Subject: Teaching Environmental Education and Natural History and utilizing Teachable Moments

Canny Title:

Presenters Name:

When to teach this topic: This topic should be discussed at the beginning of the trip- maybe in the van ride there. Also, you will demonstrate “teachable moments” on the trail, identifying native plants, animals, or sea life etc.

Who is this for (level of experience and age of participants): For those interested in teaching and guiding in the outdoors from 6th grade on.

Resources:
- Web research

Materials:
- Your group will have a portable white board and markers that can be put on a sleeping pad. So use this to make your presentation more visual.

Outcomes: Things for you to know and teach so that all participants will be able to know and do each following bullet by the end of this lesson.
- Leaders will know the definition of a teachable moment.
- Leaders will know take advantage of them.
- Leaders will understand how to present things in a timely manner, knowing that teachable moments are great to take advantage of.
- Leaders will understand more about a subject that you teach: flora, fauna, weather, geology, marine biology, ecology...
**Introduction/Hook:** If you are going to take a horse to water...make sure it’s thirsty. Make sure you are doing this at a time when the participants need this information and are ready to hear it (are people warm, hydrated and well fed?).

**Very short activity/introduction:**

**Procedures & Activities:** Steps, e.g. models, structured practice, guided practice, independent work. Include time allotments for all steps in each section. Usually 5-10 minutes per section. Timing is very important.

*Explain & Demonstrate:*

- Step 1: __ minutes
- Step 2: __ minutes
- Step 3: __ minutes
- Step 4: __ minutes

*Practice (individually if appropriate):*

**How to Assess each individual’s skills:**

**Closure/Evaluation:** How will you close the lesson? How will the students remember what they learned today? Homework? Summary? Quiz? When? Usually allow at least 5 to as much as 10 minutes for this section.

**Evaluation:** Analyze the strengths and weakness of the lesson as it actually happened. Include things to avoid next time you teach the lesson, and what went particularly well. How was the timing of the lesson?
# NOLS Environmental Education Notebook
Tools For Teaching The NOLS Environmental Studies Curriculum

## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Author</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Ann Zwingier</td>
<td>2</td>
</tr>
<tr>
<td><strong>Defining Environmental Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOLS Philosophy of Education</td>
<td>John Guokin</td>
<td>4</td>
</tr>
<tr>
<td>NOLS Expectations for Environmental Studies</td>
<td>Marco Johnson</td>
<td>5</td>
</tr>
<tr>
<td>What an &quot;A&quot; Should look Like: Student Expectations for Environmental Studies</td>
<td>Rob Maclean</td>
<td>6</td>
</tr>
<tr>
<td>Spirituality: The Softer Side Of Education</td>
<td>John Guokin</td>
<td>7</td>
</tr>
<tr>
<td><strong>Environmental Education Strategies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Values At NOLS: Can Staff Display Values And Still Be Responsible Educators?</td>
<td>John Guokin</td>
<td>9</td>
</tr>
<tr>
<td>First Things First: Planning An Environmental Curriculum</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>For The Field Chris Lay, Bridger</td>
<td>Lyons &amp; Jim Chisholm</td>
<td></td>
</tr>
<tr>
<td>Learning Ethics: What the Research Says</td>
<td>John Guokin</td>
<td>12</td>
</tr>
<tr>
<td>Stewardship, Citizenship, Advocacy, &amp; Activism: How Do They Fit In Education?</td>
<td>John Guokin</td>
<td>14</td>
</tr>
<tr>
<td>Research in Environmental Education: What works?</td>
<td>Scott Harris</td>
<td>15</td>
</tr>
<tr>
<td>Being Here Now: Teaching A Sense of Place</td>
<td>Rob Maclean</td>
<td>17</td>
</tr>
<tr>
<td><strong>Land Management And Ethics</strong></td>
<td>Bridget Lyons</td>
<td>20</td>
</tr>
<tr>
<td>US Land Management Class Outline</td>
<td>Marco Johnson</td>
<td>21</td>
</tr>
<tr>
<td>What is NEPA?</td>
<td>Bridget Lyons</td>
<td>22</td>
</tr>
<tr>
<td>Teaching Local Public Policy Issues</td>
<td>Amy Birnie</td>
<td>23</td>
</tr>
<tr>
<td>Facilitating Safe Discussions</td>
<td>Marco Johnson</td>
<td>24</td>
</tr>
<tr>
<td>Land Management Debate Format</td>
<td>Ashley Graves Lasfer</td>
<td>25</td>
</tr>
<tr>
<td>Land Management Debate Follow-Up</td>
<td>Kathy Brown</td>
<td>26</td>
</tr>
<tr>
<td>Wilderness Jeopardy: The Law Of The Land Edition</td>
<td>Trevor Deighton</td>
<td>27</td>
</tr>
<tr>
<td>Fixing Global Environmental Issues: A Lesson Plan</td>
<td>Trevor Deighton</td>
<td>29</td>
</tr>
<tr>
<td>Teaching Environmental Ethics With The Lorax by Dr. Seuss</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ecological Systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching Ecological Concepts Using The NOLS Safari Guide Series</td>
<td>Rob Maclean</td>
<td>31</td>
</tr>
<tr>
<td>Basic Field Ecology For Wilderness Travelers</td>
<td>Rob Maclean</td>
<td>32</td>
</tr>
<tr>
<td>Wilderness Jeopardy: The Basic Ecology Edition</td>
<td>Darran Wells</td>
<td>34</td>
</tr>
<tr>
<td>Reading The Land: A Basic Ecology Lesson Plan</td>
<td>Ashley Graves Lasfer</td>
<td>36</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Andy Blair &amp; Jerry Freilich PhD</td>
<td>38</td>
</tr>
<tr>
<td><strong>Observation And Interpretation Of Natural Sciences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birds Are Cool!</td>
<td>Trevor Deighton</td>
<td>39</td>
</tr>
<tr>
<td>Animal Tracking</td>
<td>Laura Schmueses</td>
<td>40</td>
</tr>
<tr>
<td>Basic Geology: Interpreting Rock</td>
<td>Laura Schmueses</td>
<td>41</td>
</tr>
<tr>
<td>Visualizing Geologic Time</td>
<td>Rick Rochelle</td>
<td>43</td>
</tr>
<tr>
<td>Astrobiology</td>
<td>Trevor Deighton</td>
<td>47</td>
</tr>
<tr>
<td>Astrophysics</td>
<td>Len Reisberg</td>
<td>48</td>
</tr>
<tr>
<td>Teaching Taxonomy</td>
<td>Rick Rochelle</td>
<td>49</td>
</tr>
<tr>
<td><strong>Transference</strong></td>
<td>Marco Johnson</td>
<td>51</td>
</tr>
<tr>
<td>Environmental Leadership: What Does A Responsible NOLS Alum Look Like?</td>
<td>Darran Wells</td>
<td>51</td>
</tr>
<tr>
<td>LNT Trainer Training: Making Your Expedition A Leave No Trace Trainer's Course</td>
<td>Jeffrey Marion and Scott Reid</td>
<td>53</td>
</tr>
<tr>
<td>LNT Inc. Timeline</td>
<td>Peggy Savick</td>
<td>53</td>
</tr>
<tr>
<td>LNT action plans for NOLS students</td>
<td></td>
<td>54</td>
</tr>
<tr>
<td>Environmental Websites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leave No Trace Resources for NOLS Alumni</td>
<td>Jim Chisholm</td>
<td>55</td>
</tr>
</tbody>
</table>
We believe that interest in nature, leads to knowledge, which is followed by understanding, and later, appreciation. Once respect is gained, it is a short step to responsibility, and ultimately action to preserve our Earth.

Ian Player

NOLS is developing a series of "safari guides" to help with the teaching of natural history and ecological concepts at each branch. For some branches safari guides have not yet been completed, but there is a generic version that explains basic ecological principles—"Basic Field Ecology For Wilderness Travelers," which is in the Student Handouts folder which accompanies this book.

There are a variety of ways to use the guides. You can:
1. Encourage your students to read it in the branch library,
2. Use it as an outline for instructor classes, discussions, or games,
3. Have students use it to teach their own classes or activities,
4. Have students write or discuss how the ecological concepts listed in the safari guide influence LNT practices in different ecosystems,
5. If you just have the basic field ecology handout, make it a group project to gather information specific for the ecosystems you are living in.

Each "guide" is written with a slightly different style and focuses on different aspects of ecology. The one thing they all have in common is that they provide examples of how you can super-charge regular natural history classes with broader ecological ideas, which can make your classes more transferrable.

A stand-alone natural history class, on a certain fish for example, may be interesting but it may not transfer back to where the student comes from. If you can tie a class on a fish to broader ideas about food chains and over-fishing (ecological concepts) and then to an ethics discussion on buying canned fish, the class can becomes much more transferrable.

Note that ecological concepts are only a link in this chain between a fish and a discussion of environmental ethics, but they are an essential link. Ecological concepts in themselves don't have much value unless connected to broader ethical, political and environmental issues. Teaching ecological concepts is not our ultimate goal but rather a means to connect local environments to global environments and to enable our students to develop a personal environmental ethic that transfers beyond the course.

The wilderness is a great classroom for ecology. We can see natural patterns and processes without obstruction. Around towns or farms, human creations hide natural patterns.

Some tricks for making your ecology class more successful:

- Define what outcome you want from the class. What key ideas or behaviors do you want your students to walk away with?
- Share "bite-sized" stories. Ecology and environmental issues are a huge subject. Keep your class simple. Focus on one piece of the puzzle at a time.
- Emphasize links and similarities between the wilderness and where your students live. This helps with transferrance.
- As much as possible tie ecology from the Safari Guides back into the LNT principles: e.g. What happens to our poop and why?
- Avoid treating ecology like a religion. It's a common mistake for people new to ecology to say something like, "the function of wolves is to control caribou." Depending on your personal spirituality there may well be a higher purpose "organizing" an ecosystem. But in terms of ecology, scientists and naturalists have no evidence of any higher purpose behind the way ecosystems are structured. An ecologist would view wolves only "function" as being to produce more wolves.

Finally, like most publications at NOLS, the safari guides are organic documents. They were conceived with the idea that they be added to, modified and reworked. If you have ideas you would like to have incorporated, shortcomings you wish to see addressed or a safari guide you'd like to write, contact curriculum@nols.edu.
Basic Field Ecology For Wilderness Travelers
by Rob MacLean

Ecology is the study of where things live and how they are connected to each other and the environment around them. It is an incredibly diverse subject, but here we introduce some key ecological ideas. Wherever you are, these same basic ideas can apply. Understanding the natural environment is more than just learning to tell one bird, fish or plant from another. The bird you may identify on your expedition may or may not be present in your hometown. The power of learning ecology is that it applies everywhere—your hometown included. Understanding ecology is key to understanding your place in the world and it may just help you save it.

Some Ecological Definitions

<table>
<thead>
<tr>
<th>Organism</th>
<th>One individual of a species (e.g. an elk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>A group of organisms that can potentially breed with one another but cannot exchange genes with other groups</td>
</tr>
<tr>
<td>Population</td>
<td>A group of organisms, all of the same species, that occupies a particular area (e.g. a herd of elk)</td>
</tr>
<tr>
<td>Community</td>
<td>Any grouping of populations of different organisms found living together in a particular environment (e.g. an elk being preyed on by grizzly bear while it feeds on aspen while the eagle flies above looking for chipmunks which...you get the idea)</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>A discrete unit that consists of living and non-living parts, interacting to form a stable system. Fundamental concepts include the flow of energy via food chains and food webs and the cycling of nutrients biogeochemically... (Now think of the community in a basin where there is a river flowing into a lake)</td>
</tr>
<tr>
<td>Biome</td>
<td>One of the major categories of the World's distinctive plant assemblages, e.g. the tundra biome, the tropical rain forest biome. Biomes are the largest geographical biotic communities that are convenient to recognize. They largely correspond with climatic conditions...</td>
</tr>
</tbody>
</table>

Adaptation

Organisms of the same species are usually not identical. Each organism is slightly different from the next. But despite differences many characteristics seen in parents will be seen in their offspring. For example, two Labrador retrievers will have Labrador retriever puppies and not poodle puppies. This is because offspring obtain their genetic blueprint from their parents. Over many generations variations that are better adapted to their environment will survive longer and have more success at reproducing. They will come to make up a larger proportion of the population. Poorly adapted variations will gradually die out. This process is known as natural selection or evolution and has created organisms with many wonderful adaptations. Moose, for example, were once like other deer but through natural selection, evolved special long legs for walking in deep snow. Those ancestors of the moose who did not have special long legs did not survive or reproduce as successfully as their long legged siblings.

Organisms of any given species can survive, grow and reproduce only within certain physical limits. These limits for survival are known as an organism’s niche. A niche has many dimensions, which include not only physical conditions such as temperature or salinity but also availability of resources such as access to water or food. A niche may also include the threat of predators, parasites or disease. For example orange trees can grow only where there are no frosts and where certain types of parasites are absent. These are two dimensions of the orange tree niche.

Environmental conditions change from place to place and create a patchwork or a mosaic of different niches. The boundaries between niches are called ecotones. A very visible example of an ecotone is treeline in the mountains. Treeline represents the highest elevation a tree can grow on a mountain or, in other words, the upper limit of its niche. Other obvious ecotones include the edge of a lake or the edge of a hayfield. Many niches meet or overlap at ecotones because ecotones represent places where different types of resources or conditions meet or overlap. Because of these diverse conditions, ecotones tend to be areas where we see the greatest biological diversity.

Interaction

Organisms in a community interact with one another. There are many different forms of interaction and they may occur within the same species or between different species. The simplest is perhaps predation where one organism like a wolf eats part or all of another organism. Parasitism is when an organism like a tapeworm uses the body of another living organism as a source of food, habitat or both. Often there is competition between organisms over a resource in short supply that both must use such as trees fighting for light in a forest. In some cases two or more organisms interact for mutual benefit. For example, certain types of fungi, called mycorrhizae live in the roots of trees and provide the tree access to water and nutrients in exchange for sugars from the tree. This type of interaction is called mutualism. Other organisms live off the dead bodies, dead body parts and wastes of other organisms. This is called decomposition. Dung beetles live off the feces of desert animals and are an example of decomposer organisms as are the fungi that you may see growing out of the stumps and logs of dead trees.
All the interactions above occur naturally. Sadly, there is one interaction that is not natural. It can affect almost all animals and only humans cause it. This is pollution. Pollution is human waste produced in a quantity or a form that is not easily decomposed. Trash, sewage, smog, acid rain and toxic chemicals are just some examples. Pollutants can change natural communities and kill organisms.

Energy
On earth practically all our energy comes from the sun. Plants capture this energy and use it to convert carbon dioxide and water into simple sugars like glucose. This feat is known as photosynthesis. It achieves two things. Firstly it provides the building blocks and fuel for all life on earth - simple sugars. Secondly it produces oxygen as a byproduct and filters carbon dioxide (which almost all organisms produce) out of the air and thus purifies our atmosphere.

Plants being the first to capture the sun’s energy are known as “primary producers”. The energy that they store in their cells is passed along to the organisms that feed on them such as herbivores and on to carnivores, parasites and decomposers. In ecology these different levels or levels of energy within communities are known as trophic levels. This movement of energy is like a waterfall cascading over a series of ledges. The first ledge the water hits is that of the primary producers, the plants (or in the oceans the phytoplankton), the second ledge is that of the herbivores, the next ledges are those of the predators and parasites. Each of these levels contribute waste, body parts or dead bodies for decomposition. It is a cascade of energy. No level can retain energy permanently and once the decomposers have finally used it, the energy has reached the bottom of the cascade and it is no more. More energy can only enter the system from the top, from the sun.

The transfer of energy between levels is not efficient. Each level uses around 90 per cent of the energy it receives just to maintain the machinery of life, giving around 10 per cent to the next trophic level. What this means is that it takes around 100 tons worth (or biomass) of grass to feed 10 tons of sheep biomass and these 10 tons of sheep can only support 1 ton of wolf biomass.

Ecosystems that have more water, nutrients and sunlight available are more productive in terms of how much biomass they can produce per area per day. This higher productivity builds a strong foundation for a richer ecosystem that is more resilient. This is exactly why it is often better for us to camp in a highly productive grassy meadow than it is to camp in the fragile understory of a forest.

Cycles
In addition to energy, organisms are dependent on natural cycles, particularly those of water and nutrients. Nutrients include elements like nitrogen, phosphorus and sulfur. Nutrients are combined with simple sugars to make the more complex building blocks of living organisms like proteins. Like energy, nutrients are passed from one trophic level to the next. Unlike energy, however, they can be recycled and most are conserved. Nitrogen in the body of a squirrel is obtained from the nitrogen in nuts produced by a tree. When the squirrel dies, the nitrogen still in its body can be released by the action of decomposers. Once the squirrel’s body has rotted away through decomposition, the same nut-producing tree can absorb some of this nitrogen. This recycling of nutrients through trophic levels is called nutrient cycling.

The water cycle is the movement of water from the earth’s surface to the atmosphere (evaporation) and back from the atmosphere to the surface (precipitation). Water acts as a lubricant and catalyst for all life on earth and all life is dependent on it. Water washes away many of the wastes and nutrients found on land and carries them to organisms in soils, rivers, lakes and the sea this is called runoff. Just as plants filter carbon dioxide out of our atmosphere, soil and water-living organisms filter water by using or storing many of these wastes or nutrients. Soils, rivers, lakes and the oceans act as waste and nutrient storage areas or sinks. Because of this they are very susceptible to pollution.

Change
Our planet is not a completely stable place for life. Viewed over a long period of time, such as 100,000 years, the earth’s climate has warmed and cooled with vast ice sheets ebbing and flowing in response. As glaciers have receded at the end of ice ages, sea levels have risen. Volcanoes have ejected millions of tons of rock and ash into the air and onto surrounding land. Fault lines have slid causing earthquakes and landslides. Viewed over a shorter period of time, the surface of the planet has been lashed by hurricanes, tornados and floods.

Lightning has caused fires that have consumed thousands of acres of forest - forests that had previously stood untouched for hundreds of years. But some ecosystems depend on fire: grasslands are the most productive terrestrial ecosystems in the world, and they depend on fire to provide nutrients and to reduce competition by trees and shrubs.

Sometimes a changing environment can lead to intolerable conditions for the survival of some organisms and lead to extinction. Extinctions can be local, regional or, as in the case of the dinosaurs, global.

The communities of organisms that inhabit the planet’s surface are constantly responding to change, even changes that happened hundreds or thousands of years ago. One of the most common biological responses to change is colonization where plants or other organisms establish in areas where previous communities have never existed or have been damaged or destroyed. Examples of this include the establishment of plants on the bare rocks of a glacial moraine after the glacier has receded, or the colonization of the bottom of a ship’s hull.
by barnacles. Colonizing species can improve conditions for other species. For example, on a glacial moraine, colonizing species drop leaves and other detritus onto the raw rock. This material decomposes and some becomes soil. The soil that colonizing plants produce on a glacial moraine makes it easier for other less hardy species to establish. Often these species are more competitive and tend to replace the harder pioneer species. The replacement of pioneer species by competitor species is known as succession. Succession can take place in many places and on many scales. It can occur on the scale of trees colonizing a 100,000 acre forest fire site, or it can occur on the scale of decomposing fungi colonizing the body of a dead ant.

**Biodiversity**

**Biodiversity** (biological diversity) in a community is a measure of the number of different species present. It also is a measure of the genetic diversity or variation within those species. For example a group of wild banana trees in a tropical forest is much more diverse than a plantation of cloned and genetically identical banana trees. Biodiversity is often considered a measure of ecological stability. The earth’s environment is changing constantly and unpredictably. High biodiversity provides many different directions that natural selection can take in response to this change. Biodiversity also helps maintain important energy flows, interactions and cycles. If certain populations or species do go extinct, biodiversity can provide alternative pathways for resources to be shared and recycled and thus prevent other populations or species from collapsing.

**The Future**

Humans are modifying the planet at a tremendous rate. By polluting, overharvesting and removing habitat we are interfering with the niches, the interactions, energy flows and cycles that maintain life and biodiversity. The wilderness provides us with a place to see these things in a natural state. It is clear from the wilderness that life on earth is not stable. It hangs on in the face of tremendous change. Its survival on this planet or in this solar system, that is as far as we know devoid of other forms of life, is a fragile miracle. It is perhaps like watching the miracle of a lifeboat still upright on a storm tossed sea. As passengers in this lifeboat we do not want to interfere with its structure or function any more than we need to.

**Reference:**


---

**Wilderness Jeopardy**

**The Basic Ecology Edition**

Darran Wells

The goal of this game is to test the student group and reinforce facts covered on the handout, "Basic Field Ecology for Wilderness Travelers," in a fun, relaxed way.

**Jeopardy Directions:** For this game, you will need a mylar sheet, ensolite pad, or light colored trash bag and dry erase markers. Each team will need a name and some unique way to “ring in” when they have an answer (hitting a pot or frypan with a cooking spoon or spatula works well.) Three to five teams of 2-4 participants works best (tent groups for example). All answers must be given in the form of a question.

Instructors can play Game Show Host, Judge, and Score Keeper. It is the judge's job to decide who rings in first and whether or not an answer is "close enough." Just remember that the point is to review ecology, not to perfect jeopardy skills. This version of the game is played in one round with 6 categories, or two rounds with 3 categories. The second round is then called double jeopardy and is for twice the values.

Instructors should have a grid on the mylar with the categories written across the top and point values written below in columns so that the higher point questions are towards the bottom of the grid. The first team to “ring in” gets to select a category and amount, then the Host reads the corresponding question. If an answer is not given in 15 seconds or an incorrect answer is given, that point value is deducted from the incorrect team’s total and opposing teams can ring in to answer the question. You may hide one “Daily Double” question (for twice the normal point value of the question you choose) in each round, but contestants should not know it is the Daily Double until after they ring in.

Final Jeopardy is a single question at the end when teams can bet any amount the want (up to their current total). They write down the amount being bet on a small piece of paper. BEFORE they hear the final answer. Then they write their answer down on the other side of the same paper. Add drama by showing everyone the amount bet first, and then pausing a bit before reading their answer.

Below are 6 categories with questions and point values for a full game. Feel free to change some questions to tailor them to your course and area. This game is best played near the end of the course when instructors have had time to touch on this material. Add categories by putting in natural history topics you encountered on your expedition. Don’t just put in species everyone knows; add some that only a few keen observers saw to give these keen (or lucky) ones a little notoriety.
Eco-Definitions

100- Answer. This is the name for any living thing.

200- A. A group of organisms that can potentially breed with each other.

Q. What is a species?

300- A. A group of organisms of the same species not separated by geographic boundaries and likely to breed.

Q. What is a population?

400- A. Another word for community, but one which emphasizes interconnectedness.

Q. What is an ecosystem?

500- A. Name for terrestrial communities of similar type extending over a large geographic area.

Q. What is a biome?

Adaptations

100- A. The process by which organisms which are better adapted to their environment come to make up a larger proportion of the population.

Q. What is Natural Selection or Evolution?

200- A. The name for the limits for survival under which a given organism can live, grow, and reproduce.

Q. What is a niche?

300- A. A patchwork of different niches created as environmental conditions change from place to place.

Q. What is a mosaic?

400- A. The boundaries between niches.

Q. What are ecotones?

500- A. The measure of the number of different species present in a community.

Q. What is biodiversity?

Interaction

100- A. This is the name for when one organism eats all or part of another organism.

Q. What is predation?

200- A. The name for when an organism uses the body of another living organism as a source of food, habitat, or both.

Q. What is parasitism?

300- A. When two or more organisms interact for mutual benefit.

Q. What is mutualism?

400- A. The name for the process that occurs when organisms live off the dead bodies, dead body parts or waste of other organisms.

Q. What is decomposition?

500- A. This unnatural interaction effects almost all animals by changing natural communities or killing organisms and is only caused by humans.

Q. What is pollution?

Energy

100- A. This is the process by which plants capture energy and use it to convert carbon dioxide and water into simple sugars.

Q. What is photosynthesis?

200- A. They are the first to capture the sun's energy.

Q. What are primary producers?

300- A. The different levels or levels of energy within communities are known as these.

Q. What are trophic levels?

400- A. This is the word ecologists use when quantifying the amount of organisms.

Q. What is biomass?

500- A. No trophic level can retain energy permanently. Once these groups of organisms have finally used it, the energy has reached the bottom of the cascade and is no more.

Q. What are decomposers?

Cycles

100- A. These include elements like nitrogen, phosphorus, and sulfur which combine with simple sugars to make the more complex building blocks of living organisms like proteins.

Q. What are nutrients?

200- A. The process by which a squirrel's body decomposes into nitrogen, which can then be, used by a nut-producing tree the squirrel once ate from.

Q. What is nutrient cycling?

300- A. This is the name for the movement of Earth's water from the surface to the atmosphere.

Q. What is evaporation?

400- A. This is the name given to the process of evaporation and precipitation.

Q. What is the water cycle?

500- A. The name for water that washes away the wastes and nutrients found on land and carries them to organisms in soils, rivers, lakes and the sea.

Q. What is runoff?

Change

100- A. This happens when environmental conditions become intolerable for the survival of some organisms.

Q. What is extinction?

200- A. This happens where plants or other organisms establish in areas where previous communities have never existed or have been damaged or destroyed.

Q. What is colonization?

300- A. The first species to colonize an area are called this.

Q. What is a pioneer species?

400- A. The replacement of pioneer species by competitor species is known as this.

Q. What is succession?

500- A. Biodiversity is considered a measure of this.

Q. What is ecological stability?
The goal of this class is for students to use a range of knowledge and observational skills to understand the driving forces behind different ecosystems and make connections between their components. This skill could be practiced once a week. Students break up into three groups, investigate the ecosystem, and then come back together to make connections and learn from each other. A course might stop to "read the land" in a variety of ecosystems, such as a late successional forest, an early successional forest, a bog or marsh ecosystem, an upper montane system, and an area with intensive human impact. Over time, as the students' skills in reading the land improve, instructors play a diminishing role in the groups. The successful student will incorporate environmental studies lessons (natural history, geology, habitats) given throughout the expedition into his or her observations. The general structure of this skill-building activity is outlined below.

I. The expedition breaks into three groups: Soil / Geology; Vegetation; Animals / Humans.

II. Each group investigates their respective subject together with an instructor. The instructor strikes a balance between allowing students to struggle on their own for answers and giving them direction and information (approx. 20 min.).

A. The SOIL / GEOLOGY Group digs a shallow soil pit and identifies soil layers, soil texture, drainage, soil organisms, etc.

B. The VEGETATION group identifies the major plant species and gets a rough idea of which are dominant and why. The group might core an older tree to figure out how old the forest probably is. Various questions would be appropriate, such as what successional stage the forest is in, what the limiting factors to growth are, and whether the vegetation is healthy, etc.

C. The ANIMALS / HUMANS group searches for signs of animals (tracks, scat, nests, habitats etc.) and investigates what kind of food might be available for animals. They might want to think about animals as dispersal vectors or limiting factors of vegetation. They should also investigate the human impacts on the land over time and in the present.

III. Groups come together and students present their findings to one another (approx. 10 min.). Guided by instructors, students make connections between vegetation, soil, climate, animals and humans. They identify and discuss the "driving forces" of the system. In later ecosystems, have students switch groups.

Biodiversity: The Key Indicator of A Healthy Planet
Andy Blair & Jerry Fritsch PhD

The goal of this fact sheet is to serve as a resource for instructors and students and to help them foster a sense of environmental stewardship. This information may be given to tent groups the night before a discussion on specific threats to biodiversity in your course area, used as a basis for comments in the group journal, or as a mini-class topic. Be creative.

What is Biodiversity?
Biodiversity is...
- The 128 species of butterflies in Yellowstone National Park
- The 300 species of birds in the state of Wyoming
- The 1400 species of bees in North America
- The 80,000 species of edible plants world wide
- The 1.4 million species already described by science
- The 5 - 100 million species that remain to be discovered

Biological diversity refers simply to the variety of life. It encompasses the myriad of variations that occur within biological kingdoms as well as the genetic variations between two individuals of the same species. It is all of the plants, animals, fungi and microorganisms that exist. Further, no each individual member of a species contributes to the overall biological diversity through the uniqueness of its own genetic diversity. It is the complex inter-working of these diverse organisms that makes our biosphere (the living portion of the earth) function. From the food we eat to the air we breathe we depend on this diversity. Biological diversity is the fabric of life itself.

What are the issues?
The abundance and diversity of life that we experience on this planet is a blessing, providing for our needs, cleaning our ecosystem, and touching our inner joy at its sheer beauty. No other planet in our solar system is known to have life, let alone
band no more than a few kilometers thick across the surface of the Earth. Earth’s organisms range in size from huge (e.g. blue whale) to microscopic (e.g. viruses). Populations range in size from many billions (think mosquitoes) to a few individuals (think black rhinos). Diverse ecosystems are thought to be more stable and more resilient than those with fewer species. We think of them as healthier. The complex interaction between all of these organisms and their environment has created the biosphere and atmosphere, as we now know them.

The numbers of species of organisms, and their population sizes, are regulated by the dual forces of evolution and extinction. These are processes carried out over geologic time. As one species dies off and vacates its niche within the ecosystem another one moves in to fill its niche space. Extinction is a part of nature. Conservation International estimates that historical rates of extinction over the last 65 million years have averaged out to between 1 and 5 species per year. In turn these extinctions may be offset by the evolution of new species. Five times in the Earth’s history, due to asteroid strikes or other outside forces, enormous numbers of extinctions have occurred over a relatively short period of time. Gradually, over millions of years, life has filled itself out again. An example of this is the extinction of the last dinosaurs. Roughly 65 million years ago, over a period of 2 million years, approximately one half of all living things, including dinosaurs, ceased to exist.

What is at issue today is that many scientists believe we are now in the midst of the sixth great extinction. Some estimates as to the current rate of extinction run as high as 10,000 to 25,000 species per year. At this rate, the Earth stands to lose one quarter of all plant and animal species within the next fifty years and one half by the end of this century, many before they have even been described by science. Habitat loss as a result of human impacts is considered to be the main cause behind this increased rate. Examples of this include, deforestation in the tropics, which threatens the habitat of three-quarters of all species on Earth while agribusiness and urban sprawl threaten the habitat of species in the temperate Northern Hemisphere. In addition to this are the global incorporation of poisons and other unscreened chemicals into the environment. Climate change brought about by global warming threatens to impact habitat world wide, possibly causing the death of all coral reefs within the next fifty years, among other impacts. The human population itself continues to grow and occupy more space in turn homogenizing species and introducing more competitive exotic ones. In a pamphlet on biodiversity the National Park Service states, "If unchecked, the accelerating extinctions now going on seem likely to transform the workings of the biosphere, and in ways not beneficial to humans."

**Why should I care?**

1) Biological diversity is linked to the health of the biosphere. Peter Reich, of the University of Minnesota, that biodiversity does increase the health and productivity of an ecosystem and that preserving more species provides a greater natural cushion against environmental damage (Greenlines 4/21/01). If the current rate of extinction is allowed to proceed unchecked we could witness the collapse of whole ecosystems. This in turn could effect the health of the biosphere. For instance, since nearly half of all oxygen present in our atmosphere is produced by single celled plants living in the ocean the collapse of their ecosystem would directly affect the amount of oxygen in the air we breathe. All species both large and small play a part in the health of their ecosystem. Studies indicate that the collapse of ecosystems can be unpredictably abrupt.

2) Roughly a quarter of all medications come directly from a plant or animal source. Alkaloids, substances common in tropical plants, are used in cancer fighting drugs, painkillers, blood pressure boosters, anti-malarias, and muscle relaxants. The rosy periwinkle provided the cure for Hodgkin’s disease and childhood lymphocytic leukemia. Penicillin is derived from a close relative of bread mold. Digitalis, a cardiac medication, was originally derived from the mandrake plant. Aspirin came from willow bark. Even when synthetic versions of drugs are developed they are usually created by following the blueprints of natural chemical compounds. There is the risk that species with important medicinal qualities could vanish before ever being discovered. A variety of industrial products come directly from plant sources. Wood and paper products account for $100 billion annually world-wide. On one hand, this is part of the incentive that encourages their destruction. On the other, sustainable harvesting of these assets would allow us to continue using these materials indefinitely. Support for biological diversity and other environmental concerns do not have to come at the expense of economic stability.

4) Wild species are necessary to assure the continued productivity of our cultivated foods. Despite there being 80,000 species of edible plants worldwide only 150 are extensively harvested and 3 (corn, wheat, and rice) make up two thirds of the world’s total grain harvest. This is a cause for concern because the Irish potato famine of the 1840’s was caused by a disease spread through one species of potato. It resulted in the death by starvation of 2 million people. Eventually, the potato was crossbred with several of its wild, disease resistant relatives producing the many reliable varieties in use today.

5) As a global society, we are meddling in an area that is little understood. Our actions are directly contributing to the accelerated rate of extinction. We do not know what the impacts of this situation will be. Potentially, they could be catastrophic for us as well as future generations. At the very least we are removing additional species and depleting the world of its most valuable resource: Life. And as far as we know, the Earth is the only place you can find it. As Aldo Leopold once wrote, the first rule of intelligent tinkering is to save all of the pieces. No one understands how an ecosystem really works. The systems involved are incredibly complex, interlocked like the gears in a watch. How many pieces can you toss out before the watch ceases to function? If you could open up the back of an ecosystem, like a watch, the level of complexity from the macro to the micro would be
the integrity of its pieces. Without those pieces the biosphere will cease to function. Natural ecosystems have built-in redundancy but how many pieces are needed for it to continue working and how many can it do without? The problem is, there is no one even close to answering these questions. By allowing these extinctions to occur we are threatening our own life support system.

6) Prominent sociobiologist, E.O. Wilson, has a theory that there is an innate relationship between all humans and their environment that he calls "Biophilia." Literally translated it means 'life loving.' This relationship includes such feelings as the desire to experience the natural world on a personal level and the idea of "Wilderness." He sees examples of this in the groups that "crowd the national parks to view natural landscapes, looking from the tops of prominences out across rugged terrain for a glimpse of tumbling water and animals living free. They travel long distances to stroll along seashores, for reasons they can't put into words." (from the Diversity of Life). He believes that this Biophilia provides humanity with a unifying value system that will assist us in working together to maintain the integrity of the biosphere. The concept of Biophilia unites everyone, even people with wildly differing viewpoints on the environment. Wilson believes that by enlightening people regarding our dependence on a healthy ecosystem they will be won over to the cause of maintaining biological diversity. This realization on the part of our global society is the key to success.

What can I do about it?
1) In order to maintain biological diversity the goal should be to preserve whole ecosystems. While charismatic megafauna draw the most attention it is the enigmatic microfauna that often count the most in this effort. Rather than focusing on the health of a local elk herd, we need to focus on the health of the ecosystem in which those elk live. Groups like The Nature Conservancy and Conservation International focus on this whole ecosystem approach. Conservation International has compiled a list of the 25 richest and most threatened plant and animal reservoirs on Earth. These hotspots occupy only 1.4% of the surface of the planet, an area the size of Alaska and Texas combined, but are the exclusive home of 44% of the Earth's plant species and 35% of all birds, mammals, reptiles, and amphibians. They have targeted these hotspots as some of their main areas of focus for biological conservation. Hotspots have been identified on every continent except Antarctica. President of Conservation International, Russell A. Mittermeier, states, "Given that we are in the midst of a species extinction crisis, we're saying it's time to put aside the gloom and doom and get down to the business at hand. The Hotspots strategy makes the extinction crisis more manageable by enabling us to prioritize and target conservation investments in order to have the greatest impact."

2) Provide space for endemic plant and animal species around your house. Get rid of the water intensive English lawn monoculture. Plant native species of plants. Encourage local bird populations. Take a look at the world around you.

3) Educate yourself. Take time out of your course to identify 15 different species of birds, trees, insects, whatever, in order to acknowledge the biological diversity around you. Present this information in a mini class or group journal entry.

4) Make your voice heard. The issue of maintaining biodiversity presses us from all sides. Change has to come from above and below. By writing your senator or representative you help bring the issue to the forefront. As the old saying goes, "If you're not part of the solution, you're part of the problem."

Direct your letters to:

The Honorable (your Senator's name)
United States Senate
Washington, D.C. 20510

The Honorable (your Representative's name)
United States House of Representative
Washington, D.C. 20515

Gale Norton
U.S. Department of Interior
1849 C Street N.W.
Washington, DC 0240
Observations and Introduction of Natural Sciences

Birds Are Cool!

Trevor Deighton

This is an easy class to teach that is fun for students and instructors alike. I would allow 45 minutes from start to finish but it is possible to trim it down. I have structured the class as a simple outline with background information and ideas for the presenter in italics. Ideally, this would be taught early and then followed up with some optional birding in small groups.

Birding is a fun and enjoyable addition to any course. We see more bird species on our courses then we do mammals and sometimes even plants. For example, it is common to see 30 species on a summer Wind River Wilderness course, 30-45 on a Canyons course, if you are in a marine environment or birding hotspots like Arizona, Alaska, Africa or Australia, it is entirely possible to see over 75 to 100 species. Birding is a way to instill a sense of natural awe and wonder in our students which better helps them to connect to the places we travel. There is nothing cooler than to see a nature nugget presented by a jazzed student about the bird they saw that morning.

Part I: Fun true/false Intro

Keep this section interactive and fast paced, while light and humorous.

1) Birds are descended from reptiles? (T) Birds split from reptiles 200 million years ago
2) 10,000 years ago there were birds with 10 meter wing spans? (F) There was a bird that was 3 meters tall and weighed 1000 pounds though.
3) All birds can fly. (F) Lots of birds can't fly, i.e., Emus, Ostriches... Some like Penguins "fly" underwater. Birds that do fly have been seen as high as 37,000 feet, migrate up to 25,000 miles a year and fly at speeds up to 200mph.
4) Birds have Cloacas. (T) Like reptiles, birds have a three chambered heart and a Cloaca. Cloaca is Latin for "common sewer" and is a shared orifice for urine, feces and reproduction.
5) Bird bones are hollow? (F) Birds have many adaptions for flight including the lightening of the skeletal system through absence, fusion, and strutted (for support) rather than hollow bones. Other adaptions include feathers and the respiratory system (which is 4x larger than mammals).
6) Bird Feathers are made from Keratin (T) Highly adapted/modified scales made from keratin (just like fingernails in humans). Birds replace their feathers (Melting) twice a year. A snow goose has 25,000 feathers.
7) There are approx. 9,300 bird species in the world? (T)
8) Birds know astronomy (T) Birds migrate by orienting themselves to the stars.
9) Birds need a compass? (F) Some birds can sense the earth's magnetic field to navigate on cloudy nights.
10) Bald Eagles are glorious birds. (T & F) A magnificent bird but really just a glorified vulture in terms of scavenging food from others.
11) Outdoors people love birds? (T) In fact, Audubon field trips can be a great way to meet other outdoors people in new places.

13) Birds are hard to get to know? (F) Birds are easy to see and learn to identify.

Part II: Bird Identification

Topography of a bird. Draw and label the key parts of a bird. Any field guide will have a labeled picture in the intro with the names to common features of a bird. The idea here is to have a common language when looking at and describing birds. I usually throw in something humorous on my drawing such as "the drumstick" for the leg.

Bird ID: Birds are identified by a variety of traits. This is a quick list in order of usefulness. I won't provide the background info on all of them but each trait should be followed by a sentence or two of information. This list comes directly from Peterson's Field Guide to Western Birds. More valuable background info can be found there. (I would suggest Peterson's as the guide to take with you in the field.)

-Habitat: Where did you see the bird? You won't find a Mallard perched in a Pine forest.

-Sound: Birds have an amazing array of calls. Each species can be identified by call.

-Size: How big is it? Use common birds as a reference, i.e., the size of a sparrow, jay, raven etc.

-Shape: long and thin, short and plump

-Wing Shape: Arc shaped, straight, tapered

-Bill Shape: The bill is a bird's foraging tool and tells you a lot about its feeding. Is the bill conical, for eating seeds (sparrows) or long and thin for eating insects (warblers), or hooked for ripping flesh (birds of prey)?

-Tail Shape

-Flight Pattern

-Does it climb trees? Different birds climb trees different ways.

-Does it swim or wade?

-Distinguishing patterns or marks including: tail patterns, rump patches, eye stripes/strings, wing bars, wing patterns, etc

-Color: Use color last. Color is usually the first thing we use in trying to ID birds but is often the least reliable trait due to individual variation, time of year, the ambient light etc.

Part III: Birding

Birding is fun, inexpensive and can be done anywhere. You can go anytime but to be most successful go in the morning or evening around sunrise/set. Go quietly in a small group (3-4) and look for habitats that are more unique like riparian corridors. All you need are three things:

1. Binoculars: (called bino's if you're really cool) around 8 power for birding. Show folks how to focus and adjust binos. Demonstrate finding the object with your eye and then bringing the bino's into your line of sight, not searching with bino's. Check bino's before leaving for the field and make sure students carry them readily accessible.

2. Bird Book: I suggest "Peterson's".

3. Hat: to keep the sun out of your eyes and to look cool.
Finally, take everyone birding! Everyone must use their pretend binos. I have the other instructors dress up as mythical birds and have some of the unique traits we just talked about. When we spot the “bird” (careful jumping out of trees) everyone must use their “binos” and then list of some traits. I’ll prompt them. I.e. “What is distinguishing marking?” “It has a shiny metallic crown (stone wind screen), a long bill (foam pad), it is strutting funny and it just stole my coffee. It must be the rare Silver-crowned Java Sucker” (not so rare in some L-towns). Another option is to place paper “birds” in the bushes and ask folks to ID them. Photocopy diagrams or cut out pictures from magazines of birds in the area you will be before leaving for the field. The 3rd option, of course, is to teach this class in an area with lots of birds, split into groups, and take your students to do some real birding. This is generally “Plan A.”

More random and interesting bird facts: You can add these to the class or mention them randomly on the trail or while birding.
- Ravens have been seen flying over the summit of Mt. Everest.
- All birds can be identified by their call alone (remember approx. 9300 different species).
- Woodpeckers have fluid in skull to cushion brain, tongues up to 12” with bristles on the tip. They impact the tree with their head/bill at speeds up to 13mph, and up to 12,000 times per day.
- Loons can dive to 600 feet, Penguins to 1700 feet for up to 18 minutes.
- Owls can rotate their heads 340 degrees.
- Pigeon crop milk has more protein than cow or human milk.
- Peregrine falcons reach 200mph in a dive, Red-breasted merganser 100mph in level flight.
- Hummingbirds = 90 wing beats per second. Vultures, 1 per second.
- Chimney swifts live 9 years and fly approx. 1,350,000 miles.
- Smallest bird is the Bee Hummingbird is 2.25 inches long and weighs 1.6 grams (.056 ounces).
- Hummingbirds eat half of their bodyweight in sugar a day.
- The human calorie equivalent is 150,000 calories per day or 285 pounds of hamburger or 370 pounds of potatoes a day.
- Oragadori, a domestic strain of the Red Jungle Fowl (chicken) has a tail feather 34.75 feet long.
- African Gray parrots can have a vocabulary of 800 words.
- Turkeys can crush metal balls requiring 400 pounds of pressure per square inch in their crop.
- Larks regularly live in temperatures up to 112 degrees Fahrenheit.
- The South Polar Skua has endured the coldest temperature -129F.
- The Emperor Penguin’s average is the coldest at -50F.
- Dusky Scrubfowl builds a nest 36 feet wide, 16 feet high and has 300 tons of forest floor litter in it.
- Oldest bird in the wild, a Royal Albatross at 58 years, in captivity a Cockatoo lived over 80 years.
- Little Spotted Kiwi lays an egg that is 26% of it’s body weight, an Ostrich 1.5% of it’s body weight.
- 8 billion domestic chickens lay 562 billion eggs per year.
- Indonesia has 126 endangered bird species, Brazil, 121. 30% of New Zealand’s birds are endangered.
- US has the highest number of introduced birds Hawaii with 68 introduced.
- The Dusky-Seaside Sparrow was the most recent bird to be declared extinct in 1987. It lived in coastal New England.
- There are many other birds that are probably extinct but haven’t been officially declared so yet (the Ivory-billed Woodpecker is one).
- The last Passenger Pigeon died in the Cincinnati Zoo in 1914.
- Once the most abundant bird on the planet with flocks of 2 billion birds. Market hunters killed hundreds

Animal Tracking
Lauren Schmrones

Goals: This outline offers a few ideas, and some background knowledge for a 30 minute tracking class. It should be taught somewhere with real animal tracks to study. Observing animal signs can give you a greater sense of the ecology of an area and can be exciting to us all.

Look for tracks in the sand, snow, mud or dust.

Background Information/Terms

| Minimal outline: it's easy to think a track is bigger due to the surface the track was made in. Look at the bottom of the track and only record the size using the minimal outline. |
| Length and width: These are the terms for measuring a single track. |
| Stride: Straddle: (illustrate by drawing tracks of rabbit, and tracks of canine) |
| Group: Walking-coyote, bounding-squirrel |

Deer:
- This is the type of movement an animal makes: trot, walk, lope or bound.

Digitigrade: Walking on tips of toes such as dogs, cats and hoofed animals

Plantigrade: Walking on soles of the foot such as bears, humans

Unguines: Hard material forming nails in humans, hoof walls in deer family, claws in other mammals. Composed of hair pasted together by body glue.

Scat terminology: cords, oval, nipple-dimple, blunt end vs. tapered end. Canine scat tends to be tapered at the end with the contents representing available food source. Felines tend to produce blunt-ended cords with slight constrictions. Bear scat usually contains vegetation and is sweet-smelling. Look for berries, and pine nuts. Moose, Elk and Deer scat differ primarily by size.
Outline:
I. Draw tracks and scat of a few local animals. (I.E. Bear, Moose, Elk, Rabbit, Dog, Cat) define key characteristics of tracks and how to measure them.
Describe how the scat tells the story of the animal it came from and what it ate.
II. Draw various gait patterns (walk, bound)
   A. define stride, straddle.
   B. Ask why animals frequently register their back legs into their front track
   C. Have students act out an animal and its typical gait, “Who can do the best rabbit?”
III. Tracking walk. If there are tracks in camp you have checked out, take everyone on an ecological tour of your findings.
   D. Otherwise, have students divide into pairs and walk around for 5-10 minutes looking for animal tracks and other signs. Have them sketch and measure the tracks to show the group.
IV. Additional animal signs. After the walk, come up with a list of other animal signs to watch for: deer browsing shrubs, porcupine chewed bark, digging, bird pellets, bones, small animals chewing on bones for minerals, urination and scratching markings by dogs, soil casts from Voles and Gophers during winter, rocks turned over by Bears looking for moths, Ungulates stripping bark from branches and trees while removing velvet from antlers, and food caches (Pikas).

VI. Wrap up with a short story or quote about animals, or perhaps about the animals who honed their tracking skills daily.
VII. Encourage people to observe tracks while hiking then report back to the group about their observations.

Resources:
• Halfpenny, James  Scat and Tracks of the Rocky Mountains. Falcon, Montana 1998 NOLS WEN

Interpreting Rock: A Basic Geology Outline
Laura Schmonsees

Goals: This 30-50 minute class can be simple or more detailed, depending on your goals, experience and location. It is important to have some specific information and key geologic terms about the area you are traveling through, rock samples, and a classroom with views to illustrate your points. These notes are a framework of basic geology: instructors need to tie this information to the activities of the course.
I. Timeline History (10 minutes)
II. Rock types / rock cycle (10 minutes)
III. Area specifics (10 - 25 minutes)
IV. Wrap up quiz (5 minutes)

Timeline History
This activity gives students a perspective of geologic time.
(For a more detailed variation, see Rick Rochelle’s “Timeline Rope Trick” article.) Spread out a climbing rope or long bear hang rope (100 feet or more is ideal). 0 represents present day and 100% of your rope length represents 4.6 bya, when the Earth was formed. Have students one at a time place themselves on the line as you read and explain each date. (For areas other than the Wind Rivers, you will need to make some area-specific changes.)
1. 4.6 bya – age of earth 100 %
2. 3.8 bya – oldest known rocks 82.6 %
3. 2.6 bya – oldest rocks in Winds 56 %
4. 500 mya – first fish - 10.8 %
5. 440 mya – terrestrial plants evolve / sediments later become Sahara oil fields 9.5 %
6. 245 mya – major extinction 53 %
7. 180 mya – Jurassic park! Climax of Dinosaurs 39 %
8. 65 mya – great extinction/rocky mountains first rise 1.4 %
9. 5 mya – 2nd major Wind River uplift 1.2 %
10. 250,000 ya – Ice Age .06 %
11. 15,000 ya – Humans cross land bridge / major extinction in North America .0038 % 12. 1760’s A.D. – Industrial revolution begins .0016 %
13. 1924 A.D. – Paul Petzolt climbs Grand Teton .0005 %

Rock Types
Geology in Latin means “study of Earth”. Rocks are made up of minerals, like quartz, which are specific crystalline arrangements of various elements (SiO2). Rocks are divided into types by the way they were formed, mineral composition and/or grain size. Draw examples of the formation of the major rock types.
Igneous (flint)
• Formed when molten lava cools either above or below the Earth’s surface.
- Crystal size depends on the rate of cooling; larger crystals mean longer cooling.

Depositional Environments: Aerial View

- Intrusive cooled underground
  - Extrusive cooled near/at surface
  - Phytotic (Pluto, god of underworld)
  - Volcanic (Vulcan, god of fire)

- Coarse grained
  - Ex. Granite
    - (light minerals)
    - Rhyolite
  - Diorite
  - Gabbro
  - Basalt

- Fine-grained
  - Ex. Granite
    - (light minerals)
    - Rhyolite
  - Diorite
  - Gabbro
  - Basalt

Depositional Environments: Aerial View of River

- Most common minerals to look for in Granite are Quartz, Feldspar, and Mica.
  - Quartz is clear and glassy, Feldspars are pink, or pearl colored and shiny with flat cleavage planes, and Micas are dark and shiny like mirrors.

Sedimentary (deposition and pressure)
- Formed when sediments are buried and then compressed and cemented together.
- Rocks are classified by depositional environment and grain size.
- Conglomerate (Large grained, formed from fast moving rivers, landslides)
- Sandstone (med. grain size, formed from rivers, deserts)
- Shale (fine grained, formed from estuaries, lakes, deltas, in deep oceans)
- Limestone (formed in shallow seas, mainly made up of Calcite)

Metamorphic (heat and/or pressure)
- Formed when rock undergoes structural and/or chemical change due to intense heat and/or pressure. Minerals align with like minerals and realign in same direction to maximize decreased space from pressure.

- Categorized by mineral composition, and degree of heat/pressure during metamorphism.
- Some metamorphics in the Wind Rivers were formed 12 miles underground at 500 degrees!
- Ex: Gneiss (looks like marble-swirl ice cream. Parent rocks = sandstone, granite) Schist (finely layered. Can have Garnets. Parent rocks vary.) Slate (comes from shale or volcanic ash)

Rock cycle: I usually draw a circular picture which goes through the cycle from molten rock, to granite, to sandstone, to gneiss, and then who knows!

Area Specifics / Geomorphology
During this section of the class I explain how geology has shaped the landscape we are traveling in, draw out examples, and do one or more of the following activities.
- Show and tell: Gather a few interesting rocks in camp and pass them around. Explain them or have students guess about the type of rock and how it formed.
- Geological Story: For those who are creatively inclined, Sedimentary or volcanic rocks work best as you can tell a story of what it looked like here when each layer was laid down. In canyonlands, it can include dinosaurs, floods and sand dunes.
- Migmataite boulders found in the Wind Rivers, like many other rock types which contain intrusions, are good places to put Geology observation skills into practice. Intrusions are younger than the parent rock they cut through. Within the migmatite, the metamorphic rock must be older than
the igneous rock which surrounds it. (Think of old Jello with younger fruit chunks suspended in it.)

**Glaciation:** A weathering process that creates broad u-shaped valleys and eratics (boulders which have been deposited by glaciers).

**Migmatite:** Rock which contains both igneous rock and partially or fully metamorphosed rock. This forms in the contact zone between igneous and other rock types.

**Dikes:** Molten intrusions into pre-existing rock.

**Unconformity:** A discontinuity in the succession of rocks, due to periods of erosion between subsequent layers.

**Synclines / Anticlines / Monoclines:** Folding of strata that creates varied shapes. Synclines are concave. Anticlines are convex and monoclines bend in one direction.

**Plate tectonics:** The theory which believes the lithosphere (crust) is divided into plates which move due to convection in the upper mantle. The margins of the plates are sites of considerable geologic activity (ex. Himalayas).

**The Earth:** Made up of crust, upper mantle, lower mantle, outer core and inner core.

**Wrap up (Interesting facts that can be used as a fun quiz)**
1. The rock on the top of Mount Everest is? **Limestone.**
2. Which mountains were formed when North America and Africa collided during the carboniferous period? **The Appalachian Mountains (and they were originally over 30,000 feet tall).**
3. The Earth’s crust represents what percentage of its total mass? **Less than 1%**.
4. What is the world’s longest lasting mineral? **Actually, “quartz is forever;” outlasting all minerals, but diamonds are the hardest.**
5. During the ice age, how far did sea levels drop? **330 feet.**
6. Geologists estimate that, at our current rate of use, how many years of oil reserves are left? **A few decades.**
7. What land feature displays more geologic history than anywhere else on earth? **The Grand Canyon.**

**Visualizing Geologic Time and a Brief History of Life**

Rick Rochelle

Have you ever tried to teach geology and watched your students’ eyes glaze over as soon you mention that the planet is 4.6 billion years old? Can you convince them a 12,000-year-old moraine is young? When teaching geology, I give students three reasons to be excited about it: 1) understanding what it used to be like here, 2) understanding geological processes that created the landscape, and 3) gaining a sense of the deep history of the earth and life on it. I’ll focus on the last item in this article and present a teaching tool to put such big numbers within students’ grasp. Giving our students a sense of the immensity of geologic time will encourage a deep sense of awe and respect for their environment. With a brief outline of the development of the biosphere, noting the tiny proportion of time humans have been on the earth, you may even encourage a spiritual sense of their place on the planet. Last, but not least, this exercise will add scientifically accurate clarity to your environmental studies curriculum.

**Visual Aid**

Use a 45 m climbing rope—the old standard 150’ rope. If it’s way too long, tie a knot the correct number of meters from the end. We’ll call that the beginning of the earth. Prepare the rope by putting wide pieces of tape at 5.4 m (~18’), 2.5 m (~8’), and 65 cm (~2’). You may also choose to put narrow pieces of tape at other key points to remind you to discuss certain events. Explain that this rope represents the history of the earth with each centimeter representing one million years. Incidentally, if you add two more ropes they would represent the history of the universe. Stack the rope about 3 m to the side of where you want center stage to be. As you stack most of it, explain that this represents Precambrian time. The Precambrian is the first of four “eras” I try to get students to learn. It isn’t officially an era, because it lumps three long eras, but it is a convenient term for teaching. When you get to the first piece of tape, explain that this represents the beginning of the Paleozoic era (“paleo”-ancient, “zoic”-life). Lay the rest of the rope down in front of the class as you talk. The second piece of tape represents the beginning of the
Mesozoic era (middle life) and the last piece of tape indicates the start of the Cenozoic era (recent life). After you’ve explained the premise to the students, go back to the point on the timeline where you want to start your story. This may be a geological story on any course, or one of evolution on natural history intensive courses.

Below is the geologic time scale—newest on top, like most rocks. I only expect students to memorize the four names in bold, but I may use the italicized time periods in class. As you read geology outlines, climbing guides, and field guides, you’ll accumulate a sense of these periods and epochs. Here are mnemonics to remember the periods of the Paleozoic era. Campbell’s Onion Soup Does Make People Perfect, and Mesozoic era: Try Jesus Christ. And here is one for the epochs of the Cenozoic era: Policemen Eat Oysters Meanwhile Playful People Hike. Be prepared for a discussion of creationism if you share the Mesozoic one! The information below is far more than I’ve presented, but it’s important to understand at least one level beyond what you teach. For each of the eras I will give a brief description of atmospheric conditions, changes in life and a little geology. In class, I typically mention the items in bold.

**Precambrian (Origin of Life)**

In the beginning was the Hadean eon. It was hellish, as the name implies. Huge objects and small particles collided at greater than 11 km/s, adding mass to the earth. This added mass increased the gravitational force, encouraging more bombardment. Energy from these collisions and radioactive decay melted iron, nickel and other metals, sinking them to the planet’s core. Any geologic formations dating back to the Hadean were destroyed by these processes.

By the beginning of the Archean eon 3.8 Ga (gigamillion-billion years ago, 8m into the rope), the crust solidified. Soon after this, the atmosphere cooled to less than 100 degrees Celsius and a truly global rainsplash formed the oceans. The atmosphere at that time was derived mostly from volcanoes and was primarily N₂ (as it is today), H₂O and CO₂. Notably, there was no oxygen. In the absence of oxygen, but energize by lightning, life evolved by 3.5 Ga (11m into the rope). Major metabolic pathways evolved, including fermentation, photosynthesis, and nitrogen fixation from the atmosphere. Though photosynthesis was occurring, primarily in cyanobacteria, oxygen did not begin to accumulate in the atmosphere until most crustal rocks were oxidized. This addition of oxygen to the crust took about two billion years, creating banded iron formations of alternating iron (Fe₃O₄) and chert (SiO₂) in the sediments of the ocean. Most of the world's great iron mines, including the U.S. Steel min on South Pass, Wyoming (3.0 Ga. 16m into the rope), date from this eon.

The Proterozoic eon began 2.6 Ga (20 m into rope). Banded iron formations gave way to red beds—Fe₂O₃ intermingled with terrestrial minerals this time—showing that free oxygen was present in the atmosphere. During this time eukaryotic organisms with cell nuclei appeared. Eukaryotes survived the poisonous efflux of O₂ by symbiotically engulfing aerobic bacteria (protokaryotes, which are non-nuclei). These were the precursors to our mitochondria, which allow us to make energy through respiration. Chloroplasts evolved from cyanobacteria living symbiotically within eukaryotic cells making photosynthesis more efficient. Multicellular plants, and then fungi and the first animals (soft-bodies) diverged from their common eukaryotic ancestor (650 Ma, 6.5m from the other end of the rope). At the end of the Precambrian, much of the world's land mass was glaciated (see graph 3).

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Epoch</th>
<th>Ma</th>
<th>Plants</th>
<th>Animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proterozoic</td>
<td></td>
<td></td>
<td></td>
<td>Agriculture</td>
<td>Early humans (H. sapiens)</td>
</tr>
<tr>
<td>Archean</td>
<td></td>
<td></td>
<td></td>
<td>First grasses</td>
<td>Hominids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permian</td>
<td>2400</td>
<td>Flowering plants</td>
<td>Dinosaur extinct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pennsylvanian</td>
<td>323</td>
<td>First mammal, birds</td>
<td>First dinosaur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carboniferous</td>
<td>354</td>
<td>Plants invade land</td>
<td>Marine algae</td>
</tr>
<tr>
<td></td>
<td>Paleozoic</td>
<td></td>
<td></td>
<td>Marine plants live</td>
<td>Many animal phylox evolve</td>
</tr>
<tr>
<td></td>
<td>Devonian</td>
<td></td>
<td></td>
<td>First carnivores</td>
<td>Eukaryotes (first plants, fungi, animals)</td>
</tr>
<tr>
<td></td>
<td>Silurian</td>
<td></td>
<td>417</td>
<td>Wood evolved</td>
<td>1st life—Prokaryotes (bacteria, cyanobacteria)</td>
</tr>
<tr>
<td></td>
<td>Ordovician</td>
<td></td>
<td>443</td>
<td>Fishes radiate</td>
<td>Reworked, accretion of Earth</td>
</tr>
<tr>
<td></td>
<td>Cambrian</td>
<td></td>
<td>490</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>543</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2500</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3800</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. The terminology can be simplified by only expecting students to memorize the eras in bold and only using a flow of the italicized periods.
Paleozoic (Ancient Life)
At the beginning of the Paleozoic era (540 Ma, 5.4 m from end), the first of six great extinctions took place. This one just meets the definition of "great": 75% of all species went extinct. By then, enough atmospheric oxygen had accumulated from photosynthesis to develop a stratospheric ozone (O₃) layer. This protected organisms from ultraviolet radiation and permitted a dramatic diversification of animals. During the Cambrian, all of the major animal phyla developed, including Mollusca (e.g., mollusks), Anthropoda (e.g., insects), Echinodermata (e.g., starfish), and Chordata (e.g., fish). Some algae species evolved to have thicker cell walls, allowing them to thrive in freshwater and terrestrial environments. At the end of the Ordovician, the second-worst mass extinction occurred, wiping out 85% of all species. The cause is not yet understood, but the generally warm climate became glacial. This led to a quick drop in sea level, draining the continental shelves where most life existed at the time (graphs c, d, e). The supercontinent Gondwana, comprised of Africa, Antarctica, Australia, South America, and India, formed during this era.

The story of the rest of the Paleozoic is stunning! Vascular plants invaded the land during the Silurian and Devonian. At first, land plants were only a few centimeters tall, but by the end of the Devonian, they reached 10 m. Seeds evolved, allowing plants to spread farther from water. Plants' roots became much deeper, allowing them to grow in drier upland environments. Next, accumulating dead plant litter released organic acids into the soil water. The global increase in plant growth, deeper roots, and more acidic soil water greatly increased the chemical weathering of bedrock. Dissolved calcium and magnesium from the rocks were carried to the oceans where they combined with carbon to form limestone, CaCO₃, and dolomite, CaMg(CO₃). With carbon being stored in the rocks, the CO₂ content of the atmosphere plummeted (graph a). By the late Devonian, with extensive photosynthesis, oxygen reached the present 21% (graph b). Spiders and centipedes were among the first animals to invade the land. From fish, amphibians evolved—the first organisms to have lungs and four limbs (354 Ma, 3.5 m).

Another extinction, wiping out ~80% of all species, occurred at the end of the Devonian. There is evidence of major extinctions in Sweden, Quebec, and Belgium which may have contributed to this extinction. Pangaea collided, forming the Appalachian Mountains and the British Isles.

At the start of the Carboniferous, global temperatures were high, and oceans flooded low-lying areas forming swamps. Land plants were well-established. Wood evolved, allowing them to grow taller and compete for light. For millions of years, there were no large herbivores to chew up and defecate the key biochemical in wood—lignin. Nor were microorganisms adapted to decompose it. This situation, combined with anoxic conditions below the swamp water, led to a buildup of carbon in soils. An incomparable accumulation of coal, oil and gas occurred in the Carboniferous. Atmospheric CO₂ levels continued to fall, decreasing the greenhouse effect. Thus, temperatures fell and glacial action was extensive (graphs a, c, d). Many of the rocks we carve in and climb on, including the Madison Limestone, formed then.

Increased photosynthesis led to a surge in O₂, perhaps to a peak of 35% by the Permian (graph b). The increase probably aided the invasion of land by vertebrates. From amphibians, reptiles diverged (250 Ma, 2.9 m). Their eggs had shells that conserved water but were permeable enough for oxygen. This allowed reptiles to lay them on land unlike their precursors. Reptile young skip the larval swimming stage, thus vertebrates were freed from the swamps and lakes of their forebears. The high oxygen concentrations also made the atmosphere more dense and provided more O₂ for peak metabolic demands in insects. This led directly to the innovation of flight. It also allowed for gigantism in insects—dragonflies with 70 cm wingspans! At the end of the Permian, a mass extinction nearly eliminated all life on the planet: 96% of all living species went extinct! The best hypothesis for why this happened includes significant volcanism in Siberia and China. This released carbon buried in rocks, increasing CO₂ to five times the current level. This, in turn, caused rapid warming, melting of the glaciers, and a rise in sea level (graphs a, c, d). Laurasia (Europe and North America) crashed into Gondwana (the rest of the continents), forming Pangaea.

Mesozoic (Middle Life)
The Mesozoic (253 Ma, 2.5 m from end) is also known as the "age of reptiles." Recovery from the near annihilation of life was slow in the Triassic. The first small, mammal-like reptiles appeared. They had larger brains relative to their size than other reptiles. They also had more efficient molars and improved hearing due to the evolution of the three ear bones. At the end of the Triassic, Pangaea split east to west, opening up the Atlantic Ocean. This corresponds with a sudden drop in sea level (graph c) and 76% of species going extinct. Dinosaurs ruled for the next 150 Ma. Pterosaurs with 13 m wingspans took flight. During the Jurassic, the reptilian precursor of birds, Archaeopteryx, appeared. During the Cretaceous, the first flowering plants appeared as did their co-evolving pollinators—ants, bees, and butterflies. The first marsupial and placental mammals evolved. At the end of the Cretaceous, again 76% of species went extinct, this time including the dinosaurs. This is now primarily attributed to a 10 km-wide asteroid hitting Chicxulub on the Yucatan Peninsula of Mexico. The asteroid led to months of darkness, a global firestorm, and decades of greenhouse warming. No animals over 25 kg survived.
Cenozoic (New Life)
The Cenozoic (66 Ma, 66 cm from end) is also known as the "age of mammals." In the Paleocene, the Laramide orogeny formed the Wind River Range. Small insectivorous mammals diversified rapidly to fill niches left vacant by the dinosaurs, such as fruit-eaters, browsers, and carnivores. These included the first primates, Perisodactyla (odd-toed ungulates) and whales evolved in the Eocene. In the Miocene, grazers co-evolved with grasses. Unlike most plants, grasses grow from the base, so they can handle grazing. Just 6 Ma (6 cm), chimpanzees separated from the human line, Hominidae. The Pleistocene had recurring ice ages. Homo habilis, "handy man," the first hominid tool-user appeared 1.6 Ma (1.6 cm). Homo sapiens as a species dates back at least 300,000 years (3 mm). Modern humans, Homo sapiens sapiens (as opposed to H. s. neanderthalensis) appeared 35,000 years ago (1/3 of a mm). They probably didn't arrive in North America until 15,000 years ago (0.15 mm). The Bering land bridge was open 24,000-15,000 years ago, but humans apparently didn't cross until the ice age that caused the low sea levels in the first place, abated. Holocene fauna (e.g. mammoths, saber-toothed cats) often went extinct soon after humans appeared in an area. Lewis and Clark explored the American West with just over 1 μm left on the rope; (1 μm=0.001 mm, 1/500 as thick as a human hair.)

Over the short-term (250,000 years, 0.25 mm), the varying tilt of the earth and shape of our orbit around the sun determine whether we’re in an ice age. But over the long-term (~10 million years, 10 cm), CO2 drives whether or not we’re in an ice age. Currently, we’re between glaciations. But to heat our homes and drive our cars, we’re quickly releasing the carbon in fossil fuel molecules which took 60 million years to store back in the Carboniferous (~300 Ma). Most scientists agree that the 3% increase in atmospheric CO2 since 1750 (to perhaps its 20 million year high) is the cause of the 0.6°C planetary temperature increase over the past 100 years. Future implications for climate and the biosphere are yet to be seen.

Reference:

Astronomy for NOLS Courses: The Astroivy
By Trevor Deighton et al

Astroivies are a great way to get folks interested in sky watching even if you can't fit a formal astrophysics class (see Lon Reisberg's Astrophysics for NOLS Instructors) in your busy schedule. Another option would be to do an astroivy and then a more formal astrophysics class. I would emphasize that I feel it is more important to give folks a fun and interesting introduction looking at stars more than the full astrophysics lecture. It also helps our students to experience this educational model they can mimic in future leadership endeavors.

When planning an astroivy, some things to consider are:
1) Planning so that you're camped in an open area with good views of the sky. 2) Watching the weather throughout the day and making sure it is clear at night. 3) Planning the class so that it doesn’t fall after a long evening meeting or a particularly hard day. 4) The goal is to teach students how to identify a FEW constellations or planets on their own and not overwhelming folks with every factoid you've ever learned about the night sky.

Here is a sample astroivy outline:
Stars versus planets: The basic difference between a star and a planet is that a star emits light produced in its interior by nuclear 'burning', whereas a planet only shines by reflected light. So stars 'twinkle' and planets don't. We can see 2,000 stars with the naked eye, with a radio telescope the number you can see is infinite. Galaxies are clusters of stars. There are thousands of known galaxies each containing billions of stars. All the stars visible in the night sky our contained in our Galaxy, the Milky Way Galaxy. The Milky Way galaxy is shaped like a cookie (Barred Spiral) When we look at the Milky Way we are looking through it. It is called "path of ghosts" by the Vikings, "ashen path" by the Kalahari bushmen, "silver river" by the Chinese, "bed of the Ganges" by Sanskrit. "The Milky Way" is of British Origin. Constellations are groups of stars (which may or may not be actually close to each other) that ancient human cultures have named and formed a myth around. There are 88 named and recognized constellations. Here are some constellations to point out on summer courses in the Northern Hemisphere: Big Dipper: Technically Ursus Major, the Great Bear.
Little Dipper: Technically Ursa Minor, The Little Bear, Polaris, the Pole or North Star is the last star in the "handle. Show students how to find the North star then you have taught students celestial navigation as well.

Cassiopeia: Teach your students to use this big W to find Polaris when the Big Dipper's out of view.

Pleades: "plead" means to sail in Greek as it's appearance marked the start of the sailing season in ancient Greece. Hebrews and Mexicans - hen and her chicks, China - 7 sisters of industry, Subaru in Japan.

Moons can be seen around Earth and Jupiter (with binos.)

Southern Cross: When in the Southern hemisphere, this is used to find South. A graphic training aid helps learn this one.

Astrophysics
Lon Riesberg

Caution: This class has the potential to be confusing and hard to present if you're not well prepared. Definitely do some background reading before attempting to present this class. There are a couple of chapters in Cosmos by Carl Sagan that provide an excellent foundation for this subject. Consider teaching this class after giving each team group a copy of Jim Chisholm's Astronomy Fact Sheet to study first.

1) Basic star science.
   a) Hydrogen is the simplest element with only 1 proton and 1 neutron. Helium is also simple with only 2 protons and 2 neutrons. These elements are the building blocks for everything and comprise 99% of all matter in the universe.
   b) All matter in the universe is attracted because of gravity. A star is born when a LOT of hydrogen and helium atoms are drawn together. The more hydrogen and helium, the bigger the mass and the bigger the gravitational attraction, drawing even more hydrogen and helium. Eventually, gravitational pressures become so great in the center (because of the "weight" of the outer layers) that hydrogen atoms fuse together. This is nuclear fusion and a star is born with light, solar storms, flares, convection currents, etc. Eventually the star finds equilibrium where the collapsing weight of the outer layers becomes supported by the "explosions" happening at the center. (See figure 1)

2) Our Star.
   a) Our sun has been stabilized like this for about 5 billion years. It converts 400 million tons of hydrogen into helium every second! Eventually (5 to 6 billion years from now) the central hydrogen will be all used up (fused into helium). There are a few things that happen here but to keep it simple...fusion stops, and the sun will collapse because there won't be enough interior pressure to counteract the forces of gravity. Eventually, it will collapse so much that the pressure will be enough to fuse helium into carbon and oxygen. Meanwhile, hot hydrogen on the outer layers of the sun will expand outwards as the heavier layers below contract. This expanding hot hydrogen shell will consume Mercury, Venus, and probably the Earth. This phase of a star's life is commonly called a "Red Giant." (See figure 2)

3) Novas.
   a) Novas happen in binary star systems. About 1/3 of all stars are actually "binary star systems" with 2 stars orbiting each other. The stars are generally in different phases of their life cycles and as one enters its "Red Giant" stage and starts spewing hydrogen, the other star flares up when the hydrogen shells interact with it. Think of the barbecue example above. If you throw pine needles onto a bunch of hot, white coals, the pine needles will flare up. That's exactly what the hydrogen from a dying star does when it interacts with another star. (Figure 3)

   b) In our own solar system, it's interesting to note that many scientists regard the planet Jupiter as a "star" that failed. Jupiter gives off twice as much energy as it receives from the sun and, in the infrared spectrum, may even be considered a star. If Jupiter were several times more massive, it would shine by its own light.

4) Large stars.
   a) Large stars still have life in them after burning through all of their hydrogen and helium. A large star will continue to collapse and fuse elements through iron.

   b) If a stars' mass is more than twice that of our sun, it can stably convert hydrogen into helium for only a few million years. Fusion progresses quickly
because of the enormous weight of the star and fusion will continue through all of the elements known. Because of the enormous gravitational pressures and the enormous nuclear forces involved with fusing heavy elements, stars this big have short and violent life cycles. Eventually, it implodes violently and the exterior rebounds violently. This is commonly called a "Supernova" and it’s where all of the heavy elements come from. Because of the abundance of heavy elements on Earth (remember 99% of the universe is hydrogen and helium), many scientists believe that a supernova had something to do with the formation of the earth. People talk about getting out to the wilderness to get back to their roots. Really, our roots are in the stars. Every atom in our bodies was forged in the furnaces of large stars.

c) The Crab Nebula in Taurus was a Supernova in 1054 A.D. From reports around the world, it was easily visible in broad daylight and people were reading by its light at night!

d) Neutron stars and Pulsars are what are left after a Supernova. Tight balls of neutrons, stripped of all protons and electrons are so dense a teaspoonful would pass effortlessly through the Earth like a rock through the air. Neutron stars spin fast and emit a beam of radiation (like a lighthouse). If the Earth happens to be in its beam, it's called a Pulsar.

5) Very large stars. A star with a mass of about 5 times our sun is so massive, nuclear reactions at the core don't prevent it from collapsing. A star this large continues to collapse on itself until it's a small point. It retains immense gravitational pull and even light can't escape.

This is a "Black Hole." Many science fiction stories probe the possibilities of Black Holes. Until recently, many people didn't believe they actually existed. Using Einstein's theories and lots of observation, scientists have discovered several black holes in the past decade.

Teaching tips: I usually teach this as a two-part class. Do the theory in the daylight. Have an "astrovibe" in the evening and have specific stars picked out. Peterson's Guide to the Stars and Planets is an excellent resource for picking out any of the star types discussed in this outline.

Other resources for preparing your astronomy, astrophysics, or astrovibe class are:
1) Toys—inflatable globes are available from the curriculum office and many branches. Red sheets of translucent plastic are great to use with a rubber band as a lense cover for your headlamp so you can look at stars without losing night vision.
2) www.exploratorium.edu/roah/solar_system/ is a website that will "scale" down your model of the universe for the field. For example, if you have an inflatable globe (let's make it the Sun instead of the Earth to get a reasonable scale) that is 10 inches in diameter, you just punch in 10 inches for the diameter of the sun, and you get the size of the Earth (.09 in.) orbit radius (99 ft.) and the size and distances of other planets (Jupiter would be 1 in.) This allows you to create a solar system to scale in the field using rocks, etc.

This can be a very fun and thought-provoking class if you put your heart into it. Sagan says that human consciousness is the stars' expression of intelligence. We are just stardust, after all. Good luck!

**Teaching Taxonomy**

Rick Rochelle

Taxonomy refers to the scientific classification of organisms, as distinguished from taxidermy which is what hunters put on the wall. I teach a 15-45 minute taxonomy class in the first week of each semester, instructor course, and many summer courses. I often do it in conjunction with the first natural history moment. Here's why and how I teach it, plus a bit of background beyond what I teach.

Why Teach Taxonomy

In India, I described my subspline for research to a local biologist. Puzzled, in a Hindi accent he asked, "But what is the real name?" Every organism has a Latin (or Greek) scientific name. Since Latin is a dead language and biologists worldwide agreed to use the first valid scientific name reported the names are universal. When I told my friend "Abies lasiocarpa" his eyes brightened and a fun conversation ensued. Often, scientific names are common—who hasn't heard *Bison*, *Rhodeodendron*, or *Giardia?* If you only work in the US, then referring to a buffalo (*Bison bison*) may get your buffalo) and in India *Bubalus bubalis* (water buffalo). Native Americans used the word kinnikinnik to refer to many plant species they smoked in a pipe. Probably what most of us at NOLS mean when we say "kinnikinnik" is *Aechostaphylos uva-ursi*, variously referred to as bearberry, mountain-box, universe vine, rapper-dandies, barren myrtle, or hog-cranberry. Yet in Canada, kinnikinnik refers to species of *Amelanchier*, the shrub usually called serviceberry in the US. You may not notice the confusion until out of the NOLS arena or your locale, but we are a global school with students from all over. Scientific names reduce the confusion.

These names also apply to extinct organisms, like *Tyrannosaurus rex*, providing a link to evolutionary history. As Wyoming Outdoor Council Staff Ecologist Jerry Freileich said, "A name is a key. It is a link. It is a path to the collective wisdom of all previous naturalists." Taxonomy is a subset of the field of systematics which includes evolutionary and comparative biology. Systematists study relationships and
inherited characteristics. We all know that reptiles have scales and mammals have fur. Knowing some taxonomy makes otherwise isolated facts like these easier to remember, giving our students hooks to hang their learning on. Slowly, one can learn bits of Latin and Greek giving names richer meaning. *Pinus flexilis* is an easy one, for example—lilimber pine. But how about *Pinus albicaulis*? The root "albi-" means white and "-caulis," stem, thus whitebark pine. Incidentally, *wu-arsti* means bear’s fruit. Finally, teaching taxonomy gives us more credibility as educators.

**How to Teach Taxonomy**

I. **Inquire** of your class about their current knowledge.
   *Your students will remember much of this from high school and all you’ll have to do is help remove the cobwebs. Seeing this science in the field will make it much more memorable. During the class, repeatedly mention scientific names and higher taxa they already know (e.g. *Giardia*, *Mammals*).

II. **Give them** reasons to be excited about it.
   *Understanding taxonomy is useful because it:
   
   A. is universal, reduces confusion, and adds richness to the meanings of names

   **Even-toed Hoofed Mammals**
   
   **Order Artiodactyla**
   
   **Family Bovidae**
   
   **Antilocapridae**
   
   Pronghorn
   
   **Cows, Goats, and Sheep**
   
   **Family Bovidae**
   
   Ox-like
   
   Subfamily Bovinae
   
   Goat-like
   
   Subfamily Caprinae
   
   Old world deer
   
   Subfamily Cervinae
   
   New world deer
   
   Subfamily Odocoilinae
   
   Tribe Alceleni
   
   Tribe Odocoilini
   
   **Genus Ovis**
   
   Sheep
   
   **Genus Alces**
   
   Moose
   
   Caribou/Reindeer Male White-tailed
   
   **Antilocapra Bison Ovis Oreamnos Ovis americana bison notchus americanus canadenlis dalli**
   
   Rocky Mt. Desert Dall Stone Rocky Mt. Alaskan Woodland Barren Ground Rocky Mt. Blacktailed

   Subspecies:
   
   *Wapiti* is a Shawnee word which biologists prefer to elk (*Cervus elaphus*) because elk gets confused with elk, which is German for moose (*Alces alces*). In Germany, they call *Cervus elaphus* red deer anyway. *Cervus elaphus* sounds less confusing to me!
Transference
Environmental Leadership: What does a responsible NOLS Alum look like?
Marco Johnson

In the fall of 1987 I received a letter from a semester student I had taught in 1986. The student was writing to tell me about an environmental issue she had become involved in. It seems that a new off ramp, for a local highway, was to be built near the college she was attending. The construction was going to destroy open space and disrupt local fauna. This student chose not only to involve herself in the particular issue, but also to rally like-minded students from her college. The off ramp did get built. While this can be seen as a defeat, I see the overall process as a huge success. This NOLS alumnus showed environmental leadership. She directly attributed her desire to get involved to her NOLS semester and the skills she had learned.

Environmental Studies at NOLS encompasses natural science, ecological principles, a relationship to the land, Leave No Trace camping, personal ethics clarification, and cultural issues. Should a student weave all of these threads into any environmental leadership they show? Is a student’s environmental leadership just as effective if they base their decisions and choices on those beliefs and knowledge areas that are most important to them and the particular issue?

In my opinion, she demonstrated a relationship to the land, a personal land ethic, and a desire to lessen impact on the land. Were some of her decisions also driven by any of the classes we might have taught on natural science or ecological principles? What was most important was that this student acted on a belief that she had, a belief that she could make a difference on an issue that was important to her. She then went on to broaden her impact by getting others involved. She educated others on the pros and cons of the off ramp and rallied a group of people to take a stand on a particular issue. She was able to empower others. Isn’t this what we want for all of our students? Having worked just over two years at NOLS at that time, this episode was a huge re-enforcement that what I was involved in was worthwhile.

Using the adage of “Think Globally, Act Locally” instructors can discuss possible initiatives students can become involved in. Some examples are:
- Examine your own life to see where one can make an impact.
  (Personal recycling, less water use, etc…)
- Is there recycling in the students’ hometown or at their school.
  Is there a program that exists or is there a need to start from scratch?
- Open or green space issues in a student’s local area. Is there a local environmental organization to work for or with?
- Is there an environmental curriculum where the student attends school? How might one go about advocating for environmental classes to be included in the school curriculum?
- Are there local opportunities to guide others in outdoor experiences to give them the opportunity to increase their personal connections to the Earth?

Making Your Expedition A Leave No Trace Trainer Course
Darren Wells

As outdoor instructors, our job on expeditions should entail not just teaching good Leave No Trace camp and travel skills, but also training students to teach LNT to others. This article will give tips and curriculum progression ideas for instructors to certify students as LNT Trainers.

The LNT Trainer Course is a shortened version of the LNT Master Course. Successful graduates of the Trainer Course gain the skills to teach Leave No Trace techniques and ethics to their clients, friends and family. Students should learn the concepts of Leave No Trace and be prepared to teach LNT principles in a variety of settings—schools, camps, parks, wilderness and front country areas.

To teach LNT well, instructors need to be able to explain the history of LNT (See the LNT Inc. Timeline and LNT Inc. Mission and Structure notes below). Additionally, students should be able to tell others where to get LNT resources—such as, the LNT Skills & Ethics Booklets, The Leave No Trace Training Cookbook, and the Soft Paths book and video. The website (www.LNT.org) provides current information on courses, educational skills and ethics literature, research, LNT partners and more. Application forms for LNT courses, scholarships and material donations are also accessible. The content of all LNT materials, including the Skills and Ethics booklets and succinct reference tags, is posted on the website and can be downloaded for printing and distribution. If you do not already have an LNT Master’s Notebook, you should familiarize yourself with the website before your course and download information, such as Development of the U.S. Leave No Trace Program: An Historical Perspective, to take into the field.

Although the general Leave No Trace principles are universal, the Leave No Trace Skills & Ethics booklet series (approximately 24 pages) offers techniques for specific regions or outdoor activities. They are available at each NOLS branch or from the NOLS-LNT Office in Lander. Although new booklets in this series are being written all the time, the current Skills & Ethics booklets available are: Alaskan Tundra, Backcountry Horse Use, Caving, Desert and Canyon Country, Lakes Regions, Mountain Bicycling, North American, Northeast Mountains, Pacific Northwest, Rock Climbing, Rocky Mountains, Southeastern States, Sierra Nevada Mountains, Temperate Coastal Zones, Tropical Rainforest & Wetlands.