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**Institution:** Furman University

**Title of Project:** Re-imagination of Interdisciplinary Non-majors Science: The Physical and Living Universes Revealed

**Date(s) of Project:** June 2007 – August 2008

**Amount Awarded:** \$14,056

### ***I. Original goals and objectives***

Our original goals and objectives were designed to provide flexibility to non-science majors by offering an interdisciplinary option for students who prefer to develop familiarity with the broad disciplines of biology, chemistry, physics, and earth and environmental science while retaining an opportunity for in-depth analysis of current controversial issues. In particular, the following was emphasized:

- hands-on inquiry and experimentation;
- expansion of research skills to include the ability to locate primary scientific data;
- development of critical thinking skills to assess technical data and apply it to problem-solving;
- advancement of written communications skills, especially in the areas of thesis formation, logic, and rhetoric;
- development of oral communication skills in the multimedia environment;
- development of an historical and social awareness of societal issues in science.

### ***II. Revised goals/objectives.***

In general, our goals and objectives have remained the same. After careful consideration since there were two courses to design, we decided to encapsulate astronomy, physics, chemistry, and some mathematics into a course we titled “Mission to Mars,” and biology, geology, and environmental science into a course titled “Earth: A Living, Changing Planet.” This themed-based approach was thought to be better suited to development of student projects. Although each course emphasizes specific scientific disciplines, all areas of science will be incorporated.

The objectives for “Mission to Mars” were:

- Develop strategies for assessment of scientific information;
- Develop healthy intellectual skepticism;
- Maintain an openness to other points of view / Critically analyze different sides of an argument;
- Develop and utilize models for analysis and prediction;
- Develop and explore different ways of organizing, representing, and visualizing data;
- Develop a deeper understanding of the nature of science;
- Develop an understanding of the contributions of Copernicus, Galileo, Kepler, and Newton and their role in shifting our view of Earth’s place in the universe;
- Use data collected from celestial observation to determine the period of a planet or

moon;

- Develop an understanding of the changing perception of Mars throughout history;
- Develop an understanding of the impact of the Gemini and Apollo missions on space exploration and technological innovation and analyze similarities and differences with current Mars proposals;
- Analyze different plans for a manned mission to Mars in detail to determine feasibility, cost, and tradeoffs and compare mission philosophies to other historical explorations;
- Understand physical principles such as Newton's laws, centripetal acceleration, conservation of momentum and energy, the Doppler Effect, friction and projectile motion in the context of Mars exploration;
- Gather and review data that supports the notion of an expanding universe;
- Based on an understanding of chemical reactions, evaluate scenarios for fuel production on Mars and rocket propellant for travel;
- Develop an understanding of the relative motion of the planets in the context of conjunction and opposition launch and disaster recovery scenarios for Mars;
- Use remote sensing data to analyze surface features on Mars and compare with similar features on Earth;
- Compare sustainability issues and strategies on Earth and Mars;
- Evaluate the proposition of terraforming Mars from an ethical, political, and scientific standpoint;
- Compare assumptions and issues behind terraforming Mars and global warming on Earth;

The objectives for "Earth: A Living, Changing Planet" included:

- Development of an understanding of the formation of the Solar System;
  - Analysis of habitability zone around stars
    - Whither Venus, Earth, Mars
  - Formation of earth-moon doublet
    - Effect on present resource distribution
    - Mining the moon for energy – helium-3
  - Chemistry of elements necessary for formation of life
- Comparison of the theories of the chemical evolution leading to formation of life on earth;
  - Origin of organic molecules
    - Miller's experiments
  - From organic molecules to protocells
    - "Genes first" models: the RNA world
    - "Metabolism first" models: iron-sulfur world and others
    - Bubble Theory
  - Other models
    - Autocatalysis
    - Clay theory
    - "Deep-hot biosphere" model of Gold
  - Counterarguments
    - Hoyle – Dirty snowball

Abiogenic synthesis of key chemicals  
Homochirality Problem  
Extraterrestrial life  
Mars – nature, contamination dangers  
Comet-borne plagues

- Analysis of biological evolution;
  - Heredity
  - Variation
    - Mutation
    - Recombination
  - Mechanisms
    - Natural selection
    - Genetic drift
    - Gene flow
  - Evidence for evolution
  - Outcomes
    - Adaptation
    - Co-evolution
    - Speciation
- Illustration of the role played by extinction in the evolution of life;
  - Genetics and demographic phenomena
  - Habitat Degradation
  - Predation, competition, and disease
  - Mass Extinctions
    - Volcanism
    - Asteroid impacts
    - Gamma-ray bursts
    - Earth's magnetic field
  - The Martian Lifeboat
  - Post-human earth
- Understanding how geological process affect the changing face of earth;
  - Processes driving oceanic composition
  - Sea floor spreading / plate tectonics
  - Glaciology
  - Mountain building
    - Effect on climate and life
  - Why Mars is a “dead” world
- Exploration of the process of climate change;
  - Atmospheric chemistry and physics
  - Effect of increasing CO<sub>2</sub> on oceanic pH
  - Methane and methane hydrates
  - Oceanic currents and distribution of heat

- Effect of continental drift on climate; modeling future climate and life forms on earth
- Discovery of DNA and molecular biology as agents facilitating changes to the biosphere;
    - Discovery of DNA – Science as a Social/Political Process
    - DNA Double Helix
    - Genetic Code
    - Genetic Manipulation
    - Genomics
    - Applications
      - E.g. Genetically modified organisms and their effect on the biosphere
  
  - Understanding the benefits of and threats to biodiversity, our “web of life”;
    - Numbers of species
      - DNA “bar-coding”
    - Benefits
      - Resistance to catastrophe
      - Food and drink
      - Medicines
      - Industrial materials
      - Other ecological services
    - Threats – Planet in Peril
      - Destruction of habitats
      - Species Loss
      - Exotic species
      - Genetic pollution
      - Human Overpopulation
  
  - Linking people with ecosystems to develop sustainable economic models.
    - Agro-ecosystems
      - Chemical Herbicide / Pesticide usage in Kansas
    - Coastal Ecosystems
      - Re-plumbing the Everglades
      - Managing the Mangrove
      - Bolinao Rallies Around its Reef
    - Forest Ecosystems
      - Up from the Roots - Regenerating the Dhani Forest through Activism
    - Freshwater Systems
      - Working for water in South Africa
      - Managing the Mekong River
    - Grassland Ecosystem
      - Sustaining the Steppe: Mongolia’s grasslands

Laboratories that illustrate each of the above major themes are still under development or being tested.

### ***III. How goals/objectives were met.***

The two courses “Mission to Mars” and “Earth: A Living, Changing Planet” will be taught for the first time in Fall 2008 and Spring 2009, respectively. As such we can only offer the following generalities on how we will meet the above objectives:

- Apply experimental design principles to new situations;
- Develop ability to identify and develop new questions from analysis of studies and learning experiences;
- Develop an appreciation for historical and societal influences on science (and vice-versa);
- Develop the ability to critically analyze information in scientific studies and the news;
- Develop an understanding of the connections between the disciplines and the relevance of science to societal issues past, present, and future;
- Explore the ethical implications of scientific and policy decisions;
- Develop an intrinsic interest in continued learning of science;
- Recognize the impact of science on our daily lives;
- Develop skills for identifying questions and strategies for finding scientific information (designing a plan for discovery).

### ***IV. Evaluation Process***

We are still developing our formal assessment rubric and instruments. A draft of the current evaluation instrument is attached.

### ***V. Re-design issues and “lessons learned”***

One surprising issue we encountered was the difficulty in finding appropriate textbooks for the two courses:

- 1) comprehensive college-level textbooks that cover all the issues raised in the courses don't exist;
- 2) textbooks generally do a poor job at covering current societal issues that interface with science;
- 3) selected topics will be covered in-depth using an inter-disciplinary approach rather than surveyed in a discipline-specific format;
- 4) a substantial part of each course will involve student presentations on topics of their choice within the overall theme of the course.

As described in the attached course proposals, we decided upon using multiple texts and articles that could be posted to the course web site. Digital video, drawn from a number of science-oriented documentaries, is also being used.

We were also somewhat amazed by the number of students who wanted to participate in this course. Initially we capped enrollment at 20 participants; we could have easily accommodated twice that number based on current course request statistics.

After we have experience teaching these courses, we will be in a better position to completely address this issue.

### ***VI. Dissemination of findings***

The Center for Teaching and Engaged Learning (CTEL) at Furman University will facilitate the sharing of lessons learned within the university through faculty learning communities, sharing seminars, the CTEL website, and digital information stations in the newly renovated Charles H. Townes Center for Science.

Beyond Furman, we are evaluating a number of national public forums to disseminate our findings including presentations at conferences sponsored by the American Association for the Advancement of Science (AAAS) or the National Association of Biology Teachers (NABT).

### ***VII. Next Steps***

We look forward to teaching “Mission to Mars” and “Earth: A Living, Changing Planet” for the first time in Fall 2008 and Spring 2009, respectively. A number of science faculty have indicated an interest in team-teaching these courses in the future; an appropriate next step would be to ensure the portability of the teaching resources so they may be useful to others.

### ***VIII Etc.***

Financial statements showing the original budget (see original grant proposal) and expenditures are attached. All funds were essentially spent; a few final items are still in transit from the vendor thus the \$80.27 left will probably be consumed by shipping charges.

We grant ACS permission to post our original proposal and the results of the project on the ACS Science Reform website.

Sincerely,

Nicholas Schisler  
Mike Winiski