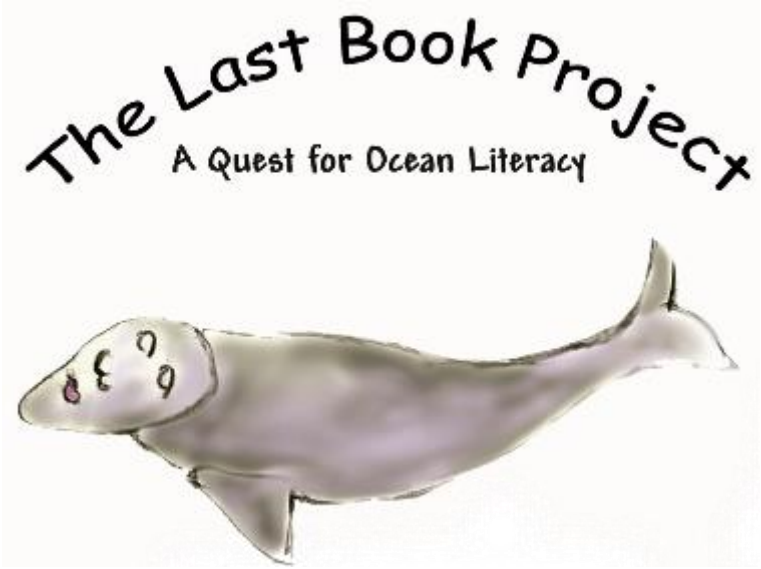

A STE*A*M Education Initiative

DIAGNOSIS: SCIENCE ILLITERACY

We live in a world where decisions based on science and technology are made on our behalf every day. And yet, most American adults do not have even a working knowledge of science - be the subject stem cell research or global warming. Few Americans understand the ocean's influence on them or their influence on the ocean, even though their very survival depends on the ocean.

Why are we science ILLiterate? Moreover, what can be done about it?

Sadly, although we live in the most technologically advanced nation in the world, **we have become a nation of poor readers**. Poor readers are generally uninformed citizens.

According to Michael McKenna and Richard Robinson, two experts in the field of content area reading and the authors of *Teaching through Text*, we science teachers **"have got an even tougher job of motivating our students. Study after study has shown that many students have a particularly negative attitude toward science in general and reading in science in particular."**

Because science content and vocabulary become substantially more difficult in middle school, educators have observed what has been labeled "The Great Turn Off" to science which begins at this level of education. NAEP scores, too, reveal a nearly direct correlation between reading comprehension and science achievement test scores among our nation's 8th graders.

As a result, the NSTA has tasked both middle and high school teachers to incorporate more reading in their science curricula. However few, if any, middle and secondary level science

teachers have had any instruction on just how to accomplish this. These educators have classrooms full of students who are reading well below that of the level of instructional materials; yet teaching reading is not a requirement for a science educator's certification. This is a problem.

We need to develop methods for helping students decode the language of science as READERS before we can expect them to advance to higher levels of science education.

WHY TEACH SCIENCE THROUGH LITERATURE??

Literature can serve as a segue into the often difficult and scary world of science. And let's face it, traditional text-based science instruction has failed to excite students to learn – especially at the middle and high school levels.

Literature helps students make connections. **It can bring meaning to science. It can act as a portal to understanding the concepts in a textbook. It can lead to more effective problem solving, the testing area in which our students are scoring most poorly.**

DATA SUPPORTING THE TEACHING OF SCIENCE THROUGH LITERATURE

In 1999, the largest international comparative study ever of mathematics and science education was undertaken. *Third International Mathematics and Science Study,* also called TIMSS (National Research Council), conducted testing in grades 4,9,and12 in forty countries, as well as made comparisons of curricula, teaching methods, and school cultures. In the U.S. it was found that *there is a tendency to address a given science topic repeatedly over a period of several grades, resulting in a course of study that is 'a mile wide and an inch deep.' Textbooks, as noted earlier, may contribute to this problem since they often cover extensive material in a cursory fashion in order to be all inclusive.* ***Trade books, on the other hand, allow students to explore fewer topics of interest in depth.***

The study adds: *Combining theme-based, hands-on science and children's literature supports many of the learning goals of the new standards that recommend students explore a variety of learning experiences that relate to previous knowledge, their experiences, or their interests. Theme-based units use hands-on activities in ways that build connections to scientific concepts. They focus on thinking, reasoning, and making sense of what they're doing. Working together at least part of the time, students can trade ideas, share tasks, and prepare classroom presentations.*

Finally, the study addresses alternative assessment methods: *Besides traditional testing, student assessment may incorporate creating portfolios of their work, such as science projects and written papers; videotapes or oral presentations to other students, parents, or the community; graphs, stories, songs, models, letters to the editor, skits, debates, field guides, crossword puzzles, class newspapers, book reviews, advertisements, charades, inventions, cartoons, games, picture dictionaries, slide shows, posters, timelines, and so on. Because it is important for all children to master science, assessments need to include some opportunities for every student to demonstrate what he or she has learned.*

NOAA'S STRATEGIC EDUCATION PLAN

In 2007, Congress passed The America COMPETES Act (P.L. 110-69). This statute directed NOAA, the National Oceanic and Atmospheric Administration, to develop a 20-year strategic education plan in partnership with ocean and atmospheric science and education experts, and interested members of the public. The Plan is to be evaluated and updated every five years. The first goal of the NOAA Strategic Education Plan is that our nation have *an environmentally literate public supported by a continuum of lifelong formal and informal education and outreach opportunities in ocean, coastal, Great Lakes, weather, and climate sciences.*

An important desired outcome of the strategic education programs is that ***educators understand and use environmental literacy principles***. But in what kind of settings do education and outreach take place? NOAA educators are working with in three kinds of "classrooms":

1. **Formal Education Settings** – structured educational school systems, in which students are required to demonstrate acceptable levels of achievement and proficiency.

2. **Informal Education Settings** – those venues where learning takes place outside the school system (such as museums, aquaria, after-school programs, and film documentaries).

3. **Outreach for Education Projects** – *Activities that are designed to build awareness, develop relationships, promote education products, and inspire educators, students, and the public to pursue further learning opportunities*

Above all, NOAA recognizes that *partnerships and collaboration are integral to establishing these changes.*

THE SEVEN ESSENTIAL PRINCIPLES FOR OCEAN SCIENCE AND DETAILED FUNDAMENTAL CONCEPTS

In July, 2009, a consensus of scientists, educators, and concerned citizens officially published the ***Seven Essential Principles of Ocean Literacy and Detailed Fundamental Concepts*** for grades K-12.
(**www.coexploration.org/oceanliteracy/documents/OceanLitChart.pdf***)*
This work outlines the ocean knowledge students should acquire as they progress and mature toward becoming ocean literate citizens. The question of their implementation remains a central focus of NOAA's educational initiative.

AGNES PFLUMM AND THE SECRET OF THE SEVEN and THE SIXTH ESSENTIAL PRINCIPLE OF OCEAN SCIENCE

The Sixth Essential Principle of Ocean Science states that: ***The ocean and humans are inextricably connected***.

For thousands of years, we humans lived in harmony with the ocean, taking only what we needed to survive. In a geologic blink of the eye, however, we overfished the oceans to the brink of global disaster. We have long forgotten how things used to be. Our baselines of what is "okay" have shifted so far that we can actually "oooh and aahhhh" over dead coral reefs and two stalwart fish. As a human race, we have lowered our standards of what is acceptable and are all living things are paying the consequences.

In the 1800's, Chief Seattle, chief of the Saquamish Indians, is said to have written the following statement in letter to the American government:

Humankind has not woven
the web of life.
We are but a thread within it.
Whatever we do to the web of life,
we do to ourselves.
All things are bound together.
All things connect.

Why and how did we forget that we are all connected to the ocean?

There are **SEVEN Fundamental Concepts** associated with the Sixth Essential Principle, and each one is addressed in the novel. These concepts are as follows:

1. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.

2. From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

3. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

4. Much of the world's population lives in coastal areas.

5. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and

rivers). In addition, humans have removed most of the large vertebrates from the ocean.

6. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).

7. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Other essential principles are addressed in *Agnes Pflumm and the Secret of the Seven*, and include 1 b,c,d,g, and h; 2e; 3b; and 7d. A list of the ocean science topics covered in the novel can be found in the appendix of the book. All seven essential principles of ocean science and the fundamental concepts associated with each one may be found at http://oceanliteracy.wp.coexploration.org/.

THE L.A.S.T. BOOK PROJECT – WHAT IT IS:

- A middle school ocean **SCIENCE-THROUGH-READING INITIATIVE** which is **L**iteracy-based, **A**rts-infused, **S**cience-centered, and **T**echnology driven. (See appendix of book.) *Agnes Pflumm and the Secret of the Seven* is the cornerstone of a middle school ocean science curriculum I have created for this project.

- A springboard to inspiring marine education programs developed by select national aquaria, the National Marine Sanctuaries Foundation **(NMSF)**, the National Oceanographic and Atmospheric Administration **(NOAA)**, **COSEE** (Centers for Ocean Science Education Excellence), the **Bridge** (**Sea Grant**'s ocean sciences education clearing house), **Project Oceanica**, and others.

- A way (I hope) of inspiring a diverse population of middle and high school students, who might then be mentored in the ocean sciences throughout high school, thus ensuring both experiential and content learning in ocean science at the secondary level. Ideally, these high school mentors would then direct these students to those colleges and universities with strong S.T.E.M.s programs.

- A thoroughly researched endeavor. Many ocean education specialists acted as my mentors during the research phase of the writing of this book and curriculum. Without them, this book would not have been possible. (See Acknowledgements in the appendix of the book.)

- An important source of marine education curriculum for the growing population of Latinos in our nation's schools, especially those ESL middle school students, who have little if no "non-watered-down" science curriculum available to them.

- A framework for a series of professional development ocean literacy workshops for middle and high school STEAM educators which result in student generated arts projects communicating understandings of and advocacy for ocean exploration, protection, and conservation. Previous projects in Charleston, SC:
    - The Science and Art of the SC Aquarium – Drawing as a Tool for Learning about Science
    - Science: A Reason to Read
    - Reading in the Science Content Area – Literacy Improvement Training for Science Teachers
    - Communicating About Science and the Environment through Murals.
    - Build Your Own ROV (Facilitated by SE-COSEE and Gray's Reef NMSF)

    - Nature drawing excursions at Barrier Island Environmental Center .
    - Special Art Projects for an 8th grade class, focusing on the creation of a mural celebrating the **North Atlantic Right Whale**, displayed at the Charleston Harbor Fest May-16-18, 2008 and the 2008National Marine Educators Association (NMEA) conference in Savannah.

THE WEBSITE

With a click on either the front cover of *Agnes Pflumm and the Secret or the Seven* OR *The Last Book Project* icon on the left side bar, you will set sail on a quest for ocean literacy.

The Quest for The Last Book …

- Sail to the Caribbean from Periwinkle Island (Click on the ship!)

EXPLORE THE OCEAN

- NOAA Ocean Explorer http://oceanexplorer.noaa.gov/
- NMSF http://www.nmsfocean.org/
- Shifting Baselines http://www.shiftingbaselines.org/index.php
- Coral Bleaching http://www.ausmepa.org.au/effects-of-climate-change-on-coral-bleaching/
- Medicines from the Sea http://oceanexplorer.noaa.gov/explorations/03bio/background/medicines/medicines.html
- Sea Grant http://www.seagrant.noaa.gov/
- COML http://www.coml.org/

The Tectonic Drag with Merrie Koester: A STEAM Lesson

FAMILY OCEAN EDUCATION OUTREACH EVENTS AT AQUARIA AND OTHER INFORMAL SETTINGS

I firmly believe that unless families are "on board" on this quest for ocean literacy, we as a nation will make little headway toward achieving this goal. For my part, I hope that I have

written a novel that might change the way teachers, students, AND their families think about the ocean.

Shared family time – dinners, conversations, and outings can provide opportunities for families to have conversations about what matters to them. **A family trip to an aquarium can catalyze and sustain a life-long interest in the ocean.** Aquaria connect visitors young and old to the ocean world, thus driving home the message inherent in the sixth Essential Principle of Ocean Literacy. **Aquaria can make people care about the ocean.** Aquaria can help visitors make more informed decisions about the impact that human activities have on the environment.

All families enjoy being entertained. A storytelling event or improvisational theater in front of, say, an aquarium's "coolest" tank, would draw people into an memorable ocean "adventure", just as listening to tales around a campsite is an event long remembered and discussed. Imagine this press release for just such a family event based on the stories on the pages of *Agnes Pflumm and the Secret of the Seven*:

Ancient pictographs and the urgent warnings from an extinct civilization leap from its pages. The future of the ocean planet is at stake, and seven primitive pictures hold the secret for its survival. A terrible, unspeakable EVIL IT is on the verge of taking the ocean into inescapable ruin. Even IF Agnes Pflumm discovers the Secret of the Seven, it will not be enough unless…..

Imagine that members of the audience would become part of a drum circle that accompanies the storytelling….

Imagine that such an event would become a springboard for family education about the Seven Essential Principles of Ocean Science and that materials and future events/ teacher workshops would be offered.

RECOGNIZING THAT PEOPLE LEARN IN DIFFERENT WAYS, THAT PROBLEM SOLVING IS NOT A LINEAR PROCESS, AND THAT MOST PEOPLE ARE VISUAL LEARNERS

Science curricula that are primarily linear, content and textbook driven are rarely effective in motivating a student to learn. This problem has been recognized for quite some time. The Third International Math and Science Study (TIMMS, 1999), citing that after fourth grade, US students fall behind their international peers, called for leading scientists and researchers to develop more effective ways to teach science. They noted that science teachers in the US often give students worksheets to fill out, solve sample problems, and review content presented through lecture and textbook reading. They then create assessments based on direct feedback from this material.

However, **problem solving is rarely a linear process**. *According to the TIMMS Scientific Problem Solving Performance Assessment (1995), problem solving is a non-linear system; in other words, problem solving involves relating parts of the problem to other parts, and also to the whole problem.* ***This kind of holistic problem solving can be accomplished with visual thinking; processing information through images instead of words.***

Five hundred years ago, Leonardo da Vinci recognized that the artist's skill in visual thinking and perception through the senses was essential to the scientist who sought to unravel the mysteries of the universe. Such understanding cannot be gleaned from a textbook. By means of his drawings, Leonardo had the genius to show ideas, principles, and their application, that could not be expressed in words. Throughout human history, technology represents the union of both science and art and the creative processes inherent in each.

THE POWER OF CREATIVITY IN THE SCIENCE CLASSROOM

Whether it is immediately apparent or not, the fact is that art and science are connected as expressions of human creativity. Separated one from the other, only the most rudimentary levels of understanding are possible. A plant uprooted from the soil has little chance of surviving. Likewise, children (small and big), deprived of the chance to exercise the muscles of their creativity have little chance of ever maximizing their potential. Our most influential scientists have been among the most creative, inventive people ever to live!

Fortunately, in this new millennium, more and more educators are realizing the importance of teaching through creative means, be it through language arts, graphic arts, creative drama, storytelling, bookmaking, computer technology, etc. The "trick" is to choose the means of creative expression that best fits the science content you're trying to teach.

Leonardo da Vinci taught that the best way to observe something is to draw it; for in the process of drawing, one gains both knowledge and understanding. The extra time spent in your classroom is well worth the investment. Also, drawing has helped many scientists evolve ideas. Such "idea sketching" was a valuable precursor to invention and discovery by the likes of inventor Thomas Edison, geologist Marie Tharp, and of course, Leonardo da Vinci, artist, scientist, inventor, architect, and even musician.

Without imagination, problems would never be solved. Jacob Bronowski has said that "we need to use all our facilities to the full – to assimilate with the scientist's brain, the poet's heart, the painter's eyes." Failure to spark the creativity and imagination of science students will severely impair their ability to see beyond the "facts" in their textbooks, leaving them with only the lowest form of cognition in the most exciting arena of learning there is!

For each of the Agnes Pflumm novels, in fact, I have offered creative arts extensions both for teaching and the assessment of student understanding, making these true **STEAM** learning experiences. This material is presented both in the appendices of my books as well as on my website. You'll find you never had so much fun teaching, because your own creativity and imagination will be tapped.

THE IMPORTANCE OF COLLABORATION

A truly successful educational endeavor will always be a collaborative effort. I saw my role in the process of advancing the quest for ocean literacy as one who might create

(through the medium of literature) a stage, if you will, upon which essential ocean science principles might be enacted.

My purpose in writing *Agnes Pflumm and the Secret of the Seven* was twofold:

1) To inspire students to want to learn as much about the ocean as possible so that they could be informed, active participants in protecting and preserving this last frontier on our planet.

2) To create a tool for middle school science teachers to teach ocean science through literature and the create arts. The novel (and lesson plans) can serve as a bridge to improved ocean literacy. It can serve as a starting point for dialogue and discussion of important ocean science content. It will allow each student in the class to begin with a well defined level of prior understanding before the teacher attempts to introduce new content, such as the phenomenal *free* ocean education program called *NOAA Ocean Explorer*. This website has an astonishing array of lesson plans, activities, and links to past and ongoing ocean exploration missions: http://oceanexplorer.noaa.gov/edu/materials.html**.**

In between the lines of *Agnes Pflumm and the Secret of the Seven*, I have planted seeds of science knowledge, which I hope will germinate into a motivation to inquire and discover. In each of the Agnes Pflumm science education novels, **the scientific content a "character" in the story, without which my books would cease to exist.** Moreover, in each, there is a central theme and moral which rises above the words, like ocean birds skimming the surface of the waves.

There is magic on this planet; it is contained in the water.
Loren Eiseley