TEACHER'S MANUAL

To Accompany
EARTH-OCEAN-ATMOSPHERE EXPLORER

CD-ROM COURSEWARE
(Version 1.7)

October, 1998

EOA Scientific Systems, Inc.

181 Herring Cove Road, Suite 200

Halifax, Nova Scotia

Canada B3P 1K9

Email: info@eoascientific.com

Web page: http://www.eoascicentific.com

Telephone: 1-888-666-6362

TABLE OF CONTENTS

Installation and Users Guide

INSTALLATION FOR WINDOWS

To install, run the "setup" program on the CD.

1. Start the "setup.exe" program by selecting the “setup.exe” icon. The Readme.txt file (containing this text) will appear; select "Continue". The default directory "c:\eoa_exp" is where your installation files will reside.

****** Do Not Choose A Different Directory *******

You must put the files into "c:\eoa_exp".
But don't worry, it is less than 1 Mb.

2. You <u>must have</u> ***QuickTime for Windows*** installed on your computer before running the program. Our setup installs two icons for your start menu (or program manager) to run the Windows 3.1 version (QTeasy16.exe) or the Windows 95/NT version (QT32inst.exe). If you aren't sure if you have *Quicktime* installed already, make sure you do so.

3. The "setup" should place shortcuts of the executable application programs "win31.exe" and "win95_NT.exe" on your Start Menu. They will be under "EarthStation Library for Win 3.1" and "EarthStation Library for Win 95 + NT". You may run the appropriate one from there. If you want a shortcut on your desktop for Win 95, just copy it from the program manager after it installs.

4. If there are any problems with the setup, you can easily perform the setup manually. To do so:
a) Make a folder, "eoa_exp", on your C drive.
b) Copy the file "usersx.cst" from the CD into the "eoa_exp" folder.
c) Change the name of "usersx.cst" to "users.cst"
d) Change the properties of the "users.cst" folder to archive only. It must NOT be read-only.
e) Make a shortcut of the "win31.exe" or "win95_NT.exe" application program for your desktop and/or for your Start Menu.

5. When you run the application program, it will take from 5 to 50 seconds to load. Make sure you do not try to run it again, or you will have two copies running at the same time, which will degrade performance. Be patient -- it is loading a very cool opening movie.

See GENERAL INFORMATION for an important note.

INSTALLATION FOR MACINTOSH

From the CD volume, named "**eoacd**", copy the folder "**Mac_2HD**" on to your hard drive. This puts 10-14 Mb of files on your hard drive.

For your PowerPC or PowerMac, run "**eoa_exp.ppc**" or for your 68000 Mac, run "**eoa_exp.68k"** to run the E-O-A Explorer.

- If the opening movie does not play, (if it goes from the opening screen straight to the login screen, without a movie of the solar system) you will have to Quit and **install *QuickTime 3***. Use the QT3MAC.SMI program that is in the root folder of the "eoacd" CD, and then use the *QuickTime* Installer that is installed in your desktop.

GENERAL INFORMATION -- PLEASE READ

The movies in the courseware look much better at higher than 256 colors. We highly recommend that you set your monitor display properties to **high-color (16-bit) or true-color (24-bit).** Either one will do the job.

Also, if you set your screen to 640x480 resolution, the pictures and movies will look better filling the whole screen.

CONTACTING US

Please check our web site for updates, fixes, information about other products and such. The E-O-A Scientific Systems, Inc. web site also provides a major information hub for the Earth Sciences (geology, oceanography and meteorlogy). Check it out!

We are:

EOA Scientific Systems, Inc.
181 Herring Cove Road, Suite 200
Halifax, Nova Scotia B3P 1K9
Toll Free: 1-888-666-6362 (sales only)
Tel: (902) 477-6336
Fax: (902) 477-6834
Web Site: www.eoascientific.com
Email: info@eoascientific.com

This product, the CD, all of its contents, and the *Explorer* binder and all its contents are:

Check our web site for information on upgrades, added courseware information, current earth science information links and other products.

1. Using the Courseware in the Classroom

1.1. WHAT IS IT? Main Lessons, Popups, Appendices, Exercises and Projects

Welcome to the *Earth-Ocean-Atmosphere Explorer* CD! The *E-O-A Explorer* is a resource for **Students** and for **Teachers**. The CD has several levels and is designed for learning and teaching the earth sciences, and for the enjoyment, exploration and investigation of science. It has been tested on students from grades 5 through 12, and adults. How can this possibly be?

The **Main Lessons**, Chapters 1 through 14 each have 8-22 screens, and each screen contains text, plus a photograph, diagram or movie. Some of the movies are narrated or have music. Several interactive exercises and projects designed to introduce or reinforce main lesson concepts, are also included.

The text in the Main Lessons (23,000 words total) is accessible to all grades (5-12); it is easily understood, but at the same time presents complex scientific information and theories. Many of the words are highlighted in red and by using the mouse to select these words results in either a **Popup Window** with a definition or an enhancement (there are 14,000 words of popup text within the 14 Main Lessons) or a link to an Appendix screen (appendices range from a few pages to over 40 pages of extensive information).

There are 24 **Appendices**, with approximately 150,000 words of text, and scores of pictures. However, the appendices do not have either movies or interactive exercises related to them; they are designed for research. The level of research is variable: the El Niño, Climate Change and several other appendices are accessible to grades 7 through 12, while several other appendices require perhaps a grade 10 or 11 science education.

The **Interactive Exercises and Projects** range in complexity from simple reinforcement of concepts to more detailed projects like the Backyard Weather Station (Chapter 12) or the tectonic plate plotting project (Chapter 5). Grades 5-8 can perform nearly all of the exercises with complete comfort (eliciting responses like "awesome", "cool", "hey, check it out!"), while other interactive exercises are designed to challenge the brightest Grade 8 minds, as well as those in higher grades.

With all of these levels of information, the *Earth-Ocean-Atmosphere Explorer* is **an excellent resource for elementary and secondary school teachers** who are not experts in earth science (and a good reference for those who are).

For younger students (grades 5-6, and perhaps grades 7-8), the Main Lessons and most of the Popup Windows can be used as direct teaching resources. Some of the Appendices can be used by younger students, but these have been designed for teachers to enhance their own understanding. Students in higher grades, or advanced motivated students in the younger grades, are also encouraged to explore the appendices.

1.2. OUR PEDAGOGICAL APPROACH

Most educational courseware is based on the premise that the teacher and the textbook are the core reference for the student. The addition in recent years of electronic media merely supplements these core pedagogical materials and personnel.

In contrast, our courseware is fundamentally computer-based, and print materials are a supplementary resource. Thus, this course has been designed from the point of view that the student jumps into it without prior preparation and explores the topic in the guided way that we have designed into the lessons. The teacher's role in this model is to fill in the details and gaps as we introduce the student to the broad sweep of concepts in the earth sciences.

In this approach, the teacher becomes even more indispensable as the human voice that provides the local context and application of the broad principles that we present. We hope our courseware liberates the teacher from long lecture sessions. We also believe that the teacher should take the lead in guiding the students' use of this courseware. We have provided a few lesson suggestions about how this may be done.

We use popup descriptions and appendices to present detailed text so as not to detract from the main flow of the logic. However, a full appreciation of the depth of the courseware requires extensive use of these features. The multiple choice questions that we suggest often assume that the student has investigated all the relevant links.

To provide a broad scope of science topics, EOA Scientific Systems, Inc. is developing a full range of interactive multimedia courseware for Earth and Environmental Science Education (for grades 6-12 and post-secondary students).

The ***EarthStation Library*** consists of:

Volume 1 Earth-Ocean-Atmosphere Explorer
Volume 2 Weather Workstation Courseware
Volume 3 Oceans Workstation Courseware
Volume 4 Geology Workstation Courseware
Volume 5 Earth Science Analysis Workstation
Supplementary Resources for all Volumes.

Volume 1 Earth-Ocean-Atmosphere Explorer
The Explorer is a collection of resources presenting basic geology, oceanography and meteorology. These are learning resources for students in geography or earth science courses, and also resources for teachers who are not specialists in all of these fields.

Volume 2 Weather Workstation Courseware
Weather Workstation Courseware covers a basic and advanced curriculum in meteorology and atmospheric science.

Volume 3 Oceans Workstation Courseware
Explore the oceans in this interactive multimedia CD presentation of the scientific foundations of oceanography. Covering the topics of physical, chemical and biological oceanography, Oceans Workstation is a sophisticated and enjoyable interactive tour of the water planet.

Volume 4 Geology Workstation Courseware

The Geology WorkStation offers a complete investigation of the planet from core to crust. With introductory sections that place the Earth within its solar system context, Geology WorkStation explores the formation and evolution of Earth in a way that allows students to discover the dynamic processes at play.

Volume 5 Earth Science Analysis Workstation

The Analysis WorkStation contains hundreds of satellite images for application in meteorology, oceanography and geology, plus a database of geophysical data and maps. Included are major analysis software packages, similar to that found in the modern professional science laboratory.

Supplementary Resources for all Volumes

- Teacher's Guides with complete lesson plans
- Physical Geology Lab Manual/Field Manual
- Weather Forecasting Field Guide
- Coastal Oceans Field Guide
- VHS Videos of volcanoes, earthquakes, tornadoes, hurricanes

1.3. CHAPTER 1 The Whole Earth System

General Guidelines

This is a general introduction to the courseware. There are two distinct sections. The first section emphasizes the role of time in how we judge processes to be important. This part of Chapter 1 thus emphasizes the fundamental dynamism of the Earth.

The second section considers the Earth from a static point of view, and its spatial diversity. We emphasize the role of climate zones in determining the biomes of the Earth. Although ecological systems and personal and societal responsibility are not themes of this courseware, we do provide hints and "doorways" into this topic. The biome overview is a theme that can be greatly elaborated on and plans are in motion to develop CD-ROM courseware that takes the biome perspective to higher levels of appreciation.

We decided to take a traditional approach to biomes, but we believe that the city should also be viewed as a biome. It may be exciting for you and your class to explore this concept. Following is text for cities written in the same style as the biome descriptions in the CD-ROM:

> These are artificial biomes created by the dominant life form on Earth, and associated with these biomes are large areas (called the "ecological footprint") of other, natural, biomes modified to meet the food, shelter, and clothing requirements of city inhabitants. (In the U.S, the average person has an ecological footprint of 12.2 acres). The first city biome to exceed a population of one million humans was London, U.K. The current ecological footprint area of London is 125 times its surface area. The footprint area includes portions of the wheat prairies of Kansas, the tea gardens of Assam, sheep grazing land in New Zealand and other areas across the globe.
>
> The number of individuals is large in the city biome, but mammalian species diversity is very small. This type of biome has been steadily growing for the past 10,000 years, with greatly accelerated growth over the last 50 years. By the year 2000 there will be nearly 400 city biomes with populations greater than one million humans. This represents over 40% of the human population on the planet. In the U.S, nearly 75,000 acres per year are modified to accommodate the spreading city biome. Cities occupy only 2% of the Earth's land surface but consume 75% of the world's resources.
>
> This biome tends to be hotter and drier than the natural biome from which it developed. This microclimate occurs because there is a general absence of vegetation, which otherwise tends to moderate the temperature. In addition, the land cover (concrete, brick, and asphalt) absorbs very little heat.
>
> Downwind of the city biome, the natural biomes usually receive more precipitation, generally from Mondays to Fridays, because the city biome produces more dust on these days. The dust attracts moisture, which forms clouds, which move downwind and cause rain.
>
> From a scientific point of view, the most profound difference between the city biome and all other biomes is that the city biome does not recycle its

"waste", where the waste from one component is food or fuel for another component. In the city biome, each component discards its waste into surrounding natural biomes. No other biome does this.

The concept of "ecological footprint" is an exciting new development in thinking about the impact of humans on the planet: this idea is strongly based on calculational procedures that quickly show our effect on the planet. The World Wide Web is the first place to search since the ideas are being quickly developed. Credit for this concept goes to Mathis Wackernagel and William Rees.

How to use Chapter 1 in the classroom

The purpose of the images in the first part of the Chapter is to heighten the student's awareness of time as profound controlling feature of our perception of the environment. What we tend to think of as important are usually events that quickly change.

After the students view Chapter 1, the following are some leading questions you can ask that may provoke some discussion:

1. What type of biome do you live in? Take a week to answer this question by writing down notes everyday about what the weather is like, what season of the year it is, etc. Research this question by calling your local meteorology department and talking to a climate specialist about whether there is anything unusual about where you live.

2. The idea of the "ecological footprint" is fairly new. Try to use it qualitatively in a day of your life. For the food you eat - where are the animals caught and raised or the plants grown? For the clothes you wear, what plants and where do they come from; if you wear synthetic clothes, which are were made from petroleum, where did the raw material come from?

1.4. CHAPTER 2 Earth Location in the Solar System

General Guidelines

In this chapter we present the oddities and chance circumstances surrounding why life-like-us managed to emerge on Earth. A common witticism in the 1960s was that the Earth peopled itself.

The first section of this chapter (screens 1 to 4) considers the planetary system and Earth's place in it. Here, we examine the physical conditions necessary for life. The principle we are discussing in this chapter is technically called the Anthropic Principle. The scientists and philosophers who have advertised this principle in recent years are Fred Hoyle, Martin Rees (although, interestingly, he his retracting some of the more strong statements he made in his early years), and Barrow and Tipler. The literature is vast and to some extent scientifically dangerous. In this chapter we present the least controversial of the "cosmic coincidences." A search on the World Wide Web for "anthropic" and "cosmic coincidences" will yield hours of happy surfing.

The second section (screens 5 to 10) of this chapter considers the issues that arise once the physical conditions occur that are necessary for life.

We do not dwell too much on theories of the appearance and development of life in Chapters 2 and 3 since the subject is quite unresolved. However, we implicitly present the mainstream views that have appeared in scientific peer-reviewed journals. This is our standard for what we have chosen to include in our courseware.

Other theories of life appearance such as the abrupt appearance theory and the intelligent design theory are thus not mentioned, primarily because these theories do not rely on physical, chemical, or biological processes. Therefore, these theories are not represented in animated sequences or included in interactive discovery explorations preformed by the student. However, it could be mentioned in class that no credible scientific mechanism has been proposed for the sudden explosion of new species at certain points in Earth's history. All that scientific speculation has been able to do is to suggest a sequence of occurrences that are **consistent** with known physical and chemical processes.

Put bluntly, extra-natural explanations are "uninteresting" to the scientific community because no new physical or chemical or biological principles could be discovered by such explanations.

How to use Chapter 2 in the classroom

Similar to Chapter 1, this chapter should be used as a springboard for discussions involving the entire class. The discussion should focus on the chance occurrences. Our attitude is that chance occurrences (or luck or divine intervention) are very important, occasionally. But, the really interesting stuff, and what science is all about, is what happens after the chance events and inexorably due physical, chemical, and biological processes. The ending message is that the universe seems to be rich in the abundance of molecules and elements that are required for life.

The discussion of carbon, water, oxygen, and amino acids (molecules in space) could be greatly elaborated upon, depending on the student's previous exposure to chemistry and biology.

Exercises for Chapter 2

1. Using the database of planetary properties provided in the CD courseware (**Appendix H**), have the students plot the values of the planet parameters against each other. From the shape of the plots have the students then present an argument about whether the values they have plotted may be related. Some suggested plotting pairs are

    - Planet diameters vs. Distance from the sun
    - Planet spin rate vs. Distance from the sun
    - Planet orbiting rate vs. Distance from the sun.

2. Have the students research what the temperature ranges are on the planets and plot these values against some of the other values. Again, have the student draw conclusions from the trends in the graphs.

1.5. CHAPTER 3 Conditions for Life on Earth

General Guidelines

There are two distinct sections (screens 1 to 7 and screens 8 to 10) in this chapter. In the first section, we present some notion of additional chance events that happened once life started and how early life itself may have modified the chemical conditions on Earth to help make even more life possible.

In the second section, we are presenting rather advanced material. However, we firmly believe that it is not necessary for a student to understand all the details – catching the flavor and feel of the interconnectivity of life on Earth is more important than understanding all the nuts and bolts. So, introducing the oxygen cycle, carbon cycle, and the chemical composition of the atmosphere should be approached qualitatively. After your students complete Chapter 7, you may want to come back to these screens to discuss them more quantitatively.

How to Use Chapter 3 in the classroom

Participation by the entire class in a discussion of the content of this chapter is the best way to proceed. The discussion should focus on the special processes that allow life to continue.

We suggest that the qualitative discussion of the geochemical cycles focus on a description of where the oxygen and carbon is stored and what processes move carbon and oxygen from one storage area to another. The discussion in the popup text on extinction events is probably worth several hours of classroom discussion alone.

Exercises for Chapter 3

1. Discuss which human activities could affect the amount of carbon or oxygen stored in each of the Earth's regions.

2. Discuss which human activities could change the rate of carbon or oxygen flow between the Earth's regions.

1.6. CHAPTER 4 History and Formation of the Earth

General Guidelines

Screens 1 to 11 continue the theme of time scale and change; the context here is the formation of the Earth itself and the small details of its orbit that cause what we think of as big changes, such as the change of the seasons and glaciation. Screens 13 to 17 – the structure of Earth's interior -- mark a transition in the courseware. Up to screen 12 of Chapter 4, the Earth has been looked at as a whole system. Beginning with screen 13, we begin to enter the scientific specialty discipline called geology. We conclude the chapter with the geologic time scale cross referenced to biological events, geological events, atmospheric events, and ocean events.

Specific Comments and Suggested Instructions

Screen 2: Though touched on here, it should be emphasized to the students that due to the ever present force of gravitation, once a lot of gas and rock are in the same region of space, very large objects will eventually be formed, whether they are stars or planets. A chance (that word again!) accumulation of more rock in one area than another will set the whole system into coalescing. Although the forces are equal between the pieces of matter, no matter their size, the larger pieces will cause the smaller pieces to move more quickly. This is what sets up the imbalance to cause planet formation.

Screen 3: This interactive on radioactive decay can be used by the students to discover for themselves the equation of radioactive decay, depending on their mathematical background. But, this will require a pencil and paper exercise using the data in the interactive.

Screens 5 to 10 and the Appendix text on the seasons: As we say, the dance of the planet in space is quite something if seen on a time scale that we can appreciate. All the animations in these screens have the spatial variations in the planetary dance EXTREMELY exaggerated so that the student can even see them. The discussion on the seasons could be greatly elaborated regarding how the dance affects the seasons. Most students are shocked to realize that as soon as 11,000 years from now (about the age of the pyramids), that summer will happen in Texas between November and March. We find that these discussions are often quite heated and fun.

Screen 11: The *Explorer Physical Geology Lab Manual* (Lab 1, Parts 1A and 1B) is an excellent resource for classroom exercises on the shape of the Earth and circumference of the Earth. Use them.

Screen 12: The *Explorer Physical Geology Lab Manual* (Lab 1, Parts II and III) contains excellent paper and pen exercises for the student to deduce that the Earth must not have the same density throughout, and therefore it must be layered.

The database of Earth properties can be extensively used to show many concepts related to layering and properties of the internal structure of the Earth. Just as we suggested with the planet database table, the earth database table can be used to create exercises for the students by having them plot pairs of variables on graph paper and determine for themselves which variables seem to be correlated. The next step in scientific inquiry, of course, is to look for the mechanism for the correlation. If no mechanism can be found, it is not yet a theory (perhaps it is a hypothesis to be investigated further).

We found that heated and fun discussions occurred when we looked at the database table and focused on the value of the gravitational acceleration – at the center of the Earth, matter has no weight, yet pressures are enormous. Expand on this paradox in the classroom to make the students think.

Screen 15 and 16: The understanding of what is happening with the solid and liquid core and the magnetic field generation is undergoing rapid rethinking. We have incorporated results that have emerged in the scientific literature only since 1996.

Screen 17: The geologic time scale in this screen can be used as jumping off point for discussions about how events in the geological column may be correlated to events in the ocean or atmosphere and biology columns. In fact, the correlations are very strong. You may also dwell a bit on the calendar analogy time scale that is next to the year column. We purposely put in a few tantalizing topics we do not mention again in the courseware, for example the natural fission reactor in Gabon. Please take advantage of this topic and other undeveloped topics in the courseware to assign research to your students.

1.7. CHAPTER 5 Continental Drift

General Guidelines

This chapter also has two themes developed in two sections (screens 1 to 6 and screens 7 to 10). The evidence for continental drift is developed in some detail in the first section. The second section begins with the students discovering for themselves where the plate boundaries are by plotting data.

Specific Comments and Suggested Instructions

Screen 1: It is very important to stress to the students that the continents of past geologic time looked extremely different than they do now. The continental drift animation uses familiar landforms so the students can get some grasp of what it is they are looking at.

Screen 4 and 5: This splitting and joining of the continents looks easy but it is not. We used a global hypsography map (topological and bathymetric information accurate to within 100 meters), cut it up digitally and then tried to join the pieces together like the text books say. When you work with real data, it takes a lot of work to get the result you want. This could be a little object lesson in the scientific method. Have your students try this themselves by having them cutting out shapes of the continents from fairly accurate photocopies of an atlas. Have them try arranging the pieces so they fit.

Screen 8: Lab 5 of the *Explorer Physical Geology Lab Manual* has a world map that can be used as an in-class pencil and paper exercise to supplement this screen. Careful though, Lab 5 is not at all about tectonics.

We quite enjoyed putting this interactive together, we hope your students enjoy doing it. When the students click on the button for the software to fill in the in between locations, we are using real data from 30,000 earthquakes and 3,000 volcanoes; the base map the students are working with is an accurate hypsography map of the globe.

If your students need help with plotting, you may need to use the *Explorer Physical Geology Lab Manual* to prepare them for screen 8. Refer to Lab 9 and Lab 10. There are some interesting historical, social, and political reasons why the "0 degree" line of longitude measurement starts at Greenwich, England. This would be an excellent research topic for your students.

Screen 9: Now that the students have discovered the plate boundaries, here we show a static image to view. What is not apparent is that the plates are **rotating** and shearing against each other, so the arrows are misleading.

Screen 10: Here again, we used accurate hypsography data and wrapped it around the globe. Your students should hang out with this animation for a while. The text that accompanies this screen was given to us by a very excited professor of geophysics at Dalhousie University in Halifax, NS (Canada). This screen and screen 5 of Chapter 6 are an inseparable pair of images.

You may wish to take advantage of the unusual perspectives of this animated rotating globe to inquire into the curious historical, political, and social reasons why most publishers of atlases and manufacturers of desk globes persist in only presenting one perspective of the Earth. Again, this would be an interesting research topic to assign your students.

1.8. CHAPTER 6 Plate Tectonics

General Guidelines

Convection currents in the mantle is the recurring theme in the chapter. It is the underlying cause for all processes that are called tectonic.

Satellite images of typical landforms caused by tectonic processes are presented in **Appendix U**.

Specific Comments and Suggested Instructions

Screen 1: A common misperception is that the continents "float on top of the lithosphere." No. The lithosphere splits into plates and the boundaries between these plates are shifting and twisting.

Screen 4: This emphasis on forces could be exploited by you to lead the students down a serious digression into the physics of forces.

Screen 5: Although we don't advertise it in the courseware, this screen displays the basic working model of active research in the geophysics of plate motion.

Screen 15: The hypothesis of where the hot spot plumes come from has recently (January 1998, *Science*) been put in doubt. In the case of Iceland, researchers have gathered evidence that the deep plumes are more likely coming from the transition boundary at 670 km below the surface, rather than from the core, at 3000 km down. This tentative result for one location may also cast doubt on the deep mantle convection theory presented in screen 3.

Screen 16: The Lab Manual contains an excellent set of pencil and paper exercises about earthquakes and earthquake measurements: Lab 12.

1.9. CHAPTER 7 The Rock Cycle

General Guidelines

This content of this chapter falls into three sections. The first section (screens 1 to 9) discuss the general features of the rock cycle. The second section (screens 10 to 14) examines in exhaustive detail the mineral compositions of the different rock types and the role of depth of formation and rate of cooling. The third section (screens 15 to 18) revisits the surface portion of the rock cycle to go into more detail about erosional processes. Whatever details we have glossed over in the CD-ROM for the sake of maintaining the logical flow, those details can be found in the *Explorer Physical Geology Lab Manual*. The lab manual is complete with regard to the components of the rock cycle, full mineral identification procedures, integrative treatment of the rock cycle, and many exercises and quizzes.

How to use Chapter 7 in the classroom

In addition to the animated depictions of the rock cycle that we use throughout this chapter, you may want to supplement our depictions with another mental model:

> Pretend you can tag a carbon atom in a volcanic eruption. Then, try to follow the carbon atom through all the geological processes: igneous to erosional products to sediment to sedimentary rock (the carbon atom may be uplifted to the surface so erosion can start acting again), to metamorphic (it may be uplifted again to the surface to start the erosion sequence over), to magma, to intrusive igneous rock, and to surface magma. Along the way, the magma may also have caused: 1) contact metamorphism and/or, 2) regional metamorphism; but the carbon atoms causing metamorphism of the rock would be different than the carbon atoms you

started out with. So, the carbon atom is back on the surface within another rock, which starts eroding again.

Focusing on the issue of partial melting and partial cooling at different temperatures and pressures can reduce the complexity of rock and mineral formation. The temperature determines which minerals percolate out of rock under partial melt conditions and which minerals solidify out of a melt under partial cooling conditions. The depth (and therefore, the pressure) and rate of cooling determine the mixture of minerals, texture, and crystal sizes in the end rock. The rest is just details!

You may want to return to Chapter 3 and repeat that lesson, with a renewed understanding of the complexity of the cycles that keep the earth in balance.

You may also at this point want to look at several appendices in detail:

1. The Geology of Texas (Appendix K)--the student sees the application of Chapters 4 to 7 to study a particular location.

2. Scientific Inquiry and History of Earth Science (Appendix R)—the student is introduced to the notion of how science is done, the application of this to tectonic theory, and an overview of the history of thought about earth science.

3. Overview of Material and Energy Flows (Appendix S)—the student is introduced to an integrative summary of the cycles and flows of the Earth. Understanding this material may require familiarity with Chapters 9, 10, and 11, but some it may be a useful preamble into Chapter 9, 10, and 11. There would be some value in looking at it now. It wouldn’t hurt to have a second look at it after Chapter 11.

Specific Comments and Suggested Instructions

Screens 1 to 9: The section of the Lab Manual that supplements these screens is Lab 4, Lab 5, Lab 6, and Lab 7. Some of the text and tables are duplicated in the CD-ROM, but we have also included some simpler databases in the CD-ROM.

Screen 6: This screen contains a link to **Appendix-J** on fossil fuels. It should be made clear that there is a major distinction between the genesis of oil and natural gas deposits. Whereas oil formation requires the presence of marine algae, natural gas also requires land plants as well as marine microorganisms.

Screen 8: **Appendix-M.2** contains a table that is the key to solving the Rock ‘n Roll interactive on igneous rocks.

Screens 10 to 14: The sections of the *Explorer Physical Geology Lab Manual* that supplement these screens are Labs 3 and 8. Some of the text and tables are duplicated in the CD-ROM, but we have also included some simpler databases in CD-ROM.

1.10. CHAPTER 8 Watersheds

General Guidelines

The topic of this chapter is water and how it shapes the land. This is the most visible aspect of a landform. There is a four-step exercise that you can have your students do:

1. Invite your students to make journal entries for a week, noticing how the water flows off the streets where they live or the lawns of their houses.

2. Obtain topographic maps from the local land survey office and have your students follow the procedures in Lab 11 of the Lab manual for reading the topographic maps and transferring this information to side view profiles (figure 11.9 of Lab Exercise 11.3). Use these plots to predict runoff directions for their neighborhoods.

3. Have your students compare their predictions to their journal entries.

4. Have your students describe any discrepancies between their observations and their predictions. If the observations are accurate, these should be trusted more than the predictions. Have your students speculate on the source of the discrepancies.

Specific Comments and Suggested Instructions

Screen 1: This is a chromadepth image; be sure to use the 3-D glasses we have provided.

Screen 2: As we suggested for the oxygen and carbon cycles in Chapter 3, the water cycle here contains an enormous amount of richness. It can be used as a springboard for a full class discussion about the reservoirs and flows depicted in the diagram. We have purposely kept numbers out of the diagram. Your students should be sophisticated enough by now to do some research into the quantitative aspects of the cycle. Some suggested leading questions are

1. Which human activities add or remove water, over and above natural processes?

2. Which human activities modify the flows into and out of the reservoirs, over and above natural processes?

3. We have now looked at the carbon cycle, the oxygen cycle, the rock cycle and the water cycle. A common characteristic shared by all three cycles is that the amount of “stuff” stored at any one time is enormous compared to the amount of stuff in motion between the storage areas. Yet, what we see, read about, and experience (the oxygen we breathe, the rain that falls, the carbon dioxide that humans pump into the atmosphere, the rocks we walk on) critically depends on these tiny little amounts that are flowing around.

   What things in your everyday world also depend on very tiny changes producing huge effects? Keep a journal for a week recording your every day observations. It may take awhile before you start seeing things in this way, so don’t be discourages if even after three or four days you have only a few examples.

   There is a message here. It isn’t how much there is - it’s how it is used!

1.11. CHAPTER 9 Oceanography

General Guidelines

Chapter 9 describes the large-scale features of the world's oceans that intimately connect it to atmospheric processes. Thus, it is very straightforward but there are some hidden subtleties.

The most notable of these subtleties is the interplay between salinity, temperature, density, buoyancy and the resulting layering of the oceans. It should be noted that the reason the coastal biome is so productive is that winds and the Coriolis effect act together to break up the ocean layering on the coastal shelves. This results in nutrients from deeper waters rising to the surface to feed the marine algae, which is the primary food source for fish.

In contrast to the atmosphere and the internal structure of the Earth, where the boundaries between the layers are pretty much stable, the crossing of matter and energy across the boundary layers (called disruption of "stratification" or "vertical mixing") of the ocean is essential to the ocean ecosystem. This process is what allows marine phytoplankton to flourish on the waters of the continental shelves.

How to use Chapter 9 in the classroom

The cycle diagrams in Chapter 3 should be returned to so as to highlight the ocean's role in the carbon and oxygen cycle. The water cycle diagram from Chapter 8 should also be reviewed. The importance of the marine phytoplankton to the oxygen cycle is that they contribute more than 80% of fresh oxygen flow back to the atmosphere and are essential in removing large quantities of carbon dioxide from the atmosphere.

Here are some leading questions to guide your students through the cycles:

1. For each diagram (water, carbon, oxygen), list the particular role and contribution of the oceans to the cycle.

2. Are there roles and contributions made by the ocean that are similar among the three cycles?

One of the more important attributes of the water cycle to keep in mind is that it is a much more quickly moving cycle than either the rock or carbon cycles. Try to visualize the cycles as interlocking gears turning at different speeds. The water cycle would be the smallest gear moving most quickly. The carbon cycle would be the next largest and moving more slowly. The rock cycle would be the largest gear and moving most slowly.

A qualitative discussion of these interlocking cycles can be found in **Appendix S**.

A satellite image of phytoplankton populations in the ocean, and the population changes over a period of years is presented in Chapter 11.

Specific Comments and Suggested Instructions

Screen 1: We have opted to present an image of the Earth based on height above average sea level—this is the way research scientists do it. Notice that because the data is displayed in this way, a number of large bodies of water do not appear. For example, the Great Lakes do not appear because they are all above the average level of the oceans.

It has become trendy in some quarters to show the ocean basin without water to emphasize the total land surface appearance of the Earth. We believe this to be a misleading approach—people already have a cavalier enough attitude about the oceans without perpetuating the point of view of land creatures. The fact is that Earth is fundamentally a water planet. A well functioning water cycle is critical to life on Earth as we know it.

Screen 2: There is the opportunity for the class to be lead through extensive discussions on the use of coastal areas by humans—as an industrial effluent and sewage filtering area, as a place where we get much of our food, and as a playground.

Screen 4: The popups on salinity and temperature are quite extensive. The thermohaline circulation is one of the hottest topics in ocean and climate change research.

1.12. CHAPTER 10 Meteorology

General Guidelines

This is a very basic introduction to weather. It is the first of 3 main lessons and 5 appendices on meteorology, atmospheric science and climate/climate change.

The topic is complicated so we devoted this chapter to orient the student to the basic issues of weather and introduce some of the terminology that is commonly used in meteorology. This chapter should be used with attention to the great outdoors, where the weather can be found. We orient the student to using his/her own observation skills, and suggest that this be reinforced. However, much can be gained from the computer.

1.13 CHAPTER 11 Climate

This is an introductory chapter on climate, why it changes and which human activities have the most effect on climate. Again, it is a bare introduction to the topic.

Appendix A describes the El Niño effect in detail, not as the bogeyman that attacks us, but as one of the natural cycles of the earth.

Appendix B and **Appendix C** are basic but comprehensive compilation of FAQ's ("Frequently asked questions") about climate change and human influences on climate. These FAQ appendices could easily be used as resource material for focused research projects by students.

Appendices E and F discuss stratospheric ozone, the ozone hole, CFCs and human impact on our atmosphere. This appendix is full of chemical analysis, and may only be useful to the student who has some chemistry background.

1.14 CHAPTER 12 Weather Forecasting

General Guidelines

With the background presented in chapters 10 and 11, the student is led into the details of weather forecasting. There are two main sections. The first section describes how simple observation of the sky (no fancy equipment needed except your eyes) allows you to predict the weather 24 hours into the future. Familiarity with cloud types is the key to this type of weather forecasting. The second section introduces the student to the techniques of professional weather forecasting, including how to read weather charts and how satellite imagery is used. There is a major project-exercise in this chapter which students should do individually and as a class project: how to construct a backyard weather station using inexpensive materials that can be obtained from hardware stores.

Appendix D displays and explains professional weather forecasting charts. Using the understanding of chart symbology gained in Chapter 12, plus this appendix, a student can start to read current charts that are found in professional internet sites, rather than the newspaper distilled versions.

Project

The goal of the weather chapters is to engage the student in a long-term project to observe, record and determine correlation and causality in weather patterns, and to begin to forecast.

1.15 CHAPTER 13 Technology

This chapter introduces the technology of remote sensing, including the nature of the electromagnetic spectrum, and the types of satellites and sensors that are commonly used for different purposes. There are several good interactives for the students to discover some curious features about the satellite viewing of our planet. Appendix T is the associated appendix for this chapter. It goes into much greater detail about how satellite sensors work.

1.16 CHAPTER 14 Applications

This chapter introduces the student to the NASA initiative originally named “Mission to Planet Earth”, now named “Earth Observation Mission.” The discussion focuses on how remote sensing technology is used to gather visual data about the Earth’s oceans, atmosphere, and geology. The critical role of remote sensing in climate change research is emphasized. Appendices U, V and X contain additional imagery and explanations about these applications.

1.17 APPENDICES

There are several appendices in the CD. These appendices are mostly text-based, but not entirely. They also have no interactive capability; they are designed as research resources. They are:

Appendix A: El Niño – some graphs
Appendix B: Climate Change 1 – FAQ text for the general student
Appendix C: Climate Change 2 – FAQ text for the general student
Appendix D: Weather Forecasting Charts – with 4 *large* professional charts.
Appendix E: Stratospheric Ozone 1 – FAQ text for students strong in chemistry
Appendix F: Stratospheric Ozone 2 – FAQ text for students strong in chemistry
Appendix G: Seismology – text and some images
Appendix H: Topics in Geology - text
Appendix I: Topics in Physics and Chemistry - text
Appendix J: Fossil Fuels and Resource Extraction – text and images
Appendix K: Geology of Texas – many physiography maps and text describing the history of Texas (480 million years ago)
Appendix L: Mineral Groupings – text
Appendix M: Igneous Rocks and Minerals – text and tables
Appendix N: Sedimentary Rocks and Minerals – text and tables
Appendix O: Metamorphic Rocks and Minerals – text and tables
Appendix P: Mineral Identification Guide – text, decision tree-chart, property tables, etc.
Appendix Q: Topics in Hydrology - text
Appendix R: Methods and History of Ideas of Earth Science – text and timelines
Appendix S: Unified Overview of Cycles and Energy Flows – a concise and useful summary for all students
Appendix T: Satellite Remote Sensing Technologies – lots of great pictures and text
Appendix U: Satellite Remote Sensing Applications 1 - lots of great pictures and text
Appendix V: Satellite Remote Sensing Applications 2 - more pictures and text
Appendix X: Radar Satellite Remote Sensing Applications - more pictures and text

2. Multiple Choice Questions

Multiple Choice Questions for Chapter 2

1. Water molecules exist
   a. only on Earth
   b. probably on all the planets orbiting the Sun
   c. everywhere in space

2. The temperature on Earth could be the same if
   a. the Sun had less mass and the Earth were farther away
   b. the solar constant was larger and the Earth was farther away
   c. the Sun had more mass and the Earth was closer

Multiple Choice Questions for Chapter 3

1. It is widely accepted that life started on Earth by
   a. amino acids and building block chemicals arriving on Earth via comets
   b. chemical reactions in the deep oceans near regions where large amounts of heat were escaping from the interior
   c. chemical reactions on the surface in the presence of an atmosphere of ammonia, hydrogen and carbon dioxide and lots of electrical energy
   d. no theory is widely accepted about the origins of life

Some people suggest that life was started or at least manipulated by intervention from intelligent beings from other planets. With regard to the science of life of how life started, this is irrelevant – how did **those** beings come to be? Life started somewhere. You may rephrase this question to read “how did life start in the universe?”

2. For life to develop from chemicals requires
   a. lots of time
   b. a very precise location of the planet in orbit around a long burning star
   c. absence of big meteorite collisions (these are very common in planetary systems)
   d. a star location in a region of space where it isn’t very crowded so that near grazes by passing stars, or supernovas do not occur
   e. all the above

Multiple choice questions for Chapter 4

1. The inner core of the Earth
    a. spins once every 24 hours relative to the Sun
    b. spins once every 70 to 400 years relative to the surface of the Earth
    c. has more mass than the moon
    d. would take a commercial airplane 6 hours to fly a distance equal to its radius
    f. all the above

2. Using radioactive decay of the nuclei of elements to find the age of rocks requires
    a. the half-life be at least 5 billion years
    b. the new nuclei to not decay
    c. knowing the exact number of “parent” nuclei
    d. knowing the exact number of “daughter’ nuclei

3. The earth is layered according to the following sequence, starting from the surface:
    a. crust, lithosphere, upper mantle, asthenosphere, lower mantle, liquid core, solid core
    b. crust, lithosphere, asthenosphere, mantle, liquid core, solid core
    c. crust, upper mantle, asthenosphere, lithosphere, lower mantle, solid core, liquid core
    d. crust, asthenosphere, lithosphere, upper mantle, lower mantle, liquid core, solid core

4. For what percentage of Earth’s life was there no evidence of animal life on land?
    a. 89%
    b. 91%
    c. 50%
    d. 99%

Multiple choice questions for Chapter 5

1. The exact value of the plate velocities can be predicted from
    a. seafloor spreading studies
    b. studies of rifting regions
    c. analysis of continent movement over the last 1 billion years
    d. the velocities cannot be predicted and the reason for their exact values is unknown.

Multiple choice questions for Chapter 6

1. New crust is created at zones of
    a. subduction
    b. divergent boundaries
    c. convergent boundaries
    d. transform faults

2. The Ural Mountains in Russia are not near any plate boundaries. They were formed by
    a. non-tectonic processes
    b. a meteorite impact
    c. collision of two plates that joined to become one plate

3. New ocean basins are formed by
   a. sea floor spreading
   b. rifting
   c. subjection
   d. magma cooling deep within the mantle, causing contraction of the crust above; the crust collapses

Multiple choice questions for Chapter 7

1. Quartzite is formed by the metamorphism of
   a. limestone
   b. basalt
   c. quartz sandstone
   d. shale

2. In the identification of minerals, which of the following properties is less useful?
   a. specific gravity
   b. hardness
   c. color
   d. streak

3. Which of the following rock transformations is probably impossible?
   a. igneous to sedimentary
   b. metamorphic to igneous
   c. igneous to metamorphic
   d. sedimentary to igneous

4. The processes that change surface rock to sedimentary rock are
   a. erosion and transport
   b. erosion, transport, and heat
   c. erosion, transport, and burial
   d. melting, transport, and burial

5. The processes that change sedimentary rock to metamorphic rock are
   a. burial, heat, pressure, and mineral composition change
   b. volcanic eruption and cooling
   c. melting and cooling

Multiple choice questions for Chapter 8

1. When water is pumped from a well, the water table will be
   a. recharged
   b. destroyed
   c. pushed up
   d. pulled down

2. Watersheds are created and destroyed by
   a. human activities
   b. tectonic processes
   c. glaciers
   d. all the above

Multiple choice questions for Chapter 9

1. The density of a mass of ocean water is determined by its
   a. temperature
   b. salinity
   c. location in the water column
   d. latitude

2. Whether a mass of ocean water will sink or rise is determined by its
   a. temperature
   b. salinity
   c. density
   d. relative density compared to the masses of water above it and below it

3. On the short term, ocean currents are determined by
   a. winds
   b. tides
   c. relative differences in density
   d. characteristics of stratification in a particular area

Multiple choice questions for Chapter 10

1. Where does the weather happen in our atmosphere?
   a. stratosphere
   b. troposphere
   c. mesosphere
   d. thermosphere
   e. chronosphere

2. Hot air in the atmosphere
   a. always rises
   b. sometimes rises
   c. flows east to west in the northern hemisphere and west to east in the southern hemisphere

3. How do storms revolve in the Northern Hemisphere?
   a. clockwise
   b. counterclockwise

4. How do storms revolve in the Southern Hemisphere?
   a. clockwise
   b. counterclockwise

5. Where are the general zones of desert around the world?
   a. 0 - 20 degrees latitude
   b. 20 - 40 degrees latitude
   c. 40 - 60 degrees latitude
   d. 20 - 40 degrees longitude
   e. 40 - 60 degrees longitude

6. What is the hydrologic cycle?
   a. movement of water throughout the surface of the earth
   b. rational thinking disturbed by sleep cycles
   c. flow of water in liquid and gaseous form throughout the surface of the earth and in the atmosphere
   d. rain
   e. ocean currents
   f. river water flows into the ocean and stays there

7. What is the difference(s) between a hurricane and a large extra-tropical cyclone?
   a. hurricane is larger
   b. hurricane always has higher winds
   c. hurricane is more compact and structured
   d. hurricane occurs only in summer or early autumn
   e. a+b
   f. c+d

8. Weather really hasn't changed history very much?
   a. true
   b. false

9. What causes more deaths during or right after big snowstorms?
   a. boating
   b. driving
   c. walking
   d. shoveling snow
   e. skiing

10. Hurricanes are fueled by:
   a. warm waters of the summer and early autumn equatorial oceans
   b. heat of condensation released as evaporated water rises
   c. low pressures in the central "eye" of the storm
   d. all of the above

11. Tropical cyclones are not called hurricanes if their winds are less than
   a. 74 mph
   b. 96 mph
   c. 100 mph
   d. 123 mph
   e. 151 mph

12. Storm surge is caused by
   a. high winds
   b. low pressure in a storm that makes the ocean level rise
   c. rain overflowing drainage sewers
   d. the moon
   e. a+b)
   f. b+c

13. On average, for the entire earth, about what percentage of the sun's energy is reflected by the atmosphere or clouds?
   a. 6%
   b. 11%
   c. 22%
   d. 44%
   e. 66%

14. What is the average net albedo (reflectance) of the earth, atmosphere and all?
   a. 10%
   b. 20%
   c. 30%
   d. 40%
   e. 50%
   f. 60%

Multiple choice questions are not provided for Chapters 11-14.

More questions will appear on our web site in coming months: **http://www.eoascientific.com**

3. Credits and Acknowledgements

This effort was for fun and profit by the devoted team of scientists, artists and programmers who composed the staff and associates of EOA Scientific Systems, Inc., mostly over the period November, 1997 through April, 1998, although some of the work was adopted from a previous product (Weather Workstation) that has been in commercial release for some years.

The following personnel acted as employees, subcontractors or consultants of EOA Scientific, and have no ownership or copyright claims to any of their output, but they did great work and deserve credit. Most of the text, except as noted in the lists below, were originally written, assembled, edited, organized, and integrated with the images, movies and animations by EOA Scientific in the persons of **Frank Johns** (as lead writer/writing and research team-leader) and **Robert A. Paul.** Steve Molroney, geography teacher at Dartmouth High School, provided various exercises and provided substantial help with general geologic time scales (especially the Texas case study). **Peter Wallace**, Dalhousie University geology instructor, provided help with the mineral/rock taxonomy/evolution scheme, which was a very big de-mystification. **Dr. Gordon Watson** helped with synthesis and critique. **Paul Mandell** helped with the glossary and various research and text on the eons and ages of the Earth, and **Andrew Craft** single-handedly wrote (with some small editing by Robert Paul) the two chapters and 4 monstrous appendices on satellite remote sensing.

The very talented artist, Robert MacDonald, and his handy six-gun Pentium 2 created all original animations from scratch. Five CDs-full of satellite imagery were accumulated and processed by **Andrew Craft**, with some help by others. **Derek Day** created the interface graphics and, assisted by **James Sarson**, created the original illustrations.

Ron Day single-handedly wrote the GUI program, and programmed the interactive exercises.

All mistakes and inaccuracies in this courseware are our responsibility, though we have worked hard to be accurate. Scientific integrity is very important to us.

We found ourselves returning again and again to the following books for inspiration and clarification:

The Dynamic Earth: An Introduction to Physical Geology (3rd edition) by Brian Skinner and Stephen Porter

Fundamentals of Geophysics by William Lowrie

Earth's Dynamic Systems by Kenneth Hamblin and Eric Christiansen

Science Desk Reference by The New York Public Library (indispensable for a one cover catalog of "factoids")

Planet Earth by Cesare Emiliani

New Views On an Old Planet by Van Andel

Healing Gaia: Practical Medicine for the Planet by James Lovelock

SPECIFIC CITATIONS

Chapter 3

Screen 4 and 7: The images in these screens are slightly modified from James Lovelock's wonderful book **Healing Gaia: Practical Medicine for the Planet**.

Screen 8: This image is slightly modified from **New Views on an Old Planet**

Chapter 5

Screen 7: This image is slightly modified from **Earth's Dynamic Systems.**

Chapter 6

Screen 4: We must give credit to William Lowrie's book "Fundamentals of Geophysics" for this view of forces acting on the plates. When we stumbled across his explanation, much came clear to us.

Chapter 7

Screen 17: This image is slightly modified from **Earth's Dynamic Systems**

Chapter 9

Screen 2: This image is slightly modified from the **Science Desk Reference**.

Screen 3: This image is slightly modified from **The Dynamic Earth**

Screen 4: This image is slightly modified from **The Dynamic Earth.**

Screen 5: This image is slightly modified from **The Dynamic Earth.**

Further Credits and Acknowledgements

Text Credits

Main Text Credits

1. The Whole Earth System - EOA
2. Earth's Location in the Solar System - EOA
3. Conditions on Earth Allowing "Life-Like-Us" - EOA
4. History and Formation of the Earth - EOA
5. Continental Drift - EOA
6. Plate Tectonics - EOA
7. The Rock Cycle – EOA/Pat Mackin
8. Watersheds - EOA
9. The Oceans - EOA
10. Weather - EOA
11. Climate - EOA
12. Weather Forecasting - EOA
13. Satellite Remote Sensing Technologies - EOA
14. Satellite Remote Sensing Applications - EOA

Appendices Text Credits

A. El Niño - EOA with help from NASA
B. Climate Change I - United Nations Information Unit on Climate Change
C. Climate Change 2 - United Nations Information Unit on Climate Change
D. Reading Weather Charts - EOA with help from Bedford, Nova Scotia Weather Station
E. Stratospheric Ozone I - Robert Parson, Dept. of Chemistry and Biochemistry, University of Colorado
F. Stratospheric Ozone II - Robert Parson, Dept. of Chemistry and Biochemistry, University of Colorado
G. Seismology - EOA
H. Topics in Geology - EOA
I. Topics in Physics and Chemistry - EOA
J. Fossil Fuels and Resource Extraction - EOA
K. Geology of Texas - EOA / Steve Moroney, Dartmouth High School, Nova Scotia
L. Mineral Groupings - EOA
M. Igneous Rocks and Minerals - EOA
N. Sedimentary Rocks and Minerals - EOA
O. Metamorphic Rocks and Minerals - EOA
P. Mineral Identification Guide - EOA
Q. Topics in Hydrology - EOA
R. Methods and History of Ideas of Earth Science - EOA
S. Unified Overview of Cycles and Energy Flows - EOA / Gordon Watson
T. Satellite Remote Sensing Technologies - EOA / Andrew Craft
U. Satellite Remote Sensing Applications 1 - EOA / Andrew Craft
V. Satellite Remote Sensing Applications 2 - EOA / Andrew Craft

Digital Video

All video and animations, even if originally from a government source, are now copyright by EOA Scientific because of all the value-added work in editing and processing it.

1. Hurricanes-movie and discussion - USGS
2. Tornadoes-storm chasers - National Severe Storms Lab, Norman, OK.
3. Cumulus Clouds Rolling By - EOA
4. The 1993 Mississippi-Missouri Flood - USGS
5. Volcanoes- Maurice Kraft
6. Earth from the shuttle - NASA
7. Storm of 1993 (GOES) - EOA, with help from NOAA
8. Full globe visible GOES over several days - EOA, with help from NOAA
9. Iceberg rolling over - Geologic Survey of Canada, Russell Parrott
10. Greenhouse- discussion of experiments - NASA

Animations

All but those marked with * are original by EOA Scientific Systems, Inc. **All video and animations, even if originally from a government source, are now copyright by EOA Scientific because of all the value-added work in editing and processing it.**

1. Tour of the solar system -- opening movie
2. Solar system formation * - NASA
3. Molecules of life formation
4. Axis of the earth's rotation - DD
5. Eccentricity of the earth's orbit - DD
6. Continental drift - JS
7. Plate boundaries on 3D rotating globe - FJ's pet idea
8. Hot spots and lithospheric plate drift - DD
9. Polar wandering - DD
10. Seafloor spreading - RM
11. Erosion & weathering - RM
12. Sedimentation - RM
13. Subduction - RM
14. all others are original by EOA Scientific Systems, Inc.

Satellite imagery with help of the U.S. Government.

Interactive animations are used as "mini-games" or student exercises to introduce and/or reinforce a discussion of concepts presented in the text/graphic layer of the courseware. Each interactive, therefore, is included in the context of other layers of the course. The following interactive animations are all collective efforts in conception by the research team and the innovative effort, and frequently imagination, of **Ron Day**.

1. Radioactive Half-Life
2. Earth's Position in Orbit
3. Sun's Energy Output
4. Oxygen In The Atmosphere
5. Sedimentary Rocks And Minerals
6. Plotting Earthquakes
7. Plotting Volcanoes
8. Discovering Tectonic Plates

9. Sea Level and Global Topography / Bathymetry
10. Climate Zones and Biomes
11. Coriolis Effect In Naval Combat
12. Generating a Hydrologic Cycle
13. Causes of Deaths In Snowstorms
14. Atmospheric Layers
15. Global Atmospheric Circulation Zones
16. Altitude of Satellites
17. How Many Satellites Are There In Orbit?
18. Wavelength, Frequency and Amplitude
19. The Electromagnetic Spectrum
20. Source of Satellite Images
21. Solar Radiation
22. Killer Cosmic Rays from Supernova
23. Comet/Meteor Impact on Earth
24. Weather Clues: Birds
25. Weather Clues: Insects
26. Weather Clues: Animals
27. Weather Clues: Plants
28. Backyard Weather Station