Abstract

Developing an Online Course in Geology at Indiana University Purdue University Indianapolis (IUPUI): An Internship

by Christopher William Thomas

This report describes and analyzes an internship in technical and scientific communication during my full-time employment at IUPUI as a Lecturer in Geology. My key project was to develop an online course G107 Environmental Geology. At the time of this internship, development of high quality online courses that equaled learning in on-campus courses was an emerging field. The project entailed the planning, researching, designing, writing, editing, evaluating, and revising an online course. The course consisted of learning modules that contained a compilation of written text, images, animations, and integrated media. Development required analyzing the best practices in online learning and web design, designing the documentation using the best practices of technical communication, and evaluating the success of the project. Specifically, the successful development required a foundation in problem solving, rhetoric and linguistics, technical and scientific writing, and information design. This internship revealed that a strong foundation in scientific communication is a prerequisite for developing online learning media.
Developing an Online Course in Geology at Indiana University Purdue University Indianapolis (IUPUI): An Internship

AN INTERNSHIP

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I want to thank the Department of Geology at Miami University, where I was involved with several projects while attending as a MTSC. Finally, I thank Dr. John Hughes and Dr. Kendall Hauer from the Department of Geology as well as Dr. Jean Lutz and Dr. Michele Simmons and the other MTSC faculty members. Several people at IUPUI assisted in making this internship possible, including Gabe Filippelli, Michelle Hacker, and Tom Janke.
Dedication

INCORRECT  I dedicate this internship to the run-on sentence, regular doses of grammar in the MTSC program (partially) broke my bad run-on sentence habits.

CORRECT  I dedicate this internship to the run-on sentence. Regular doses of grammar in the MTSC program (partially) broke my bad run-on sentence habits.
Chapter 1: Introduction

This report describes and analyzes an internship that occurred between May 2004 and January 2005 during my full-time employment at Indiana University Purdue University-Indianapolis (IUPUI) as a Lecturer in Geology. To complete my internship requirements for a Masters of Technical and Scientific Communication (MTSC) degree at Miami University, I developed an online internet course as part of my job duties. The development of this course was supported by my direct supervisor, Dr. Gabriel Filippelli, but supervised by Mr. Tom Janke, who works as an Instructional Developer for IUPUI’s Center for Teaching and Learning.

The internship included one project: developing and presenting an introductory online geology course. My primary goal was to develop a course that supported student learning using best practices in instructional design, online learning, and online communication. Technical and scientific communication played a very important role in this project, as online courses include a significant writing component and require an understanding of usability and information design. This project used my existing knowledge of geology, that I obtained through a B.S. and M.S. in geology I received prior to entering the MTSC program.

This report is organized into the following framework:

- Chapter 1: Explains the background, stakeholders, and context of my internship
- Chapter 2: Discusses in detail the strategies and choices made while planning and developing an online course.
- Chapter 3: Provides general and specific details on the technical communication processes exercised during the project
- Chapter 4: Analyzes how the MTSC curriculum and Anderson Problem Solving Model supported my problem definition and solutions.

I will continue with Chapter 1 by explaining the organization and structure of IUPUI and the role of the stakeholders within this internship.
About IUPUI

IUPUI is a jointly managed branch campus of both Indiana and Purdue Universities located in downtown Indianapolis, Indiana. It is primarily a commuter campus of 29,000 students, many of whom are non-traditional in background, meaning they did not enroll directly after high school. IUPUI offers associate through PhD degrees, but most students attend while earning their Bachelor’s degrees. IUPUI is divided into separate schools, and the Department of Geology falls under the Purdue School of Science, which is housed in a large building on the main campus quadrangle. IUPUI, the School of Science, and the Department of Geology were growing in size during this internship; the whole campus was considered by many to be “up and coming” and continually growing in academic reputation and national status.

School of Science / Department of Geology

The Purdue School of Science includes 8 departments, ranging from psychology to physics. Each department is managed individually by the department chairperson under the direction of a dean. Although part of a Purdue school, the Department of Geology awards degrees through Indiana University, and is managed by Indiana University—which manages the facilities and issues the paychecks. The Department includes 11 faculty members and seven staff members, several whom work within its Center for Earth and Environmental Science (CEES). The department offers Bachelor’s and Master’s degrees in geology, and in 2005 was in the process of adding an additional bachelors degree in environmental science and a PhD degree involving applied geosciences. Part of the department’s mission is to teach service courses at the 100-level for students across the university who need to fulfill a program-specific science requirement. The department recruits most of its undergraduate majors from these courses.

Online Course Development at IUPUI

With many non-traditional commuter students who have children, maintain full-time jobs, or live outside Indianapolis, online courses at IUPUI provide a “customer-friendly” medium for students to engage in learning without the hassles of schedule conflicts or parking on campus. However, many of the first generation of online courses (1998-2002) proved unsuccessful, unacceptable, or
unsustainable.\textsuperscript{1,2} To respond to this problem, IUPUI’s Center for Teaching and Learning developed an Online IUPUI initiative to expand the number and quality of online courses on campus. The mission of the Center for Teaching and Learning is to help faculty achieve excellence in their teaching through a wide range of support services in instructional design and development, instructional technology, and information resources. To meet the initiative’s goals, the Jump Start program was developed to provide free and in-depth instructional development support for developing online courses. I applied to this program, and was accepted to the Summer 2004 cohort with nine other faculty from across the University. The Jump Start program is designed to overcome many of the barriers that prevent faculty from developing quality online courses. Admission into the program included a stipend and internal university support.

The program consisted of a three day workshop followed by three months of continuing support from university resources. During the workshop, each faculty member was teamed with a graphic designer, instructional designer or developer, librarian, web designer, multimedia developer, and copyright manager. The roles of these stakeholders are explained later in this chapter. The three month support included continued support from the instructional developer, web designer, and multimedia developer. Outside the Jump Start program, the instructional developers do not offer this high level of support to faculty members, and the web designer and multimedia developers work on a fee schedule.

**Online Courses in Geology**

Prior to my hiring in January 2004, the department offered two “off campus” courses. One course was a video course, G135 Indiana Geology, developed by a retiring faculty member. The other online course, G132 Environmental Problems, had languished for a variety of reasons. Although offered on the internet, G132 was run as a textbook correspondence course. Students read the textbook, and completed online homework and quizzes provided by the textbook company. Dr. Filippelli asked if I could redevelop and expand our online geology curriculum, based on my background and interests in technical communication. For this internship and my

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\textsuperscript{1} As a note to anyone reading this in the distant future (after 2005), online learning was still in its infancy, even though many corporations had transitioned to online training at this time.

application into the Jump Start program, I chose to develop an online version of our most popular course, G107 Environmental Geology, a semester long (15 week) course. I chose G107 because it was our most popular on campus course, and it would replace the G132 course, which was unfortunately a replica of the G107 course.

Culture and Organization

IUPUI is a non-traditional campus compared to Miami University (Oxford); IUPUI has an average student age of 25, and students on average work 25 or more hours a week in regular jobs. Less than 10% of students reside on campus; most live at home or live in apartments around Indianapolis. It is very typical for students to work 40 hours a week and take several classes, or enroll full-time while raising children.

The Department of Geology is one of the smallest departments in the School of Science. The department teaches a lot of service courses with 50-100 students in each course section; upper-level courses have 5-15 students per class. The department is relatively well funded; however, the department typically has trouble recruiting undergraduates to major into geology. The reasons are uncertain; however, the 100-level classes are the best opportunity to recruit new majors due to a high volume of students that includes a higher proportion of undecided majors.

Based on the metaphor concepts of organizational communication\(^3\), the department behaves organizationally as an organism. Leadership is decentralized, with decision making occurring at the individual faculty and staff levels or by consensus. Each individual acts as a subsystem of the organism with a strong emphasis on self control and creativity. “Adhocracies” are formed to deal with specific issues or problems, either by established or one-time committees. Based on this system, the development of this online course was driven by my own initiative and my acceptance into the Jump Start program. The project operated nearly independently of the organization, culture, or politics of the department.

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Stakeholder and Their Roles

Because of the organization of the Department of Geology, I completed this internship by primarily working with people outside of our department. My primary contact and supervisor, Mr. Janke, is part of the Center for Teaching and Learning (CTL), a non-departmental administrative support group housed within the IUPUI main library. The CTL provided the funding and general supervision for this internship. My writing mentor, whose responsibilities were external to IUPUI, provided me with an external view of the progress and success of my project. Other participants who impacted this internship and their role are also explained below. The power and relationships between these stakeholders are shown in Figure 1.

![Diagram of stakeholder relationships](image)

**Figure 1.** The relationships of the stakeholders as shown on a Venn diagram. The size of the circles indicates the importance of the stakeholder to the project. Overlapping indicates how the stakeholders interacted.

Dr. Filippelli, Chairperson, Department of Geology

Routine decision making in the department is made by Dr. Filippelli; major decisions are made by the faculty at monthly meetings. Since I was hired as a faculty member, Dr. Filippelli gave me and the other faculty members complete freedom to make our own decisions about how we design and teach courses. Prior to the start of the internship, I met briefly with Dr. Filippelli and explained my goals for this project. He concurred that G107 would best meet the department’s
needs as an online courses and reiterated his commitment to expanding our online curriculum. Aside from this pre-internship meeting, Dr. Filippelli did not play any other role in the decisions or progress made in this internship.

**Ms. Michelle Hacker, Administrative Coordinator**

The only other member of the geology department who provided input on this project during the internship period was our administrative coordinator. Ms. Hacker had recently earned her masters in Adult Education with a focus on distance learning, and she was frustrated by the quality of our existing online course offerings. Ms. Hacker provided feedback on the history of the online courses within the department, and based on her background and interests shared some of her own ideas on how to improve the courses. At the end of the internship, Ms. Hacker left the department to become an assistant director of financial aid.

**Tom Janke, Instructional Developer**

Mr. Janke, or Tom, was my primary contact and “supervisor” for this internship. He acted entirely as a mentor or coach, and his only supervisory role was to ensure my project met the project deadlines required for receiving my stipend. Tom’s background is in teaching and playing music, but through his use of technology in music he migrated to the role of instructional developer. Tom was responsible for managing the development of the online course, teaching me numerous types of available technology, planning my project schedule, coordinating with other university employees, and troubleshooting any problems. Additionally, Tom advised me on making the best choices in the design of this project. In May, I worked directly with Tom for 3 full days, with subsequent meetings every week through the end of August. From September through December, I met with Tom intermittently.

**Sally Neal, Librarian**

Ms. Neal is the Assistant Librarian for Science, Engineering & Technology, Informatics, and Nursing (SETIN) Team within the University Library. She coordinated my use of library resources in my project. She helped develop a library resources module for my project and advised me on resources I could include in my project. I met with Sally intermittently throughout the internship.
**Erik Scull, Web Developer**

Erik is a member of IUPUI’s Digital Media Services, an administrative division that provides for fee support to academic departments. As part of my acceptance into the Jump Start program, Erik’s services were provided for free. Erik was responsible for completing all the web development required for my project. I met with Erik intermittently throughout the internship. As a note, Tom, Sally, and Erik worked within different operating units within the University that normally do not work with each other. As part of the campus-wide IUPUI Online Initiative and Jump Start program, they formed a cross-disciplinary team to assist the development of my project.

**Dr. Kendall Hauer, Writing Mentor**

Dr. Hauer is the interim director of Miami University’s Limper Geology Museum. I chose Dr. Hauer as my mentor based on his interests in geoscience education and his previous interaction with the MTSC program. I worked with Dr. Hauer by email and phone. Dr. Hauer provided feedback on the decisions I made throughout the internship and also provided detailed and helpful editing and feedback on select portions of my writing.

**Chris Thomas, Lecturer (Content Developer)**

I was hired as a full-time faculty level lecturer at IUPUI to teach undergraduate courses, primarily at the freshman and sophomore level. Additionally, as a faculty member, I had additional duties similar to the other tenured and tenure-track faculty. As a faculty member, I was entirely responsible for the choices I made in creating this online course. My role was to determine the audience, content, technology, and delivery of the online course, as well as determine the timeline for completing the project. During the internship, I developed and obtained graphics, and researched and wrote content. Finally, I also managed and taught this course in fall 2004. This internship also covered the teaching of this course so I could evaluate the usability. Many of my choices were guided by what I had learned from the MTSC program and my previous employment as a software technical writer for a defense contractor. Additionally, my teaching experience as a graduate teaching assistant at Miami University and Vanderbilt University aided my decision making.
Other Team Members

As I noted earlier, the Jump Start program offered me support from other university staff members. These people played a minor role in this project, but included a graphic artist, copyright manager, multimedia artist, and other instructional designers.
Chapter 2: Strategies for Developing an Online Course

In this Chapter, I describe some problematic approaches to designing online learning materials and describe strategies I incorporated to avoid these approaches in developing the materials for G107. Specific strategies I would like to draw attention to include my strategies towards:

- Rhetorical choices
- Content choices
- Design choices
- Pedagogical Choices

Since demand for online courses has outpaced the ability of faculty to learn how to develop them, the following undesirable strategies are frequently found in online learning. These approaches towards communicating and teaching in an online medium go against many of the goals of online learning and web design that are explained later in this chapter and the references within. I will use these strategies to discuss my approach, which is further described in Chapter 4 as I place my strategy in the context of the Anderson Problem Solving Model.

First, I would like to explain some of the common problematic design approaches to online learning, both in terms of general strategies and specific issues.

**Problematic Strategies**

In abbreviated form, most online courses offered in the year 2005 are substandard when compared to their on campus offering. Some developers have created online courses to reduce their teaching duties (often to increase research time) believing that an online course can run itself with minimal instructor interaction. However, many courses usually fail due to a lack of resources or lack of understanding in creating online learning. Many campus educators have labeled online learning as problematic, cost inefficient, or substandard\(^4\), educators continue to add online courses to their curriculum, with enrollment in distance education increasing greatly.

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every year\textsuperscript{5}. The answer to this confusing situation is college administrations are forcing more instructors to create more online courses while providing very limited opportunities to develop quality online courses. Below I explain several broad approaches that are representative of commonly used problematic approaches to online learning.

**Problematic Approaches of Delivery**

The approaches discussed in this section are based on common mistakes witnessed personally, discussed in literature\textsuperscript{6}, or described during the Jump Start workshop.

**Handout Approach.** Many instructors create their on campus course handouts in Microsoft Word and their on campus lectures in Microsoft PowerPoint. To create their online course, instructors simply post the handouts and lectures (designed for an in-class lecture) online in a course management system such as Oncourse. They then tell students to read the textbook, handouts, and lectures asynchronously on their own time. Testing is administered online. The G132 Environmental Problems course, which this project replaced, followed this model. The key problems of this approach are that first the instructor repurposes documentation not meant for online dissemination, which significantly reduces usability and comprehension. Second, it entirely eliminates the element of instructor interaction present in a traditional lecture—the instructor mistakenly assumes students can learn the same information simply by reading the documentation.

**Correspondence Approach.** With a correspondence approach, the instructor creates an online course that students complete on their own time, asynchronously, by primarily using the course textbook. The instructor may create exercises specific to the distance learning environment, but the only online component is the use of the course management system to handle email, turning in assignments, and distributing handouts. In other cases, students simply read the textbook with no other support. This approach closely follows how distance learning courses were managed prior to the existence of the Internet. Wheras some programs (such as Indiana U.-Bloomington) successfully implement this model, many use this approach incorrectly as a cheap and quick


route to online learning. This approach becomes problematic when a developer fails to create exercises that force students to a) apply and demonstrate their knowledge obtained through the readings, and b) engage the instructor and other students.

**Fire Hose Approach.** In this approach, designers push a huge amount of information onto students (like water from a fire hose). Instructors design their lectures for the online course by creating a website that hosts their content. Lacking knowledge of communication or learning, the faculty tend to post an overwhelming amount of information, with numerous images, long paragraphs of text, and a huge numbers of external links on their course webpage. Often, they cross link to information in PowerPoint presentations and Microsoft Word documents, in addition to the online content they created. Some of these courses are managed synchronously while others are managed asynchronously. The key problem is that students are overwhelmed with information or confused by the dispersion and depth of the information.

**Problematic Issues of Delivery**

Assuming an instructor does not choose one of the problematic strategies outlined above, other issues that can cause the usability of an online course to suffer.

- **Isolation:** Isolation occurs when the course manager does not respond immediately to student emails, students have no ability to interface with other students, or students do not feel a physical connection towards the person managing the course.

- **Pacing:** Learning can occur synchronously (everyone learns together—such as a live video distance learning course), asynchronously (everyone learns on his/her own schedule), or semi-synchronous (learning on a semi-rigid schedule with flexibility). If an instructor chooses an inappropriate pace for their specific audience, learning ability will decline.

- **Confusion:** A poorly designed interface or course management system will force students to spend more time on navigating or searching for content than studying the material. The location of learning materials should be as intuitive as possible.
• **Reading Fatigue:** Online courses that rely on excessive reading decrease learning and engagement by the students.\(^7\) Online learning must be dynamic and include other methods of engagement besides reading.

**Communication Strategies**

There are many common strategies to creating an online course as defined by the Jump Start program and the Center for Teaching and Learning at IUPUI, as well as within the instructional design community\(^8,9\). I specifically address a few I believe were relevant to technical communication and important to the design of the project.

**Rhetorical Choices**

In order to combat the problems of isolation and reading fatigue, I decided to use a conversational voice for my course content. My desire was to create a dialog that mimicked a verbal dialog I would use in a classroom. A conversational tone can reduce reader fatigue by decreasing the distance between the reader and the writer—so the reader does not feel like they are reading a mundane technical bulletin or narrative. A decreased distance translates into engagement that encourages a reader to continue reading. A formal, passive dialog, common to many science textbooks, places distance between the reader and the author. My goal was to minimize the distance between my audience and me. I did not want the readers to view the online course as a “black box” managed by an unseen person behind a curtain. With the conversational voice, students could more easily imagine the content was speaking directly to them. Below are two examples of this strategy:

(From a module on rivers and floods). It’s been raining the past few days. You are driving to the grocery store on a quick errand when you encounter a stream flooding over the roadway. You never noticed the stream there before, but you notice everyone in front of you is driving their car through the flooded road without a problem.

(From a module on soils). Most of you probably use the engineering definition of soil—meaning any loose earth material. In this section, we will be referring to the geologic definition of soil (which is commonly referred to as “top soil”).

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Content Choices

One of the key issues I dealt with in content choices was selecting a textbook. Most textbooks now come bundled with multimedia materials, including videos, graphics, and animations. Early in the development process, I determined I needed a strong mix of media elements to fight reader fatigue. My decision was based on which vendor provided the best multimedia and could also give my copyright permission to use these media within my course. I ended up choosing Pearson- Prentice Hall, one of the leaders in the geoscience textbook market, because they would allow me access to their full suite of animations and graphics across their entire geoscience textbook series, as long as I adopted their Introduction to Environmental Geology textbook.

In addition to multimedia, I sought to bring in selected dynamic material to add to the text and images within each module. I also integrated audio, video, and text news stories from mainstream news media into select modules, where appropriate, to accompany my narratives. Research into online learning and online design\(^\text{10}\) indicates that using various types of content can fight reader fatigue and boredom.

Design Choices

Many online courses suffer from students having to learn how to navigate a course’s infrastructure. I chose a design infrastructure of the course content that approximated other online courses created by the Jump Start program. The design is fairly simple and approximates many well-designed websites that have simple layouts, and internal links along the left margin and top of the page. Examples of other design choices that increase readability include limiting the amount of content per page, chunking information into small paragraphs, and mixing a combination of text, images, and graphics on every page.

Additionally, the first module within the course includes a tutorial that explains to the students how to use the course. Integrating an audio-visual presentation into the module allowed me to explain the organization of the website, the location of key information, and the features of the course management system. I thought this tutorial was key to preventing confusion by users

who were not familiar with Oncourse, had never taken an online course before, or were not comfortable with using websites.

**Pedagogical Choices**

One of the key differences between online learning (and corporate training) and other online materials is the role of the instructor in leading the users through the content. Unlike a normal website, the instructor has the ability to dictate when students can view content. Regulation occurs by requiring students to complete an assessment (i.e. quiz) that covers a select set of content on a specific date.

The standard model for most online courses is to make all the modules available at once, and have students move through the material asynchronously at their own pace. Research\(^\text{11}\) shows this model is not effective for 100 to 200 level undergraduate courses. Some students will work ahead, cramming as much information as possible early in the semester. Fewer students will pace themselves throughout the semester, while most students will wait until the last moment and cram as much information as possible. The “cramming” effect dilutes the potential for students to recall what they have learned.

I chose a semi-synchronous model for content regulation. Modules were posted on a schedule, usually one week before an assessment. Assessments occurred on fixed dates on the calendar. With this model, students were still given flexibility to chose when to read the modules, but given rigidity that prevent them from working ahead or falling behind.

**A Successful Strategy**

The key to successfully completing this project was clearly defining the problem within a limited scope, and choosing the right approach to minimize these problems. My final project as well as the final projects of many other Jump Start participants were deemed very successful by current standards, but as the standards change over time, the problem definition within online learning will change. The Jump Start workshop served as a collective problem solving session where the

solution, or right approach, was solved by clearly defining the prevalent problems that limited the communication and dissemination of information in an online medium.
Chapter 3: Managing and Developing an Online Course

This internship was designed around the planning, developing, and managing of an online introductory course in geology. The course I developed was Environmental Geology, which I will refer to in the remainder of this internship as G107—the course number. My internship followed the schedule and milestones outlined in Table 1. This schedule, and the other decisions I made in the development process, were based on the training I received during the initial Jump Start workshop, consultations with Tom and other project stakeholders, and my knowledge from my MTSC courses and previous teaching experience. This chapter is organized into the processes I followed to complete this project, organized by the chronology I completed the tasks:

- **Step 1: Organizing and planning**
  - Determine the project variables and plan the objectives
  - Determine the organization and architecture
  - Determine the content areas and modules
- **Step 2: Determining the project schedule**
  - Adjust milestones to meet major deadline
- **Step 3: Developing the content**
  - Research and develop content
  - Develop graphics and the user interface
- **Step 4: Testing the content and revising**

**Organizing and Planning**

Most organization and planning occurred during the initial intensive Jump Start workshop. The workshop consisted of presentations on online learning, cognitive theory, usability and conceptual design testing, learning objectives, visual design, and course design interspersed with team based planning and development sessions.

**Project Variables and Objectives**

The variables and objectives for this project were centered on the audience: freshman through senior IUPUI students who are non-science majors. Assumptions we made about this audience included that the typical user would:
• Access the course via a dial up 56K modem connection (or slow connection) on a computer less than 5 years old.\textsuperscript{12}

• Possess literacy in computer and internet (website) use and range in age from late teens to late 40s in age.

• Own the latest versions of internet browsing software and plug-in software on their computer.

• Access the course via the internet browser program Internet Explorer, the default browser recommended by the campus information technology support.

• Be trained on using the campuses course management system, Oncourse, within which this course would run.

• Make no visits to campus and complete the entire course online.

• Have minimal interest or no previous understanding of science or geology.

In terms of the content and visual design for the course, we made the following assumptions, which were based on principles I learned in the MTSC program and training provided during the Jump Start workshop.

• Use one visual design style for all webpages, in order to unify the content within the course.

• Organize lecture material into modules that students could jump to by hyperlink

• Organize text into chunked paragraphs for easier reading

• Spread information out among numerous pages to minimize scrolling and to increase user activity

• Use multiple subheadings, pictures, sidebars, and graphics to diversify content so users did not get eye fatigue from reading too much text.

• Strategically use hyperlinks to take students to required additional content hosted elsewhere or to connect students to other content of interest.

**Organization and Architecture**

The content I developed for this project would be hosted by Indiana University’s course management system, Oncourse (Figure 2). Course management systems are an intranet-like tool

\textsuperscript{12} As of 2005, 40\% of students still used this type of internet connection, and it was common for some students to have minimal experience with email or the internet—especially some students over the age of 25.
that permit students to access, interact, and manage all courses they are enrolled in. Major functions include announcement posting, hosting of tailored content from the instructor, interactive class rosters, communication tools (email, live chat, discussion groups), online testing tools, and grade book. Because Oncourse provided my project architecture, my purpose was to provide the “Syllabus” and “Schedule” webpage content within the Oncourse architecture.

When the users clicked the link to “Syllabus” and “Schedule” (Figure 2), they would be directed to the content I would be creating. The top portion of the Oncourse webpage remains visible regardless of the tab clicked; however, the bottom portion can be replaced by another custom built webpage that is framed (or nested) within the Oncourse webpage.

![Figure 2. The main Oncourse interface for an individual class. Features are accessed by clicking the tabbed headings.](image)

We chose to organize our course within the Oncourse architecture, and divide our customized information between the “Syllabus” tab and “Schedule” tab. The syllabus tab contains all information not directly related to a course lecture, while the schedule tab contains only lecture content (Figure 3 and Figure 4). We believed this organization would separate lectures (e.g.
what am I learning?) from the logistics (e.g. What is a quiz worth? What is going on this week?). Unfortunately, Oncourse was not designed for online courses but as a resource for on-campus courses, so the “schedule” tab was adopted by me and other designers to hold content (instead of the schedule of events), while the “syllabus” tab contains the actual schedule of events (just as a syllabus handed out on the first day of class contains the schedule of events).

Figure 3. The syllabus tab of the final product. The document is organized by the links on the left-hand side that change the content of the main window. (Note: The weblog space was added after the internship period and is not described here.)

Main Content Areas

Within the Oncourse architecture, we had to determine the specific content and organization within the syllabus and schedule tab. On the syllabus tab (Figure 3 and Appendix A: Syllabus), I chose to organize content into categories defined by the key information about which students most typically have questions. This tab contained typical syllabus-type information, but also
contained information to assist users uneasy or uncertain about taking an online course. Information included:

- Explaining the procedure if a webpage had a problem or a test taking problem occurred.
- Establishing the technology guidelines the student was required to meet
- Explaining who to contact if they required certain assistance.

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Figure 4. The schedule tab of the final product.

On the schedule tab (Figure 4), Tom, Erik, and I determined the best strategy for organizing the course content (which would be normally delivered orally in a classroom). We decided to organize content into modules that represented a “lecture” a student in an on-campus course would attend. The main page of the schedule tab listed all modules; once a student linked to a specific module, the webpage changed to the module’s specific content (Figure 5). The initial version of this project included 19 modules. The module based system, which is explained in more detail in the next section, is based on principles of online learning presented in the Jump Start workshop.
Within my Jump Start development team, we decided to include two links common to both the syllabus and schedule tabs. One link connected students to information on instructor contact; the other link connected to information on library resources. We chose this strategy because these links did not fit well within our architecture but were important enough to be accessible to students at any time.

Figure 5. A module within the course, accessed from the course Schedule tab.

Modules

Based on the training of the Center for Teaching and Learning, I chose to organize information by module. Each module represented a lecture topic (such as earthquakes), mimicking the familiar structure of individual lectures of an on campus course. Students could work through each module at their own pace within the limits of the course schedule. The module concept allows for synchronous learning, where all students work through the course at the same pace module by module. Alternatives to the lecture-module concept include problem-based learning or inquiry based learning models, where students would complete smaller and shorter activities that revolve around solving a particular problem or question. While this is a viable option, I did
not believe I had a strong enough background in educational theory to successfully implement these models. Another suggested alternative is to create long narratives broken into stories, where students progress through the narrative at their own pace and decide their own stopping and starting points. However, this model is recommended for upper level and graduate courses where asynchronous student learning is more successful.

Each module is organized into six content areas (left-hand links that change the content of the main window), plus three global links available that link outside of the lecture. Each module (Appendix B: Course Modules) has a series of main-content links on the left-hand side organized by how the student would sequentially move through the module.

- **Introduction:** Describes the importance of the module, provides a broad overview of the lecture and motivates the student to be interested in the reading.
- **Readings:** Indicates the required readings for the course, along with optional readings and field trips.
- **Objectives:** Lists learning objectives for the student
- **Lecture:** Opens a series of webpages of academic content that includes pictures, sidebars, animations, and links to news media resources.
- **Global View:** Describes how the lecture and readings are integrated with other ideas covered in other modules
- **Assessment:** Gives instructions on how to complete a quiz, discussion group, or homework related to the content.

The “lecture” content area is then organized into subsections that vary by lecture (in the example in Figure 5 the subsections are named “The Differences” and “The Conflict”).

I developed the visual design and layout of the final product in consultation with a graphic designer in the Center for Teaching and Learning. I chose an outdoor image and earthy green and brown colors to mimic the outdoor nature of a geology course.

**Determine the Project Schedule**

Portions of the project schedule were predetermined by my admission into the Jump Start program. The project schedule was determined at the end of the Jump Start workshop, which is
why it is sequentially presented after the project design within this report. Timeline dates and
milestones predefined by the program are asterisked in Table 1. This schedule included a key
milestone of the first day of class, August 24, 2004, when the project had to be operational.
Most of the other milestones related to the completion of individual modules within the project.
As the internship progressed, the development time to complete modules was longer than we
estimated. I made the decision to eliminate two modules that were in the initial schedule to keep
the project on schedule. I believed the audience would prefer fewer, well developed modules in
lieu of more, less developed modules.

By task, my duties throughout the internship are indicated in Figure 6. Most of my time was
spent researching, writing, and design the modules within the project.

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2004</td>
<td>1</td>
<td>Read pre-assigned book “e-Learning and the Science of Instruction” by Clark and Mayer.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Start of Project/Internship</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Complete project schedule, visual design rough draft, full course content outline. Submit prototype design plan</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Submit one prototype module (Volcanoes)</td>
</tr>
<tr>
<td>June 2004</td>
<td>4</td>
<td>Submit the first series of modules to the web developer, receive feedback on prototype module and revise as necessary. (Earthquakes, Volcanoes, Rivers and Floods, Surficial Processes)</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Submit the second series of modules (Geologic Time and Plate Tectonics)</td>
</tr>
<tr>
<td>July 2004</td>
<td>2</td>
<td>Submit the third series of modules (Pollution, Consumerism, Global Warming)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Submit the fourth series of modules (Introduction, Scientific Method, Science and Religion)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Submit the fifth series of modules (Rocks and Minerals, Soils, Other Earth Components)</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Submit the sixth and final series of modules (Resources, Energy, Resource Disposal)</td>
</tr>
<tr>
<td>August 2004</td>
<td>6</td>
<td>Received all developed modules back from the web developer.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Complete testing, editing, and revising of entire project</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Complete any final issues</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Release the course to students</td>
</tr>
<tr>
<td>December 2004</td>
<td>15</td>
<td>Receive feedback from students and evaluate the usability and effectiveness of course content. Revise where necessary.</td>
</tr>
<tr>
<td>January 2005</td>
<td>15</td>
<td>Determine a plan for revising course content. Completion of internship.</td>
</tr>
</tbody>
</table>

*Table 1.* The general project schedule for developing the G107 course.
Figure 6. The allocation of the time spent on each task over the internship period. The teaching of the course is discounted, though writing, editing, and evaluation that occurred as part of the teaching period is included.

**Development**

I spent over 75% of my time in this internship researching and developing content for the course modules. This process involved:

- Choosing a textbook that offered content that best fit my priorities for the course, and offered the best support in terms of access to graphics and animations
- Outlining the major headings and content areas for the “lecture” portion of each module
- Finding images, animations, or online resources (such as news stories) to dynamically support the text
- Conducting research to find new sources of information or verify existing information
- Designing graphics to support the text
- Writing the content

Since I would be the faculty member teaching the course, the topics for each module were determined by my own preferences. Typically it would take me three days to develop one module. I developed each module by writing the content and design notes into a Microsoft Word document (Appendix C: Design Sheets). Once complete, Tom would proofread the content, and offer feedback. After I revised the content based on Tom’s suggestions, I would pass the
document to Erik Skull. Erik would then create the website based on my document. The development process is described in more detail in Chapters 2 and 4 of this report.

**Test and Revise**

During the summer, I received informal user testing feedback about the design of the course interface and course content from my writing mentor, Dr. Hauer, prior to teaching the course. Dr. Hauer provided valuable grammatical and technical edits as well as comments on how to best describe complicated ideas. An example of his comments is found in Appendix D: Mentor’s Feedback.

As part of this internship, I included the teaching of G107 Environmental Geology in the Fall 2004 semester. I received permission to teach the course to a smaller group of students (55 total) who would essentially user test the course. Within a university academic program this is accepted practice when launching a new course. Although I continued some content development, revision, and editing, the goal of including teaching within the internship’s scope was to allow for inclusion of student (or user) feedback. User feedback was collected by comments emailed to me by students, and from end of semester evaluations of the course. Although Indiana University has a user testing lab available at its Bloomington campus, I did not have the time or money within my allocated budget to use this resource. I was comfortable teaching the course for 1 semester as a user test since a majority of the project’s architecture and usability was predetermined by using the Oncourse interface, and I had the ability to test the course’s usability the first semester it was presented.
Chapter 4: Application of Technical Communication Theory to Online Course Development

The curriculum of the MTSC program impacted my decision making process within this internship. In this chapter, I explain how specific areas of the MTSC program related to specific issues I encountered during the internship. As I mentioned in Chapter 3, the Jump Start program included elements that overlapped with ideas presented in the MTSC curriculum. Rather than broadly assessing the impact of the MTSC curriculum, I will address some specific elements that were most relevant to this internship using the lens of the Anderson Problem Solving Model. Through the scope of this model, I explain the role information design, linguistics and rhetoric, and technical and scientific communication played in my problem definition and solution.

Anderson Problem Solving Model

Creating an online course required me to analyze the problems with online learning (as described in Chapter 2) and determine a solution. Within technical communication, the Anderson Problem Solving Model\textsuperscript{13} is an accepted method for using problem solving to improve technical communication processes. I discuss the five steps of the Anderson model within the context of this project below, followed by an analysis of how the model applies to online course development.

Defining the Problem

Prior to the start of this internship, in coordination with Ms. Hacker and initial consultations with the Center for Teaching and Learning, I determined that the design of the current online courses in the Department of Geology was inadequate. At the beginning of this internship, I attended the Jump Start workshop and determined the best approach would be to start an entirely new project (in lieu of revising an existing course). At this stage, the problem was framed in the broad context of the common problems and pitfalls that defined online learning in the year 2004, as defined in Chapter 2. Therefore, my strategy was to avoid the problems that plagued the developers of other online courses. The Jump Start workshop provided the resources to quickly identify these problems.

Other aspects of the problem definition include defining the context and audience of my project. I researched these aspects during the Jump Start Workshop as well. Fortunately, my context and audience was fairly restricted and clear. The Jump Start program clearly outlined the context of my project and provided the resources to overcome the known restraints that hindered online course production. Second, I already had a clear understanding of my audience and their needs given my previous experience teaching at IUPUI.

Role of the Curriculum: Prior to the internship period, Dr. Shulman’s Organizational Communication theory course gave me a foundation for winning acceptance within the department to redevelop an online course (as opposed to status quo or eliminating online teaching). The basic principles are to quickly identify the political and organizational structure, and work within this structure to accomplish a goal. Because Ms. Hacker was interested in seeing the online courses redeveloped, I realized by working with her I could accomplish my goal. Ms. Hacker was most familiar with the political and organizational atmosphere of the department and understood the resources required to accomplish my project. At the time I was a new hire; and without her knowledge I would not have been able to progress quickly from problem definition to solution design.

The Organism metaphor for the Department of Geology’s organization, as described in Chapter 1, allowed this type of change to happen quickly. My project did not represent a major departure from our existing curriculum or pedagogical goals, but rather a change in strategy and resources. As a result, I could implement the change this project represented within the realm of my control fairly easily (moderate to major changes in an academic department can take years to occur).

Designing the Solution

To develop my online course, I relied heavily on the feedback from Ms. Hacker and the Center for Teaching and Learning. They provided the framework for me to transfer my knowledge of on-campus teaching, geology, and science communication into creating online materials. Additionally, Jump Start provided any needed expertise for answering basic questions like: How
should I organize the information? What software should I use? What distribution method should I use?

**Role of the Curriculum:** My design was heavily influenced by the general theories of information design and technical and scientific communication. For example, principles of contrast, repetition, alignment, and proximity\(^{14}\) were my bases for the visual design of the schedule and syllabus tabs. Additionally, I used these principles to guide the design of the modules, such as the size of images, the use of side bars, and limits on page length. Other basic principles, such as font choices, content choices, writing style, writing tone, and the inclusion of a tutorial in the course were driven by a variety of sources covered throughout the MTSC program.\(^{15,16,17}\) Specifically, the linguistics course encouraged me to choose a more informal writing tone that would decrease distance between the text and the reader.

**Testing the Solution**

In this project, I departed from the Anderson model by conducting most of my testing after implementation. As I outlined earlier, user testing was not feasible and standard practice in an academic environment is to test a deliverable such as a course or textbook on an actual class. Despite this challenge, I was able to test some of my solutions as I designed them. First, we created one module at the beginning of the project for the specific purpose of having all project participants critique its effectiveness. Since subsequent modules would be based on the design of this first module, I used the feedback from this test module to implement changes to our design of subsequent modules. The Center for Teaching and Learning staff was able to critique the design and architecture based on their expertise, and my writing mentor was able to test usability, technical accuracy, and writing style based on his expertise.

**Role of the Curriculum:** After reading a variety of prior internship reports, I knew completion of advanced user testing was difficult to accomplish. However, based on the basic user testing

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methods I learned in the MTSC program while completing in-class projects, I learned to critically analyze the limited amount of feedback I gained from the critiques of my project team and writing mentor.

**Implementing the Solution**

Most of my time was spent implementing my solution, primarily through researching and creating copy within each module. Because I chose the module as the structure for most of my content, my primary goal in my implementation was to ensure each module was consistent and of the same quality. The key problem I encountered in this implementation was that the amount of time required to research the content for each module exceeded my expectations when my initial schedule was created. Given this problem, I had to decide whether to do less research (and sacrifice quality) to complete all the planned modules, or to eliminate some of the planned modules. Since I had authority to make this decision, I chose to eliminate some of the planned modules. The eliminated modules would be slowly added to the content over the next year.

**Role of the Curriculum:** Part of the Publications Development Life Cycle\(^{18}\), a tool I used in the MTSC program, is managing change successfully during the implementation of a project. When determining changes to a project, “the least acceptable alternative when you can neither increase schedule or staff is to cut quality.” Based on this premise, I determined early in the project schedule to cut scope in lieu of quality. Fortunately, part of the Jump Start program was to provide an instructional developer to aid in project management. Tom was able to give me a sense of the resources, time, and scope that were appropriate for my project from the onset, since he had previous experience developing similar courses.

**Evaluating the Solution**

The online course was delivered to 55 students who enrolled in the online section of G107 in Fall 2004. As this course was taught throughout Fall 2004, I received valuable feedback from the students who enrolled in the course. This feedback was received in two forms: unsolicited feedback and solicited feedback.

Unsolicited Feedback: One key difference of education in an online environment is the significant amount of email generated by students. Given the distance between the instructor and students, many would freely send unsolicited emails critiquing or praising the course. Many of these discussions were generated by one message (positive or negative) sent by a student to everyone; this would generate a flurry of subsequent emails. Below is an excerpt from one of these discussions which occurred after the internship period:

(Comment 1) It is not that the material is hard per say. The problem is that a 100 level course is supposed to [sic] gage how well a student can grasp the basic concept of the processes, not how well we can navigate websites that are not a part of the class material and retain that material over a matter of weeks.

(Comment 2) I have found that most on-line classes are harder and require more discipline and work than the traditional class. For example, I took COMM R110 speech class on-line last semester and found out later that we were a good three weeks ahead of our counterparts in the traditional class. Bottom line - You signed up for this. It was also CLEAR in the orientation that "On-line doesn't mean anytime" (direct quote from the orientation by the way).

Solicited Feedback: At the end of the course in Fall 2004, students were asked to voluntarily fill out an anonymous online survey that included questions that measured the success of the course in meeting their needs. Examples of questions included:

Please briefly explain how the instructor/online interface helped you to learn.

On a scale of 1-10 (with 5 being the same, 1 much worse, and 10 much better), how does this course compare to other online courses you have taken.

Some of the comments received from this feedback included:

Content was fine. I liked the little quotes that we would sometimes find in our lecture reading material.

The online modules were interesting, well thought out, and a nice change of pace from the video taped lectures of the other independent learning geology courses.

I found this course to be boring and uninteresting. It had nothing to do with Nursing, but some things were helpful to know about the earth and where we live.

I used this feedback to evaluate the success of multiple aspects of the course. My evaluation became my problem definition for the second cycle of the Anderson Problem Solving Model, which guided changes that were implemented the following year in 2005.

Role of the Curriculum: Aspects of the rhetoric and linguistics courses aided my ability to analyze the unsolicited feedback. Some text was straightforward and easy to interpret (the
student specifically indicated an identified problem), while other analysis required reading into a set of general complaints. One major change I made based on the unsolicited feedback was to significantly change how I communicated with students within the course. Using email was not effective in broadcasting messages to students, so in the second run of the course I set up a weblog (a moderated type of discussion board) to facilitate two way communication. In the other case, based on the written feedback, students were having trouble meeting many of the deadlines in the course (the online course required a quiz or homework every week). I realized having multiple deadlines (from 0 to 2 per week) on different days was too confusing to the users. As a result, in the second run of the course all deadlines occurred on Wednesday, and only one item was due per week.

**Analysis**

Problem solving was a prerequisite for developing an online course, and the Anderson model is a useful tool for strategically making decisions. The only major variation is that Step 3 and Step 4 are intermingled in a teaching environment; in my case, most development occurred prior to testing. As an overall analysis of the impact of the MTSC curriculum on this internship, I thought the curriculum was very relevant to this project. However, I would have benefited from a course in instructional design and theory, which is a key element to designing an online learning environment.
Appendix A: Syllabus

The following is a series of screen shots of the syllabus content developed within the course.

Figure 7. The main page of the syllabus tab.
Welcome to Environmental Geology.

This course was developed as part of the Online IUPUI initiative and the Center for Teaching and Learning Jump Start program. The initiative adds more online courses to allow for flexible scheduling of courses for IUPUI students and creates online courses that use the best practices in online learning, online communication, and online testing. This course parallels the material that would be covered in the on-campus sections of Environmental Geology.

There are several primary differences between this course and a course you would take on campus:

Figure 8. The Background page of the syllabus tab.
Figure 9. The Course Guidelines page of the syllabus tab.
Figure 10. The Course Calendar page of the syllabus tab.
Figure 11. The Tests and Homework page of the syllabus tab.
Figure 12. The Research Paper page of the syllabus tab.
Appendix B: Course Modules

The following is a series of screen shots of one course module developed within the course.

**Figure 13.** The Introduction page within a learning module linked from the Schedule tab (Figure 4). This example is from the Earth Science module.
Objectives

This section will help you to:

- give examples of what geologists do.
- identify the key sub-disciplines of geology.
- explain the key scientific principles of geology.
- distinguish the relationship of geology to other sciences.
- identify the general history of the field of geology.
- recognize the role of plate tectonics and the rock cycle to geology.

Figure 14. The Objectives page within a module. This page is scrolled down to show the bottom content.
Readings and Articles

For this section, please:

- Selectively skim and read the Illinois Geological Survey and Indiana Geological Survey websites. Both these websites will give you an idea of what geologists do.
- There is no textbook reading for this section, but you will want to review Chapter 1. The themes discussed here are scattered throughout your textbook.

Additional resources you may check out:

- **Stories from the Underground.** Geotimes magazine published information on earth science in an easy to read format, in language you’d find in a regular news magazine. In this report, the Geotimes staff takes a look at 3 earth scientists whose job involves working underground.
- **Off the Beaten Career Path.** Geotimes magazine takes a look at white collar, blue collar, and pretty off the wall jobs earth scientists are doing.

In case you are bored this weekend:

- Read *Evidence from the Earth: Forensic Geology and Criminal Investigation* by Ray Murray. Could some dirt stuck in a tire solve a murder? Is there a dead body buried under your driveway? Ray Murray combines his expertise as a forensic scientist...
Figure 16. The Lecture page within a course module. This page links into the remaining lecture content, which can be a series of 10-30 additional webpages.
There are a few disciplines often confused with geology, and I would like to explain their differences: geography and archaeology. Geography, while rooted in science, studies the surface features of earth, and the distribution and influence of human life on earth’s surface. Archeology is the study of ancient human civilizations and human cultures. Both geographers and archeologists sometimes work together closely with geologists, because overlap between their interests often occurs.

To fully understand what geologists can do, I wanted to provide the following common scenarios where a geologist would typically become involved:

- **Completing Environmental Impact Statements:** When a large public project is being studied, a geologist will determine the impact of the project on the public health and the health of ecosystems. Example: The planning of I-69 from Indianapolis to Evansville.

- **Assessing Environmental Contamination:** Geologists are often called in to take...
Many of the key principles of geology were first described by the wealthy landowners of the United Kingdom who had a hobby in scientific inquiry in the 1700s and 1800s. While old, millions of scientific experiments have proven their ideas to be correct. Since this time, geologists have used more modern technology to refine the geologic time scale and unify the Theory of Plate Tectonics.

**Rock Cycle:** The rock cycle is a combination of ideas from early geologists. Early geologists recognized that rocks can form by crystallizing out of molten liquid, from the break down of other rocks, or from the heat and pressure of the earth. You will learn more about the rock cycle in another lecture.

**Bowen’s Reaction Series:** A scientist named Bowen recognized that minerals would crystallize out of molten rock in a specific sequence, based on the temperature of the molten rock, and the chemistry of the minerals. In reverse, he noted minerals would melt within a rock in the reverse sequence.

**Did I Break the Law?** Earlier, we learned hypotheses only become theories or law when they stand up to years of scientific inquiry. Well, since there is no “Law of the Periodic Table” or “Theory of Cigarette Smoking Hazards”—but they are both principles the entire scientific community agrees upon.

**Geologic Time:** James Hutton

**Figure 18.** An example of a page within the lecture content.
Figure 19. The Global View page within a course module.
Figure 20. The Assessment page within a course module.
Appendix C: Design Sheets

The following is an example of a design sheet I created in Microsoft Word. This sheet was used in coordination with a set of computer files referenced within the document by the web developer to create the actual web pages.

4.1 -> Introduction

200 million years ago if you wanted to travel to Africa or France, it might involve a 14 hour drive from Indiana. Why?—well all the continents were connected to each other at the time. You are about to learn two of the key concepts of geology: geologic time and plate tectonics. Both of these ideas drive the thinking behind geologic events, earth processes, and modern science. We’ll discover why you cannot drive to Africa today (well at least that’s what they tell me) and why you better be wearing your swimsuit if you lived in Indiana 400 million years ago.

As you learned in the last section, the idea of “geologic time” was coined as early geologists separated their views from the time line people gathered from Western religion. Geologic time is no different from the time shown on your watch or cell phone—it’s the vastness of geologic time that is difficult for the average person to grasp. You will learn how to imagine geologic time, learn the rates of geologic processes, and discover the geologic time scale.

Unlike geologic time, plate tectonics is a more recent theory to science—a theory not totally accepted until the mid 1970s. Plate tectonics, the theory that the earth’s crust is made out of moving plates, was discovered based on good old fashioned rock collecting, along with data collected from modern and sophisticated equipment. Its pretty hard to imagine the continents and oceans are moving around (it makes believing in UFOs seem simple)—so I’ll give you the “mountains” of evidence that support the plate tectonics theory.

Greetings from Indiana! Back in the Ordovician and Silurian time period, Indiana was covered by a shallow sea and located in a tropical climate—much like the Bahamas of today seen in this photo (USGS).

4.2 -> Objectives

This section will help you to:

- use the geologic time scale
- identify the key geologic time periods
- differentiate “human time” from “geologic time”
- distinguish the rates of geologic processes
- describe the internal structure and processes of earth
- identify the mechanism of plate tectonics
- list the evidence for plate tectonics
- list the evidence for geologic time
This is what the earth looked like 94 million years ago when the dinosaurs roamed the earth in the Cretaceous time period. You will learn more about how plate tectonics changed the face of the earth. (PALEOMAP Project, 2003)

http://www.scotese.com/. License is granted for educational uses on the website.

4.3 -> Readings and Articles

For this module, please:

- Read Chapter 1: pages 25-27, and read the sections on the geologic time scale. Know the general events that occurred on the geologic time scale, as well as the starting dates of the four geologic eras (PreCambrian, Paleozoic, Mesozoic, Cenozoic).
- Read Chapter 2

Additional resources you may check out:

- Continents on the Move <http://www.pbs.org/wgbh/nova/ice/continents/> As part of a PBS TV series on the ice age, PBS developed this fun activity for learning about the history of plate tectonics, and the tools used to measure the movement of continents. The website will lead you into other geology documentaries—showing you how plate tectonics connects into a lot of earth’s features. A related plate tectonics activity <http://www.pbs.org/wgbh/aso/tryit/tectonics/index.html#> allows you to interactively move plates apart, together, and past each other.
- Geologic Time Machine <http://www.ucmp.berkeley.edu/help/timeform.html>. This website gives you specific information, pictures, and histories of each geologic time period. You simple click the interactive time scale to find out more about earth’s history.

In case you are bored this weekend:

- Go to Falls of the Ohio State Park <http://www.fallsoftheohio.org/>—which is at the last exit in Indiana prior to crossing I-65 into Louisville. This park features extensive exposures of Devonian (350-400 million years ago) age limestones containing numerous fossils of the ancient seas that once covered Indiana. The state park includes a museum explaining the geologic history of southern Indiana. After your visit you can head into Louisville for a mint julep or hit the casino in Harrison, IN.

4.4 -> Lecture

- Visit the Indiana State Museum <http://www.in.gov/ism/>. The museums’ first floor includes a wonderful and recently opened exhibit on fossils found in Indiana. The exhibit includes representative samples from various geologic time periods. The most exciting part of the exhibit is the ice age fossils—where you can see complete skeletons of the extinct Mastodon and Stag Moose.
The biggest mysteries of geology are answered by the geologic time scale and plate tectonics. They are like the “Periodic Table” or “Evolution” of geology—without geologic time and plate tectonics answers to geologic problems just would not add up.

Please consult your geologic time scale in your text for this portion of the course. (From Keller; Pearson/Prentice Hall).

4.4.1.a-- Geologic Time

John McPhee, a New Yorker writer who wrote several popular books on geology, attempted to capture geologic time by calling it “deep time.” In this excerpt from the book *Deep Time*, McPhee describes a conversation with Princeton University geologist Ken Deffeyes.

“In geologists’ own lives, the least effect of time is that they think in two languages, function on two different scales…A sense of geologic time is the most important thing to suggest to the nongeologist: the slow rate of geologic processes, centimeters per year, with huge effects, if continued for enough years. A million years is a short time—the shortest worth messing with for most problems. You begin tuning your mind to a timescale that is the planet’s time scale.”

What is Old? <h2>

Geologic time is no different from “normal time.” Geologic time consists of seconds, years, decades, and millennium. The only difference is how geologists view time. If you ask the normal person what “really old is”, they’ll probably say a few hundred years, maybe a few thousand years ago. He or she may point to something—like the county courthouse built in 1830 as being really old. To a geologist, “old” means millions of years old. To the normal person, a fast event probably lasts a few minutes to a few hours. To a geologist, a geologic event that happens over a period of 10 million years can be “really fast.”

Look at the example to the right…imagine simply asking people at different stages in their life what “old means.” To a grandparent, old may mean the Depression, or World War II. To an 8th grader, the era before the internet seems “really old.” To a child in 2nd grade, Pre-school seems like a pretty long time ago.

Take a look at the geologic time scale in your textbook in the front part of Chapter 1. This scale is somewhat skewed—the table doesn’t visually show the size of each time period. Look at the far right-hand part of the scale under the column “True Scale.” This gives you a sense of how massive geologic time is. Of the 4.6 billion years Earth has been around, 88% of the time was absent of any significant (complex) life. The scale in the text exaggerates the past 550 million years because most Earth events of interest have only happened in this time frame.

4.4.1.b--

Geologic Metaphors <h2>

Geologists often use metaphors to explain how massive the geologic time scale is. Let’s use a metaphor to give you a sense of the size of geologic time. Let’s use money as an example—if
the earth is 4.6 billion years old—then let’s use $4.6 billion dollars as our example. But money is still a little too abstract—unless you rob banks for a living you probably haven’t held more than a few hundred dollars in your hands. So let’s go buy a bunch of 2005 Porsche 911 Targa Coupe, retailing at $77,600. So using our $4.6 billion, we can buy 59,278 Porsches.

Now on to our example—so our 59,278 Porsches—lined up end to end represents all of geologic time. So how many Porsches equal the PreCambrian time period—the longest time period on Earth at a little over 4 billion years? Well, 52,191 to be exact.

Let’s continue with our metaphor. Dinosaurs appeared in the Triassic time period, 245 million years ago. So how many our Porsches would equal this amount of time? 3,157 Porsches—That isn’t very many of our original amount of 59,278.

Let’s move closer to today. The Rocky Mountains were forming 56 million years ago in the Eocene—that’s equal to 721 Porsches. Human-like mammals first appeared less than 2.5 million years ago—that’s equal to 32 Porsches.

The last ice age ended in Indiana 10,000 years ago—and you cannot even buy a 2005 Porsche with that amount of geologic time—you’d have to settle for buying the engine of the very last Porsche in our line. Of our original $4.6 billion in this metaphor—how much Porsche could you buy with the American Revolution (at around 230 years ago)? Maybe the tail light of the very last Porsche.

Note: 59,278 Porsches is enough Porsches to line up bumper to bumper on the entire portion of I-70 in Indiana, from the Illinois to Ohio state line—with 11 miles of extra cars to spare.

4.4.1.c–>

Geologic Events <h2>

The important geologic events are outlined on the geologic time scale in your text. Let me put some of these events into context. Earth has been a pretty boring place for most of its life. It took almost 2 billion years before bacteria even appeared. It took almost another 2 billion years before complex life evolved. That’s billion—and you thought this semester was long. Prior to about 550 million years ago, no vertebrate animals existed. As the Cambrian time period approached, geologists have found evidence that jellyfish like creatures started to evolve—the 1st sign of complex life on earth.

After 550 million years ago, this geologic party got started. Pretty soon earth was teeming with life. First invertebrates evolved. Fish evolved. Reptiles and amphibians evolved. Trees
evolved. Mammals evolved. Grass evolved. However, most people’s interest in geologic time lies with the dinosaurs and with human evolution.

*Hallucigenia.gif*  *Hallucigenia* is one of many strange soft bodied fossils discovered at the end of the PreCambrian time period. This and many other odd fossils found in a spectacular exposure of rocks in the Canadian Rockies signaled the beginning of quick evolutionary advances of complex life. (Natural Resources Canada).

Dinosaurs first appeared at the beginning of the Triassic period, but they did not flourish and dominate until the Cretaceous time period. Most dinosaurs you are familiar with lived in the Cretaceous Era. As you know, the dinosaur party ended 65 million years ago when they, and many other aquatic and land organisms, went extinct. Geology’s most supported hypothesis on dinosaur extinction is a meteor impact, which cooled the climate and destroyed the plants most dinosaurs relied on. However, this debate continues—some geologists believe it was a combination of factors. Other geologists think disease, not a meteor impact, killed the dinosaurs. Other geologists suggest a super nova (explosion of a star) in a nearby galaxy zapped earth with excessive radiation killed the dinosaurs.

In more recent earth history, geologists and anthropologists have unearthed a wide variety of skeletons that date within the past few million years that show the evolution of “apes” to “humans” It is widely believed these early humans originated in East Africa, prior to migrating to Europe and Asia. Anthropologists estimate about 10,000 to 15,000 years ago humans began forming tribes and began using language and symbols to communicate.

*How was the Time Scale Created?*  The time scale was created in the 1800s and early 1900s, and continues to be refined today. The scale is an arbitrary way for scientists to easily communicate about events in earth’s history. The main time period divisions are based on the careful observations of rock exposures all over Earth in the 1800s and early 1900s. More accurate ages were assigned to time periods when dating of rocks via radioactive decay became available. Divisions between time periods are based on extinctions seen in the rock record, major plate tectonic events, and evolution of certain key fossils, or even climatic changes.

*4.4.1.d- Geologic Rates <h2>*

Take a look at the figure to the right, which comes from your text book. Familiarize yourself with the speed of these earth processes. Some earth processes happen frequently enough for us to notice, like flooding. Others happen so slowly that only scientific experiments and equipment can measure their rates.

*TB01_04_small*  *(From Keller; Pearson/Prentice Hall).*
Our exercise in geologic time should teach you to think big. Take any of these events and multiply them by one million, 10 million, and 100 million—and you should get the picture of what can happen if you sit around and wait long enough. If you were to view the earth on “fast forward” you would see rivers appear and disappear almost instantly; you would see mountains rise up and be eroded back down to flat land. Sea level would zig zag higher and lower. The continents would slowly roam across the planet due to the motions of plate tectonics.

Even relatively slow geologic processes like earthquakes and erosion make sudden appearances in our daily lives. Earthquakes, volcanoes, landslides, and rockfalls are part of our every day lives—but over thousands and millions of years earthquakes move continents, volcanoes build mountains, rockfalls destroy mountains. For example, the old man on the mountain, a state symbol of New Hampshire fell down in 2003 in a rock fall [http://www.geotimes.org/current/feature_oldman.html]. The side of a mountain appeared like a profile of a man’s face—and appears on New Hampshire’s state quarter. Looks like New Hampshire needs a new symbol. While we will never notice an entire mountain range eroding, these small events—like the fall of the old man—eventually will bring down the mountain ranges of New England.

The textbook gives you a great example of what can happen to earth processes given enough time. You can see what unfolds when a river erodes down in a mountains area over the course of 250,000 and 1,000,000 years.

4.4.1.e->

**Geologic Time and Indiana <h2>**

To localize our discussion of geologic time, let’s take a look at geologic events that occurred in Indiana (this brief history is biased towards central Indiana—and ignores some events).

First, Indiana did not exist prior to 1.5 to 1.4 billion years ago—somewhere in this time frame the early North American continent expanded in size to cover the present-day Indiana. You can still find these rocks, but you’ll have to dig down thousands of feet. Drill cores of these rocks are on display at the Indiana State Museum. Then in the Cambrian time period, Indiana became covered with 100s of feet of sand and mud eroded off of a distant Canadian shield, volcanoes near present day Arkansas, or the uprising Appalachian Mountains. These rocks are again buried, but only a few hundred feet below the surface in some areas.

*Did Dinosaurs Roam Indiana?* Nobody knows! Dinosaurs are found in rocks of Mesozoic age—but no Mesozoic rocks are found in Indiana (or any nearby state). One exception is central North Carolina—there, small valleys (called rifts) opened up wide enough and deep enough to collect Mesozoic sediments—and in these sediments dinosaurs were found. These deep valleys were spared from the erosion that wiped out the rest of the Mesozoic rocks in the Eastern U.S.
Between the Ordovician and the Pennsylvanian time periods, a majority of Indiana was submerged under a shallow warm ocean. Great amounts of limestone were deposited, intermixed with sand and mud eroding off of the far away Appalachian Mountains. All of these rocks are exposed in various places around southern Indiana. Then in the Mississippian time period, Indiana emerged from these seas—only to be covered by massive amounts of sand and mud, covered in the newly evolved plants and trees which later formed thick coal beds. While most of these rocks have been eroded off Indiana, they still remain exposed in southwestern Indiana.

Then nothing. Between the Permian and mid Tertiary time periods, any evidence of what happened in Indiana has long been eroded away. All the evidence was washed into the ocean. That’s over a 100 million years of time missing from Indiana! The next significant event recorded in Indiana was the advent of glaciers within the last few million years. Northern Indiana records the scarring and massive deposits of sediment that these glaciers left behind. The glacial debris contains numerous fossils of ice age creatures. Southern Indiana was spared by the glaciers—which is why we can easily find the rocks deposited in the Paleozoic. In northern Indiana, the Paleozoic rocks are buried under 10s to 100s of feet of glacial sediment.

The hills of Brown County State Park, IN expose Mississippian rocks formed as Indiana transitioned from a shallow sea to dry land (Indiana DNR).

Now that we have climbed the mountain of geologic time, we are ready to move on two the next major pillar of geology….plate tectonics.

**4.4.2.a–>Plate Tectonics**

Your textbook has an excellent chapter on plate tectonics. Within the next few pages I will provide some additional resources to help you understand this large, but also complicated, concept.

Let’s start our journey through plate tectonics by summarizing its key concepts:

- The earth’s crust is broken up into plates, or sections.
- These plates are less dense than the mantle, so they float on the mantle.
- Temperature differences in the mantle create convection, which causes the plates to move around.
- These plates move at very slow rates into each other, apart from each other, and rub against each other.
- The continents are formed of thicker crust that is less dense; the oceans are made of thinner crust that is denser.
- In some places, the oceanic plates and continental plates are fused together (such as the Atlantic coast).
- When these crustal plates collide, their differences in density will determine whether they subduct (like in the Western U.S.) or build huge mountain ranges (like in the Himalayas).
A hard boiled egg is a great example of how the earth’s crust is broken up in plates. Other planets, like Mars, are like an unbroken egg—where the shell represents the crust. The earth is like a hard boiled egg you’ve broken…the shell has broken up into different sized pieces. Earth’s thin crust is much like the shell of an egg—extremely thin relative to the interior of the earth.

A view of Earth’s internal structure and their relative sizes. The earth’s interior is divided into the inner core, outer core, mantle, and crust. The crust is sometimes referred to as the lithosphere, and the upper part of the mantle is referred to as the asthenosphere. The two enlargements give you a sense of the size of the crust and upper mantle. (Earth Pearson/Prentice Hall)

4.4.2.b–>

Continental Drift <h2>

While it may appear the plates are unchanging in their position—you’ll have to remember what we learned about geologic time and the rates of geologic processes. The plates move very slowly, a few centimeters per year. But over the course of millions of years—a few centimeters a year adds up. This movement of the plates was coined “continental drift”—but the oceanic plates drift just like the continents do. Two hundred million years ago the continents all collided with each other to form one massive super-continent.

Below is an animation of the break-up of Pangaea that illustrates how Pangea broke apart to form separate continents. You can see this “fast forward” of how Pangaea broke apart to form the current “look” of the globe.

Click the “Animation” button or “View Profile” to learn more.

4.4.2.c–>

Plate Boundaries <h2>

Now that you’ve seen how the plates can move over time, let’s zoom in and see how the different plates move around on the surface. As your book states, there are three kinds of plate boundaries:

<table>
<thead>
<tr>
<th>Plate Boundary Movement</th>
<th>Example Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collisional</td>
<td></td>
</tr>
<tr>
<td>• Continent-Continent</td>
<td>Himalayan Mountains—India/Nepal/Pakistan</td>
</tr>
<tr>
<td>• Ocean-Continent</td>
<td>Japan, Andes Mountains, Cascade Mountains</td>
</tr>
</tbody>
</table>
• Ocean-Ocean

2. Transform Boundaries (slide past each other)
San Andreas Fault, Denali Fault (Alaska)

3. Divergent (spreading ridge, or sea floor spreading)
Iceland, Baja California, Red Sea

The major and minor plate boundaries are shown in the graphic below, along with the current direction of plate movement. The U.S. is currently moving closer to Asia, and further from Europe. The graphic also shows examples of the three main types of plate boundaries. Find the example locations of the plate boundaries listed above on this map.

<02_19small.jpg> A mosaic of rigid plates creates earth’s outer shell. The black jagged lines mark subduction (collisional) zones. Click the picture to see a larger image (this may download slowly) (Earth Pearson/Prentice Hall)

>Note—link the above picture to a pop up window of 02_19large.jpg>

4.4.2.d–>
To expand our journey through plate boundaries, let’s see the relationship between collisional and divergent boundaries.

This animation below shows you how plate tectonics works when an oceanic plate spreads apart at one end (divergent boundary), while being shoved beneath a continental plate at the other end (collisional ocean-continent boundary). Note the “time scale” at the bottom of the animation. What you can see below takes millions of years to happen—but it looks so simple when you speed it up to our sense of time. Press the play icon to view the animation.

<30_seafloor.swf>

If you are confused, take a look at the previous animation on Pangaea and notice how the oceanic and continental plates interact.

Collisional Boundaries <h3>

Why does the oceanic plate get shoved under the continent? Because oceanic plates are denser than continental plates—so when the two collide the continent “floats” over the oceanic plate, forcing it underneath. As the oceanic plate gets shoved (subducted) into the mantle, it creates melting in the upper crust (which forms volcanoes). If two oceanic plates collide, usually small density differences exist (older plates get less dense as they cool) and one of the plates subduct. Again, volcanoes result as one of the plates melt.

4.4.2.e–>
If two continental plates collide—their thickness and equally low density prevents either plate from subducting fully. Instead, the plates pile up to form extremely large and tall mountain ranges. Presently, the Himalayas are the only active place on earth where two continents are fully colliding. This animation below shows you how the Indian plate and the oceanic crust
preceding it collided with Asia, forming the Himalayan Mountains—where the tallest mountains on earth are located.

<02_convmarg_02.swf>

It’s a common misconception that the continents are “moving” through the ocean. This is not true. The only way two continents can collide is if the oceanic plate between them is subducted in the process.

4.4.2.e->

Divergent Boundaries <h3>
Building on our last example, what happens when two plates move apart at a divergent boundary? Does the earth split open? The simple answer is the hot mantle fills in the area with volcanic activity, creating new oceanic crust—this is how new oceans form. This process of sea floor spreading is shown in this movie, where two continents separated by a small ocean (as we see in Baja California) drift apart, forming a new ocean in-between. The processes shown in this movie are sped up to show 10s of millions of years in 10 seconds. Press the play icon to view the animation.

< DivergingPlates.mov> (GEODE3, Pearson/Prentice Hall)

Transform Boundaries <h3>
The final method plates come in contact with each other is at transform boundaries. These boundaries are where plates slide or rub past each other. They don’t collide. A sideswipe automobile accident is a good example of a transform boundary. As mentioned before, the San Andres Fault marks the location where the Pacific plate is sliding northward past the North American plate. Since Los Angeles and San Diego sit on the Pacific plate—eventually they will find their way to Alaska as the Pacific plate continues moving north. California won’t fall in the ocean—this is just a myth of Hollywood movies.

<Place in a Colored Box>

How did Earth end up with continents? Geologists believe the presence of water played a large part in the formation of continents. They believe earth was first covered in an oceanic-like crust—and as the mechanisms of plate tectonics started, some oceanic crust was subducted. The water allowed the plates to partially melt during subduction (by lowering the melting temperature), leaving the dense minerals unmelted deep in the ground, while the less dense minerals melted, came to the surface via volcanoes, and began the formation of continents. Because continents cannot subduct—they can avoid the destructive forces of plate tectonics.

<Place in a Colored Box>

4.4.2.g->
Volcanoes and Earthquakes

The beauty of plate tectonics is it provides a mechanism to describe the presence and location of the majority of earthquakes and volcanoes on earth. The role of volcanoes and earthquakes in plate tectonics are outlined below.

<table>
<thead>
<tr>
<th>Plate Boundary</th>
<th>Volcanoes</th>
<th>Earthquakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spreading Ridge</td>
<td>Numerous</td>
<td>Moderate to Weak</td>
</tr>
<tr>
<td>Continent-Continent Collision</td>
<td>Few</td>
<td>Numerous</td>
</tr>
<tr>
<td>Ocean-Continent Collision</td>
<td>Many</td>
<td>Numerous</td>
</tr>
<tr>
<td>Ocean-Ocean Collisions</td>
<td>Many</td>
<td>Many</td>
</tr>
<tr>
<td>Transform Boundaries</td>
<td>None</td>
<td>Many to Numerous</td>
</tr>
</tbody>
</table>

Note, in some places on earth, multiple types of plate boundaries may occur together. For example, in southern Alaska, a transform boundary between ocean and continental crust is also partially colliding.

Earthquakes occur when two plates are moving past each other—either via collision or sliding past each other. Although you’ll learn later that earthquakes can happen for other reasons, a large majority of earthquakes are directly tied to plate tectonics. The slow gradual movement of the plates builds up stress which leads to the sudden movement of an earthquake.

A majority of volcanic activity is also related to plate tectonics. As shown in your text, most volcanoes are found at the plate boundaries. Like earthquakes, you’ll learn in a later section of the other ways volcanoes can form.

4.4.2.h->

Evidence of Plate Tectonics

Your text provides a list of all the supporting evidence that led geologists to conclude the continents were indeed connected. Your author spreads out the evidence throughout the chapter—so here is the complete list. Asterisked items are discussed in more detail below.

- Most earthquakes and volcanoes are concentrated in certain areas of the earth, many which parallel the ocean-continent boundaries
- The ocean floor records magnetic reversals—indicating it was not formed all at once*
- No ocean floor is older than Jurassic in age
- The ages of the ocean floor progress smoothly from young to old
- Several continents “fit” together like a jigsaw puzzle
- Plate movements are recorded by sensitive satellites and ground based measuring devices*
- Plant and animal fossils on different continents match up exactly
- Sequences of rock formation match up exactly across continents*
- Ridges of newly forming oceanic crust are found in the middle of the ocean
This is only the incomplete list. In more technical detail, geologists have a wealth of other evidence that proves the plates move around the earth.

**Magnetic Reversals.** Your book presents the complex idea of magnetic reversals. In more common terms, the magnetic North pole isn’t always at the North pole. Geologists realize the North and South pole switch positions from time to time—on average every few hundred thousand years. When an igneous rock (which crystallizes from molten earth) forms—Iron-bearing minerals in rocks record where the north pole points. Geologists can use magnetometers on the rock to determine which way the poles pointed when the rock formed. Although the book leads you to think the ocean floor may be “striped” by these magnetic reversals—geologists simply use these striped patterns to illustrate these reversals. The magnetism can only be “seen” by sensitive magnetometers.

<image> (From Keller; Pearson/Prentice Hall).

Geologists discovered that the rocks of the sea floor perfectly record all of these reversals. How do reversals support plate tectonics? The ocean floor could only record millions of years of these reversals if it was constantly forming. If plate tectonics didn’t exist (like on the moon)—we’d expect the entire ocean floor to have formed at the same time—and only record one magnetic direction.

4.4.2.i—>

**Recording Plate Movement**. Within the past 10 years, geologists were given a new tool to measure the movement of plate tectonics. Government Global Positioning System satellites (which power in-car navigation systems, General Motors OnStar®, and allow the U.S. Government to drop bombs on specific houses) are sensitive enough to record small movements on earth’s surface—down a centimeter. Geologists installed sensitive markers on the ground, and waited for results. What did they discover? The plates were moving in the direction and general speed they predicted. Thanks to these satellites, geologists have very accurate estimates of the rate of plate movement.

<image> GPS Base stations like this one in Antarctica are sensitive enough to record the movement of continents (U. of Manitoba)

http://home.cc.umanitoba.ca/~wmoon/esi3/news/more1.htm

**Sequences of Rocks Match.** Early geologists recognized something odd. Sequences of sedimentary rocks in Pennsylvania and New York matched up with sequences in the United Kingdom. As the theory of plate tectonics came together, geologists discovered not only did fossils match up across continents—but in some places the same rocks formations are found split between continents.

<image>

**Do Plate Tectonics Exist Elsewhere?** In Earth’s neighborhood, NASA’s moon missions proved plate tectonics never happened on the moon. The surface of the moon formed all at the same time billions of years ago. The story on Mars is still being debated. The 2004 Mars
missions helped collect more data that will help scientists build a theory. Plate tectonics may have existed at one time on Mars, but today it appears tectonically inactive.

This is the end of our discussion on the evidence of plate tectonics. Please continue on to the Global View, and then the Assessment.

### 4.5-> Global View

The founding of geologic time was based on the observational science of early geologists. A century later, the emerging field of radioactivity verified that the earth was billions of years old. Although geologic time is a tenant of all sciences, biologists and geologists struggle alike in having the science of evolution and geologic time taught in the primary and secondary school systems. Unfortunately, America is still at the level of many developing countries where religious extremism can influence the educational system.

Geologic time leads to some of the ideas of plate tectonics—that given massive amounts of time big things can happen. Originally proposed in the early 1900s, plate tectonics did not become a theory until modern scientific equipment answered the remaining questions geologists had on how continents could possibly move.

The discoveries of geologic time and plate tectonics were lead by average people making interesting observations about their surroundings. These initial discoveries have been supplemented by decades of scientific experiments that have continued to prove the ideas correct, discover new evidence, and pose new questions.

<PlateTectonics.mov> <this could be aligned left or right> This movie shows the locations of major plate boundaries overlain on top of the spinning globe. Press the play icon to view the animation. (GEODE3, Pearson/Prentice Hall)

Please complete this section by taking the assessment. <assessment_on.gif and assessment_off.gif>

### 4.6-> Assessment

In this assessment, you will be submitting two postings to the discussion group. When completing this exercise, please make sure your answer meets the grading criteria guidelines.

1. Post one question to the discussion group—The question should be based on something you don’t understand or want to know more about plate tectonics or geologic time.
2. Post one answer to someone else’s question. You are welcome to answer a question someone else already answered—so long you have something new to add, or you think the previous answer contained errors.

**To Create a Question:**
Questions must be related to plate tectonics or geologic time. While you are welcome to post questions about the evidence for either process, questions cannot be framed with our previous
debate on science and religion (though some of you may see several connections). Your question should be detailed—explain your question, give an example, and tell what type of answer you are looking for.

**Directions for Posting:**
1. Select the “In Touch” tab in Oncourse.
2. Select the Class Discussion Forum link.
3. Choose the Time and Tectonics folder
4. Post a new message.

**To Reply to a Question:**
Since this is an open forum, you may use any resources you have available. For most of you, this probably will mean an internet search. Also consider using specific websites on geology, or books and magazines in the library.

List any sources you use when you answer a question. If you don’t list your sources, you don’t receive credit. If you think someone else answered a question using a lousy or inaccurate source—submit your own answer to the question!

**Directions for Replying:**
1. Select the “In Touch” tab in Oncourse.
2. Select the Class Discussion Forum link.
3. Choose the Time and Tectonics folder
4. Select the message you wish to reply to. The message opens on the right side.
5. Find the “Reply to This Message” header at the bottom of the message
6. Enter your reply below the “Reply to This Message” header.
Appendix D: Mentor’s Feedback

The writing mentor for my project provided feedback on 4 of the modules, both in terms of technical accuracy but also writing style. A sample of these comments is attached, shown using the “comment” feature of Microsoft Word.
Chris,
Here are my comments on the volcanoes unit.
Kendall

Intro Page: [http://www.iupui.edu/~g107cw11_volcanoes/intro01.html](http://www.iupui.edu/~g107cw11_volcanoes/intro01.html)

When people think of geology, they often immediately think of volcanoes. Volcanoes, along with earthquakes, let us know that the earth is “alive” and that its landscape is slowly changing over time. As you learned earlier, volcanic activity is often connected to plate tectonics. In this section, you will discover why volcanoes happen and how they work.

Volcanoes are much more than lava flows. Volcanoes erupt numerous types of earth materials and can cause a chain reaction of dangerous events with other earth processes. Moreover, much of a volcano’s activity actually occurs below the ground. In this module, you’ll learn to classify a volcano based on the type of material it erupts. Additionally, you’ll discover the risks associated with volcanic eruptions.

Equipped with this information, you will learn the three different styles of volcanic activity and take a look at examples of each kind. Once you know how they work, you can understand why Alaska has many volcanoes, whereas Indiana hasn’t had a volcano for over 500 million years. We’ll finish with a look at a few case studies of past volcanic eruptions.

Technically, the page is fine. I like the way the text generates interest in the subject. Also, what about including a definition of the term “volcano”? Given that you only discuss volcanoes in the strict sense (you don’t include calderas and fissure eruptions), you may want to mention these at some point.

Objectives Page: [http://www.iupui.edu/~g107cw11_volcanoes/obj01.html](http://www.iupui.edu/~g107cw11_volcanoes/obj01.html)

- Understand the relationship between volcanoes and plate tectonics

Consider mentioning the influence of volcanic activity on the composition of Earth’s atmosphere.

Readings and Articles Page: [http://www.iupui.edu/~g107cw11_volcanoes/read01.html](http://www.iupui.edu/~g107cw11_volcanoes/read01.html)

- Rent Dante’s Peak (1997) with Pierce Brosnan and Linda Hamilton. The movie is not scientifically accurate because it depicts an unrealistic combination of volcanic hazards (they wouldn’t all happen at the same time at a single volcano). However, it does provide a fairly realistic sense of the hazards associated with volcanoes.

Great additional resources and movie/book choices!
Concepts – page 1 -  

Volcanism is a direct result of the availability of molten (melted) rock below earth’s crust. A volcano is simply an outlet where magma, gases, and fluids from the earth’s mantle and crust escape to the surface. Geologists usually imply a hill or mountain, to differentiate this term from a fissure or caldera. Magma, when it reaches the earth’s surface, is called lava. Magma and lava are both molten rock, but the two terms are used simply to indicate its location relative to the earth’s surface. Each type of volcano has a characteristic style of eruption activity that is a result of the chemistry, temperature, and viscosity of the magma. Magma contains not only the liquid of melted rock, but mineral crystals, dissolved gases, and fluids as well.

A volcano begins when magma is emplaced within or near the earth’s crust in what geologists call a magma chamber. In some cases, the magma cools in the chamber and never reaches the surface. But, when the magma continues to move forcefully toward the surface, its path usually narrows into one or more pipes that pierce the earth’s surface as an opening called a vent. It’s through this vent that magma, gases, and fluids will erupt to build a volcano.

‘Gases’ is the more common spelling of this word.

Concepts – page 2 -  

Every volcano starts as a small vent. Over time (years to millions of years) the continued eruptions from this vent slowly build up into a volcano—or in the case of Hawaii—a volcano big enough to become a state (a bit confusing—the “Big Island” itself is made of 5 volcanoes). Geologists have learned that a magma chamber can be huge—and cover an area equivalent to several counties. Therefore, one magma chamber can lead to the creation of several volcanoes.

In the example to the right, an illustration shows several volcanoes spawned by a single magma chamber sitting within the earth’s crust. The “fissure eruption” example is an example of a newly formed volcano.

Figure A caption – would it be better to include “...and eruption of lava, gases, and ash” to the caption?

Concepts – page 3 -  

WOW – very nice!

Concepts – page 4 -  

Volcanoes typically occur in three types of settings:

1. Mid ocean ridges: As part of plate tectonics, in areas where two plates are moving apart, hot magma will move to fill the void, producing a ridge of volcanoes that produce new oceanic crust.

Examples of a mid ocean ridge volcano include the country of Iceland.

2. Subduction zones: As part of plate tectonics, in areas where one plate is being subducted beneath another, melting will occur. This molten rock will eventually erupt to produce a volcano.

Examples of a subduction zone area volcanoes include the Cascade Mountains in northern California, western Oregon, and western Washington.

3. Hot Spots: Separate from plate tectonics, certain parts of earth’s crust may be subject to excessive heat from the mantle. This heat can produce melting in the crust, which creates a hot spot volcano. The state of Hawaii and Yellowstone National Park are examples of hot spot area volcanoes. The type of material erupted by a hot spot volcano is dependent on whether it is in an oceanic or continental setting.

Concepts – page 5 -  

Deletions: spiked in

Miscellaneous: It’s a change in taxonomy

Deletions: Molten rock

Deletions: It can also contain

Deletions: Stop

Deletions: It

Deletions: A caption – would it be better to include “...and eruption of lava, gases, and ash” to the caption?

Deletions: These tectonic locations

Deletions: Area

Deletions: Plate
Volcanoes are located in many areas familiar and unfamiliar to you. For example, Antarctica has a volcano. Most of the islands in the Caribbean Sea are formed by volcanoes—many which are still active.

**Concepts** — page 6 - [http://www.ipmi.edu/~g107/csw/11_volcanoes/concepts06.html](http://www.ipmi.edu/~g107/csw/11_volcanoes/concepts06.html)

**Lava:** Lava, or molten rock, is the most familiar product of volcanic activity. Lava comes in a wide range of varieties, from runny (low viscosity) basaltic types to thick (high viscosity) rhyolite. Highly viscous lava tends not to flow easily—similar to toothpaste. In contrast, low viscosity lava tends to flow easily, like warm honey. Highly viscous lavas are rich in the element silica (greater than about 70% of the rock), whereas less viscous lavas contain smaller amounts of silica. More viscous lavas tend to form igneous rocks called andesite and rhyolite, which are higher in color. Less viscous lavas usually form basalt, which is typically dark in color. (Chris, the SiO2 wt. % divisions between mafic, intermediate, and felsic are usually given as 45%–52%, 52%–66%, and >66%, respectively.)

All lava, regardless of its viscosity, moves slowly enough that people can evacuate and get out of its way. Although lava can destroy property, it rarely causes deaths. Lava tends to erupt gently from a volcano; explosive eruptions generate pyroclastic materials.

**Pyroclastics:** Pyroclastics are solid material ejected from the vent of a volcano. The smallest form of pyroclastics is volcanic ash, which ranges from fine sand to microscopic in size. The largest pyroclastics are volcanic bombs and blocks, which are the large rocks thrown from the vent of a volcano—these can be the size of a basketball up to the size of a bus! Pyroclastics are usually ejected by explosive eruptions and can move at extremely high speeds. Large amounts of ash can move down the side of a volcano as an ash flow of steaming hot material and gases. Pyroclastics activity can be extremely dangerous for humans, causing deaths from the superheated ash flows and the explosive start of the eruption. A hot ash flow killed 23,000 people on the Caribbean island of Martinique in 1902.

Gasses. Numerous gasses, including several that are poisonous to humans, can be erupted in large quantity from the vent of a volcano. These gasses can be erupted “silently but violently” leaving little sign of warning—because their eruption cause little noise and the gasses are invisible. Because these gasses are denser than air (our air is made of primarily nitrogen and oxygen)—they hug the ground and displace the air. As a result, people can suffocate and die. This risk is rare, but can be severe when it occurs.

**Concepts** — page 7 - [http://www.ipmi.edu/~g107/csw/11_volcanoes/concepts07.html](http://www.ipmi.edu/~g107/csw/11_volcanoes/concepts07.html)

**Secondary Effects**

The eruption of lava, pyroclastics, and gasses combined with the explosions and rumblings of an eruption can cause dangerous secondary effects.

**Earthquakes:** The movement of magma beneath a volcano often causes mild earthquakes. While these earthquakes do not cause significant damage or loss of life, geologists now understand that volcanic activity is usually preceded by a specific type of seismic activity, i.e., harmonic tremors. These earthquakes can be used to predict an impending eruption. Take a look at earthquake monitoring at the Hawaiian Volcano Observatory.

**Fire:** The flow of hot lava and the ejection of hot pyroclastic material can create forest fires or cause towns to catch on fire.

**Debris/Mud Flows:** Perhaps the most dangerous secondary volcanic hazards are debris flows and mud flows. These are collectively known as lahars. Lahars occur when large amounts of volcanic ash, mud, and snow (from the peak of the volcano) or water mix together and move down the steep slope of the volcano. Think of a lahar as a flood of mud. The quick speed of these massive walls of debris are responsible for the largest number of volcano-related deaths around the globe.

**Tsunami/Tidal Waves:** Volcanic eruptions that occur in the ocean can trigger a tidal wave. A tidal wave can be caused by either: 1) an explosive coastal or island eruption sending energy waves into the ocean 2) massive amounts of debris being suddenly dumped into the ocean by an eruption. Tsunami
waves can be caused by other geologic events, but typically form when water is suddenly displaced by some form of energy. Volcano-induced tsunamis are less common but can lead to numerous casualties. Global Cooling: The Krakatoa eruption of 1883 threw so much volcanic ash into the upper atmosphere of Earth that it caused spectacular red sunsets and a slight, but measurable drop in global temperatures for about two years. In the United States, it was known as the year without a summer. Even the smaller eruption of Mt. Pinatubo in 1991 caused a 1 to 2 degree Fahrenheit decrease in global temperatures for a few years.

(Chris, it was the eruption of Tambora in 1815 that resulted in the "year without a summer" in 1816.)

Types – Page 1 - http://www.ipu.edu/~g107cw/11_volcanoes/types/index.html
Shield volcanoes typically occur at hot spots and divergent plate margin settings. These volcanoes emit large amounts of low viscosity, silica-poor lava that build up to form a broad shield profile. They tend to have more frequent eruptions, such as the nearly constant eruptions of the Hawaiian volcano system. Pyroclastics are relatively minor products of shield volcano eruptions. Shield volcanoes that occur in continental hot spot settings can include a mixture of more viscous lavas and contain more pyroclastics and the possibility of explosive caldera-forming eruptions. Kiluaea, on the island of Hawaii, is a great example of a shield volcano created by an oceanic hot spot; whereas Yellowstone National Park is located within a large caldera created by explosive eruptions of a continental hotspot.

Types – Page 2 - http://www.ipu.edu/~g107cw/11_volcanoes/types/02.html
Composite volcanoes are associated with convergent plate margin settings, where one plate is being subducted beneath another. They tend to produce a mixture of gas-rich high and low viscosity lavas and abundant pyroclastics that build up to form the stereotypical cone shape of a volcano. Composite volcanoes typically emit more pyroclastic material than shield volcanoes. They also erupt less frequently and much more explosively than shield volcanoes.

Types – Page 3 - http://www.ipu.edu/~g107cw/11_volcanoes/types/03.html
Both of these styles of volcanism typically occur in convergent plate margin settings. These volcanoes tend to exclusively erupt the high viscosity, silica-rich lava. They either exclusively erupt pyroclastics (in the case of cinder cones), or explosively erupt high viscosity magma (volcanic domes). Lava flows are less common for these types of eruption centers.

Caption, page 3 - Lassen Volcano in Lassen National Park (California) is an example of a volcano that exploded less than 100 years ago. The volcano last erupted in 1917 (C. Thomas).

In addition to the case studies in your book, I want to outline two other important volcanoes and areas of volcanic activity. Mt. Rainier near Seattle, Washington, and Krakatoa in Indonesia. Additional case study information can be found in this article from History Magazine.

Mt. Rainier
Seattle-Tacoma, Washington is perhaps the U.S. city at greatest risk to a volcanic eruption. Even though the state of Hawaii is a volcano—the eruptions are gentle and predictable. This is not the case for Mt. Rainier, the composite volcano that looms within 30 miles of the Seattle-Tacoma metropolitan area in Washington State. Mt. Rainier has erupted several times in human history, including as recently as a few hundred years ago.

As we learned earlier—it's not the lava that places Seattle-Tacoma at risk, it is the possibility of debris flows and ash flows that can travel great distances at high speeds. As the risk map to the right

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shows, a moderate eruption could send debris into the Tacoma suburbs and Puget Sound. The lava flows would only affect the remote areas far away from populated areas.

Because Mt. Rainier is a composite volcano, an eruption could be sudden and violent with little warning. People would not be able to evacuate to avoid the lahars. However, if some warning existed—as was the case in Mt. St. Helens, an evacuation could easily take place. If no warning exists, the Tacoma region could be subjected to a sudden inundation of ash and mud that could easily result in a high rate of casualties.

(Are you sure you want to group lahars and debris flows together? I would prefer to restrict the use of the term lahar to a volcanic mudflow, whereas a debris flow involves the rapid incoherent downslope movement of a mixture of materials—everything on the slope—but for a fairly restricted distance. Note that the hazards figure refers to lahars only.)

Case Studies – Page 2 - [http://www.iguan.edu/~g107cwt/11_volcanoes/casesudy/02.html](http://www.iguan.edu/~g107cwt/11_volcanoes/casesudy/02.html)

Krakatoa

Perhaps the best example of the massive and sudden capabilities of a volcano is Krakatoa. Unlike Hawaii, Krakatoa was an uninhabited composite volcanic island in Indonesia. On August 27, 1883, Krakatoa didn’t just erupt—it literally exploded—the entire volcano and island were destroyed in a massive explosive eruption. The sound of the explosion was heard 3,000 miles away. The ensuing tidal wave caused by the massive shockwave drowned 36,000 people. Eleven cubic miles of the island vanished and were pulverized by the eruption into fine ash and rock particles that blocked out the sun for two days to a distance of 250 miles from the volcano.

Rather than explain the impact of this eruption, I’d like you to listen to a news excerpt of this story. From National Public Radio. In the interview, Geologist and writer Simon Winchester is interviewed about his recent book on the eruption. In this interview, Winchester presents details of how word of the event spread and what it was like near the scene in the days leading up to the blast, and about the short- and long-term aftermath. It’s final explosion created a noise said to be the loudest heard in recorded history.

Global View - [http://www.iguan.edu/~g107cwt/11_volcanoes/global01.html](http://www.iguan.edu/~g107cwt/11_volcanoes/global01.html)

With an understanding of plate tectonics, and how volcanoes, you are adding to your “geologic repertoire” of how the earth works. Although you may not have to worry about outrunning lava flows in Indianapolis, worldwide volcanoes pose a significant risk to human populations. Both your textbook and our lecture point to evidence of how volcanic events can have global impacts. The good news is geologists can predict with some certainty when a volcanic eruption may take place. The U.S. Geological Survey constantly monitors the volcanically active portions of the United States for signs of an upcoming eruption. Geologists have not come up with a strict classification scheme for whether a volcano can be dangerous. A general classification scheme follows:

- **Active:** Recent activity has been measured or an eruption has occurred in the last 200-300 years.
- **Dormant:** No measurable activity, but evidence exists for activity in recorded human history years.
- **Extinct:** No activity in the last 3,000-3000 years. However, extinct volcanoes can come back to life.

(Chris, perhaps a plate tectonics-based approach to classification would be clearer. Active—active in the last few hundred years and located in a plate tectonic setting that suggests continued activity. Dormant—no recent activity, but located in a plate tectonic setting that indicates the potential for continued activity. Extinct—no activity in the last few thousand years and now removed from an active plate tectonic setting. Not expected to show additional activity.)