

## COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) <small>(Indicate the most specific unit known, i.e., program, division, etc.)</small>				<b>FOR NSF USE ONLY</b> NSF PROPOSAL NUMBER	
PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE// not in response to a program announcement/solicitation enter GPG, NSF 95-27					
DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	FILE LOCATION	
EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)  87-6000525	SHOW PREVIOUS AWARD NO. IF THIS IS <input type="checkbox"/> A RENEWAL OR <input type="checkbox"/> AN ACCOMPLISHMENT-BASED RENEWAL		IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES <input type="checkbox"/> NO <input type="checkbox"/> IF YES, LIST ACRONYM(S)		
NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE Ctr for Integrated Science Education, U of U		ADDRESS OF AWARDEE ORGANIZATION, INCLUDING ZIP CODE Center for Integrated Science Education University of Utah 2480 MEB Salt Lake City, Utah 84112			
AWARDEE ORGANIZATION CODE (IF KNOWN)					
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE		ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING ZIP CODE			
PERFORMING ORGANIZATION CODE (IF KNOWN)					
IS AWARDEE ORGANIZATION (Check All That Apply) <small>(See GPG II.D.1 For Definitions)</small> <input type="checkbox"/> FOR-PROFIT ORGANIZATION <input type="checkbox"/> SMALL BUSINESS <input type="checkbox"/> MINORITY BUSINESS <input type="checkbox"/> WOMAN-OWNED BUSINESS					
TITLE OF PROPOSED PROJECT <div style="text-align: center; border: 1px solid black; border-radius: 50%; padding: 10px; width: fit-content; margin: 0 auto;">                     SCIENCE WITHIN YOU                 </div>					
REQUESTED AMOUNT \$ 494,473	PROPOSED DURATION (1-66 MONTHS) 36 months		REQUESTED STARTING DATE 1/98-12/2000		
CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW					
<input type="checkbox"/> BEGINNING INVESTIGATOR (GPG I.A.3)			<input type="checkbox"/> VERTEBRATE ANIMALS (GPG II.D.12) IACUC App. Date _____		
<input type="checkbox"/> DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)			<input type="checkbox"/> HUMAN SUBJECTS (GPG II.D.12) Exemption Subsection _____ or IRB App. Date _____		
<input type="checkbox"/> PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)			<input type="checkbox"/> INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES _____		
<input type="checkbox"/> NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)			<input type="checkbox"/> FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)		
<input type="checkbox"/> HISTORIC PLACES (GPG II.D.10)			<input type="checkbox"/> RESEARCH OPPORTUNITY AWARD (GPG V.H)		
<input type="checkbox"/> SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)					
<input type="checkbox"/> GROUP PROPOSAL (GPG II.D.12)					
P/VPD DEPARTMENT Bioengineering		P/VPD POSTAL ADDRESS 2480 MEB Salt Lake City, UT 84112			
P/VPD FAX NUMBER 801-585-5361		6-1997			

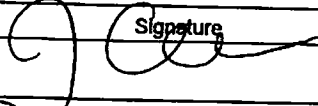
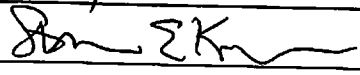
## CERTIFICATION PAGE

### Certification for Principal Investigators and Co-Principal Investigators

I certify to the best of my knowledge that:

- (1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and
- (2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of this application.

I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

Name (Typed)	Signature	Date
PI/PI J.D. Andrade		6/2/97
Co-PI/PI S.E. Kern		6/2/97
Co-PI/PI		
Co-PI/PI		
Co-PI/PI		

### Certification for Authorized Organizational Representative or Individual Applicant

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and suspension, drugfree workplace, and lobbying activities (see below), as set forth in the *Grant Proposal Guide (GPG)*, NSF 95-27. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of *Grant Policy Manual* Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

#### Debt and Debarment Certifications (If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt?

Yes

No

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal Department or agency?

Yes

No

#### Certification Regarding Lobbying

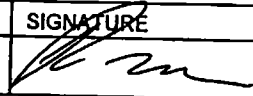
This certification is required for an award of a Federal contract, grant or cooperative agreement exceeding \$100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding \$150,000.

#### Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME/TITLE (TYPED) Robert G. Glass, Director		6/4/97
TELEPHONE NUMBER (801) 581-3003	ELECTRONIC MAIL ADDRESS robert.glass@osp.utah.edu	FAX NUMBER (801) 581-3007

## PROJECT SUMMARY

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The Project Summary should include a statement of objectives, methods to be employed, and the significance of the proposed activity to the advancement of knowledge or education. Avoid use of first person to complete this summary. **DO NOT EXCEED ONE PAGE.** (Some Programs may impose more stringent limits.)

### Science Within You

#### **Project Summary:**

*Science Within You* is an interdisciplinary undergraduate course using the fundamental chemical, physical, and biological principles of the human body to improve scientific literacy among non-science majors. The course uses VHS technologies for public television broadcasting combined with Internet access and home-based science labs, known as "Labless Labs", to create an accessible, stimulating, and hands-on approach to scientific understanding.

This approach extends the course's accessibility to non-traditional and underserved groups including inservice teachers, students with disabilities or special circumstances that prevent them from attending classes on campus, working parents who are unable to be on campus due to a combined work schedule and parental obligations, and a rural population that is separated from a campus environment by fifty miles or more. In addition to the course video series, WWW page, and home-based labs, plans include to develop a CD-ROM and textbook to extend the course series beyond the needs of our university to other college campuses.

Assessment is designed to determine effectiveness of technologies to students learning of fundamental science concepts, and effectiveness of using basic science within the human body to boost the participant's scientific understanding. *Science Within You* will begin as an Undergraduate Explorations, or general education course, at the University of Utah with an expected enrollment of 1,000 students over a five year period.

## **Science Within You**

### **Project Description**

#### **Background and Significance**

The goal of *Science Within You* is to use modern telecommunication and information technologies to teach fundamentals of basic science to increase personal awareness and understanding of fundamental sciences surrounding our own bodies.

The ongoing national discussions on undergraduate education is leading to reforms of undergraduate general or liberal education requirements. "*Shaping the Future*", a report on undergraduate education issued by an advisory committee to the National Science Foundation, calls for the need to educate all students in the science, mathematics, engineering, and technology disciplines. The University of Utah is following this call by a complete restructuring of the undergraduate "experience." The increasing technological basis and sophistication of our society's problems - and opportunities - is shifting a significant focus on science, math, engineering, and technology topics. It is generally agreed that all graduates need to be "literate" in science, math, and technology - what is not agreed to is a definition of "literacy."

The general problem of scientific illiterate students was identified in the 1983 "A Nation At Risk" report. This report and others lead to a variety of studies as well as major efforts by the National Science Foundation and the National Science Teachers Association. Many professional organizations also became involved, including the American Association for the Advancement of Science (AAAS) whose extensive report "Project 2061: Science for All Americans" was particularly comprehensive and effective. The report argued strongly for an experienced-based literacy which emphasizes the integration, and interconnection, among all of the sciences. It was that report, issued in 1989, which greatly stimulated our interests to pursue an integrated approach to science education. It lead to the founding of the Center for Integrated Science Education at the University of

Utah in 1992 and its range of programs focusing on the integration of science concepts and themes.

### **Project Detail**

The national dialogue and experience with interest-based and experience-based science education, as well as our own experiences, lead to our development two years ago of a unique new telecourse *Science Without Walls: Science in Your World (SW/OW)*. The course set a high standard at the University of Utah for the extensive use of video in a telecourse format. It is not a "talking head" telecourse but integrates moderator narration with video clips that complement and reinforce science concepts. The course is beginning its second year of offering this fall. Simon & Schuster Publishers is currently developing a national text to accompany the course.

*Science Within You* is a laboratory-oriented "science" telecourse, which builds on SW/OW. The main technology for this project will include 15 one-hour videos for television broadcast via a local network. The programs will be produced locally using the telecommunication resources of KULC Channel 9, a University of Utah affiliated educational television station in Salt Lake City. KULC reaches over 80% of the state's geographic region and overlaps into four neighboring states. The beauty and potential of our statewide telecommunications technologies is that practically all segments of the population and all geographic regions can be readily served, because the television receiver is nearly ubiquitous in our society.

We will also use non-telecommunication resources that allow viewers to conduct lab experiments on their own or in mentored sessions at regional learning centers. Known as the hands-on "Lainless Labs" and the mentored "Briefcase Labs", these lab experiences will allow for self-directed and mentor-directed experimental learning to complement the material in the videos. The real world can never be fully appreciated or experienced from a television or computer screen alone -- virtual realities are virtual, not real. We feel strongly

that this complementary approach, focusing on personal physiology, will provide a means to involve a much larger segment of the student population in the enhancement of their scientific educational backgrounds.

Since much of classical and traditional science was first discovered by anatomists, physiologists, and physicians, we can teach a great deal of science and technology through the topics of health, medicine, and pathology. We call this approach "*science by seduction*" -- find a topic such as their bodies in which they are interested, involve them in the fascination by which their bodies function, and then use their body to teach them basic science in which they might not have been interested.

Table 1 notes the general structure and organization of the course and of the 15 one-hour weekly programs. It is basically organized in five general sections: the introductory section deals specifically with measurement and basic physical concepts; the second section focuses on energy, the third section focuses on the delivery of energy; the fourth section covers the consumption and utilization of that energy; and the final part focuses on sensation, the gathering of information and the utilization of that information which serves as feedback to control consumption of energy. The title of each one-hour lecture is intentionally made interesting, and is descriptive of that particular topic.

*See Table 1 on next page.*

Table I *Science Within You*

Week	Section Structure	Lecture Title	Companion Lab (H = home B= briefcase)
1	Introductory	You're Abnormal	Temperature measurement (H)
2		You're Imperfect	Morphometry (H)
3	Energy	Lies and Electrons	Body impedance / fat (B)
4		More Power to you	Urinalysis (H)
5		Hiking, Diving, Running	Pco <sub>2</sub> (H)
6	Delivery	Can't even break even	Basal Metabolism (B)
7		Hot stuff - warm blood	Blood pressure (H)
8		Body electric	Heart rate (H)
9	Consumption	Body magnetic	Electrocardiography (B)
10		Gravity wins	Muscle fatigue (H)
11		Newton rules biology	Friction forces (H)
12	Sensation	Where did the energy go	Chicken Bone Mechanics (B)
13		Senses and sensibility	Tactile senses (H)
14		Photon world	Taste (H)
15		Summary	Vision / Auditory experiments (B)

On the far right of Table I the various laboratory experiments and measurements are indicated. There are two types of laboratories. H refers to the home-based or personal laboratory which we call the Labless Lab. With these simple labs, the students perform measurements in their home or apartment. A more extensive, comprehensive lab, is the Briefcase Lab, noted as B in Table I.

Table II presents the topics of the 15 programs in slightly more detail. We have also included in Table II some brief notes on how the content of each program connects to key topics in more traditionally organized physics, chemistry, and/or biology basic science courses.

Table II *Science Within You*

Program 1: ***You are Abnormal!*** What is normalcy? Abnormality? Measures of normality. Personal Physiology. Measurement in physiology.

- Program 2: **You are Imperfect?** The human form in art and history. Symmetry, proportion, ratios, perspective, ancient physiologists and anatomists-especially Leonardo.
- Program 3: **Lies and Electrons.** Bio-electricity. Twitching frogs and electro therapies. Sweat, skin, and lie detectors.
- Program 4: **More Power to You!** Solar powered man and woman. Food, fuel, and aerobics. Anaerobics. Why bladders? Why the other stuff? What a waste!
- Program 5: **Hiking, Diving, and Running.** Why oxygen? Why altitude or pressure? Acidosis-alkalosis-and Maalox. Fun with pH and CO<sub>2</sub>.
- Program 6: **You Can't Even Break Even!** Energy, inefficiency, and entropy. Fatness, thinness, and biochemistry.
- Program 7: **Hot Stuff - Warm Blood.** Do you have a temperature? When? Is it constant or varying? Cycles and rhythms. Hot blood v. cold blood; hypothermia.
- Program 8: **The Body Electric.** Private and not so private auras and fields. Let's start the heart! EMG, EKG, EEG, and bio-feed back.
- Program 9: **The Body Magnetic?** E and M- electricity is magnetism - and vice versa. Birds and bacteria do it - do you? Magnetic "Vision". Medical imaging.
- Program 10: **Gravity Wins!** You can't jump very high. What goes up...the oppressive atmosphere. Mass-weight. Big folks and little folks.
- Program 11: **Newton Rules Biology - and You.** Those laws of motion! Sneakers, high jumps, baseballs, and skis.
- Program 12: **Where did the Energy Go?** Crashing, deceleration and fracture; Resurrection of bones, but not cartilage? Tendons, ligaments, and joints. Controlling motion.
- Program 13: **Senses and Sensibility.** The Acoustic World - and other worlds - waves, but different ones. Pressure, frequency, intensity, sound - voice, music, taste, smell. A dog's view of you!
- Program 14: **The Photon World** - eyes and vision. Is it real? Perception and "reality". How many photons - night vision, me? Color, depth, and 3-D.



Program 15: Summary - wide ranges of normalcy, pitfalls of measurement, use for understanding of medical science, where to next??

Table III shows how these topics and how each of the individual programs connect to the basic concepts and themes developed in the "Project 2061" report and used in our *Science Without Walls* telecourse.

**Table III Summary Matrix of Program/Concept/Discipline Relation  
Basic Concepts and Themes.**

Week	Basic Sciences				S Y S T E M	M O D E L	S C A L E	C O N S T A N C Y	C H A N G E	M A T T E R	E N E R G Y	D I S O R D E R	L I F E
	Math	Physics	Chem	Biology									
1							x	x	x				
2					x	x	x						x
3					x	x				x	x		x
4					x	x				x	x	x	
5									x	x	x	x	
6								x	x		x	x	
7								x	x		x		
8					x	x			x		x		x
9						x			x				x
10					x		x		x	x	x		
11							x		x	x	x		x
12					x		x		x	x	x	x	
13					x				x		x	x	x
14								x	x		x		
15					x	x	x	x	x	x	x	x	x

Table IV on the next page summarizes the laboratory experiments and measurements for each of the fifteen programs, emphasizing the key principles which will be experienced and developed in each. While such a course cannot substitute for individual courses in physics, chemistry, and/or biology; nevertheless, it is possible to represent and

develop many of the key concepts in the three traditional disciplines through such an integrated approach.

Table IV *Science Within You* Labs and Basic Science Principles

<b>Week</b>	<b>Lab/Topic</b>	<b>Basic Science Topics and Principles</b>
1	Temperature	Heat energy
2	Morphology	Size relationships and patterns
3	Impedance	Electricity
4	Urine	Molecular characteristics
5	pCO <sub>2</sub>	Gases
6	Basal Metabolism	Free energy and conservation of energy
7	Blood Pressure	Force and pressure
8	Heart Rate	Waves and cycles
9	ECG	Electricity & magnetism
10	Muscle Fatigue	Chemical energy and momentum
11	Friction Forces	Newton's Laws
12	Chicken Bone Mechanics	Structure
13	Tactile	Pressure and nervous system
14	Taste & Smell	Chemicals vapors
15	Vision & Auditory	Waves and color perception

The lab components of the telecourse reinforce concepts from the video presentation and allow the participant to do self-directed and mentor directed experimentation. Each class is divided into main sections which deal with an aspect of physiologic function. These include conversion and utilization of energy by the body, delivery of the energy to appropriate tissues, consumption of that energy in exchange for work, and feedback from the environment in the form of sensation to modify the energy-delivery-consumption cycles. Within each section, there are two self-directed home labs from the "Labless Lab" kit and one mentor directed "Briefcase Lab" to be conducted at a local area site by a trained graduate student.

As an example, the labs for the Consumption section of the course include the home labs on Muscle Fatigue and Reaction Time and the Mentored lab on Chicken Bone

**Mechanics.** These labs reinforce the concepts taught in the lectures on Gravity wins, Newton rules biology - and you, and Where did the energy go? which were described above. In the Muscle Fatigue lab, students will investigate the effects of gravity and mass on the development of muscle fatigue. Students will do simple experiments where they jump up repeatedly until they reach fatigue. They can then use energy equations to calculate the work they performed and related it other energy consuming and producing source. Finally, the experiment will be repeated with extra mass in the student's hands. The student can then repeat the calculations and assess the consistency of work required to reach fatigue. This lab will also tie into previous material of body weight, energy consumption, and effects on cardiac workload taught in earlier sections of the class.

In the Friction lab, students will evaluate the impact of different surface properties and different mass on the forces required to produce motion. By sliding books on table tops, glass, sandpaper, and surfaces coated with lubricants, students will investigate the properties of friction and Newton's third law. This experiment will complement the mentored lab that follows on Chicken Bone Mechanics.

Finally, in the mentored lab on Chicken Bone Mechanics students use an ordinary leg of chicken purchased from a grocery store to investigate properties of articular cartilage at bone joints, the effect of wear and abrasion on the joint function, and the strength and characteristics of the natural joint and bone materials relative to other common materials. This will provide a perspective on the different properties that make up the components of bones and joints and why loads may be taken up differentially by different components of the body.

Through the combined impact of a mentored lab session that provides access to interesting technology, a home based lab that induces self experimentation and discovery, and an interesting media format for presentation of didactic material, we will provide science in a way that non-science majors find inviting, accessible, and coherent because it works from a domain in which they are intimately familiar, *themselves!* This not only

provides a stimulating platform from which to learn science concepts, but may create a better understanding of personal physiology which increases their personal health and physical science literacy simultaneously.

### **Copyright and Production**

Each program will be outlined by the team of J.D. Andrade, K. Horch, S. Kern, and G. Pantalos with the input of M. McDonald (*see personnel*). A three to five person team of basic science and medical science colleagues will be organized for each program and will suggest material, which will be developed into a tight, informative script and text. (Each *Science Without Walls* script went through at least six drafts with multiple expert reviews).

Working closely with Media Solutions, producer of *Science Without Walls*, appropriate video segments will be identified for 60-90% of the script. A shooting and acquisition list and schedule will be made. Working with our existing, extensive video library – including the 20 hours of *Science Without Walls* – and with video materials and suggestions provided by our clinical and technical colleagues, including Fellows of the American Institute for Medical and Biological Engineering (AIMBE), we will select, acquire, and implement the needed broadcast quality video. Perhaps 25% of the video needed will be shot in local hospitals, clinics, and biology/physiology/bioengineering labs by the Media Solutions team in close cooperation with the project technical and education staff. The script will then be revised to reflect the available video, and finally, the studio shooting of the host-narrator will be obtained. The shows will be produced in sequence, so later shows can refer to earlier programs, thereby helping to integrate and tie together all the programs. The video and audio tracts can be readily digitized and fed to any appropriate optical medium, particularly CD-ROM. We will make the tapes available so that end users can deploy the contents as they see fit for not-for-profit use.