# Agenda for LTER ASM Working Group: Materials and Resources for *Next Generation Science Standards* Estes Park, Colorado, September 10, 2012 Charles W. (Andy) Anderson, KBS; Alan Berkowitz, BES; John Moore, SGS; Ali Whitmer, SBC

## Abstract

The National Research Council has issued a report: *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* This report is the basis for the *Next Generation Science Standards* (NGSS), currently in development, and scheduled for release in 2013. Twenty-six states have already committed to using these new national standards as the basis for their state standards. These new standards will provide both challenges and opportunities for LTER efforts in K-12 education. In particular, they emphasize scientific inquiry and application practices, and they emphasize climate change and other interactions between Earth systems and human activities. In this session we will (a) review key features of NGSS, (b) discuss ways in which LTER education can help schools to respond to the expectations of NGSS, and (c) share teaching resources that could be used for this purpose.

## Some Useful Links

*Framework for K-12 Science Education: Practices, Cross-cutting Concepts, and Core Ideas* (National Research Council Report and basis for NGSS—free download): <http://www.nap.edu/catalog.php?record_id=13165>

*Next Generation Science Standards* webpage: <http://www.nextgenscience.org/>

Michigan State University Environmental Literacy website (has links for assessments, teaching materials, and professional development resources associated with Carbon, Water, and Biodiversity strands. We will add materials used in this session): <http://edr1.educ.msu.edu/EnvironmentalLit/index.htm>

## Outline of Activities

1. Overview of NRC *Framework for K-12 Science Education* and development of *Next Generation Science Standards (NGSS).*
2. Learning progressions in the NRC *Framework* and our research
3. *NGSS* development process
4. Group work: Connecting LTER education with the *Framework*
5. Materials developed by the *Pathways to Environmental Science Literacy* Math-Science Partnership (MSP)
6. Questions and open discussion of future directions

# Materials on Environmental Literacy Website: Carbon Strand

## Teaching Materials: Plant Growth and Gas Exchange: 2012-13

*Note: All teaching materials are packaged as ZIP file. You can download individual files from the following paragraphs, or download the whole package here.* <Carbon 2012 TE resources.zip>

*Target Grades*: Middle School and High School (modification suggestions for each level are included).

*Description:* The activities in this unit engage students in collecting data about plant growth and gas exchange, then in developing a scientific explanation for their observations. A major focus of the unit is to engage students in the question of where the dry plant matter came from (i.e., not from the soil or water, but from the air), and what plant matter is (it is based on carbon). These activities will lay a foundation for tracing carbon through organisms and ecosystems, improving student understanding of the global carbon cycle.

*Learning Goals:*  This unit is designed to help students make the connections described above by engaging them in two kinds of practices:

1. Inquiry or investigating practices, in which students learn to:

a) Make careful measurements of plants’ dry weight or biomass and gas exchange (absorbing and releasing carbon dioxide) in light and dark conditions, and

b) Construct arguments from evidence about how plants grow and exchange gases with their environment, and how growth and gas exchange are related.

2. Accounts or explaining and predicting practices. This unit addresses five different aspects of explaining and predicting plants’ growth and gas exchange. Two are core goals of this unit. They are:

a) Identifying reactants and products of the key carbon-transforming

b) Processes in plants: photosynthesis, biosynthesis, and cellular respiration..

Three other explaining and predicting practices are less central. They are:

3. Explaining photosynthesis, biosynthesis, and cellular respiration using atomic molecular theory

4. Explaining energy transformations in photosynthesis, biosynthesis, and cellular respiration

5. Locating photosynthesis, biosynthesis, and cellular respiration in the general carbon cycle

**Lesson Plans –** These documents contain teacher instructions and student worksheets for all of the lessons in this unit.

Teacher Guide <Carbon\_2012PlantUnitTeachersGuide\_Final.doc>

Student Activities <2012PlantUnit\_StudentActivities.doc>

Student Readings <2012PlantUnit\_StudentReadings.pdf>

**Assessments –** Please plan to do the pre-test within 2 weeks of starting the lessons and post-tests within 2 weeks of ending the lesson. The pre and post test forms are the same.

o Version A <MSP 2011 Carbon-A + QR.pdf> (randomly give half the students this form)

o Version B <MSP 2011 Carbon-B + QR.pdf> (randomly give half the students this form)

### Additional Support Materials for Lessons

Powers of 10 Poster <powers-of-ten-poster\_36x48.pdf> – Chart containing notations for spatial scales from 10^-10 to 10^5 meters, with areas for the four ‘benchmark’ scales (atomic-molecular, microscopic, macroscopic and large-scale) color-coded. This simple tool can be used to discuss the relative sizes of nearly any object that you might discuss in your courses, even outside of this unit.

Lesson 2: Powers of 10 (General) <2Powersof10General.ppt> – Presentation which moves students from the scale of the whole earth to a single carbon atom.

Lesson 3: Powers of 10 (Animated answers) <3Powersof10withCards.ppt> – Single slide with animation that brings in all of the powers of 10 cards in this lesson to their proper places on the chart (i.e.- an answer key).

Lesson 4: Powers of 10 (Air) <4Powersof10Plant.ppt> and Powers of 10 (Plant) <4PowersofTenAir.ppt> – Slideshows which move students through a subset of the powers of 10 to focus more directly on the structure of both air and plants. This introduction can then help students to make sense of the explanations that their observations in the upcoming activities will be pointing them towards. (Note: this animation--air molecule movement <air molecule movement.avi> is necessary for the final slide on the ‘air’ slideshow to work correctly.)

Lesson 5: Weight Gain and Loss <5WeightGain Loss.ppt> – Slideshow which guides students through the process and rationale for tracing wet and dry biomass separately.

Lesson 7: Probe Difficulties <7Probe Difficulties.ppt> – Sample probe graphs

Lesson 8: Plants & Photosynthesis <8PlantsPhotosynthesis.ppt> and Plants & Respiration <8PlantsRespiration.ppt> – Slideshows which build off of the ‘plant’ slideshow used in Lesson 4 to focus students on the structures that allow plants to undergo photosynthesis and respiration. Both slideshows have an animation you will need to download (Photosynthesis Video <photosynthesis video.avi>, Cell Respiration Video <Cell Respiration.avi>).

Lesson 9: Sample Data and Graphing Template <9PlantGrowthGrapherandSampleData.xls> – Excel template for graphing class data, or comparing to sample data set.

Lessons 10: Matter Tracing Process Tool <10MatterTracingProcessTools.ppt> – Slideshow for class discussions of photosynthesis, biosynthesis and respiration.

Lesson 11: CO2 Process Tool <11CO2ProcessTool.ppt> – Slideshow including a simple terrestrial carbon cycle and atmospheric accumulation tool.

Development of these materials was supported by a grant from the National Science Foundation: Targeted Partnership: Culturally relevant ecology, learning progressions and environmental literacy (NSF-0832173). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

## Carbon: Transformations in Matter and Energy (Carbon TIME) Units

Three units developed with support from the *Carbon TIME* project are available to teachers participating in the *Pathways to Environmental Literacy* Math-Science Partnership.

### Systems and Scale

This unit introduces students to key ideas that form the basis for all the other units by developing a scientific account of organic and inorganic materials, and how *combustion* transforms organic materials to inorganic materials and chemical energy to heat and light.

### Plants (due September, 2012)

This unit focuses on three carbon-transforming processes that take place in plants. Plant growth starts with a process of *photosynthesis*, using the energy from sunlight to create an organic substance (glucose) from inorganic materials—carbon dioxide and water. Plant cells grow by transforming glucose and soil minerals into all the complex organic materials that plants are made of, including fats, proteins, and complex carbohydrates—the process of *biosynthesis.* Finally, plants get the energy they need to function by oxidizing glucose—the process of *cellular respiration.*

### Ecosystems (due October, 2012)

This unit focuses on carbon-transforming processes, *photosynthesis, biosynthesis, digestion,* and *cellular respiration,* that are constantly occurring in every ecosystem. In combination, they constitute food chains, food webs, and energy and biomass pyramids—all components of the ecological carbon cycle, which cycles matter between inorganic carbon dioxide and organic materials.

Development of these materials was supported by a grant from the National Science Foundation: A Learning Progression-based System for Promoting Understanding of Carbon-transforming Processes (DRL 1020187). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

## Professional Development Materials

This page contains materials used for professional development in association with teaching units and assessments on Plant Growth and Gas Exchange. Materials used at four different Long Term Ecological Research Sites are available.

### Teacher Assessments

Teachers take an assessment <TeacherAssessment\_TestVersion0516.pdf> of their content knowledge and pedagogical content knowledge before beginning professional development and after completing a teaching unit.

### Baltimore Ecosystem Study

Graphic Organizer <SoA\_LP\_graphicorganizer.xls> for the Story of Adrienne. Teachers explore the thinking of three students, the challenges they will face as they go through the Plant Growth and Gas Exchange unit, and ways to adapt instruction to further their learning.

Introduction <Presentation-Carbon TE Intro.ppt> to the Plant Growth and Gas Exchange unit and associated instructional aides and Carbon Learning Progression for Baltimore Professional Development workshop.

### Kellogg Biological Station

Summary of the carbon learning progression framework <611CarbonSummaryTable.doc>

Materials for sorting student responses to two assessment questions (THINGTREE and CARBPATH) <THINGTREEandCARBPATHStudentResponses.doc>

Materials for sorting student responses to an assessment question about the role of food in cricket growth <MSP Cricket Packet.doc>

Zip file with materials used for an NSTA short course on the carbon learning progression <NSTA 2012 Carbon Strand>

Zip file with materials for comparing learning goals for the Carbon, Water, and Biodiversity strands with the NRC *Framework for K-12 Science Education <*Su2012 NGSS>

Zip file with materials on inquiry associated with *Carbon TIME* units <Su2012 Inquiry>

Zip file with materials on accounts (explanations and predictions) associated with *Carbon TIME* units <Su2012 Accounts>

### Santa Barbara Coastal

Introduction < Carbon TE Intro.ppt> to the big ideas of the Plant Growth and Gas Exchange unit and associated instructional aides and Carbon Learning Progression for Santa Barbara Professional Development workshop.

### Shortgrass Steppe

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# Biodiversity Strand: Diversity in a Leaf Pack

*Note: All teaching materials are packaged as ZIP file. You can download individual file from the following paragraphs, or download the whole package here.* <Biodiv 2012 TE resources.zip>

*Target Grades*: Middle School and High School (modification suggestions for each level are included).

*Description:* Students will explore functional and taxonomic diversity in a stream ecosystem, learn about food web relationships, and learn about the ways in which abiotic and biotic factors determine what organisms are present a community.  Students will make and install leaf packs in a stream, wait for the leaf packs to be colonized by stream organisms, measure abiotic variables that could influence leaf pack colonization, retrieve the leaf packs and classify the organisms they find in both taxonomic and functional ways, and discuss how the leaf pack community is situated within a larger ecosystem.

*Learning Goals:*  The purpose of this unit is to increase students’ ability to apply principles of biodiversity to their observations and reasoning about the natural world, using the freshwater stream ecosystem as the context for learning.   This unit focuses on the following principles of biodiversity:

* Organisms vary genetically, thus also vary phenotypically & functionally
* Ecological communities are constrained and shaped by: Biotic resources & interactions, Abiotic resources & conditions, and Dispersal
* Matter and Energy are finite in space and time, and organisms interact with and impact matter and energy resources.

**Lesson Plans** <Biodiv 2012 TE Aquatic Full Version 6-7-12.docx>– This document includes Teacher Notes, Student Worksheets, Teacher Answer Keys, and Additional Handouts. Power points and other resources can be found below. Appendices, including optional lesson plans, can be found here <Biodiv 2012 TE Appendices inc optional lessons.docx>.

**MSP researcher Contacts for Support or Questions**

For Baltimore Ecosystem Study (BES) or New York Teachers: Lia Harris ([harrisc@caryinstitute.org](mailto:harrisc@caryinstitute.org))

For Kellogg Biological Station (KBS) Teachers: Jennifer Doherty ([dohertyjh@gmail.com](mailto:dohertyjh@gmail.com))  
For Shortgrass Steppe (SGS) or Wyoming Teachers: MaryAnn Murphy ([MMURPHY1@greeleyschools.org](mailto:MMURPHY1@greeleyschools.org)) or Laurel Hartley ([laurel.hartley@ucdenver.edu](mailto:laurel.hartley@ucdenver.edu))  
For Santa Barbara Coastal (SBC) Teachers: Scott Simon ([simon@msi.uscb.edu](mailto:simon@msi.uscb.edu))

For all others: Jennifer Doherty ([dohertyjh@gmail.com](mailto:dohertyjh@gmail.com))

**Additional Support Materials for Lessons**

***Posters and sorting cards:***

*Bird population maps* (For Lesson 4) < Biodiv 2012 TE Les 4 Bird pop maps.pptx>

*Organism sorting cards* (For Lessons 6, 9, 10, and 11) Sorting cards for students to use with the three posters below.  There are smaller versions for student desk work< Biodiv 2012 TE Les 6, 9, 10, 11 Classification cards students.pdf> and larger versions for whole class board work<updated file to come>.

*Food Web Poster*< Biodiv 2012 TE Les 6 and 11 Food web template and poster.pdf> (For Lessons 5 & 11) This food web diagram will help scaffold student understanding of the feeding relationships between organism groups in a stream ecosystem.  More advanced students may not need this tool, although it might be a useful organizing framework. Food web templates to print on 8.5"x11" sheets or to project or print in large format for board work.  Two scaffoldings included: 1 with some matter and energy transfer arrows included and 1 with none.

*Powers of 10 poster*<Biodiv Biodiv 2012 TE Powersof10poster.pptx> (For optional lesson D) This diagram is designed to help students understand the relative sizes of organisms identified in the leaf pack.

*Classification Poster* (For Lesson 9) This phylogeny based diagram of organismal relatedness is designed to help scaffold student understanding of the evolutionary relationships between organism groups in a stream ecosystem. Classification poster for board work< Biodiv 2012 TE Les 9 Classification poster to project.pdf> to project or print large scale. Classification poster for each student group, print on 2 11"x17"< Biodiv 2012 TE Les 9 Classification poster student 11 by 17.pdf> sheets or 4 8.5”x11”< Biodiv 2012 TE Les 9 Classification poster student 8.5 by 11.pdf> and tape together

***Powerpoint presentations:***

*Feeding Groups PowerPoint Slide Presentation*<Biodiv 2011 TE Les 6 Function Feeding groups.ppt> (For Lesson 6) This powerpoint introduces different feedings strategies, helps students see the different types of mouthparts present on stream invertebrates, and helps them think about how mouthparts are related to functional feeding groups.

*Decomposer PowerPoint Slide Presentation*<Biodiv 2011 TE Les 8 Decomposers.pptx> (For Lesson 8) This PowerPoint presentation contains pictures and information about different groups of microscopic decomposer organisms that are likely present in the leaf packs. It is focused primarily on bacteria and fungi and how microorganisms acquire resources (food).

*Biological Classification PowerPoint Slide Presentation*<Biodiv 2011 TE Les 9 Biological Classification.pptx> (For Lesson 9) This PowerPoint presentation contains an introduction to biological classification and what it means for organisms to be related.

***Excel Templates:***

*Graphing template* (For Lessons 5 and 7) < Biodiv 2012 TE Les 5 and 7 Class Template - Exploring your data.xlsx >

*Example leaf pack data* <Biodiv 2012 TE Les 5 and 7 Class Template - Exploring your data - Example data.xlsx> (For Lesson 5 and 7)

*Beans example template* (For Lesson 7) <Biodiv 2012 TE Les 5 and 7 Class Template - Exploring your data.xlsx>

*Shannon Index Template* (For Lesson 12) <Biodiv 2012 TE Les 12 Shannon Index Template.xlsx>

### Assessments

Randomly give 1/3 of you students each form (A, B or C); please make sure to use all three forms evenly.

* Middle School Form A, Form B, Form C
* High School Form A, Form B, Form C

# Water Strand Materials

## Teaching Materials

[Schoolyard Water Pathways Teaching Experiment](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20TeachingExperiment/12-13/Schoolyard_Water_Pathways_-_Teacher_pages%206.2012.doc)

[Tools for Reasoning](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20TeachingExperiment/12-13/Blank%20Tools%207.26.11.pdf)

[Schoolyard Substances in Water Teaching Experiment](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20TeachingExperiment/12-13/Substances%20in%20water%20-%20Teacher%20Pages%206.2012.doc)

[Schoolyard Substances in Water Student Pages](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20TeachingExperiment/12-13/Substances%20in%20Water%20-%20student%20data%20sheet%205.18.2012.doc)

[Schoolyard Substances in Water Presentation](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20TeachingExperiment/12-13/Substances%20in%20Water%20presentation%20-%205.17.2012.ppt)

Additional teacher resources are available at: <http://www.cns-eoc.colostate.edu/msp-nrel.html>

## Assessments

Water Budget Pre-Post 2011 – ( [Version A](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20Assessment/11-12/MSPWaterAsessmentRevisions2011VA2.doc), [VersionB](http://edr1.educ.msu.edu/EnvironmentalLit/publicsite/files/WaterCycle/WC%20Assessment/11-12/MSPWaterAsessmentRevisions2011VB2.doc) )