science Education Standards (see p. 40). Each unit includes:



- 1 Evolution TV show
- 2 "At a Glance" learning goals
- 3 Quick Clicks: Teacher's Guide Web Resources
- 4 "Background" content to help build your knowledge of evolution
- 5 "Know More" offering Web, video, and print-based resources outside the *Evolution* project universe
- 6 "Activities" to support students' exploration of the subject
- 7 "Online Lessons for Students: Learning Evolution"
- 8 "Videos for Students: Evolving Ideas," short videos for students, each one focusing on a core question that serves as a springboard for discussion
- 9 "Take It Further" box with *Evolution* project resources/Web features and "Extensions" (activities outside the *Evolution* project universe) to deepen your students' learning experience
- 10 "In-depth Investigation" for students, providing detailed learning objective, materials, and procedures (Assessment Rubrics on pp. 34–35)

Access all the Web resources referenced in this guide...



- Handouts
- Video resources
- Evolution Web features
- Online Lessons for Students: Learning Evolution
- Online Course for Teachers: Teaching Evolution
- Videos for Students: Evolving Ideas
- Teaching Evolution Case Studies
- External Web links

...by going to **pbs.org/evolution**, clicking on Teachers and Students, and then going to the *Evolution Teacher's Guide*, where you'll find the resources organized by unit.



CURRICULUM LINKS

Evolution is the cornerstone of biology and we hope you'll use this guide to fortify and amplify your evolution lessons. But there also are many ways you can creatively integrate the units in this guide into your yearlong curriculum. Here are a few suggestions.

- Use “Unit 1: What Is the Nature of Science?” at the beginning of your course to introduce the processes of science.
- Use “Unit 2: Who Was Charles Darwin?” to enhance your lessons focusing on scientists and how they do their work.
- Use “Unit 3: What Is the Evidence for Evolution?” to fortify your lessons on how scientists seek multiple lines of evidence to support or refute hypotheses.
- Use “Unit 4: How Does Evolution Work?” when you're covering genetics as well as biodiversity.
- Use “Unit 5: How Did Humans Evolve?” as part of your lessons on human biology.
- Use “Unit 6: Why Does Evolution Matter Now?” in your lessons on microbes, antibiotic resistance, biodiversity, and ecology.

GUIDE TIPS

Time to Learn!



Each clock represents approximately one 45-minute classroom session. Use these clock icons as a guide to the amount of classroom time (not homework time!) needed to complete the activity or in-depth lesson.



SciLinks

SciLinks allow you to access activities, news articles, and other Web resources collected and annotated by NSTA (National Science Teachers Association). Simply go to www.scilinks.org and enter the keyword number referenced in the SciLinks boxes included in each unit of this guide.

It's in the Glossary

This guide includes a glossary of key terms on pp. 36–37. Glossary terms appear in **bold** within the units for easy reference.

ACTIVITY PLANNING GRID

Follow the units in this guide sequentially or choose those activities that complement your lesson plans and match your students' interests, aptitudes, and learning styles.

Our Activity Planning Grid offers you several ways to navigate the material. Whatever path you choose *or* create, we suggest you review the background section of the particular unit before presenting the activity, and that you use the unit's introductory vignette to engage your students.

PATH ONE focuses on the processes of science

UNIT 1

Activity: “Scientists in Action” (p. 8)

Activity: “Observe This” or “Different Points of View” (p. 8)

In-depth Investigation: “Solving the Puzzle” (p. 9)

UNIT 2 Video 2 for Students: “Who Was Charles Darwin?” and discussion questions (p. 12)

UNIT 3 Video 3 for Students: “How Do We Know Evolution Happens?” and discussion questions (p. 16)

UNIT 4

Video 4 for Students: “How Does Evolution Really Work?” and discussion questions (p. 20)

Online Student Lesson 4, Activity 2: “Sex and the Single Guppy”

UNIT 6

Video 6 for Students: “Why Does Evolution Matter Now?” (p. 28) or watch the entire broadcast of “The Evolutionary Arms Race” (how science works with medicine)

Activity: “When an Apple a Day Isn't Enough” (p. 28)

PATH TWO focuses on the processes of science, evolutionary concepts/mechanisms, and evidence for evolution

UNIT 1

Activity: “Scientists in Action” (p. 8)

Activity: “Observe This” or “Different Points of View” (p. 8)

UNIT 2

Online Student Lesson 2, Activity 1: “Darwin's Great Voyage of Discovery”

In-depth Investigation: “Seeds at Sea” (p. 13)

UNIT 3

Video 3 for Students: “How Do We Know Evolution Happens?” and discussion questions (p. 16)

Activity: “A Whale of a Change” (p. 17)

UNIT 4

In-depth Investigation: Read introductory vignette, and then go to In-depth Investigation, “Birds, Beaks, and Natural Selection” (p. 21)

Activity: “Darwin's Finches” (p. 20)

PATH THREE focuses on humans and evolution—how humans have evolved, the evidence for it, and why it matters to us now

UNIT 5

Activity: “Watch Your Step” (p. 24)

Video 5 for Students: “Did Humans Evolve?” and discussion questions (p. 24)

Online Student Lesson 5, Activity 1: “Riddle of the Bones” and **Activity 2:** “Becoming Human”

In-depth Investigation: “Fossils and Migration Patterns of Early Hominids” (p. 25)

UNIT 6

Video 6 for Students: “Why Does Evolution Matter Now?” and discussion questions (p. 28)

In-depth Investigation: “Big Decisions” (p. 29)