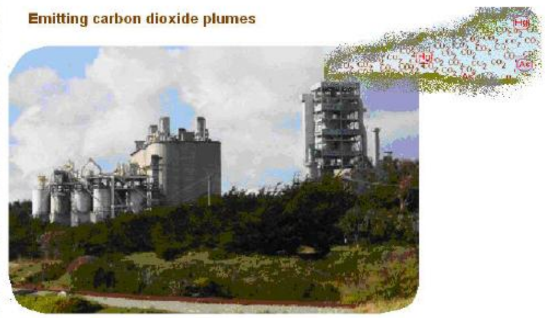
Geoengineering study plan

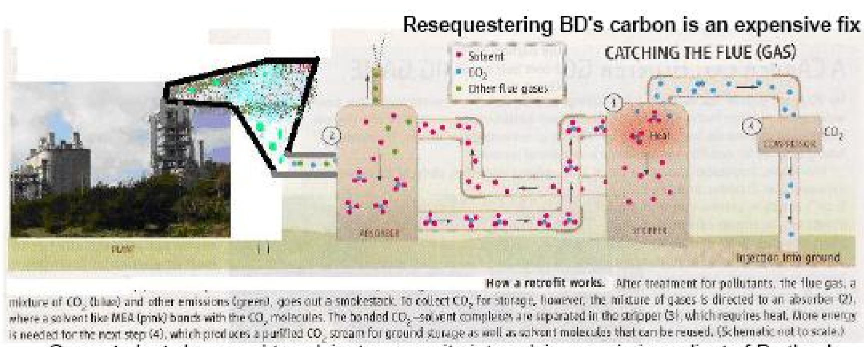
My father -- a civil engineer *(1)* -- labeled me 'gyurimernok', and that hungarianism translates to *georgengineer*. I abbreviated this self-referencing indulgence to 'geoengineer' when social, life and physical sciences began being embodied into geoengineered technology. The environmental violence perpetrated in Bonny Doon, my granddaughters' home, started my studies of the futile process of influencing local policies.

Sequestering Bonny Doon carbonates (calcified shell and skeletons) took millions of years. It took less than a century to dearagonite those 87 limestoned acres.



Last year a million tons of cement were produced from the quarried limestone. And Santa Cruz County was dosed in 2006 with 200,000 to 300,000 tons of CO_2 spewed out from that process. Can this local embarrassment be fixed?

So I calculated how much would it cost to retrofit a cement plant to resequester the CO_2 into inland rocks. I concluded that it could add 50% to 100% to the price of locally produced cement.



Cement plants burn coal to calcinate aragonite into calcia, a main ingredient of Portland cement. The carbon dioxide in a flue gas is resequestered by sending it to an absorber, where it bonds to the solvent, is stripped out into a CO_2 stream and -- in the Cemex retrofit concept -- would be injected into nearby serpentinite. It will be expensive (50 ¢/sack to 1.5 $/sack) to capture local carbon dioxide emissions. Why not a carbon tax?

As a docent at the Long Marine Lab of UCSC, I will offer some thoughts on what a newly-minted geoengineer can do to maintain and enhance the deteriorating integrity of the Pacific Ocean *(2)*. Soon *(3)* there'll be a plethora of ideas on quantification of the feasibility of a lexicon of marine technology options for improving the pace of engineering design of mechanisms for ocean solutions. I'll review the rapidity of development, demonstration and deployment for the most prominent, or conspicuously absent or maldistributed progress. In the meantime, I'll evaluate *(3)*'s precedents *(4).*

Notes and references

(1) Oscar Hoffman, *Statica Delle Dighe A Gravita*, Ulrico Hoepli Editore, Milano, 1939 see Part III, OH's Memories, in http://www.proper.com/george.hoffman/ancestors.pdf

(2) John P. Holdren, *Science and Technology for Sustainable Well-Being*, Science, Vol. 319, p.424, 25 January 2008.

(3)

Gordon Research Confe

BIOMINERALIZATION
Aug 10-15, 2008
Colby-Sawyer College
New London, NH
Chair: James J. De Yoreo
Vice Chair: Lia Addadi

- **Mineral Growth and Organization I: Matrix-Mineral Relationships**
  (*Arthur Veis* / Anne George / Nils Kroger)
- **Mineral Growth and Organization II: In Vitro Models**
  (*Patricia Dove* / Laurie Gower / John Harding / Paul Fenter)
- **Pathological Mineralization**
  (*Saeed Khan* / Linda Demer / Jose Luis Millan)
- **Biomineral Evolution and Architecture in Marine Invertebrates**
  (*Jose Luis Arias* / Bernard Degnen / Stephanie Reynaud / Ingrid Weiss / Maggie Cusack)
- **From Architecture to Function**
  (*Peter Fratzl* / Himadri S. Gupta / Andrew Parker)
- **Macromolecular Scaffolds for Materials Synthesis and Organization**
  (*Ichiro Yamashita* / Dirk Volkmer / Tadashi Matsunaga / Mark Young)
- **Defining the Molecular Contacts Between Organic and Mineral Components**
  (*Nita Sahai* / Patrick Stayton)
- **Cellular Controls on Mineralization: Towards Tissue Engineering**
  (*Graeme Hunter, David Kohn* / Lynda Bonewald / Molly Stevens)
- **Keynote Lecture: Biomineralization Through Time**
  (*Lia Addadi* / Steven Stanley)

FLOW & TRANSPORT IN PERMEABLE MEDIA
Jul 13-18, 2008
Magdalen College
Oxford, United Kingdom
Chair: Dani Or
Vice Chair: Pal-Eric Oren

- **CO_2 Storage in Geologic Formations**
  (*Hamdi Tchelepi* / Amir Riaz / Tara LaForce)
- **Pore-Scale Processes - Imaging, Modeling, & Engineering**
  (*Mario Ioannidis* / Todd Squires / Knut Jørgen Måløy / Rainer Kimmich)
- **Transport and Retention of Colloids and Nanoparticles**
  (*Thomas Baumann* / Greg Lowry / Yan Jin)
- **Multiphase Processes**
  (*Tissa Illangasekare* / Kjetil Haugen / Charlie Werth / Carolyn Ann Koh)
- **Transport in Biological Porous Media**
  (*Rainer Helmig* / Maciej A. Zwieniecki / Melody Swartz)
- **Advances in Reservoir and Macroscopic Flows Modeling**
  (*Margot Gerritsen* / Ivar Aavatsmarks / Rudolf Hilfer / Patrick Jenny)
- **Advances in Geophysical Methods**
  (*David Dicarlo* / Susan Hubbard / André Revil)
- **Transport Through Dynamic Pore Spaces**
  (*Dorthe Wildenschild* / Martin Schneebli / George Scherer)
- **Special Transport Processes**
  (*Majid Hassanizadeh* / Massoud Kavlany / Marc Prat)

MARINE MICROBES
Jul 13-18, 2008
Il Ciocco
Lucca (Barga), Italy
Chairs: Carlos Pedros-Alio & Laure Guillou
Vice Chair: David L. Kirchman

- **Microbial Oceanography**
  (*David L. Kirchman* / Paul G. Falkowski / Susannah G. Tringe)
- **Diversity 1: Diversity at Large Scales**
  (SangHoon Lee / Mitchell L. Sogin / Douglas B. Rusch)
- **Interactions at the Global Scale**
  (Matthew B. Sullivan / Michael Steinke)
- **Interactions at the Single Cell Level**
  (James G. Mitchell / Hans-Peter Grossart / Roberto Kolter)
- **Diversity 2: Populations and Dynamics**
  (Laura A. Katz / Birgitta Bergman)
- **Antagonistic Interactions**
  (Esther Garcés / Emily C. Roberts / Edna Granéli)
- **Mutualistic Interactions 1: Microbes with Microbes**
  (Antje Boetius / Rebecca J. Gast)
- **Diversity 3: Walking Across Species Limits**
  (Marina Montresor / Simonetta Gribaldo / Martin Polz / Åke Hagström)
- **Mutualistic Interactions 2: Microbes with Animals**
  (Nicole Dubilier / Michael Wagner)

NEW! OCEANS & HUMAN HEALTH
Jun 29 - Jul 4, 2008
Tilton School
Tilton, NH
Chairs: John J. Stegeman & Lora Fleming
Vice Chairs: Edward A. Laws & Lorrie Backer

- **Broad Directions in Oceans and Human Health**
  (*Rita Colwell* / Dan Baden / Robert Bowen)
- **Diversity of Marine Pathogen and HAB Populations: Health Implications**
  (*Donald Anderson* / Jeremiah Hackett / Martin Polz / Mark Strom)
- **Pathogen Sources, Distribution and Refuge**
  (*Al Dufour* / Christine Moe / Gerard Cangelosi)
- **The Physical-Biological Link: Modeling and Forecasting**
  (*Jay Grimes* / Rick Stumpf / Dennis McGillicuddy / Barbara Hickey)
- **Novel Genomic Approaches in OHH - Agents and Hosts**
  (*Ginger Armbrust* / Ed Delong / Vera Trainer)
- **Clinical Linkages in OHH: Pharmaceutical Discovery; Epidemiology**
  (*Amy Wright* / William Gerwick / Andrea Bourdelais / Eric Dewailly / Tim Wade)
- **Climate Change and OHH Issues**
  (*Kenny Broad* / Madeline Thomson / Roger Pulwarty)
- **Sensors and Sentinels**
  (*Patrick Walsh* / Chris Scholin / Frances Gulland / Danielle McDonald)
- **Looming Global Issues in OHH**
  (*Michael Depledge* / Michael Depledge / Mohammed Boulaya / William Bird)

NEW! GRADUATE RESEARCH SEMINAR OCEANS & HUMAN HEALTH
Jun 28-29, 2008
Colby-Sawyer College
New London, NH
Chairs: Michael L. Brosnahan & Mary E. Wright

- **Global Climate Change, Oceans and Human Health**
  (*Jessica Bolson*)
- **Microbial Pollution, Harmful Algal Blooms and Human Health**
  (*Emily A. Monroe*)

The Graduate Research Seminar on **Oceans and Human Health** is a two-day Gordon Conference-style meeting exclusively for graduate students and postdoctoral fellows. Speakers will be chosen from among the attendees. The Gordon Research Conference on **Oceans and Human Health** will take place at a different location (Tilton School), immediately following the Seminar.

NATURAL PRODUCTS
Jul 20-25, 2008
Tilton School
Tilton, NH
Chair: Scott R. Gilbertson
Vice Chair: Marvin M. Hansen

- **Catalysis and Synthetic Methodology I**
  (David W.C. MacMillan / M. Christina White)
- **Catalysis and Synthetic Methodology II**
  (F. Dean Toste / Kay Brummond / Matthew Gaunt)
- **Novel Methods in Synthesis**
  (Jeffrey W. Bode / Kevin Moeller)

- **Geochemical Challenges in Energy Alternatives**
  (Daniel Schrag)
- **Vistas from New Analytical Windows**
  (*Helen Talbot* / Ellen Hopmans / Ryan Rodgers)
- **Frontiers in the Development and Application of Molecular Proxies**
  (*Stefan Schouten* / Julian Sachs / Tim Eglinton / Isla Casteñeda)
- **New Insights and Linkages in Methane and Sulfur Cycles**
  (*Kai Hinrichs* / Chris House / Yu-Shih Lin)
- **Novel Molecular Biogeochemistry: H-Fueled Life in the Dark**
  (*Roger Summons* / Alex Bradley / David Valentine)
- **Frontiers in Biogeochemistry**
  (Selected from Poster Presenters)
- **Frontiers in Energy Resources**
  (Selected from Poster Presenters)

(4) With Faculty guidance (WFG) the GSR associated with this effort will be tasked with contacting Prof. Daniel P. Scrag, schrag@eps.harvard.edu , to view -- if available -- the proceedings of the 8, 9 Nov 07 conference at Harvard. Other WFG must-read should include

❑ K. Z. House *et al.*, Proceedings of the National Academy Sciences 103, 12291, (2006)

❑ N. Stern and C. Taylor, *Climate Change: Risks, Ethics,* Science, Vol. 317, p.203, 13 July 07

❑ http://www.sciam.com/article.cfm?id=4D9BFC3D-E7F2-99DF-3E6E1A60C23D44E6&page=1

In short, the report finds that coal will remain the electricity-generation king and geologic sequestration is the solution best suited to minimize the attendant carbon dioxide pollution. This will require building a liquid CO_2 infrastructure comparable to the national highway system as well as assessing which coal-burning technologies work best with which carbon capture technologies. In other words, the way such carbon capture and sequestration will work remains as hazy as the smog coal-fired power plants produce but it needs to become clear quickly if the world plans to continue burning such fossil sunlight. "How hard and how far can we push capacity in a safe, virtually riskless way?" Moniz asks. "There remains a scientific consensus on viability. Implementation is a different issue." Klaus Lackner of Columbia University, for one, advocates sequestering the carbon in minerals like magnesium silicates, although currently the associated cost is much too high. Whatever the approach, "we need to do it now," he insists. "We cannot afford to sit back and say some great invention will come along sometime in the middle of the century."

(5) If I may add to Laackner's 'cost-is-too-high' assertion, my take on the first coal-burning powerplant (Warrior Run, WR) being retrofitted for CO_2 recapture. WR burns 65000 $t_{\mathbf{coal}}$/y and on the first demo may grab 5 to 20% of the CO_2 emitted if all goes well. WR produces 4>5 Mw/y and the retrofit will almost double the consumers' price of electricity. All this points to an initial 10 $\$/ t_{\mathbf{CO_2}}$ for the first (easiest) quintile of flue gas decarbonization. As a geoengineer I forecast sequestration of the next quintile or two to run around 20>30 10 $\$_{07}/ t_{\mathbf{CO_2}}$ **.** At the time of this writing, eurocredits of about 40 $\$_{08}/ t_{CO_2}$ are saleable/buyable to/from over/ /under-emitters in the cap-&-trade market. Furthermore I'd read all the follow-on links to

http://www.sciam.com/article.cfm?articleId=7D0F7914-E7F2-99DF-324A350B33629F97

CONCRETE SOLUTION: Energy efficiency and material substitutions at cement kilns can cut greenhouse gas emissions but carbon capture and storage will be required to fully control such emissions from industry.

Making cement, which requires heating to 1,450 degrees Celsius a mass of limestone and other ingredients, caused the release of nearly 46 teragrams (roughly 50.7 million tons) of greenhouse gases in the U.S. in 2005, according to the U.S. Environmental Protection Agency. It is the basic ingredient in concrete (first used by the Romans), which paves our walks, supports our walls and even is used in our furniture in some cases. It is the essential substrate of modern life—and therefore the third largest source of U.S. greenhouse gas emissions (though dwarfed by fossil fuel consumption).

Following it in the list of significant industrial sources in the U.S. are the production of iron and steel, ammonia, aluminum and petrochemicals—the building blocks of much of modern endeavor. A host of new techniques and technologies will be required to reduce emissions from these sources that includes reusing heat and power generated in manufacturing processes; recycling materials or substituting them; controlling greenhouse gases other than carbon dioxide (CO_2); and, ultimately, capturing and burying the CO_2 produced. "The key approach is energy efficiency, but its application has to be tailored to each specific industrial situation," says Lenny Bernstein, an environmental consultant and coordinating lead author for the Intergovernmental Panel on Climate Change (IPCC) report chapter on mitigating emissions from industry.

For example, cement manufacturers can use either blast furnace slag from steel mills or pozzolans—natural or manufactured reactive materials that increase the long-term strength of concrete—as substitutes for other, more traditional materials. Either reduce the energy needed to form the cement. Or manufacturers can use alternative fuels. "Cement kilns are great for disposing of almost anything," Bernstein says. "You can extend the fuel source with these and thus avoid the energy associated with new fossil fuels."

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