



NSDL in Pre-service Science Teacher Education

NSDL Annual Meeting
Washington DC, November 1-3, 2010

**Cases compiled by Laura Moin
NSDL - Resource Center
Outreach and Professional Development Manager**

A very simple agenda

■ Introduction

- Why is it important that NSDL has a presence in pre-service science and math teacher education?

■ Cases compiled

■ Your cases

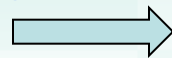
■ Discussion

- Can we synthesize effective models or principles for including NSDL in pre-service science and math teacher education?
- What should NSDL do to more effectively be included in pre-service science and math teacher education?



Introduction

Mid-1990s: first
entire state
digital libraries



Phase 1: getting it started
(growth and initial success)



Phase 2: consolidation
(transition stage)



Phase 3: sustainability
(overarching strategic plan
supported by budget, marketing,
projects, business, operations)

Teachers have to become a strategic focus for the success of digital libraries ... [digital libraries have] to help them change the way they teach.

The school faculty needs to know how to use the electronic resources aligned with state standards

Fuller, D. (2006)

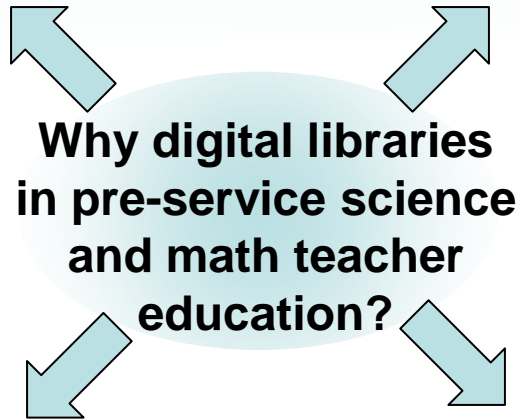
Introduction

The *incunabula* of digital material in SOE libraries

Bull & Sites (2009): Curry School of Education library of the University of Virginia is the first known instance in which a school of education made a transition from physical to digital books. It is likely the harbinger of a significant evolution that will affect both schools and society.

Policy and demographic perspectives

NASBE symposium (December 2009): the need for improved access to OERs is perhaps more critical than ever in light of adequate yearly progress requirements and the growing diversity of the student population, as well as the movement toward voluntary, common state standards.



A new definition of effective teachers

U.S. Secretary of Education Arne Duncan (2009): “This new report reinforces that effective teachers need to incorporate digital content into everyday classes and consider open-source learning management systems, ...”

Providing math & science OER’s PD for school staff is a challenge NASBE

Speak Up 2009 survey – Project Tomorrow
Recker et al. (2005): discoverability of resources by standards
Linn (2003), the kinds of technologies that have had an advantageous impact on instruction are those that support user customization.

Introduction



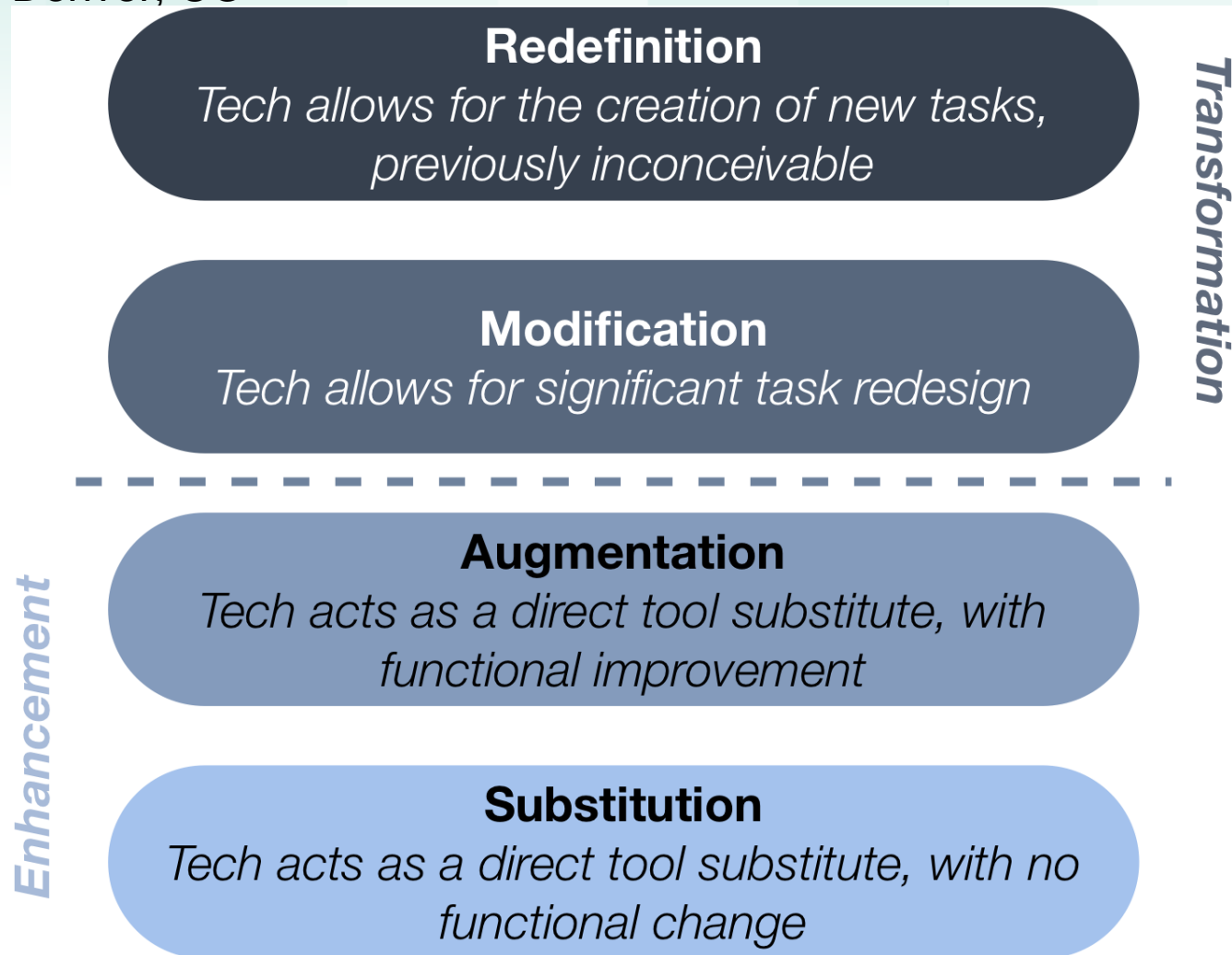
Introduction

Other conclusions from the PW meeting – August 2010, Boulder, CO

- There is a movement toward digitalization of the curriculum
- There is a need to articulate NSDL niche/value-added/unique value propositions by looking comprehensively at systemic educational landscape (pre-service teachers explicitly mentioned)
- Focus on early adopters of instructional digital content

The SAMR Model

Cynthia Curry, Steve Garton, Jeff Mao, and Ruben Puentedura
Leading Teachers from Substitution to Redefinition
ISTE 2010 - Denver, CO



The three cases compiled from
non-NSDL community members

Strand Maps – as a planning tool

The screenshot shows a Mozilla Firefox browser window displaying the NSDL Science Literacy Maps website. The page title is "NSDL Science Literacy Maps: The Nature of Science > Evidence and Reasoning in Inquiry". The main content area features a search bar and a dropdown menu for "Select a Topic". A "Benchmark Details" window is open, showing information for the benchmark "1B/H3 (ID: SMS-BMK-1906)". The details include a description: "Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns." and a "Grade range: 9 - 12". Below the description are tabs for "Top Picks", "NSES Standards", and "Related Benchmarks". The "NSES Standards" tab is active, showing "Results 1 - 3 out of 3". Two results are listed: "On a Wing and a Prayer" and "What Darwin Never Saw". A "9-12" label is positioned to the left of the benchmark details. A diagram at the bottom of the page shows a network of nodes connected by lines, with two callout boxes pointing to specific nodes. One callout box says "Insist that the key assumptions and reasoning in any argument -- whether one's own or that of others -- be made..." and the other says "Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical...". A "Strand Map" window is also visible, showing a network diagram with a red box highlighting a specific node.

NSDL Science Literacy Maps: The Nature of Science > Evidence and Reasoning in Inquiry - Mozilla Firefox

File Edit View History Bookmarks Tools Help Google

http://strandmaps.nsdl.org/?id=SMS-MAP-1200

NSDL Science Literacy Maps: The Nat... Home Help

NSDL NSDL Science Literacy Maps Helping teachers connect concepts, standards, and NSDL resources

Search for maps Search or

The Nature of Science > Evidence and Reasoning in Inquiry Print view Link to this page

View Student Misconceptions

Benchmark Details

Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns. *1B/H3 (ID: SMS-BMK-1906)*

Grade range: 9 - 12

Top Picks NSES Standards Related Benchmarks

Results 1 - 3 out of 3

On a Wing and a Prayer
<http://www.chias.org/www/edu/cse/owphome.html>
America's songbirds are disappearing. But why? This episode of the popular New Explorers documentary series traces the birds' migratory route from Central America, across the Gulf of Mexico, all the way to southern Illinois. By watching the video, you and your students can join a team of researchers and ornithologists on an investigative expedition to find out why these birds are returning ...

What Darwin Never Saw
<http://www.chias.org/www/edu/cse/wdnhome.html>
The great biologist Charles Darwin saw many things in his lifetime. During his travels to the Galapagos Islands, 600 miles off the coast of South America, he witnessed some of the most remarkable types of life found anywhere on earth! Darwin kept detailed journals highlighting the characteristics of species which he noticed. Later, after returning to England, he started a revolution in scientific ...

9-12

Insist that the key assumptions and reasoning in any argument -- whether one's own or that of others -- be made...

Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical...

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THE NATIONAL SCIENCE DIGITAL LIBRARY <http://nsdl.org> NSF NSDL

Case 1

Daniel Timothy (Tim) Gerber: **NSDL Use in “Broader Impacts”**

Assoc. Prof., Biology Dept.

University of Wisconsin – La Crosse

Audience: Pre-service teachers in science methods class
(initial certification for MS and HS science, 80% undergrads, 20% grads)

Task: Look for science lessons (in NSDL, NetLinks, and other sources) and identify the benchmarks they address within a large printout of the NSDL science literacy maps.

Dr. Gerber developed two websites:

Alice Hagar
Curriculum Resource Center

- 1) Topic of interest on the standards docs
- 2) On the NSDL STEM literacy maps, look at:
 - Science, Technology, Engineering, Math & Social Studies (STEMSS)
 - the standards in relation to one another
 - the "misconceptions" section
- 3) Look for lessons already developed (Science NetLinks, NSDL, TULIP, others); use Science NetLinks template
- 4) If they can't find a lesson/unit plan on the topic, build your own lesson plan (smaller topic focus)
- 5) Build own unit plan (larger topic focus)
- 6) Building a Case Study: more focus on one topic
- 7) Building International Connections into a lesson or unit.
- 8) Use books (novels, stories, etc.)

How to Use Site | About Us - STEMSS | Contact Us - STEMSS

Welcome to the STEMSS page of the Murphy Library. This page is designed for teachers, librarians, and others interested in STEMSS education.

STEMSS-Related Educational Standards: AAAS, National Council of Teachers of Mathematics, National Science Foundation, National Council for the Social Studies, National Council of Teachers of Mathematics, and International Technology Teachers Association.

• The nature of Science - Science Education Standards
 • The nature of Engineering - Mathematics Standards
 • The nature of Technology - Technology Standards
 • Human Society - Social Studies Standards
 • Additional STEMSS-Related Standards & Materials
 K-12 Trade Books, Websites, etc.




- The physical world
- The living environment
- The human condition
- Human society
- The designed world
- Mathematics
- Historical perspectives
- Common themes and connections

Other Resources

- Effective Teaching and Learning - Selected Unit Plans
- Reforming Education - STEM educational reform
- Professional STEMSS Societies and Organizations with Educational Outreach Materials
- Professional Learning Societies/Organizations and Teacher-Related Materials
- International Connections - International Connections
- Science Fair Information
- PK-12 Student Websites
- STEM-related Teaching Resources at Murphy Library
- STEMSS Case Studies

Outreach

- TULIP Project
- STEM Professional Development - School Year 2009-10 documents
- SB & F
- Teacher Resource List
- International Connections - Scotland

Teachers Using Living Plants (TULIP)


UW-L

Welcome to the TULIP Project Homepage

About TULIP

- Objectives
- Curriculum Connections
- Projects and Research
- Collaboration with TULIP
- Funding
- Contact Info

NSDL SCOUT REPORTS
LIFE SCIENCES
FEATURED SITE




The **Main purpose** of the TULIP Project is to help improve botanical education by providing information and ideas to pre-service teachers, in-service teachers, and anyone generally interested in botany. The **three objectives** of this website are aimed at promoting better understanding of plants and encouraging their use in the K-12 classroom. The **Secondary purpose** of this site is to improve K-12 science education, in general, by weaving informed recommendations from professional science societies, academies, etc. (e.g., AAAS, 1998; Glenn Commission, 2000; NRC, 2000) into the information provided in this site.

References:

AAAS (American Association for the Advancement of Science). 1998. Blueprints for reform: science, mathematics, and technology education. Oxford University Press. NY.

Glenn Commission. 2000. Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century. <http://www.ed.gov/initi/Math/glenn/index.html>



NRC (National Research Council). 2000. How people learn (Expanded ed.). National Academy Press. Washington, D.C.

Materials on this website are under © 2004 D. Timothy Gerber
If you have comments regarding this site, please direct them to gerber.dan@uwlax.edu.



First, the team develops the HS lesson

Science NetLinks AAAS Search AboutSNL Email

Lessons Tools Resources Benchmarks

9-12 Lesson Plan Navigator 9-12 and 5. The Living Environment Display

Benchmark 3
The Nature of Technology
3C Issues in Technology #4
The human species has a major impact on other species in many ways: reducing the amount of the earth's surface available to those other species, interfering with their food sources, changing the temperature and chemical composition of their habitats, introducing foreign species into their ecosystems, and altering organisms directly through selective breeding and genetic engineering....

Benchmark 5
The Living Environment
5D Interdependence of Life #1
Ecosystems can be reasonably stable over hundreds or thousands of years....
5D Interdependence of Life #3
Human beings are part of the

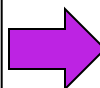
Related Lessons

Simulating Climate Change Research in Grasslands

Purpose
To understand organism interactions and how those interactions shift in response to climate change, especially in grassland communities.

Context
Climate change has been discussed widely in newspapers, magazines, science books, and professional science journals. This lesson provides you with an opportunity to explore the climate change concept with your students in more depth. Many science topics can be explored in relation to climate change. Here, the focus is on how organisms interact (plant competition specifically) and how the dynamics of those interactions may potentially vary based on climate change predictions.
Since there are many physical conditions across the world, we find a variety of ecosystems, such as forests, deserts, oceans, grasslands, and many others. Organisms that live in these ecosystems interact with each other and the environment in various ways, and these interactions are generally stable over hundreds or thousands of years. However, the stability of ecosystems changes with events such as the appearance of new species by migration or evolution, introductions of new species by humans, or, as in this case, climate change. (*Science for All Americans*, pp. 65-66.)
After eighth grade, students should have a basic understanding of the Interdependence of Life Strands: that organisms interact within ecosystems, that ecosystem structure can change, that organisms are dependent on their environment, and that human activities can ultimately have an impact on those ecosystems. (*Benchmarks for Science Literacy*, pp. 65-66.) However, students often have misconceptions about climate change and its effects on ecosystems. Therefore, it is important for teachers to query their students to discover these misconceptions.

Planning Ahead
Materials:



Then, they develop the MS lesson

Science NetLinks AAAS Search AboutSNL Email

Lessons Tools Resources Benchmarks

6-8 Lesson Plan Navigator 6-8 and 5. The Living Environment Display

Benchmark 4
The Physical Setting
4C Processes that Shape the Earth #7
Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere....

Benchmark 5
The Living Environment
5D Interdependence of Life #1
In any particular environment, the growth and survival of organisms depend on the physical conditions....
5F Evolution of Life #2
Individual organisms with certain traits are more likely than others to survive and have offspring....

Related Lessons

Grasslands and Climate Change

Purpose
To understand the underlying ecological properties of grassland communities and to distinguish between short- and long-term responses to climate change, which allows the prediction of changes in grassland reproductive mechanisms and community structure.

Context
Since global climate change can vary local environmental conditions, organisms may need to adapt to new conditions. Will these new environmental conditions change the amounts of fruits and seeds produced by the plants? This is an important question to ask since the new environmental conditions may affect plant survival and reproductive output.
This lesson provides students with an opportunity to explore the climate change concept in greater depth. Many science topics can be explored in relation to climate change. However, here the focus is on plant competition, reproductive output, and how these concepts may vary based on climate change predictions. The emphasis in this lesson is the effect of increasing amounts of water, predicted by global climate change models for some parts of the United States, on the production of fruits and seeds (measures of reproductive output). Equally, some parts of the United States are predicted to get dryer; however, it is easier to simulate water additions rather than trying to simulate dryer conditions.
Organisms that live in ecosystems interact with each other and the environment in various ways. Ecosystems are shaped by the nonliving environment (e.g., land, topography, water, solar radiation, rainfall, mineral concentrations, and temperature). In ecosystems, organisms use vital earth resources, each seeking their share of resources for survival in specific ways that are limited by other organisms. (*Science for All Americans*, pp. 65-6.) Reproduction is also necessary for species survival. Limitations, such as competition, on resource acquisition can limit growth, survival, and affect reproductive output. Change in resource supply and acquisition, whether by competition or changing environmental conditions due to global climate change, can therefore affect species survival by limiting growth and/or changing reproductive output (production of fruits, seeds, cones, or other reproductive plant structures).
By the end of the fifth grade, students should have a basic understanding that for any particular

NSDL Use in “Broader Impacts”

Audience: PD for in-service teachers

Objective: to highlight the functionalities of the interactive NSDL science literacy maps and using them as a method for better understanding K-12 science both horizontally within a grade band and across grade bands.

Task: Examine the structure of the map and its content, find resources that address a given sequence of benchmarks, and discuss the resources and their sequences.



Case 2

Ted Fowler, Professor Emeritus

Kathie Maynard, Visiting Assist. Prof. in Teacher Ed.
CECH, University of Cincinnati

“Re-calibration”

Audience: pre-service and in-service teachers

Re-calibration main features:

- Focus on a particular part, topic, or process of curricular and instructional planning
- Aim at establishing a habit of mind that gets a teacher to engage with rather than side-step weak areas of content
- Teachers need to reflect in a structured manner on what they know themselves and what is known about a topic as they plan and execute instruction

While recalibration can be accomplished in many ways (such as reading or discussing with colleagues), *NSDL* and the interactive *NSDL science literacy maps* facilitate this process.



“Re-calibration”

1. Content coherence through "learning progressions"

2. Missing or mis-understandings

3. Deeper accessing of NSDL resources

4. Deeper Inquiry

5. Richer Design Process

6. Structuring of Project/Problem-Based Learning activities

7. Considering Social Justice

- 1. Identify target benchmark on NSDL science literacy map
- 2. Identify related benchmarks looking for necessary pre-requisite knowledge or analogous knowledge
- 1. Identify mis-understandings
- 2. Identify benchmarks on the NSDL science literacy maps that could be contributing to the mis-understanding
- 3. Assemble relevant instructional activities, using NSDL and other resources.
- 3.1. Assemble relevant instructional activities, using the instructional resources for the primary, NSDL and other resources to address mis-pre-requisite, and following benchmarks
- 1.2. Select an inquiry lesson and identify what the lesson is trying to accomplish
- 2. Using the Atlas Nature of Science map, choose one “big idea” that could improve this lesson and reflect on how it could be accomplished.
- 1. Select a design challenge lesson and identify what the lesson is trying to accomplish
- 2. Using the Atlas Designed World map, choose one “big idea” that could improve this lesson and reflect on how it could be accomplished.
- 1. Using the Atlas Energy Resources map, identify a lesson or unit that could be extended by connecting the topic with an appropriate societal implication strand
- 1. Select a lesson or unit that could be extended by connecting the topic with an appropriate societal implication strand
- 2. Paraphrase the idea into a *PBE Driving Question*.
- 3. Identify sub-questions to get at the details
- 2. Using the Human Society map, choose one “big idea” that could be used to teach the societal implication of the topic being studied.

“Re-calibration”

1. Content coherence through "learning progressions"

1. Identify target benchmark on **NSDL science literacy map**
2. Identify related benchmarks looking for necessary pre-requisite knowledge or analogous knowledge.
3. Assemble relevant instructional activities, using NSDL and other resources.

2. Missing or mis-understandings

1. Identify mis-understandings
2. Identify benchmarks on the NSDL science literacy maps that could be contributing to the mis-understanding
3. Assemble relevant instructional activities, using NSDL and other resources to address mis-understandings.

3. Deeper accessing of NSDL resources

1. Access the instructional resources for the primary, pre-requisite, and following benchmarks
2. Gather a sample that has coherence and is rich in examples and applications.

4. Deeper Inquiry

1. Select an inquiry lesson and identify what the lesson is trying to accomplish
2. Using the **Atlas Nature of Science map**, choose one "big idea" that could improve this lesson and reflect on how it could be accomplished.

5. Richer Design Process

1. Select a design challenge lesson and identify what the lesson is trying to accomplish
2. Using the **Atlas Designed World map**, choose one "big idea" that could improve this lesson and reflect on how it could be accomplished.

6. Structuring of Project/Problem-Based Learning actives

1. Using **the Atlas Energy Resources map**, identify a big idea that could be used to frame a PBL.
2. Paraphrase the idea into a *PBL Driving Question*.
3. Identify sub-questions to get at the details

7. Considering Social Justice

1. Select a lesson or unit that could be extended by connecting the topic with an appropriate societal implication strand.
2. Using the **Human Society map**, choose one "big idea" that could be used to teach the societal implication of the topic being studied.



Case 3

Steven Haderlie: NSDL Use in HS, College Freshman Chem., & Teacher Ed.

Springville High School
Chemistry Dept.

Brigham Young University (BYU)
Provo, UT 84602

Audience:

High School:

- Regular Chemistry and AP Chemistry high school students
- On-line high school chemistry class for BYU Independent Study (asynchronous class that enrolls 1,500 students world-wide)

College:

- Second semester freshman chemistry at BYU in the summer

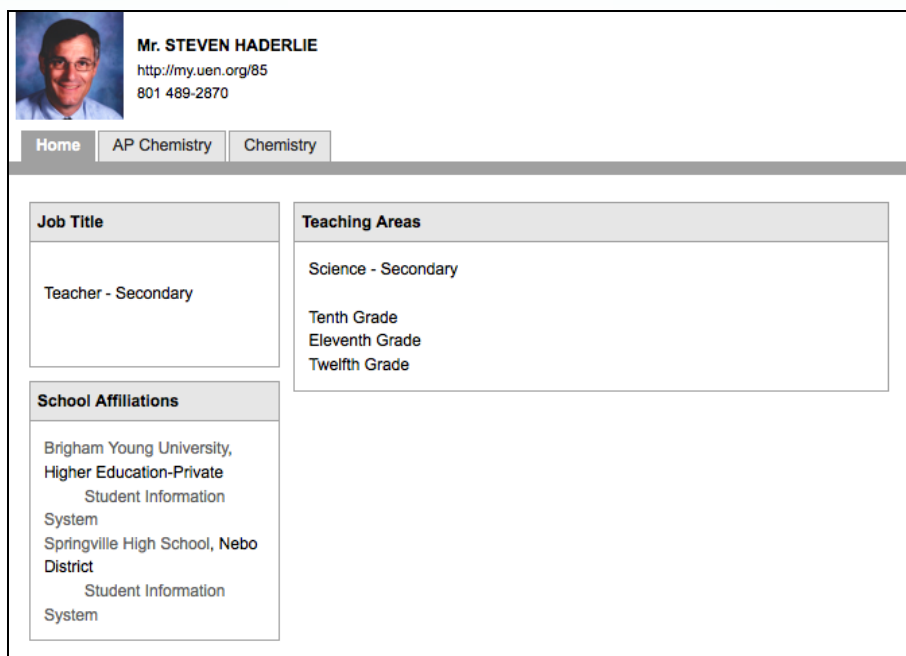
Teacher Ed.:

- Chemistry teaching methods for Chem Ed majors (3-5 students) in winter

Case 3

Steven Haderlie: NSDL Use in HS, College Freshman Chem., & Teacher Ed.

Mr. Haderlie's UT Education Network webpages



Mr. STEVEN HADERLIE
http://my.uen.org/85
801 489-2870

Home AP Chemistry Chemistry

Job Title
Teacher - Secondary

Teaching Areas
Science - Secondary
Tenth Grade
Eleventh Grade
Twelfth Grade

School Affiliations
Brigham Young University,
Higher Education-Private
Student Information
System
Springville High School, Nebo
District
Student Information
System

Mr. Haderlie's HS webpage



Springville High School
Dedicated to Excellence - United in Service - Educated for Success

Home
Announcements
Calendar
School News
Students
Parents
Athletics
Administration
Faculty/Staff
Counseling
Mr. Haderlie's Links
Alumni
SHS Library
Art Museum
Weather
Article of the Week

MR. HADERLIE'S LINKS
Steven Haderlie's Bookmarks
For K - 12 Educational Purposes

- BUSINESS
- CAREER/COUNSELING CENTER
- COMPUTER INFORMATION
- FAMILY/PARENTING
- FAMILY AND CONSUMER SCIENCE/RECIPES
- FINE ARTS
- FOREIGN LANGUAGE
- GENERAL ITEMS
- GOVERNMENT
- HIGHER EDUCATION
- K - 12
- LANGUAGE ARTS
- LDS RESOURCES
- LIBRARY
- MATHEMATICS
- MEDICAL INFORMATION
- MUSEUMS
- PHYSICAL EDUCATION/HEALTH/FITNESS/DIETS
- SCIENCE
- SOCIAL SCIENCE
- SPECIAL EDUCATION
- SPORTS
- TODAY IN HISTORY
- UTAH
- WWW SEARCHING

SHS INFORMATION
Address:
1205 E 900 S
Springville, UT 84663
Phone:
(801) 489-2870
Fax:
(801) 489-2806
Attendance:
(801) 489-2816
Counseling:
(801) 489-2817
Lunch:
(801) 489-2876

Log In

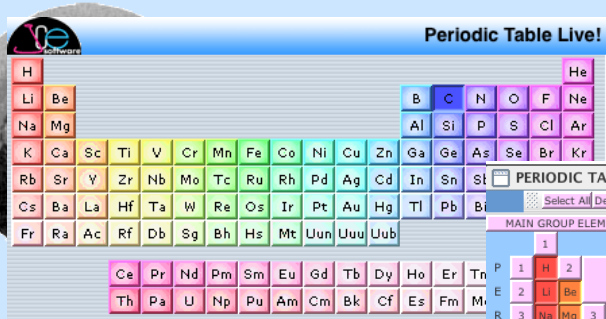
In both sites, Mr. Haderlie includes links for students to use

High School

Periodic Table Live!

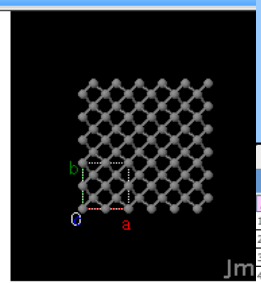
Chart/Sort... Glossary...

- Start!
- Download Required Components
- Charting & Sorting Documentation
- Acknowledgements



Carbon

- Crystal
- Graphite
- Diamond
- Bucky Ball
- Images
- Video



- Display unit cell
- Display lattice
- wireframe
- ball & stick
- Van der Waals
- spin
- Display cell parameters
- Display distances in the cell

PERIODIC TABLE

Select All Deselect All Select Metals Select Non-Metals Select Semi-Metals

MAIN GROUP ELEMENTS

TRANSITION METALS

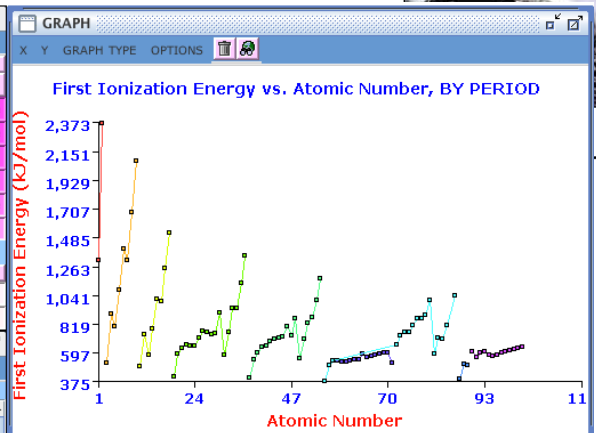
INNER-TRANSITION METALS

*LANTHANIDES

**ACTINIDES

TABLE

Atomic Nu...	Element Sv...	Number of...	First Ioniz...
1	H	1	1312.0496
2	He	2	2372.3236
3	Li	2	520.2217
4	Be	1	899.5035
5	B	2	800.6379
6	C	2	1086.4534
7	N	2	1402.3309
8	O	3	1313.9426
9	F	1	1681.046
10	Ne	3	2080.6669
11	Na	1	495.8457
12	Mg	3	737.7498
13	Al	1	577.5388
14	Si	3	786.5183
15	P	1	1011.8114
16	S	4	999.5887
17	Cl	3	1251.0866
18	Ar	3	1520.9374
19	K	1	418.8099
20	Ca	2	590.7896



They see videos (for example diamond and graphite structures)
They also see the graphs of atomic properties



High School and College freshman classes

Molecules 360 in regular Chemistry high school classes as a visualization tool for molecular geometry

ChemEd DL
Chemical Education Digital Library

Collections Communities Online Services About

Molecules 360

List of Molecules
Use this menu to choose a molecule.
Sulfur Tetrafluoride SF4

Molecule Properties

Display Options:
 Spin Molecule VdW radii Atom Labels

Geometry:
 Show Bond Distances Show Angles

Electronic Properties:
 Show Dipole Charges

Show Electrostatic Map

Show Molecular Orbitals

Symmetry elements for group C_{2v}

No elements selected
C₂
σ₁
σ₂

Normal modes of vibration:

No vibrations selected
N1 A1 187.731
N2 B2 331.265
N3 A2 436.197

View IR Spectrum

From ChemEd DL Labs

We are developing a larger collection of molecule properties. For a sneak preview at this workshop see [A Visual Database of Molecules](#).

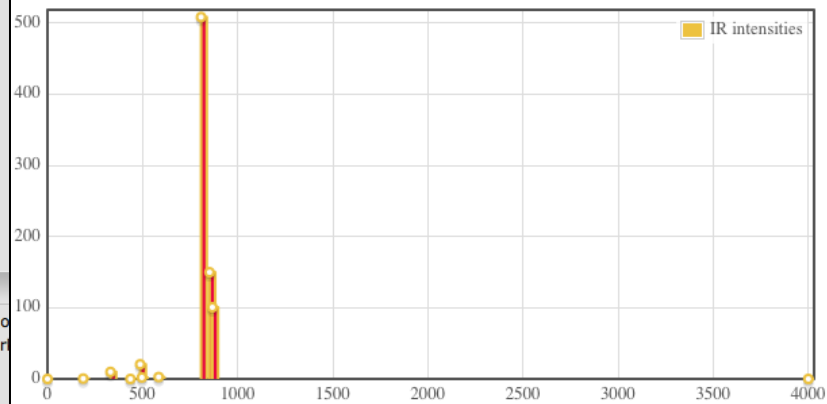
Sulfur Tetrafluoride Jmol

Popup Jmol window

In AP Chemistry and College freshman classes, they also use Molecules 360 to demonstrate how entropy increases with increasing molecular complexity and add vibrational modes linked to IR


IR spectrum

click on the IR bands to see the vibration in Jmol



Stop Vibration

Chemical Education (BYU)



main page | talk | view source | history

Log in / create account

ChemPRIME

v · cp · e ChemPRIME [-]

1. Introduction: The Ambit of Chemistry [+]

Log in / create account

Mars Meteor ALH84001 and Extraterrestrial Life

From ChemPRIME

[back to Properties of Organic Compounds and Other Covalent Substances](#)

The search for life elsewhere in the universe has centered on finding **organic compounds** because they are the stuff of all life on earth. Organic compounds are easily synthesized by abiotic (non-living) processes, however, so the search for extraterrestrial life has occasionally centered on other "biomarkers" (chemical structures that are typically found in living things).

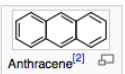
Contents [hide]

- 1 ALH84001
- 2 Abiotic Organic Compounds
- 3 Other Biomarkers
- 4 Weird Life
- 5 Physical Properties
- 6 References

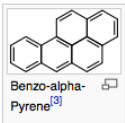
ALH84001

A meteorite from Mars collided with the earth and was collected in 1984 from the Allan Hills region of Antarctica ^[1] and thus designated ALH84001. An asteroid probably collided with Mars, breaking off the chunk which circled the sun for eons before colliding with the earth as a meteorite.

The meteorite contained [PAHs](#) (Polycyclic Aromatic Hydrocarbons) containing rings of six carbon atoms, fused together in arrays like those shown below. Benzo- α -pyrene is formed when meat is barbecued (it may be a carcinogen) and anthracene is found in coal as a relic of it's biological origin.



Anthracene^[2]



Benzo- α -Pyrene^[3]

Note that these organic compounds have even numbers of carbon atoms (a sign of biotic origin). They are considered **organic** because they contains carbon chains and hydrogen atoms (H atoms are not shown in the figure by convention; organic chemists know that there must be hydrogen atoms where necessary to make a total of four bonds to each carbon). Carbon-carbon bonds are quite strong, allowing formation of long chains to which side branches and a variety of functional groups may be attached. Hence the number of molecular structures which can be adopted by organic compounds is extremely large. PAHs are **hydrocarbons** because they contain only carbon and hydrogen, like the simpler hydrocarbon ethane (shown below). Hydrocarbons are further categorized as **alkanes**, **cycloalkanes**, **aromatic compounds**, **alkenes** and **alkynes**.

Organic compounds often also contain oxygen, nitrogen, and small proportions of other elements. Addition elements other than

navigation

- Main Page
- Site News
- Collaboration
- Student Assignments
- Recent changes
- Random page
- ChemEd DL
- Find Resources
- Help

search

Go Search

toolbox

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For help with

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