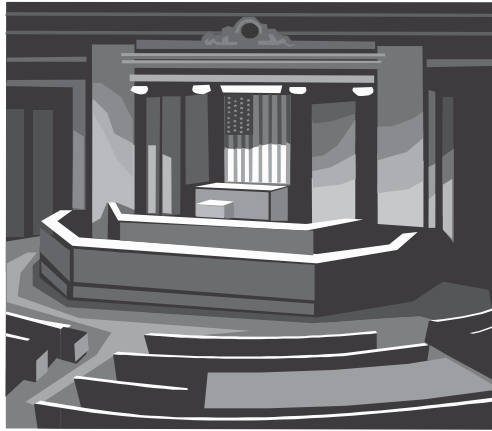


Solving Health Problems in Your Community



Controlling Question for Culminating Activity:

Fighting for Funding: How does a public interest group acquire funding to address a community health need?

**Interdisciplinary
Curriculum Project**

**Suggested for
12th Grade**

The following Interdisciplinary Curriculum Development team members have worked countless hours in the development, collation, and editing of the interdisciplinary, integrated curriculum project model. To say thank you seems inadequate for their energy and time spent throughout the entire process. The team members were not acquainted with one another prior to the inception of this work, yet through the numerous work sessions and process struggles they truly became an incredible team. Jeanne Shaw deserves special credit for her tireless efforts as the team coordinator. Her expertise in her subject area, as well as with the entire interdisciplinary teaming process in curriculum development, guided the team to a previously elusive sophistication. I have taken great delight in participating in this process.

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Data analysis and visualization are at the center of most interdisciplinary projects because social problems and questions frequently grow out of data collection activities. This is especially true of health issues.
— Tom Walters

Solving Health Problems in Your Community

Controlling Question for Unit

Fighting for Funding: How does a public interest group acquire funding to address a community health need?

Culminating Activity

After choosing a community health problem, students will attempt to secure funding from a panel of adults with a well-organized presentation describing the extent of the problem and its solution. Students should strive to justify the amount of money requested by using a variety of presentation strategies.

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Project Introduction

Project Introduction

One thing that education does quite well is to visit and revisit a theory until a plethora of writings exist on the subject. A case in point is curriculum integration. The following document is yet another example of interdisciplinary, integrated curriculum. As a reader, you might ask yourself, “Why should I read this document?” The answer lies in your motivation: a sincere search for high-quality strategies to facilitate motivation, learning and achievement in your students. This document contains a model of an interdisciplinary, integrated curriculum project to designed to help you achieve this goal.

For the purpose of this model, the term interdisciplinary, integrated curriculum has a dual intent:

- ❶ To team five different discipline areas in an effort to reduce the boundaries between content areas, so that students will make natural connections between the disciplines;
- ❷ To integrate an issue or issues surrounding health care into existing standards-based curriculum where it fits naturally to facilitate students’ making the connection that content taught in school will be important in the outside world.

Research indicates that this approach will facilitate more coherent learning and thereby greater student achievement. Additionally, this kind of project presents an opportunity for students to apply and to demonstrate mastery of standards addressed.

One caution before implementation of any integrated activity. Do not try to “force-fit” the career area into the course of study. This can and will happen successfully around an issue or a theme when students are allowed to make the connections through active involvement in their learning process and by providing a context to their academic content.

This introduction is intended to address the process of utilizing the interdisciplinary, integrated curriculum model in this document. This project and three others were created by an interdisciplinary team of teachers from throughout California, field-tested by various school sites, and then revised accordingly. Even though this project can be utilized as is, the overall goal of its development is to provide a guide or a “road map” for individual interdisciplinary teams to use as one resource in developing their own contextual, instructional strategies to facilitate student learning and achievement.

Why Be Involved?

With many viable methods or models for curriculum integration available, one might become confused as to which one is the best. The good news is that there is no single “right way” for interdisciplinary, integrated curriculum development; rather, there are strategies that might be preferred by a team, dependent upon the team’s and the school’s personality. The bottom line with every method is to make **connections** between subject areas, to stress linkages and relationships between knowledge groups.

Students will have more desire to learn when they see the connections, both between their individual courses and between school as a whole and the “real” world in which they live. At the danger of restating a concept that has been shouted from the mountaintops, we do not live in a compartmentalized society, and therefore we should not expect our students to truly learn in a compartmentalized academic setting. When the content barriers come down for the students, teachers will find greater connectedness to their colleagues as well. The last thing that teachers want, or need, is to have more tasks added to their already impacted schedules. In light of this well-recognized fact, why should a teacher or a school site

become involved in interdisciplinary, integrated curriculum? As educators, we must decide whether our focus is to be on teaching strategies or on learning strategies. We can teach brilliantly, and yet our students may never truly learn a single concept. With interdisciplinary, integrated curriculum students learn because the concepts are made meaningful to them. It is important to restate an important principle of this type of strategy: to be successful, this **cannot be an add-on to the curriculum**, rather it must be a strategy that is solidly standards-based.

Make no mistake, this type of curriculum requires effort as well as change. However, the benefits gained from this effort are real for students as well as for teachers. Those teachers able to let go of the need to be in control will then be able to learn new concepts themselves, and thereby model the concept of life-long learning for their students. Students will find that too-oft sought after, yet seemingly elusive connection between school and the “real world.” If, in fact, the overarching goal of the educational process is to develop productive, thinking citizens for the 21st century, then the result of interdisciplinary, integrated teaching will be students who think.

“ . . . students who will see, understand, and articulate connections; students who are able to apply knowledge and skills across content; and students who will, themselves, consciously look for and make connections between and among the content and skills they are taught both as young people and as adults—in other words, students who think.”

Joan Palmer, ASCD Yearbook

One Team’s Journey

As a development team, we found that the process was equally as important as the product. As teachers, we often work alone, so our collaborative skills may be underdeveloped. How can we then encourage our students toward collaborative learning? Again, teachers who take the risk to move outside of their comfort zone or out of the traditional teaching “box” as some have described, find that they become models for their students in the collaborative process of learning.

The first question we dealt with as a team was the rationale for the time spent on interdisciplinary integrated projects. Our conclusion was that encouraging stronger understanding in one subject area by building on the knowledge gained in another is not “add-on” work, but rather is a strategy to make curriculum meaningful for students and thereby truly address standards in each of the disciplines. The theory that the team overwhelmingly adheres to is that higher-order thinking is stimulated by relevant curriculum: Students learn because something is meaningful to them.

Current research indicates that the characteristics of the ideal team include:

- voluntary members
- willingness to implement the product
- love of teaching and of students
- willingness to learn
- risk-takers as members
- demonstration of interpersonal skills
- perception of the teacher as a facilitator

- generalists who “love” a specialized area or
- specialists interested in a generalized approach
- members are innovative and creative
- members have taught several subjects
- members are technologically literate

As a team, we felt that we possessed many of these characteristics and therefore should be able to accomplish our goal without difficulty. After all, we had support, financing, enthusiasm, understanding—what more did we need? We found our own set of hurdles, hurdles that caused some conflict. However, in conflict there is often creativity.

We found that frequently one teacher will have an idea, or the team will create an interdisciplinary, integrated project where the largest percentage of the work fits best in a particular subject area. The work is still interdisciplinary, but the impetus comes from a particular subject area and therefore the leadership role, not the overwhelming workload, may fall in a particular course.

Another hurdle that we encountered was the tendency to create individual “mini-projects” within the context of the whole. To jump this hurdle will take **active** communication between team members, revisiting the central focus frequently, and big chunks of team development time.

Explanation of Project Format

As you peruse the following project model, you will notice some distinct formatting styles that bear explanation at this point. Following the Table of Contents there is a “Project at a Glance” and a “Venn Diagram of Subject Area Activities” that are designed to provide a visual overview of the entire project and how the activities overlap. The “Project at a Glance” was created as a quasi-flow chart with and the overarching theme and question as the focal points. The process standards are the SCANS Competencies, and the Content Standards are those addressed in the whole of the project. Each of the five subject areas contains a list of the activities by title which flow into the culminating project and then finally into the overall assessment. The “Venn Diagram” was created as an alternative visual to display what activities overlap within the disciplines. These were found to be useful for the Development Team, but may not be helpful for your particular team. Some interdisciplinary teams may prefer a traditional activities timeline. The important idea is that a visual display of interrelatedness is helpful to maintain the team’s focus.

The section delineated “Process and Tools” contains some tips and suggestions on technology usage, Web searches, and student-centered behaviors. These will not be necessary for every team, but new teachers or newly formed teams may benefit from the suggestions. We felt these items were of such importance that they should be available at the beginning of the project rather than buried in the appendix.

The “Standards” section contains an overall list of every subject-matter standard that is addressed in the project if done in its entirety. Where the actual standards are addressed is listed on the appropriate activity. In this section, you will also find a concise description of the SCANS Competencies and Three-Part Foundations. The Secretary’s Commission on Achieving Necessary Skills (SCANS) identified five competencies or skills they felt necessary for workplace success, and foundations that were necessary qualities to achieve the aforementioned. These are listed for your information as you begin. Again, the team felt that their overall importance in the project and in the overall process warranted their placement.

Next, you will find a description of the suggested culminating project and the actual activities that surround this culmination of the project. The activities for each subject area follow under their individual sections. Each of these sections has its own Appendix that contains back-up materials for activities and possible “Extension” activities where indicated for advanced classes.

It is important to note that the culminating project is to have a health care context, whereas many of the activities in the individual subject areas will appear to lack that context. This is due, in large part, to the fact that these activities frequently are process oriented. For example, when developing a magazine that centers around a medical context, the process activities in language arts might be the development of skills in technical writing or the editing process. The beauty of this aspect is that as the students meet English standards, they are building necessary skills for the completion of the culminating project, which in turn will demonstrate that they mastered the addressed standard.

At the end of the model, you will find a generic “Resources” section that contains booklists, agencies, and other resources that fit with the whole project rather than a specific subject area. Finally, there is an extensive “Assessment” section that contains a variety of rubrics for use in an activity or in the culminating project assessment. These rubrics have been gleaned from a variety of sources and can be used “as is” or modified to fit your particular needs.

Conclusion

Each project model was developed with the philosophical goal of providing a health care context by which students can truly learn their subject matter. There was never the intent to create career search projects, per se, but to allow the natural evolution of career awareness to occur throughout the students’ work. This is not to indicate that one is superior to the other, but merely that it was this particular teacher teams’ preference.

Project at a Glance

Solving Health Problems in Your Community

How does a public interest group acquire funding to address a community health need?

Process Standards

Resources Interpersonal
Information Systems Technology

Content Standards

<p>Science Culminating Project (feasibility analysis, epidemiology, research skills) Evaluating Research Identifying Health Concerns Chemistry Mercury Madness Physiology Blood, Lymph & Angionesis Inhibitors Genetic Vaccines Physics Human Work & Power</p>	<p>Math Culminating Project (data feasibility studies, final graph/visual for presentation) Study and Critique Data Graphs</p>	<p>Language Arts Culminating Project (preparation, writing, presentation) Choosing a Health Issue to Write a Grant What Is Technical Writing?</p>	<p>History Culminating Project (a center discipline) How Does a Public Interest Group Acquire Funding? Community Health Issues in the News Locating Public & Private Agencies for Support Choosing a Health Issue to Write a Grant</p>	<p>Health Careers Culminating Project (a center discipline) Community Health Issues in the News Locating Public & Private Agencies for Support Choosing a Health Issue to Write a Grant</p>	<p style="text-align: center;">T I M E</p>
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Interdisciplinary Culminating Project

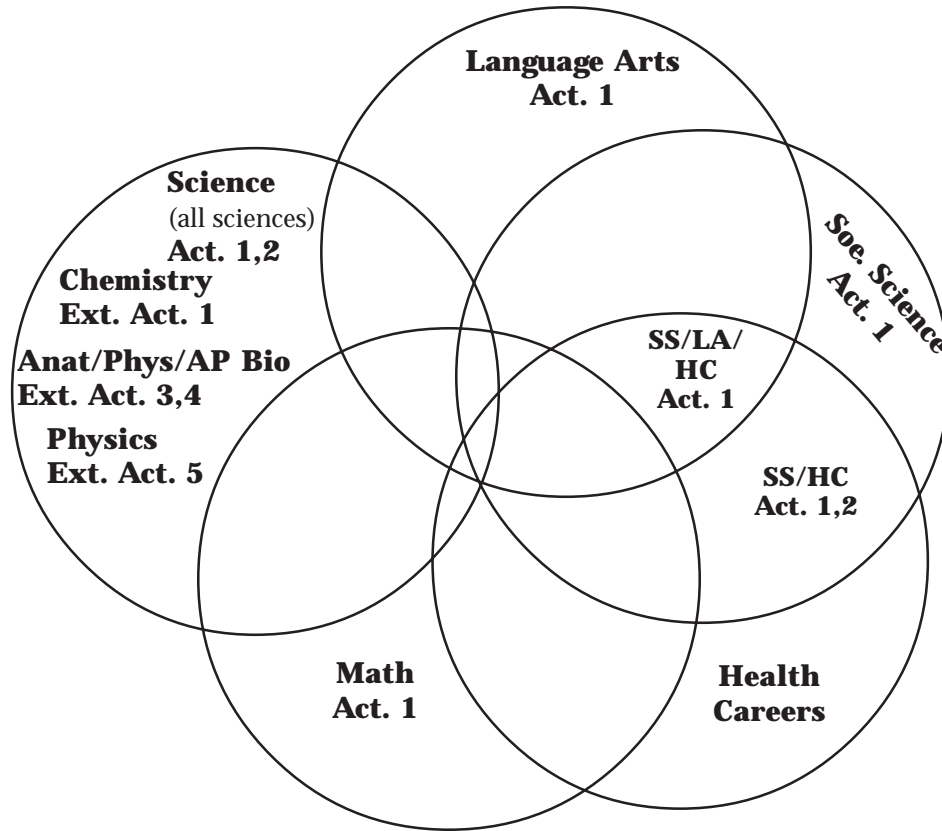
Students choose a community health problem and attempt to secure funding from a panel of adults with a well-organized presentation describing the problem and its solution and justifying the amount of funding requested.

Interdisciplinary Assessment

Rubrics for project & performance assessment, including writing and posters.

Integration of Subject Area Activities

Solving Health Problems in Your Community



Suggested Use of Venn Diagram

This diagram or the Project at a Glance on the previous page can be enlarged and posted to serve as a daily reminder to assist the teachers in judging how their activities are flowing with the other disciplines involved in the integrated project. This will also serve as a good reminder to teachers to bridge the concepts between disciplines at the appropriate times.

Involvement of the actual disciplines in areas of integration, especially in the Culminating Project, will vary according to teachers, site and topic selected by student.

Processes and Tools

Using Technology

The use of technology as a tool to enhance learning is growing rapidly. Depending on the availability of technology at the school site, this can be effectively integrated into the project. Utilization is encouraged as an invisible partner to enrich all activities, particularly the quality of presentations, videos, magazine production and exhibits.

Suggested technology to use for this project:

- Internet for research and distribution of product
- desktop publishing program to format the product
- photo equipment (e.g., digital camera, scanner) to visually enrich the culminating product and document work in progress
- presentation program to promote the product to classmates (e.g., PowerPoint, Hyper Studio)
- World-Wide Web display of a video, a presentation or a “virtual” magazine
- media centers
- libraries

Conducting a Web Search

Basic Search Guidelines

Most search engines found on the World Wide Web are organized like an outline. They start with general topics such as Arts, Government, Science, etc. After you select from such a list of broad topics, the search engine then proceeds to more specialized sub-topics. For example, under science are found branches of science such as agriculture, medicine, or physics. At each level you are asked to choose from a range of more specialized topics until you arrive at the level of individual “sites” which may contain the information that you are seeking. Commonly used search engines include Yahoo, Alta Vista, Ask Jeeves, Excite, Google, GoTo, Lycos, Dogpile and Netscape. Most of these can be found by typing [www.\(engine name\).com](http://www.(engine name).com).

When conducting web search in health-related areas, there are things that you can do to ensure that the sites found contain accurate information:

- Utilize a medical search engine* to provide links to other relevant sites.
- Find out who is behind the site to gain insight into the site’s point of view as well as the reliability of the information provided. One way to conduct this research is to do a “Whois” search at Network Solutions (www.nsi.com).
- Determine whether the site demonstrates only opinions and biases, or facts and pertinent data. On what data is the information based? This determines the reliability of

such information.

- Be aware that information sponsored by advertisers may indicate a varying amount of editorializing.
- Check the date to ascertain current information. Medical information is changing rapidly. If the information is more than two years old, it may be out of date.

The individual **must** take responsibility for the direction of the search in order for it to be subject-relevant as well as timely. The following Web sites will be valuable, but only as a start in connecting with information driven by questions and organization that are well designed from the heart of the research/project topic.

***Reliable health-related Web sites/search engines:**

Achoo—www.achoo.com (search engine)

Alzheimer's Association—www.alz.org

American Botanical Council—www.herbalgram.org

American Heart Association—www.americanheart.org

American Medical Associatio—www.ama-assn.org

CBSHealthWatch—www.healthwatch.medscape.com

Federal Trade Commission—www.ftc.gov

Food and Drug Administration—www.fda.gov

HealthAtoZ.com—www.healthatoz.com

Healthfinder—www.healthfinder.gov (search engine)

Medlineplus—www.medlineplus.gov

MedWebPlus—www.medwebplus.com (search engine)

Quackwatch—www.quackwatch.org (also in German, French, Spanish, Portuguese)

Reuters Health—www.reutershealth.com (also in Spanish and Portuguese)

The Med Engine—www.themedengine.com (search engine)

WebMedLit—www.ovid.com

Web Site Evaluation

1. Site Name _____
2. Site Address http:// _____
3. Did this site load: quickly or slowly?
4. What kinds of information or topics are covered at this site? _____

5. Check the features of this site: Pictures Sound Movies
 Fill-in Forms Animations Hyperlinks
6. Rate the quality and depth of the site: H= high M= medium L= low
 Quality (H) (M) (L) Depth (H) (M) (L)
7. Does the page have a table of contents? Yes No
Was the table of contents useful? Yes No
8. Evaluate the ease of reading the text:
Was the vocabulary easily understood? Yes No
Were the colors of text and background easy to see? Yes No
9. Rate from 1–10 (10 top rating) the appeal of the page: 1 2 3 4 5 6 7 8 9 10
10. Does the site have: a long opening page or hyperlinks to underlying pages?
11. Were there useful hyperlinks to others related sites on this page? Yes No
If so, name one other good hyperlink site: _____
12. Write down two interesting things you learned at this site. _____

13. Was the information from a reliable source? Yes No
What makes you think so? _____

14. Was there an e-mail address at the bottom of the first page? Yes No
15. Would you recommend this site to others for:
Research? Yes No **Fun?** Yes No

Student-Centered Behaviors

A student-centered classroom can be difficult to manage if expectations for the students are not made clear. Due to years of conditioning, students are often very teacher-dependent and wait until the teacher tells them what to do. However, certain tools help promote student independence while maintaining teacher-student communication. They include:

Teacher as Facilitator

Teachers act as coaches, observe as well as periodically participate in groups, help with research, and clarify what is expected of their students. Remember, a student-centered classroom is usually the foundation for research and is driven by an essential question, so your planning is based on how best to facilitate your students' research, and secondly, their understanding of the material they find. Teachers may find it tiresome to have 30 or more students involved in different tasks. Facilitating this takes practice and often patience. Some days will feel out of control; others will run smoothly. Teachers need to plan for this type of teaching and be flexible in respect to their students' pacing. They also need to plan for down time. For example, in an English class, everyone should have a novel to read during down time. If the class gets too hectic, call off the research for a day and take a rest.

Time Management

Calendar

Students need to learn how to plan their time. Once the students understand a particular project, pass out a blank calendar to help them plan their use of time in and out of the classroom. As the teacher, you can help them plan their first weeks of research and then slowly allow them to take over this responsibility. As time progresses, student groups will manage their own calendar. Start out class with five minutes of planning and/or reporting on what students expect to accomplish each day. This clarifies activities for both students and teacher.

Progress Memos

Students can also write "Progress Memos" at the end of the week to update the teacher on the group's progress.

Weekend Planning

On Fridays, students need to spend time planning possible weekend activities related to their project.

Due Dates

Due dates are the prerogative of the teacher. Generally, students should write them on their calendar and expect to meet each deadline. However, a student-centered classroom is often surprising. When students become deeply involved in a project, they can have a legitimate reason for needing more time. Allow for the possibility of flexibility when you are planning.

Peer Teaching

Peer teaching can take a variety of forms. Provide a board where students can share information such as times that libraries and bookstores are open, organizations that might be helpful to other groups, teachers on campus who are knowledgeable about a certain subject, Web sites of interest, etc.

Peer teaching can also mean that students share their work in-progress so that students having difficulty may gather ideas in relation to their project work. Frequently, students can be highly effective in helping their peers understand a project or an idea.

Students who are efficient and catch on quickly can tutor once they complete their project. Offer extra credit for helping others.

Expected Behaviors

Identify the role of each student in a group by writing the roles out or having the class develop a list. The facilitator must be someone who can keep the group moving, the recorder a decent writer, etc. Ask the recorder to write down what each student is expected to do for their particular project. This becomes an accountability strategy and protects the integrity of the group process.

Interdisciplinary Project Log

(Optional)

Rationale

The interdisciplinary project log is a “process portfolio” that can be used with any of the interdisciplinary units. The project log provides students with continuity as they move from class to class and helps them make connections between subject areas as they build a knowledge base. It is also a method of assessing each student’s involvement in the project.

Introductory Activity: The Interdisciplinary Project Log

Students organize a notebook in which they keep notes, research information, labs, reading logs, ideas, assignments, etc. They utilize this notebook in classes involved with the interdisciplinary project.

Objective

The student will:

- Keep the project work organized;
- Build a body of information for the culminating project;
- Make connections between subject areas;
- Demonstrate individual involvement in the interdisciplinary project;
- Assess individual involvement in the interdisciplinary project.

Process

The student will:

- Organize a notebook to use as an interdisciplinary project log;
- Carry the interdisciplinary project log for use in each class;
- Keep notes, research information, labs, reading logs, ideas, assignments, etc. in the interdisciplinary project log;
- Use the material in the interdisciplinary project log for class discussions and planning;
- Periodically evaluate their progress with peers and teachers;
- Write a letter of evaluation assessing individual work and study habits.

The teacher will:

- Explain the purpose of the interdisciplinary project log;
- Provide students with an appropriate format for the interdisciplinary project log;
- Use the interdisciplinary project log to assess the needs of individual students;
- Provide feedback;
- Develop a scoring guide for assessing the interdisciplinary project logs. (The team of teachers can develop the scoring guide alone or in conjunction with the students.)

Assessment

- Students write letter of evaluation to put in the front of their interdisciplinary project log;
- Students turn in interdisciplinary project log for teacher(s) to evaluate using scoring guide.

Standards

Standards

Content Standards Alignment

Health Careers Core Standards

1. **Socioeconomic:** Students will know the relationships of various health care systems.
2. **Growth and Development:** Students will know how diseases impact the human body systems.
3. **Safety:** Students will know the potential hazards to employers, employees, and patients within various health care settings.
4. **Communication and decision making:** Students will know how to use critical and creative thinking, logical reasoning and problem-solving skills using various methods.
5. **Ethical and Legal Responsibilities:** Students will know ethical considerations, legal constraints, and professional codes affecting health care delivery systems.
6. **Career Planning:** Students will know the importance of comparing personal profiles to various health career requirements.
7. **Career Planning:** Students will know the steps necessary to achieve career goals and expectations.

History-Social Science Standards

Principles of American Democracy and Economics

- 12.7:** Students analyze and compare the powers and procedures of the national, state, tribal, and local governments.
1. Explain how conflicts between levels of government and branches of government are resolved.
 2. Identify the major responsibilities and sources of revenue for state and local governments.
 5. Explain how public policy is formed, including the setting of the public agenda and implementation of it through regulations and executive orders.
 8. Understand the scope of presidential power and decision making through examination of case studies such as the Cuban Missile Crisis, passage of Great Society legislation, War Powers Act, Gulf War, and Bosnia.
- 12.8:** Students evaluate and take and defend positions on the influence of the media on American political life.
3. Explain how public officials use the media to communicate with the citizenry and to shape public opinion.

Math Standards

Mathematical Reasoning (Grades 3–7)

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.

English-Language Arts Standards, 11–12

Reading

Reading 2.0 Reading Comprehension (Focus on Informational Materials)

Students read and understand grade-level-appropriate material. They analyze the organizational patterns, arguments, and positions advanced.

2.1 Analyze both the features and the rhetorical devices of different types of public documents and the way in which authors use those features and devices.

2.2 Analyze the way in which clarity of meaning is affected by the patterns of organization, hierarchical structures, repetition of the main ideas, syntax, and word choice in the text.

2.3 Verify and clarify facts presented in other types of expository texts by using a variety of consumer, workplace, and public documents.

Writing

Writing 1.0 Writing Strategies

Students write coherent and focused texts that convey a well-defined perspective and tightly reasoned argument. The writing demonstrates students' awareness of the audience and purpose and progression through the stages of the writing process.

1.1 Demonstrate an understanding of the elements of discourse when completing narrative, expository, persuasive, or descriptive writing assignments.

1.2 Use point of view, characterization, style, and related elements for specific rhetorical and aesthetic purposes.

1.3 Structure ideas and arguments in a sustained, persuasive, and sophisticated way and support them with precise and relevant examples.

1.4 Enhance meaning by employing rhetorical devices, including the extended use of parallelism, repetition, and analogy; the incorporation of visual aids; and the issuance of a call to action.

1.5 Use language in natural, fresh, and vivid ways to establish a specific tone.

1.6 Develop presentations by using clear research questions and creative and critical research strategies.

1.7 Use systematic strategies to organize and record information.

1.8 Integrate databases, graphics, and spreadsheets into word-processed documents.

1.9 Revise text to highlight the individual voice, improve sentence variety and style, and enhance subtlety of meaning and tone in ways that are consistent with the purpose, audience, and genre.

Science Standards

Investigation and Experimentation

1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations.

- a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data;
- b. Identify and communicate sources of unavoidable experimental error;
- c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions;

- d. Formulate explanations using logic and evidence;
- e. Solve scientific problems using quadratic equations, and simple trigonometric, exponential, and logarithmic functions
- f. Distinguish between hypothesis and theory as scientific terms;
- g. Recognize the usefulness and limitations of models and theories as scientific representations of reality
- i. Analyze the locations, sequences or time intervals of natural phenomena;
- j. Recognize the issues of statistical variability and the need for controlled tests;
- k. Recognize the cumulative nature of scientific evidence;
- l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science;
- m. Know that when an observation does not agree with an accepted scientific theory, sometimes is mistaken or fraudulent and the theory is sometimes wrong.

Physics

Conservation of Energy and Momentum

2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects.

Heat and Thermodynamics

3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat.

Chemistry

Atomic and Molecular Structure

1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure.

Biology/Life Sciences

Cell Biology

1. The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells.

Genetics

4. Genes are a set of instructions encoded in the DNA sequence of each organism that specify the sequence of amino acids in proteins characteristic of that organism.

5. The genetic composition of cells can be altered by incorporation of exogenous DNA into the cells.

Ecology

6. Stability in an ecosystem is a balance between competing effects.

Evolution

7. The frequency of an allele in a gene pool of a population depends on many factors and may be stable or unstable over time.

8. Evolution is the result of genetic changes that occur in constantly changing environments.

Physiology

9. As a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable (homeostatic), despite changes in the outside environment.

10. Organisms have a variety of mechanisms to combat disease.

SCANS Competencies and Foundation

Secretary's Commission on Achieving Necessary Skills (SCANS)
U.S. Department of Labor, 1991

Three-Part Foundation

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks

- A. Reading—locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules
- B. Writing—communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts
- C. Arithmetic/Mathematics—performs basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques
- D. Listening—receives, attends to, interprets, and responds to verbal messages and other cues
- E. Speaking—organizes ideas and communicates orally

Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn, and reasons

- A. Creative Thinking—generates new ideas
- B. Decision-Making—Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative
- C. Problem-Solving—recognizes problems and devises and implements plan of action
- D. Seeing Things in the Mind's Eye—organizes and processes symbols, pictures, graphs, objects, and other information
- E. Knowing How to Learn—uses efficient learning techniques to acquire and apply new knowledge and skills
- F. Reasoning—discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem

Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

- A. Responsibility—exerts a high level of effort and perseveres towards goal attainment
- B. Self-Esteem—believes in own self-worth and maintains a positive view of self
- C. Sociability—demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings
- D. Self-Management—assesses self accurately, sets personal goals, monitors progress, and exhibits self-control

Five Competencies

Resources: Identifies, organizes, plans, and allocates resources

- A. Time—selects goal-relevant activities, ranks them, allocates time, and prepares and follows schedules
- B. Money—uses or prepares budgets, makes forecasts, keeps records, and makes adjustments to meet objectives
- C. Material and Facilities—acquires, stores, allocates, and uses materials or space efficiently
- D. Human Resources—assesses skills and distributes work accordingly, evaluates performance and provides feedback

Interpersonal: Works with others

- A. Participates as Member of a Team—contributes to group effort
- B. Teaches Others New Skills
- C. Serves Clients/Customers—works to satisfy customers' expectations
- D. Exercises Leadership—communicate ideas to justify position, persuades and convinces others, responsibly challenges existing procedures and policies
- E. Negotiates—works toward agreements involving exchange of resources, resolves divergent interests
- F. Works with Diversity—works well with men and women from diverse backgrounds

Information: Acquires and uses information

- A. Acquires and Evaluates Information
- B. Organizes and Maintains Information
- C. Interprets and Communicates Information
- D. Uses Computers to Process Information

Systems: Understands complex inter-relationships

- A. Understands Systems—knows how social, organizational, and technological systems work and operates effectively with them
- B. Monitors and Corrects Performance—distinguishes trends, predicts impacts on system operations, diagnoses deviations in systems' performance and corrects malfunctions
- C. Improves or Designs Systems—suggests modifications to existing systems and develops new or alternative systems to improve performance

Technology: Works with a variety of technologies

- A. Selects Technology—chooses procedures, tools or equipment including computers and related technologies
- B. Applies Technology to Task—understands overall intent and proper procedures for setup and operation of equipment
- C. Maintains and Troubleshoots Equipment—prevents, identifies, or solves problems with equipment, including computers and other technologies

Culminating Project

Interdisciplinary Culminating Project

Philosophical Overview

With standards-based education on everyone's mind, it is important to examine every curriculum guide, course model, teaching strategy, and lesson plan to determine how it fits in with the standards. The following simulation meets California content standards for all disciplines included. What we like best about this project is that it focuses on preparing the student to solve real world challenges or performance standards. Students must recognize existing health problems in their community and then create solutions for them. This moves them into an involvement with their community.

Some educators have suggested that this project may be adjusted so that it can be used as a Service Learning or Community Action Project. Since the project is student-centered (students choose the problem and the solution), students pursue their own course of action in depth. The culminating project is a presentation. Students must present their solutions to a panel of adults (and/or peers) and then ask for fiscal support for their program. The assessment is authentic: the closer students get to their stated financial goal, the higher their score. Finally, many districts in California are requiring a senior exhibition as part of the graduation component. This project meets that obligation nicely.

Standards Addressed

English-Language Arts: Reading Comprehension 2.1, 2.2, 2.3; Writing 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9 (for writing of the culminating project)

Social Science, Health Careers, Mathematics, and Science standards are included in the activities that support the culminating project.

Overview of Culminating Project

Students develop a proposal to solve a community health problem by simulating the role of a health agency they believe is in the best position to solve the health issue they have chosen for their proposal. This student-centered project lasts approximately three weeks and culminates with a presentation to a panel of adults and/or peers.

Step 1

After introductory lessons, students form groups and discuss health problems faced by their community. They choose one on which to focus.

Step 2

Students begin to brainstorm how the community health problem might be solved.

Step 3

Students are given a grant application and begin to formulate a plan on how much money they will require for a solution to their chosen community health problem. Students should contact the agency that will supply the resources they will need. The students may role-play the organization. Other options are to actually service the community themselves or through the organization.* (See “fitness center” example in the physics extended activity.)

Step 4

Students must agree upon a detailed plan for solving the community health problem and a rationale for the specific amount of funding they are requesting.

Step 5

Students fill out the initial application for the grant. If the application is accepted (it must be perfect), students begin to plan their presentation to the panel.

Step 6

Students present their proposal to the panel. The panel evaluates it according to the rubric and the students are notified of their award of grant monies.

*Refer to Culminating Project Appendix 1, 2, 3 following this section.

A Strategy for Completing a Grant Application

Begin class by passing out the grant application forms. Explain to students that they must strictly adhere to the application requirements. The applications must be without error or they will be rejected. (Some teachers may wish to allow for second and third attempts so that no group's application is rejected.)

Here are some points the teacher should cover in regards to the application process:

- In order to receive funding for their proposal, students must apply for a federal grant that is being redistributed at the state level. One million dollars is available and each group may apply for any or all of the award. Their assessment will include what percent of their target goal they actually are awarded (so a group that receives 100% of the \$35,000 requested would score higher than a group that received only 50% of \$100,000 requested).
- Applying for the grant consists of two stages. First, the grant application must be filled out correctly. Secondly, if the application qualifies, then the group must present its proposal to a panel from the state assembly or the city council who will hear the proposal and then award the group their allotment.

Sample Project

Students discover that the community's water source consists of five underground water wells and there have been some reports of people getting sick and children contracting rare forms of leukemia, possibly from drinking the city's tap water. The students decide that they will become representatives of the American Cancer Society and apply for a portion of the health block grant to fund their research on the water contamination. After creating a budget of how the research will be conducted, the student group decides to apply for \$75,000. Students fill out the grant application, using a PowerPoint presentation that displays graphs and shows significant toxin levels in the city's drinking water. In a well-organized presentation, the group, acting on behalf of the American Cancer Society, clearly demonstrates the threat to the community's health if the problem is not addressed. The panel, much impressed, awards the entire \$75,000 requested.

Teachers should point out that a group's success will depend on their ability to fill out the application, develop a new program, and present it to the committee. Students should carefully read the application in order to insure they understand all the requirements. Applications should be kept in dossiers or folders.

Give students some time to ask questions, form their groups, then ask more questions. Finally, allow students to come to a consensus and decide upon deadline dates listed in the student project guide.

Begin class by asking groups to exchange phone numbers, select leaders, etc. Inform the class that the project is now being turned over to them. The teacher will act as a facilitator and give as much advice and assistance as possible.

I. Theme. Problems should be roughly defined at this point. However, ask students what they think is the priority of the project. Answers will include solving community health problems or finding the funding to finance solutions.

II. Brainstorm. This phase gives students an opportunity to be at their best. Groups should be encouraged to turn in a timeline to their teacher. This will require planning and organization. The facilitator should have each group's timeline. Make sure students have given themselves ample time to meet grant application and panel presentation deadlines.

During this stage, groups will have chosen which problem to attack and how they intend to do it. Teachers should pass out a list of local health and human services agencies or research organizations from the appendix. Encourage students to contact the service or research organization they intend to role-play or to use for setting up an actual service for the simulation. Give students tips on how to speak on the phone or make in-person requests for assistance from these groups. Guide students in reading and analyzing relevant documents that they can obtain from their organizations.

Here are some questions they may want answered by the agency, service or researcher they contact:

- What are the overall goals of the health agency?
- Has the agency attempted a new program in the past couple of years? Why did it succeed or fail?
- Should the idea for a grant be one that has already been attempted?
- What target groups does your agency serve?
- What resources are available to support the development and implementation of your community agency?
- Are there other institutions that might support your community agency?
- Are the most recent health promises available? If not, is there a reason why?
- Where might the research backing the topic be found?
- Are their stakeholders? What is their effect on solutions?

The challenges the students face are real-world problems with many possible solutions. At this time, the realization should occur that many obvious solutions are limited by fiscal constraints. A new problem has now appeared—how to acquire funding to finance the students' proposal.

III. Proposal. The proposal for the solution should be finalized at this point. Ask students to write a rationale for why they chose the problem and how they arrived at the solution. They should begin planning what their program will look like and how much it will cost. As this detailed planning progresses, many questions will arise. Students must begin to figure out where they are going to look for the answers to their questions.

IV. Research. At this stage, the facilitator will play an important role. How are students going to conduct their research? Obviously, libraries and health agencies can provide statistical data, demographic information, and the resources to find other necessary information. **See individual activities in all disciplines for evaluating and organizing information.** Municipalities should also be able to give some direction, and some have Web sites that contain invaluable information. The Internet possibilities are infinite. Firsthand field data gathering might be necessary. (See Math Activity and Science Activity 2.) Conducting actual hands-on science research may give an avenue to solve the problem. (See physics and anatomy/physiology lessons.)

V. Processing. With all the information collected, how are the student groups going to put an organized proposal together to present to a panel? This is where the project takes on a truly interdisciplinary look. Math will play an integral role as the budgets need to be delineated, while graphs and matrices can be utilized for justification of the funds needed. Science and health can help if research is conducted on drinking water contamination, antibiotic resistance, medical instrumentation, or other health/research topic specifics. English-Language Arts can help the students in the writing of the grants, their oral presentation skills, and their research. Work collaboratively over the Internet or in person with experts even up to a final review asking for comments.

While the students are processing the information, the science and math teachers should be active in supplying the evidence with actual data. Methods and vocabulary differ in areas of science/math compared to social science/language arts. It is important that students receive help in processing the science and math information to make wise topic choices and assess the causes and viability of their recommendation for a solution.

Present as models the following activities:

- Math—Study and Critique – Data Graphs
- Chemistry—Mercury Madness
- Anatomy/Physiology—Blood and Lymph Circulation: Genetic Vaccines
- Physics—Human Work and Power

Monitor and encourage each step of the scientific method to facilitate the data and scientific process being integrated into the grant application process. The student paper “Scientific Techniques Provided for Assembly Hearing Simulation—Gathering Rationale” (page xx) is provided for easy facilitation.

As students follow the process, guide them in their particular topic to see that the deadline date on the “problem” (science student project guide) might come soon after the “brainstorming” described above in this section. The “information search” (science) due dates might co-align with “brainstorming” (above section) and “research” (above section). The “hypothesis” (science) might appropriately be the same date as “proposal” (above section). The “procedure” (science) and “conclusion” (science), must be carried out before the final “processing” (above). A project involving hands-on lab work may have a later science segment due date than one where the science segment is analyzing literature for good scientific method. The ideal is to facilitate merging the various disciplines for the strength of solution to their problem.

It is essential that all disciplines collaborate, activity by activity and step by step, in the culminating project for a successful product. It is not enough for each discipline to simply do its own part in the culminating project without a holistic view.

* Refer to Culminating Project Appendix 1,2,3 following this section.

Assembly Hearing Simulation

Advanced Health Careers

Welcome to the simulation we will call *Assembly Hearing*. Have you ever wondered why the government will not or cannot fix certain health problems in your community? Isn't it the job of government to solve problems of pollution, drug use, hunger, child or spousal abuse, and prostitution? Is lack of money the problem? In *Assembly Hearing*, you will be working with a small group of students who will attempt to address some of these problems. You will learn about the following issues during our simulation:

- The health problems faced by your community;
- The functions of some of the health agencies and health services that serve in your region;
- How to apply for a federal grant;
- How federal grants are awarded;
- How to plan and organize a successful presentation.

Here are the steps and deadlines you need to be aware of:

① Go to the library and find newspaper articles that describe local health problems. Ask the librarian for help. You may need to look at back issues of your local newspapers going back months or even a few years. Make photocopies of the articles and make sure you write the date of publication.

Due date _____

② Brainstorm reasons why some of these community health problems have not been solved. Write down at least five explanations as to why you think these issues have not been addressed. Bring to class on _____.

③ Form a team with at least one other student. Make sure your team is no larger than four.

④ Choose a health problem faced by your community. Your goal here will be to try to create ways to solve this health-related problem. Do this by _____.

⑤ Choose and contact a health agency or health service that could provide you with resources to help you think of ways to overcome the health problem in your community you have chosen. You may want to contact more than one agency. At this point, you must choose one of these services that you will role-play or actually perform for the rest of the simulation. For example, if you choose the **Red Cross**, you will want to get as much information on how they operate, who they actually help and what their goals are. The **Red Cross** should be able to provide you with plenty of data about the demographics of the area. This could save you a couple of trips to the library.

As you gather information, use science and math skills to determine if a health problem is in fact relevant to your community, then hypothesize what can be done. Use data and problem-solving skills for the determination. For example, you may wish to choose the math maps and the science simulation, "Identifying a Health Concern," for the techniques.

Make sure you have contacted at least one health agency and at least one illustration of data and/or problem-solving by: _____.

⑥ Begin to plan and organize how you will solve the health-related problem your group has chosen. Check to determine if there is proof and logic behind your hope of a solution. Check your reasoning, literature obtained, and the medical research status. Is the solution feasible? One objective of this exercise is for you to understand how to make a quality presentation to a panel from the state assembly or city council that will garner the money you need for your program. You will be asking for that government money through the grant application process. Therefore, it is essential to plan every step and detail of your program and how much it will cost. When awarding grant money, officials want to know how every dollar will be spent and how your group will justify it. Planning this aspect of the project should be complete by the time you begin to fill out the initial grant application.

⑦ Inspect the grant application provided to you by your teacher. Make sure you note the deadline for application submission. Late applications will not be accepted. Read the invitation to apply for the funding. Review the checklist and make sure you have addressed every requirement. For section one, the cover page data must be complete with the signature of the lead person in your group. On a separate page, include a brief description of the group of people who will be benefiting from your program (*Health Group Demographic information*). For section two (*Prospectus Components*), you will actually receive points for filling out this portion of the application. The more complete the information you provide, the more points received. The *Prospectus* also serves as a guide to how you will make your presentation to the members of the Assembly. The members of the Assembly will have a copy of your *Prospectus*, so it is essential that the form and information of both the application and the presentation to the panel are the same. Remember, the *Prospectus* is simply asking you to: a) provide a brief summary of your program; b) describe who will be helped by your program; c) provide data and statistics (charts, tables, graphs) that prove the need for your program; and d) tell what you expect the outcome will be. Please note that the mathematics component is an extremely important part of the presentation. Enhance this portion of the presentation by using PowerPoint presentations, overhead transparencies, colorful charts, etc.

Application completed and turned in by _____.

⑧ The last stage of the process is your presentation to the Assembly or City Council panel. Your teacher will provide you with information on how long your presentation should be, what you should wear, who in your group should do the presentation, and tips on how to make public presentations. By this time most of the hard work is done. Once you have completed the *Prospectus*, your presentation is almost ready. All you need to do at this point is to practice your public speaking skills and prepare the graphics for the presentation.

Your appointment with the Assembly Panel is _____.

⑨ One last piece of advice: you are going to be judged by your professionalism, your enthusiasm, and your knowledge. Keep those ideas in mind as you prepare your presentation. As you enter the adult world, you will be encountering numerous situations in which you will be judged in exactly the same way whether it is a job interview, a business meeting, or an audience with a very important person. Here's your opportunity to anticipate the future and prepare for it.

Scientific Techniques Provided for Assembly Hearing Simulation Gathering Rationale

By providing a model for processing scientific information, your team will be able to not only choose a community problem, but also to provide evidence for the grant proposal. You will:

- Use science to explore a health-related problem in your community;
- Provide scientific evidence to demonstrate the validity of your hypothesis;
- Integrate social science and science to define a plan of action for your grant application.

Work with your group to follow the steps of the scientific method in choosing a community health-related topic and process it with a logically documented solution. Plan and meet your deadline.

❶ **Choose a problem.** Choose a problem in your school, town, city, county, work, or other local venue that has a health/chemistry, health/anatomy-physiology, or health/physics component (suggested topics were presented in previous science lessons; an Internet or newspaper investigation can identify current concerns). **Sample:** At school, students and teachers are becoming ill in epidemic numbers with headaches, nausea, runny noses, sore throats, sleeping difficulties, fatigue, breathing difficulties, chest pain, and bronchitis. Absences increased dramatically. The community is concerned. The school district’s search for the cause has not been successful, and the district would appreciate assistance. Can the population be defined and air and water be tested to identify the source, enabling a solution?

Due date _____

❷ **Do a thorough information search.** Find agencies, organizations, and/or research or university labs that address the health issue you have chosen. Use the Internet. Call and/or visit representatives from these agencies and organizations that serve local needs. Or seek a science partner by contacting science consultants and/or universities. There are several Web sites available to post a call for collaborators, e.g.:

Ask a Scientist: <http://www.cedarnet.org/aska/scientist/index.html>

Access Excellence: <http://www.accessexcellence.org>

Or contact a scientist from the Web sites visited. Seek information from all points of view. If there are stakeholders, seek to find information on another perspective. Gather enough data to thoroughly and accurately process a solution. **Sample:** An environmental testing lab and a nearby University of California agreed to help students on obtaining, testing, and reading scientific information. Due date _____

❸ **Define a Hypothesis.** Based on solid evidence and data, define a solution to the health problem. Are you basing your hypothesis on sound sources and research? With an overview of procedures, make the leap and predict the outcome. **Sample:** Use “Scientific/Medical Article Analysis — What Do the Numbers Mean?” to evaluate the case studies and procedures you read or discuss them with your experts. Make certain that your procedures detect a positive reading on a chemical, you can put together complete reliable, convincing evidence without having to jump to a conclusion. Due date _____

④ **Describe Procedure.** The project calls for organizing, evaluating, and putting together evidence. Your conclusions will be as good as the evidence you obtain. Remember that strong science has actual data from a rigorous research process that is designed for needed results. Or better yet, obtain data by doing the procedures yourself. **Sample:** 1) Work with the school site and district to obtain information and do your field work by surveying teachers, students, classes, and clubs. Create a dot map to show where the victims have been. 2) Run chemical tests on air and water with the guidance of the experts. 3) Talk to the facility's director about the materials that make up the facilities and the design of construction as this may pertain to air or water quality. **Other Samples** (Chose an appropriate topic.):

Chemistry—Test local medical waste, quality of water as related to fish we eat or water we drink, pesticide residues, residential hazardous waste. Do mini-trials on proposed solutions if possible.

Physics—Set up health exercise center using knowledge on work and power. Design and assimilate equipment or instruments.

Anatomy/Physiology—Decide on a needed technique or good medicine by analyzing research as you did in the angiogenesis inhibitors studies. Assist in a clinical trial or program with a doctor or hospital (e.g., educate people to become involved in a new heart, diabetes or flu shot program that your grant brings to the community). Due date _____

⑤ **Results.** Display clear supportive evidence to convey solutions for the targeted population. Data must be factual from keen observation (either from you or from a medical researcher you trust). The data needs to be well organized and visually clear so that the conclusion is evident. **Sample:** Use dot maps, chemical test data from water and air, maps of structural components clearly displayed. **Other Samples:** Use data from designed equipment, fitness improvement, mini-trials, clinical trials. Due date _____

⑥ **Conclusion.** Display evidence clearly to form step-by-step thinking leading to the conclusion. The data should show a population's problems, what the cause and the effects mean. These details brought together for meaning should lead to a well-defined intervention to the problem in the next step. **Sample:** The activities of the people who were ill were in a cluster of new classroom portables that were air-tight for environmental efficiency. The tests showed formaldehyde was above the federally allowed parts per million. Construction was of fiberboard. The visuals from all three sets of data show a link. Conclusion: fiberboard degassing in an air-tight area causes illness. Due date _____

⑦ **Analysis and Proposal.** State how the problem can be corrected and add a clear rationale for the funding request. **Sample:** Either replace fiberboard or install an effective air vent system. Present the data visually so that it is manifestly evident that the cause is formaldehyde and the problem has a structural remedy. If testing is expensive, request the cost of the lab phase in your grant. Due date _____

Culminating Project Appendix

List of Health and Human Services Agencies

Other Health Groups for Research and Assistance

Grant Application

List of Health and Human Services Agencies

ADAPT (Alcohol and Drug Abuse
Prevention Task Force Coalition)
Adult Children of Alcoholics
Agency on Aging
AIDS Foundation
Alcoholics Anonymous
Alternatives Pregnancy Care Clinic
Alliance for the Mentally Ill
Alzheimer Association
American Cancer Society
American Diabetes Association
American Heart Association
American Lung Association
American Red Cross
Arthritis Foundation
Autism Society of America
Burn Institute
Center for the Developmentally Disabled
Child Abuse Prevention Foundation
Children Having Children, Inc.
City of Hope
Cystic Fibrosis Foundation
Deaf Community Services
Down Syndrome Association
GLAAD (Gay and Lesbian Alliance
Against Defamation)
Hospice
Indian Health Council
La Leche League
MADD (Mothers Against Drunk Driving)
Make a Wish Foundation
March of Dimes

Meals on Wheels
Muscular Dystrophy Association
Narcotics Anonymous
National Multiple Sclerosis Society
Planned Parenthood
Pregnancy Care Center
Primary Care Perinatal Services
Pro-Life Pregnancy Counseling and
Education League
Salvation Army
Urban League
Special Olympics
United Cerebral Palsy Association
United Way
Volunteers of America
Womancare, Inc.
Women's Resource Center
YMCA

Directions 1997, Directory of Health and Human Care
Services, San Diego County

Other Health Organizations for Research and Assistance

Project ALS

Doctors' offices

Physical therapy facilities

Hospitals

Drug companies

National Science Foundation

National Institutes of Health

Centers for Disease Control

County Health Departments

Environmental Protection Agency

Occupational Safety and Health Agency

Human Genome Project

Government Labs (genetics, nutrition, etc.)

www.FirstGov.gov gives literally thousands of government organizations whose web sites cover any topic imaginable for your city, county or state

Grant application form contains the following components:

- Invitation to apply for grant

- Checklist of requirements for application

- Cover and signature page requirements (Section 1)

- Prospectus Component requirements (Section 2)

Date: October 30, 2001

TO: Health Care Groups

FROM: Assemblyman Jane Doe
Chairman of Appropriations Committee
State Assembly
Sacramento, California

**Subject: Application for Specialized Health Care Programs (Shcp)
Funding for 2001-2002 Planning Grants**

The purpose of this letter is to invite qualified health care groups to submit a proposal for funding to establish a specialized health care program (**one serving California residents only**). The application describes the procedures for submitting a SHCP planning grant prospectus. *The grant for which you will be applying is for **program planning costs only** with the intent to develop and establish a new program.*

The purpose of SHCP is to provide funding for a worthy public interest group to address a community health need.

Planning grants between \$100,000 and \$350,000 will be available for the development of SHCP **never before awarded a grant** through this funding source. Because of the competition for these grants, it is requested that all initial applicants go through a planning process before considering application for first-year implementation funding. Applicants engaged in the planning grant phase of a Specialized Health Care Program will, therefore, compete only with others applying for planning grants. Those receiving one of the grants will have up to one year to develop a high-quality program.

Deadline for application is: _____ .

Cover and Signature Page

Mail To: Appropriations Committee
State Assembly
Sacramento, California 95814

Health Group Information *(Please type)*

Health Group Submitting Proposal:

Contact Person:

Health Group Mailing Address:

Phone #:

Total Amount Requested:

Signature:

Checklist

Section I. Forms (5 points)

_____ Cover and Signature

_____ Health Group Demographic Information

Section II. Prospectus Components (30 points)

_____ A. Program Summary (5 points)

_____ B. Description of Target Group and Need (5 points)

_____ C. Mathematical Support (15 points)

_____ D. Evaluation of Expected Outcomes (5 points)

Formal Requirements (5 points):

- ◆ Double-spaced, typed;
- ◆ 12-point type (using easy-to-read font such as CG Times or Times New Roman);
- ◆ Charts may be single spaced. Use no smaller than 10-point type;
- ◆ One-inch margins;
- ◆ Do not attach additional pages or information not requested in this application. Staple. Do not use binders or folders when submitting proposal.

During review, emphasis will be placed on delineation of the intended planning process and how well the prospectus communicates the critical features of the program. Formal requirements must be strictly followed; no exceptions will be considered.

Prospectus Review

A subcommittee appointed by the Appropriations Committee of the State Assembly will evaluate each application and hear presentations to determine eligibility and qualifications for each grant awarded. The subcommittee will consist of representatives who are considered experienced in the area of social and health care programs. The highest scoring prospectuses and presentations will be recommended for full awards.

I. Forms:

Cover page

Demographic information of community (population of community, racial/ethnic composition)

II. Prospectus Components:

A. Program summary (5 points): Present a one-page summary of your proposed program that includes its focus and any special features.

B. Description of Target Group and Need (5 points): Describe the group that will benefit from your proposed program and the nature of their needs.

C. Mathematical Support (15 points): Show with charts and graphs, data that supports your proposed program.

D. Evaluation of Expected Outcomes (5 points): Describe what the goals of your program are. How will you measure your success? What longitudinal data will you use to determine the effect of your program over time?

Social Science Activity

Social Science Activity #1

How does a public interest group acquire funding to address a community health need?

An introduction of federalism, grants, and the significance of these topics. Students will analyze a table that accurately converts data on a table to a line chart. This chart will demonstrate how the federal government has increased block and categorical grants to help solve state and local problems.

Rationale

Students are introduced to federal or state grants and how they are used as a way to meet the needs of state and local government.

Basic Health Services Connection

This is a foundational skill-development activity where students gain understanding of the grant process.

Standards Addressed

History-Social Science: Principles of American Democracy and Economics 12.7.1, 12.7.2

Objective

The student will draw a graph that shows how revenue sharing, block and categorical grants have increased by the federal government to help solve state and local problems.

Process

The student will:

- Take notes on teacher-delivered lecture and definitions regarding federalism and the grant program, including block and categorical grants;
- Accurately convert data on table provided by teacher into a line graph.

Assessment

Accurately completed line chart and its data.

Introduction/Significance

In 1913, Congress used the power granted to it by the Sixteenth Amendment to levy the first income tax. The revenue generated by this new law enabled the federal government to distribute money to state and local governments, which it continues to do (California H/SS standard #12.7). In this way, the federal government establishes certain general domestic policies but allows state policy to be determined locally. This is one example of how the sharing of power between the national and state governments, called *federalism*, works.

The manner in which the funds have been allocated has varied over the years. One of the most common forms of awarding money to local governments is through the *categorical grant*. These grants, utilized extensively by the Lyndon B. Johnson (LBJ) administration, are awarded for projects that are specified by the federal government, for example the building of a bridge or development of a literacy program at elementary schools. Another way the federal government gives its moneys to the states is through *block grants*. These grants are to be used in broad areas such as education or health, and it is up to the state or local governments to decide where and how to distribute these funds. For the purpose of our simulation, the distribution of funds supplied by a *block grant* will be the basis for our activity.

For the sake of the simulation, we will pretend that Congress has awarded the state of California a \$1 million health block grant. The Appropriations Committee of the State Assembly has invited any California agencies or groups to apply for the money. The Committee has decided the money will be awarded to local health agencies that propose direct action that solves health problems in their communities. Examples could include drug addicts leaving needles in public places, toxic levels of contaminants in municipal water supplies, hunger among the homeless, high level of teen suicide, etc. The Committee has created a sub-committee or panel that will hear proposals from the agencies applying for a portion of the grant.

Types of Federal Aid

There are three types of federal aid:

General revenue sharing (GRS) was begun by President Nixon and the State and Local Fiscal Assistance Act of 1972. This program distributed \$4 to \$6 billion dollars a year until its termination in 1986. It gave state and local governments money to use as they saw fit with no strings attached. This gave the localities maximum say as to how to use this money and shifted power away from Washington and Congress.

Categorical grants can be used only for specific purposes as stated in the law that created each particular grant. This gives Congress control on how federal money is spent. This type of grant might be used to create a drug education program or to build a hospital. Categorical grants outnumber block grants in dollars spent by almost ten to one (\$155 billion to \$14 billion in 1992).

Block grants are popular with those who believe that state and local governments are more in touch with how to solve their problems and should have more control over how federal money is spent. Congress decides which policy area should receive money and the amount to be spent. For example, Congress may decide to issue a block grant to a state in the policy area of education. It is then up to the state government to decide how to redistribute those funds.

Federal Government Grants-in-Aid Spending Chart

Using the information from the table below, draw a graph (line, bar or pie) that clearly shows how the federal government has increased its grants-in-aid spending since the beginning of the twentieth century. Remember, graphs are a tool used to display data or statistics in a visual way. Pie graphs are better for showing proportions and percentages with the slices of the pie showing how different groups are represented. Line graphs are considered superior in showing trends and changes over time with the vertical axis displaying statistics and the horizontal axis showing increments of time. Bar graphs are used to compare data. Choose the best graph type, and use the data below as well as the questions that follow to set up your graph. These questions will be used in assessing your graph.

Year	Dollars Allocated
1916	6 million
1937	300 million
1960	7 billion
1968	19 billion
1980	91.5 billion
1994	226 billion

When building a graph, consider the following questions:

- Does your title identify the purpose of the graph?
- Are all aspects of the graph clearly labeled (both axes)?
- Are units on the axis in equal increments?
- Are colors utilized to enhance information in the graph?
- Is a key or legend necessary?
- Was the type of graph chosen best for displaying data?
- Is the graph clear, neat and accurate?

Social Science/ Health Careers Activities

Social Science/Health Careers Activity #1 Community Health Issues in the News

Students share local news articles about community health issues with the class and develop a list of possible proposal ideas.

Rationale

Students gain an understanding of health-related issues in their community.

Basic Health Services Connection

This is a foundational skill-development activity where students gain understanding of the current issues surrounding the community. Even though this is not a career activity per se, as students begin research into community health issues natural connections will occur with the world of work.

Standards Addressed

History-Social Science: Principles of American Democracy and Economics 12.7.5, 12.8.3

Health Careers Core: 1,2,3,4,5,7.

Objectives

The student will:

- Gain an awareness of the health problems specific to his/her community;
- Work with other students to begin the proposal process.

Process

The student will:

- Summarize his/her news article on a community health issue to the class;
- Participate in a class discussion and make a list of appropriate health issues.

Assessment

- News articles that the students found regarding community health issues;
- Participation in class discussion.

Bibliography/Resources

Newspapers
Magazines
Internet

Teacher Note: Work with the science and mathematics teacher for choice of topic, reliability of research and information, and gathering or evaluating data. If science classes are not participating, refer to Science Activity 1 and 2, and guide students through an introductory awareness and completion of criteria of health problems specific to their community. The students should also evaluate the quality of the news articles, brochures, scientific journals, or Web sites.

Social Science/Health Careers Activity #2

Locating Public and Private Agencies for Support

The class gathers information on public and private agencies that support the community health issues they have listed.

Rationale

Students must understand the role of community health agencies, both public and private, when writing a proposal.

Basic Health Services Connection

This is a foundational skill-development activity where students gain understanding of the community health agencies. This will provide great insight and connection with the actual health services career areas.

Standards Addressed

History-Social Science: Principles of American Democracy and Economics 12.7.8, 12.8.3

Health Careers Core: 1,4

Objective

The student will understand the nature of public and private agencies, how they are organized, how they are funded, and how they support local communities.

Process

The student will:

- Participate in a class discussion regarding the community health issues that most often receive public and private support;
- Eliminate health issues that do not have enough community support;
- Discuss which agencies would be best to use for their simulation.

Assessment

Demonstration of an understanding of the role of community interest and funding for health-related issues.

Bibliography/Resources:

Newspapers
Magazines
Internet

**Social Science/
Language
Arts/Health
Careers
Activity**

Social Science/Language Arts/ Health Careers Activity

Choosing a Health Issue to Write a Grant

Divide class into groups according to their interest in a specific health issue and discuss their rationale for choosing their topic for writing a proposal.

Rationale

Students need to understand the importance of completing background information and rationale before writing a grant.

Basic Health Services Connection

This is a foundational skill-development activity where students gain understanding of the grant process.

Standards Addressed

History-Social Science: Principles of American Democracy and Economics 12.7.5

Health Careers Core: 1,2,3,4,5,7

English-Language Arts: Writing 1.1, 1.3, 1.6, 1.7

Objectives

The student will:

- Clarify his/her purpose;
- Get to know other students in a group.

Process

The students will:

- Divide into small grant writing groups (no more than four students to a group);
- Clarify choice of a topic through an initial discussion of community need and support;
- Brainstorm ideas on how to improve or develop a new program to deal with the chosen health issue;
- Demonstrate the feasibility of simulating a health organization involved with the health issue **or** demonstrate the feasibility of performing services for the health issue by obtaining support from or working under a health organization;
- Complete a teacher provided contract of group commitment to the grant topic;
- Complete research worksheet.*

Assessment

Completed form of grant topic.

**Refer to following page.*

Teacher Note: All teachers and students should work closely since science and mathematics activities will give needed skills and information to make the final choice.

Questions to Ask About Your Health Issue

1. Are there specific reasons that the health issue that you have chosen stands out as important in your community? Has it been in the news? Is it a political issue? Can you find evidence of medical research on your topic? What segment(s) of the population does it affect?
2. After doing some preliminary research on your topic, did you find evidence that your local government is concerned about this health issue?
3. What community agency, public or private, is concerned with this health issue?
4. What programs exist in your community related to this health issue?
5. Do you have any personal contacts in the community that might provide your group with support or information for this project?
6. If your group obtained financial assistance and could tap into the necessary knowledge, how many medical/science skills do you have that can facilitate a solution to the health issue?
7. How reliable were the resources and/or the medical research?

Extended Questions

8. In general, does government have unlimited resources to spend on health issues? What gives one issue priority over another?
9. When is it the government's responsibility (local, state, federal) to solve community health issues?
10. After researching the role of federal and state government, did you find that funding was spread fairly evenly among categories: hereditary diseases, social issues, environmental issues?

English- Language Arts Activity

English-Language Arts Activity

What Is Technical Writing?

Read “The Eagle” by Tennyson as well as a technical description of an eagle and compare the writing.*

Rationale

Technical writing is used frequently in the health services industry, but this form of communication is seldom taught in high school. Due to the preponderance of technical writing in industry, students need to be fluent in this arena.

Basic Health Services Connection

This is a foundational skill-development activity where students gain understanding of technical writing for the purpose of completing the culminating activity.

Standards Addressed

English-Language Arts: Writing 1.1, 1.2, 1.5

Objectives

The student will:

- Understand the difference between technical and descriptive writing;
- Use the elements of technical writing when writing the grant proposal.

Process

The student will:

- Read the poem and the technical description of an eagle;
- Brainstorm a list of differences between the writing styles;
- Read the following list describing technical writing and compare it to his/her list.

Assessment:

Ongoing writing assessment throughout the process of writing the proposal.

Technical Documents

A technical document:

- Is written by a writer who fully understands the subject;
- Conveys one meaning, allowing one interpretation;
- Is tailored to the needs of a specific audience;
- Is written at a level of technicality that will be understood by a specific audience;
- Is efficient. Every word advances the writer's meaning. Nothing is wasted.

Comparing Descriptive and Technical Writing The Eagle

He clasps the crag with crooked hands;
Close to the sun in lonely lands
Ringed with azure world he stands.

The wrinkled sea beneath him crawls;
He watches from his mountain walls
And like a thunderbolt he falls.

Alfred, Lord Tennyson

The bald eagle, *Haliaeetus leucocephalus*, is named for its snow-white head. One of the sea eagles, it nests along fresh or salt waters in polar regions of the northern hemisphere, throughout most of the United States and south into Mexico. In recent years the number of bald eagles has been much reduced, and they are now most numerous in Alaska. The adult is blackish brown, with a snow-white head and tail. The bald eagle has unfeathered feet and toes. It is 30 to 40 inches long, and has a wingspan of 6 to 8 feet. It feeds mainly on fish; however, it catches very few itself, either pirating its food from other birds or picking up dead fish on the shore. In 1782, Congress adopted a design displaying the bird for the Great Seal of the United States, and the bald eagle became the national bird.

From *Collier's Encyclopedia* c. 1971, Crowell-Collier Educational Corporation

*This exercise was taken from *Technical Writing* by John M. Lannon, 1985, Little, Brown & Company.

Mathematics

Activity

Mathematics Activity

Study and Critique Data Graphs

After studying examples of good and bad use of data graphs, student will critique examples taken from the front page of two national newspapers.

Rationale

Data and graphs are frequently used to communicate effectively about health issues. Therefore, understanding the proper techniques of data presentation is an important skill.

Basic Health Services Connection

This is a foundational skill-development activity where student gains understanding of data representation for the grant writing process.

Standards Addressed

Mathematics: Mathematical Reasoning 1.1

Objective

The student will understand the use of good data graphs as well as the misuse of bad data graphs.

Process

Studies of health problems usually involve the collection and organization of data. Presenting this data in a simple, clear, and honest way is an important skill. Examples:

Figure 1 shows a famous and powerful early use of a dot map by Dr. John Snow in London. In 1854 he was working to control a cholera epidemic and started to plot deaths from the disease as dots on a map of the city. The map also included the water wells serving the city. They were shown as x's on the map. His observation, clearly shown by the dot pattern, was that the deaths seemed to be most strongly concentrated near the well on Broad Street, near the center of the map. Based on that image, he had the well closed and was able to stop the epidemic that had claimed more than 500 lives.

Figure 2 is one of a series of maps showing comparative cancer death rates in the counties of the United States. In simplest terms, a darker color means a higher cancer rate. A map such as this is really a form of a graph and summarizes hundreds of thousands of bits of data. It lets medical investigators quickly zero in on regions or hot spots where the disease, in this case stomach cancer, is exceptionally common. The high rates of stomach cancer in the north-central part of the country could be caused by eating habits including consumption of smoked meats and fish.

Figure 3 is a famous graph that illustrates the diminishing purchasing power of the dollar over time. It actually overstates the case because it shrinks the dollar in two directions. Both the width and height are made to decrease. A dollar with one-half the purchasing power of the original will be shown as having only one-fourth the size of the original. Although such errors may be inadvertent, they are statistical or graphical "lies" because they convey a false impression.

Our purpose in making graphs and charts in this unit is to summarize clearly and honestly real data that may help us solve problems.

Use graphs or dot maps for assessing the topic for the proposal. Also, design them for the presentation visual display of the project.

Assessment

Correct answers to completed exercise and how this is utilized in project.

Exercise

Figures 4 and 5 are front-page articles that appeared in the *New York Times* and the *Los Angeles Times* on the same day in early 1998. They were written in response to a press release by the United States Department of Health. Examine each figure carefully and answer the following questions:

1. What are the strengths and weaknesses of the graphics in each?
2. Which graphic contains the most information? Be specific and list the features in each.
3. The *Los Angeles Times* features a dramatic graph. How is it shown differently in the *New York Times* version?
4. Which of the two has the most “wasted space” in its graphic?
5. Which graphic does the best overall job of being complete and honest?

Figures 1–3 were taken from *The Visual Display of Quantitative Information* by Edward Tufte, Graphics Press, 1983.

Critique of Data Graphs

Possible Solutions

The clarity of student analysis and response to the two front-page graphics will not be easy to assess. Opinions based on feelings, rather than clear observations, should be discouraged. Facts about the quantity and quality of the information presented in the graphic are the goal. The solutions below are by no means complete.

The final analysis of this exercise will be the amount of learning transferred to the culminating project on a community health problem and the proposal for funding the solution(s). The goal is powerful, yet honest, communicated through data representation.

1. The *Los Angeles Times* has only one graph. It is larger and easy to read, but the vertical scaling tends to mislead readers as to the extent of increases and decreases. One is forced to go searching for the meaning of the “426.2.” All the other information is written, not pictured or presented in a table.

The *New York Times* version presents more data, including a second graph, and it interjects the only note of caution—melanomas are increasing. Students may disagree about the importance of including the female figure.

2. The *Los Angeles Times* pictures only one data set while the *New York Times* version has two data graphs and a table. The sources, disclaimers, and scaling are more clear in the latter graphic.

3. The *Los Angeles Times* uses the graph of cancer incidence as the central element in their graphic. In turn, this is dominated by the trivially related “operating room” scene in the background. The *Los Angeles* paper presents the graph without a properly scaled vertical axis. Such “depressed zero” graphs tend to overemphasize the increases and the decreases in the data. The *New York Times* chooses not to emphasize the graph, treating it as only one of several visual elements. The *New York* paper presents the graph with a proper vertical scale, pairs it with data showing “deaths from cancer,” and lists the units per 100,000 people, with the title.

4. Does the *New York Times* really need to list all the years from '73 to '95 when five-year intervals would be sufficient? The operating room is interesting but unnecessary. Do most readers need the labeled feminine silhouette to locate cancer sites?

5. The *New York Times* gets the nod for best use of graphic space. It includes the most important and useable information in the least space, using only 26 square inches to the rival's 33 square inches.

Sample Graphs

Figure 1

The famous dot map of Dr. John Snow, who plotted the location of deaths from cholera in central London for September 1854. Deaths were marked by dots and the area's eleven water pumps were located by crosses.



Figure 2

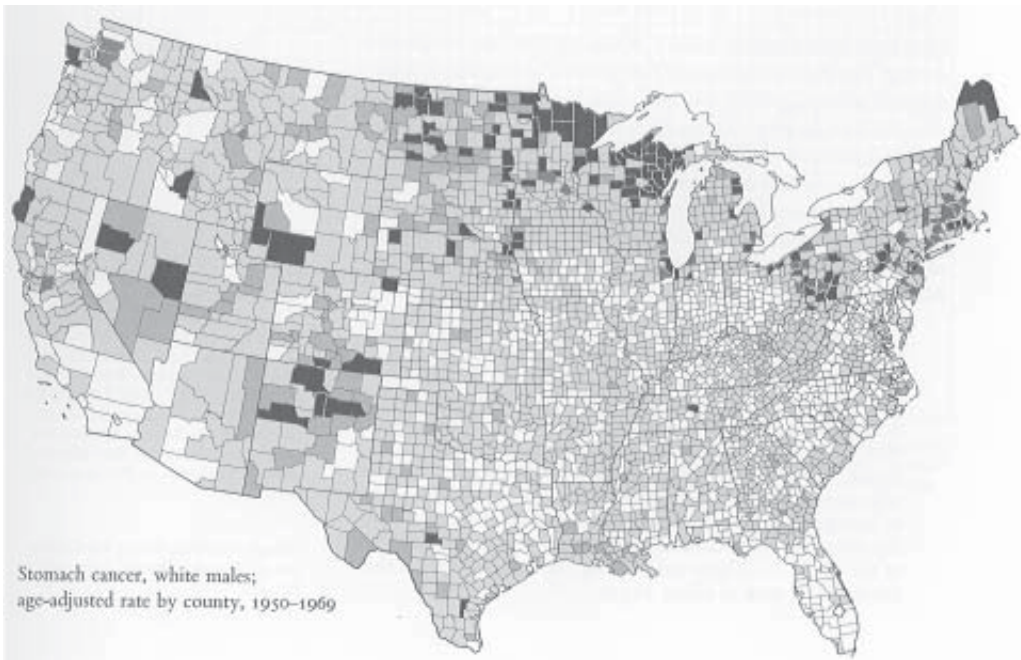
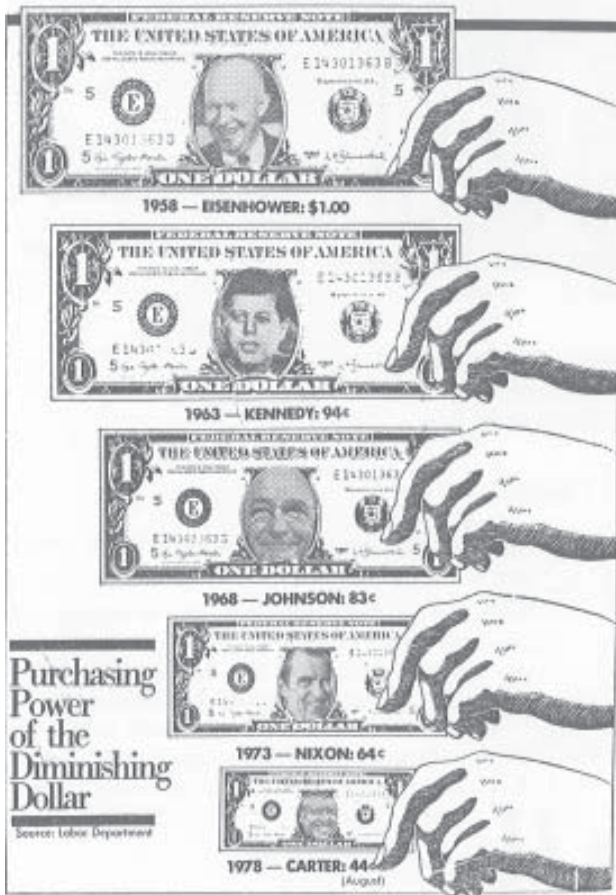
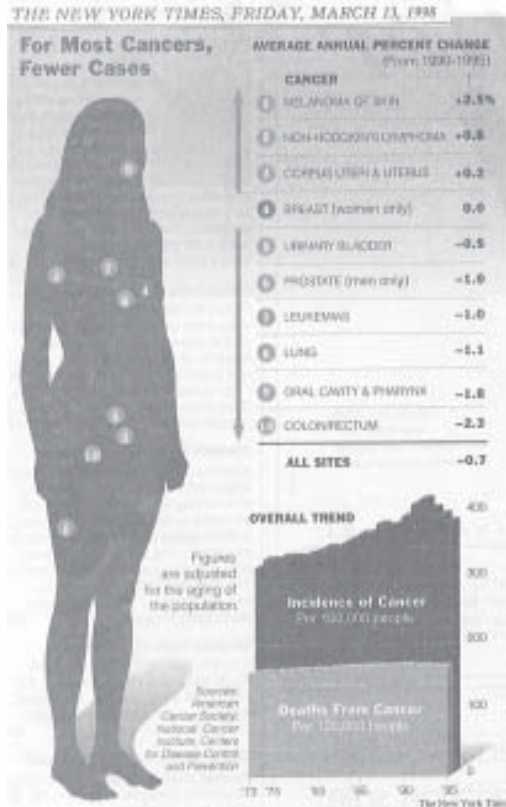


Figure 3



If the area of the dollar is accurately to reflect its *purchasing power*, then the 1978 dollar should be about twice as big as that shown.

Figure 4



NEW CANCER CASES DECREASING IN U.S. AS DEATHS DO, TOO

DROP IS FIRST SINCE 1930'S

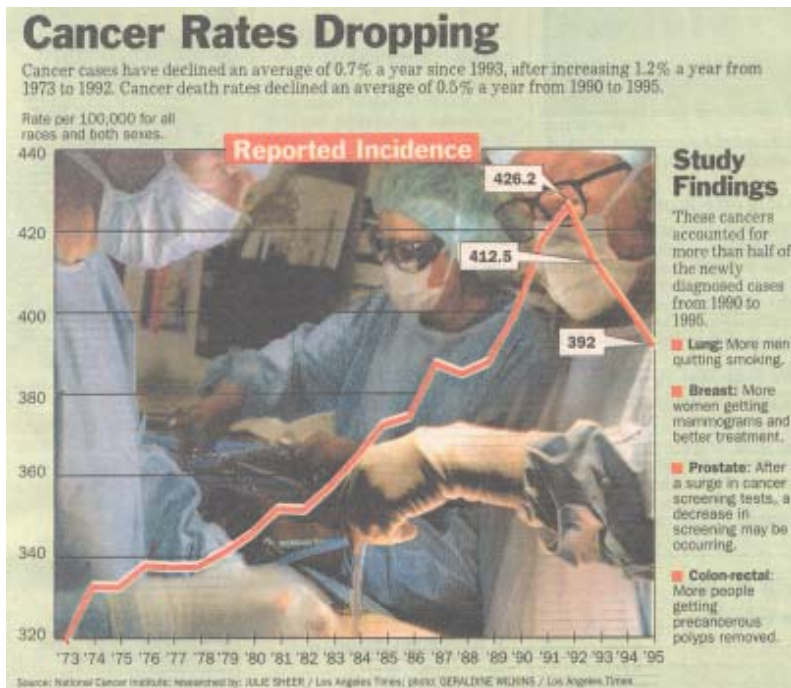
But Minorities and Women Are Still Particularly at Risk – Black Men Fare Worst

By SHERYL GAY STOLBERG

WASHINGTON, March 12 – For the first time since the 1930's, the number of new cancer cases in the United States is declining, Federal officials said today in announcing a sharp reversal in the incidence of diseases that kill more than 1,500 Americans each day.

***The entire article can be obtained through the NY Times archives.*

Figure 5



Cancer Now on Decline in the U.S., Study Shows

• **Health:** The incidence of all forms the disease fell an average of 0.7% a year from 1990 to '95, reversing nearly 20 years of escalating cases, officials announce. Deaths have also decreased.

**By MARLENE CIMONS
TIMES STAFF WRITER**

The entire article can be located through the Los Angeles Times archives for March 13, 1998.

Science Activities

(includes all disciplines)

Students can be guided to use the relevant discipline choices to carry out the scientific method practices that are modeled in the activities.

Science Activity #1

Cancer Hope Analysis: Evaluating Research

- Analyze *New York Times* article on cancer “hope” in the lab;
- Analyze status, from further information (either the 20/20 video or follow-up articles);
- Analyze an article of the student’s choice that may be relevant to his/her community;
- Use cancer as a class model that can directly guide a grant proposal.

Rationale

The *New York Times* article of May ’98 brought hopes to cancer research. However, it brought a mass excitement that was hard to put in perspective as people were hysterically calling research doctors for the “cure.” This activity gives students practice in analytical thinking and the scientific method; both are necessary for determining wise decisions and realistic hope for health care. The students discover whether they fall into the same publicity trap on first-time exposure to the topic of angiogenesis (generating small blood vessel growth) inhibitors (therefore blocking tumor growth) as the first-time readers/patients might. A follow-up status video allows them to see and analyze medical research in perspective. *Instead of* the video, current related articles can serve the same purpose. Finally, an article analysis turns a news article appropriate for any subject of science into an instant in-depth lesson. At the center stage of science and its standards, the activity focuses on the scientific method and modern research. This major health need, a cancer solution, serves as a model of how to research the actual data to assess if what appears to be an answer in fact would give desired outcomes and be a good basis for a grant proposal. This lesson teaches in-depth analysis as a tool for obtaining a good grant.

Refer to the appendix for Anatomy and Physiology Classes:

Students understand the following anatomy/physiology topics more deeply when studied in concert with real medical research and diseases: circulatory system and blood vessel action related to delivery of drugs and to enzyme activity of normal cells versus cancer types.

Basic Health Services Connection

This is a foundational skill-development activity in the scientific method. To effectively complete the culminating project, the student must have an understanding of research methodologies. Health services career connections will naturally occur in the process.

Standards Addressed

Science: Investigation & Experimentation 1; Biology/Life Science—Physiology 9, 10.

Objectives

The student will:

- Demonstrate understanding of the steps of the scientific method by analyzing two sources of the cancer research;
- React to the research status and its relationship to society’s desires. Plan the grant proposal for cancer research and its solutions. Students use the cancer model to prepare a grant proposal on the health topic appropriate to the community and of the student’s choice.

Process

The student will:

- Read and answer the questions on cancer research in the *New York Times*;
- Use the 20/20 video analysis *or* the “Angiogenesis Inhibitors Follow-up Article Analysis” to push for scientific process thought (*see question sets to either use as examples for breaking research examples or “as is”*);
- Organize a grant proposal for cancer research as a model. Use the analysis as a litmus test for what to pursue as a means to provide power to the proposal. Decide the proper organization as well as the best direction in which to pursue this research. Students should be sensitive to the class discussion as they become aware of community reactions about cancer. Research how organizations might meet these needs and what students can do with funding for their cause;
- Analyze a health article (use “Scientific/Medical Article Analysis”), in groups or individually, of the student’s choice that is appropriate for his/her science subject area (for seniors probably physics, anatomy/physiology, chemistry or AP biology). Analyze if it is an authentic community concern and apply the classroom model for the project.

Assessment

- Written and oral responses to the article;
- Written and oral responses to the video *or* to the written article analysis on follow-up studies;
- Article analysis on article of choice and relevant to the community needs; may be used as basis of the grant proposal.

Bibliography/Resources

- “Hope in the Lab,” *New York Times*, May 3, 1998
- ABC 20/20 video, Topic: Angiogenesis inhibitors for cancer
- Current Internet resources
- Current magazine and newspaper articles

*Refer to Science Appendix 1, 2 & 3

Science Activity #2

Mystery: Hot Zone of the New York Outbreak

To identify a health concern, role-play the interview and the scientific investigation to simulate an outbreak of a disease for analysis and development of a proposal. Create an individual scatter graph for a local cause, which can be used for the culminating project.

Rationale and Background

Dr. John Snow is considered to be the father of the science of modern epidemiology. In 1853 in London he interviewed victims and their families and by tracing and plotting their steps before they became ill he was able to identify a common activity, drinking at a common well. By removing the well pump handle the disease we now know to be cholera was stopped; the water no longer carried the bacteria to the people! By simulating a recent outbreak of a disease, students are able to use the John Snow method to recommend a plan to curtail the cause of disease, an ideal model of the scientific method! With modern knowledge and technology we can also go beyond John Snow and identify the disease. This method has shown such importance that the Centers for Disease Control has a coveted award called the “John Snow Award” for the best case investigation. By using communication skills, students innately problem solve, thereby understanding the scientific method. It also reveals an unbalanced ecological equilibrium resulting from the introduction of a foreign disease. This is an ideal model for students to use in researching local health needs, gathering math data similar to the scatter graphs, and making a proposal for the culminating project.

Basic Health Services Connection

This is a foundational skill-development activity in the scientific method. Health services career connections will naturally occur in the process.

Standards Addressed

Science: Investigation & Experimentation 1; Biology/Life Science—Ecology 6, 7, 8; Physiology 9, 10.

Objectives

The student will:

- Simulate an investigation of an actual disease outbreak;
- Problem solve, using the scientific method;
- Connect science scatter graph (mapping) methods to math lesson;
- Use the technique relevant to the student’s current science discipline to gather local health needs information for the culminating project.

Teacher Preparation

The teacher will:

- Copy the three pages of role play cards either on thick paper that you can quarter or on regular paper that can be cut in fours and glued on 4" X 6" cards. Copy enough investigator cards so that the remaining class members can be investigators;
- n Copy the map onto five overhead transparencies and have transparency colored pens

available for students to place their dots as the role cards direct;

- Copy the lab results for each student (*Note example: West Nile Encephalitis is nearly like all tested in the outbreak with the Israeli type closer than others*);
- Distribute role cards to the students as they enter and tell students to read and prepare roles;
- Write visibly:
 - Problem**
 1. What is the outbreak's cause? (What, Where?)
 2. How does it spread?
 3. Will it become indigenous to the area?

What is the plan?

Facilitate the problem solving of the actual August–September 1999 outbreak of West Nile Encephalitis in the north eastern United States as follows: (*Keep the disease a secret!*)

- Ask the investigative team to generate possible vector ideas for a disease(s) with symptoms that include bizarre actions, stupor, flu-like illness or even death of horses, birds and human beings. Disease transmissions to suggest to students if they need a starter: food, water, person-to-person, animal to person, insect to person (**hypothesis**);
- Tell the students that you have eight people, both victims and responsible observers available. The class decides on the course of action to test the hypothesis (**procedure**). Students decide on an interview and structure a good process;
- Generate student involvement by letting them express what should happen next to solve the problem. Guide them where necessary and explain what step they are doing after they are involved in the step. Encourage the student playing New York City Assistant Commissioner for Communicable Disease to facilitate the interview between the investigative team and the victims/observers even though you interpret the scientific method. Guide interviewees to put the color dot to code species and the correct number affected on the map of New York. Display it on the overhead projector as an overlay to the other students' transparencies;
- Encourage students to take note of any relevant information to solve the mystery. See that the lab technician/gene sequencer communicates to students the lab results pages and that the students record the nearest match of Encephalitis to the NY outbreak sequences (**data**);
- Guide students to state the source of the outbreak (**conclusion**). Refer back to the three guide questions on the board. They should be able to **1)** identify the disease as West Nile Encephalitis and that perhaps it came from Israel; **2)** discover it spreads by mosquitoes, but exactly which of the birds is the source and how far the infection has currently spread in asymptomatic birds is uncertain; **3)** determine that if we do not know the source of an ever ready infected blood supply we do not know if it will settle down to stay. They must continue the same investigative process during the next year. This is real science. It continues to cycle in order to conclusively know the best approach to combat disease;
- Guide a **plan**. They can suggest a short-term plan to spray for mosquitoes and prepare mosquito bite prevention publicity. Help them brainstorm a long-term plan. Location where the mosquitoes obtain the virus (reservoir) must be addressed. Refer to the maps. Advise them that we know a disease is more difficult to spread if the persons or animals die quickly. They cannot incubate the virus for mosquitoes to obtain. **Ask: what has a**

reservoir of blood that can be transmitted? The class can use the preceding activity to suggest a plan for tracking the birds that are so widespread, alive and carrying the virus (**Extend scientific method and check for understanding**).

Process

The student will:

- Develop the character of the role playing card and respond factually to the investigative team's questions *or*, if the student is part of the investigative team, ask good questions leading scientific facts;
- Recognize and use the steps of the scientific method;
- Put dots on the overhead New York map transparency (if directed on the role card) and recognize the connection of math scatter graph techniques;
- Make notes of the discussion and analyze lab work results; search for updates;
- Write a report of the class findings: a step-by-step account of the scientific method process used in finding the outbreak cause and a plan for future research (for 3 problem steps);
- Use the process of the scientific method and scatter graphs to gather information (from Internet/articles/books or from own epidemiological collection) that is community relevant. For example, outbreaks of flu or colds, geographic areas of cancer, people/travel location, from water pollution, *or* graph the events of Richard Preston's *Cobra Event* or *Civil Action* (movie or book) and connect their insights to the community needs;
- Apply the method to generate excellent data for the assembly hearing grant proposal.

Assessment:

- Written report of the classroom process and the plan. Check for the scientific method;
- Individual community or book scatter graph data;
- Possible inclusion in grant proposal and presentation.

Extension Activity

Students update the West Nile Encephalitis Virus for the current outbreak. Teacher posts a map that allows for students to display the spread of the disease for any given year.

Inspired by Milius, Susan, *Science News*, "Animals Who Dunit, Medical Mystery", Dec 11, 1999 and Cronin, Jim *Science Scope*, "Cholera and the Scientific Method", Nov/Dec 1993

Note: Be certain the grant process includes a good topic choice and evidence of cause by using and processing data.

*Refer to Science Appendix 1, 2 & 3 following this section.

Science

Appendix

New York Times Article Analysis and Consumer Response on
"Cancer Hope in the Lab" with attached *New York Times* Article

Analyze and Compare Follow-up Video to *New York Times* Article

Angiogenesis Inhibitor Follow-up Article Analysis

Scientific/Medical Analysis: What Do the Numbers Mean?

Questions to Answer for Article Analysis

Role Cards

Lab Results for the Outbreak Mystery

Maps

***New York Times* Article Analysis & Consumer Response on "Cancer Hope in the Lab"**

Cautious Awe Greet Drugs That Eradicate Tumors in Mice The World's Most Celebrated Cancer Experiment in Mice!

Read the attached article from the *New York Times* and by analyzing it decide what you would do and how you would react if an immediate family member or your patient were dying of cancer. Answer the following questions:

1. What is the key idea being tested? (*Purpose*)

2. A. Is there hope? If so, on what is the hope based? (*Hypothesis*)

B. Are there cautions and concerns for the future? (*Hypothesis*)

3. A. What is the *data* in mice? (In what form, and is it complete?)

B. What is the data in humans? (In what form, and is it complete?)

4. Is this newspaper a reliable source?

5. Are the researchers, journalists, universities, and hospitals reliable?

6. Has the research proven anything? (Can a *conclusion* be drawn?) Consider how the testing was carried out. (Are there control groups? Is it double blind? For whom are the tests relevant? Have the results been replicated elsewhere? Is there consistency over time?)

7. If a family member or patient of yours were dying of cancer, how would you respond? How would you respond to health care as an advocate for this very sick person? Is this a gamble for life? What would your thinking be and what would you do?

Science Appendix 1a

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Section 1; Page 1; Column 1; National Desk; 2185 words

Hope in the Lab: A Special Report—A Cautious Awe Greets Drugs That Eradicate Tumors in Mice, by Gina Kolata
(Correction Appended)

Within a year, if all goes well, the first cancer patient will be injected with two new drugs that can eradicate any type of cancer, with no obvious side effects and no drug resistance—in mice.

Some cancer researchers say the drugs are the most exciting treatment that they have ever seen. But then they temper their enthusiasm with caution, noting that the history of cancer treatments is full of high expectations followed by dashed hopes when drugs with remarkable effects in animals are tested in people.

Still, the National Cancer Institute has made the drugs its top priority, said Dr. Richard D. Klausner, the director. Dr. Klausner called them “the single most exciting thing on the horizon” for the treatment of cancer.

“I am putting nothing on higher priority than getting this into clinical trials,” Dr. Klausner said. The mouse studies are “remarkable and wonderful,” he said, and “very compelling.” But he pointed out that the studies were in mice and so, when it comes to humans, he said he wanted to emphasize “the if’s.”

The new drugs, *angiostatin* and *endostatin*, work by interfering with the blood supply tumors need. Given together, they make tumors disappear and not return.

Dr. James M. Pluda, who is directing the cancer institute’s planned tests of the drugs in patients, said he and others at the institute were “electrified” when they heard the drug’s discoverer deliver a lecture about the newest results. “People were almost overwhelmed,” Dr. Pluda said. “The data was remarkable.”

Although the discovery of the drugs, and some of their effects, have been reported over the past few years, Dr. Pluda said that “if people understood how many steps ahead” the research was compared to what had been published, “they’d be even more in awe.”

But Dr. Jerome Groopman, a cancer researcher at the Harvard Medical School, was wary. “We are all driven by hope,” Dr. Groopman said. “But a sober scientist waits for the data.” And until the drugs are given to humans, he said, the crucial data simply do not exist.

So far, the drugs are the only ones ever tested that can seemingly eradicate all tumors in mice, even gigantic ones, equivalent to a two-pound growth in a person. The best that other cancer drugs have done is slow the growth of these large tumors. Mice are the traditional test animals in cancer research.

But even the drugs’ discoverer, Dr. Judah Folkman, a cancer researcher at Children’s Hospital in Boston, is cautious about the drugs’ promise. Until patients take them, he said, it is dangerous to make predictions. All he knows, Dr. Folkman said, is that “if you have cancer and you are a mouse, we can take good care of you.”

Other scientists are not so restrained. “Judah is going to cure cancer in two years,” said Dr. James D. Watson, a Nobel laureate who directs the Cold Spring Harbor Laboratory, a

cancer research center on Long Island. Dr. Watson said Dr. Folkman would be remembered along with scientists like Charles Darwin as someone who permanently altered civilization.

The long trail to the discovery of the new drugs began more than 30 years ago when Dr. Folkman became obsessed by what many saw as a quixotic notion: that cancers cannot grow beyond the size of a pinhead unless they have their own blood supply. If he could block a tumor's blood supply, he reasoned, the tumor should shrink to a minuscule size.

The first major break in the efforts came a decade ago when Dr. Folkman and his collaborators found drugs that did what he envisioned. He called them anti-angiogenesis drugs because they stopped the process of developing new blood vessels, or angiogenesis. They slow tumor growth in animals but do not eradicate the tumors. Early results in patients indicate that the drugs may slow human cancers. Dozens of companies are developing such drugs.

The results with these weaker drugs were "a proof of principle," said Dr. Bart Chernow, a professor of medicine and dean for research and technology at the Johns Hopkins University School of Medicine. Dr. Chernow is a founder of Entremed, a company in Rockville, Md, that was formed to make and market angostatin, endostatin and other weaker drugs that can slow cancer growth.

But the real breakthrough—and the two new drugs—came from Dr. Folkman's efforts to understand a peculiar phenomenon that has been known to cancer surgeons for 100 years: sometimes a patient will have a single tumor, with no evidence whatsoever of metastases, the satellite cancers that can pepper a patient's body. A doctor will remove the tumor and all will seem fine. But then, a few months later, a whole series of metastases will appear, grow and kill the patient.

In 1989, Dr. Folkman proposed a reason for the effect, which he wrote on a large white board in a room where his laboratory group had its weekly seminars. Is it possible, he asked, that a tumor could be making both stimulators and inhibitors of blood vessel growth? If so, the inhibitors might travel through the bloodstream, squelching metastases. When the large tumor was removed, it would no longer be a source of inhibitors, allowing the tiny metastases to proliferate.

Dr. Folkman tried to get one of his doctoral or post-doctoral students to work on the idea. "Each Friday, at our meeting," he said, "I would say, 'here's a great experiment.' But no one wanted to work on it." It seemed too wild, Dr. Folkman said, too unlikely to result in findings that would end up in a scientific journal, a major goal of young scientists.

Undertaking the Big Challenge

It was in 1991, a post-doctoral student, Dr. Michael O'Reilly, decided to take on the challenge. Dr. O'Reilly focused on a particularly deadly mouse cancer that grows to the equivalent of a two-pound tumor in a person.

As long as mice had the large tumor, they had no signs of metastases. But five days after the tumors were surgically removed, metastases invariably sprang up in the animals' lungs. Within 15 days, the animals would be dead, their lungs packed with large red tumors, like grapes.

Eventually, after arduous work in collaboration with chemists, Dr. O'Reilly discovered that the large tumors made a substance that stymied the growth of other tumors. This substance showed up in the animals' urine, but was present in such minute quantities that Dr. O'Reilly had to collect 10 quarts of mouse urine to obtain 30-thousandth of an ounce of the mysterious substance. It turned out to be a piece of a larger and very common protein, plasminogen that the body uses in blood clotting. Dr. Folkman named the new substance angiostatin.

Apparently, cells can use the plasminogen gene for two purposes: they can use it at its full length to make plasminogen, or they can use just a piece of it and make angiostatin. Plasminogen does nothing to stop tumor growth. The question was, would angiostatin?

Dr. Folkman and Dr. O'Reilly discovered that angiostatin also appears, in minute quantities, in human blood. Using outdated human blood discarded by the Red Cross, they extracted enough angiostatin to treat mice. Then they began their experiment.

They had 20 mice with large tumors on their backs. The investigator removed the tumors and then injected half of the mice with angiostatin each day and the others with salt water, as a comparison.

After 15 days, the researchers killed the mice and cut them open. As more than a dozen scientists gathered around a table in the laboratory, Dr. O'Reilly opened the first mouse. It had huge tumors filling its lungs. Then Dr. Folkman checked a notebook to see what the animal had received: salt water. They looked at the next mouse. No tumors. Dr. Folkman checked to see the treatment: angiostatin. And so it went. All 10 of the mice that had been injected with angiostatin were free of cancer. All 10 of those that had received salt water had huge new tumors.

A Jubilant Celebration and a Second Discovery

The room was buzzing, the scientists were grinning, Dr. Folkman said. Everyone in the room knew what the results meant, and they were elated. They responded, he said, like men at a football game. "Everyone clapped O'Reilly on the back," Dr. Folkman said.

Then the researchers found a second protein fragment, secreted by tumors, that also squelches metastases, Dr. Folkman said. It was a piece of a different protein, collagen 18, that is in all blood vessels but by itself has no effect on cancer. They named the collagen fragment endostatin.

"It was even more potent than angiostatin," Dr. Folkman said. If he gave it to a mouse with a huge tumor, he said, the equivalent of one weighing a pound and a half in a human, endostatin would shrink the cancer down to a microscopic size.

Moreover, tumors never became resistant to endostatin, said Dr. Folkman, who added that he had given the drug to mice with large tumors and they had shrunk to almost nothing. He stopped the drug, he said, and the tumors grew back. Then he gave the drug continuously for the rest of the animals' lives. The tumors remained small and harmless and the animals remained healthy.

Dr. Robert S. Kerbel, a cancer researcher at Sunnybrook Health Science Center in Toronto, said he was not surprised that the cancers never became resistant to endostatin. Tumors become resistant to chemotherapy drugs, Dr. Kerbel said, because cancer cells constantly reshuffle their genetic information. The result, he said, is that the tumors spin off mutant cells that resist the drugs and, ultimately, the tumors grow back, invulnerable.

But, Dr. Kerbel said, angiostatin and endostatin do not act on tumors. Instead, they act on normal blood vessels that feed tumors. And normal cells, he said, do not reshuffle their genes and so do not develop drug resistance. That is why chemotherapy drugs continue to devastate normal cells—causing bone marrow suppression, loss of hair, nausea and vomiting—even when the cancer cells have grown impervious to their effects, Dr. Kerbel said.

Drug Combination Knocks Out Tumors

Then Dr. Folkman discovered that he could actually obliterate tumors in mice with his new drugs. He gave endostatin and angiostatin together, treating mice for 25 days. To his surprise, Dr. Folkman said, "there was no tumor left—we do not know why—as cancer."

In contrast, Dr. Folkman said, mice become very ill when they receive commonly used chemotherapy—their hair falls out, they bleed, they refuse to eat.

For the past four years, Dr. Folkman said, he and his colleagues have found that all tumors responded to the drugs in the same way. Even leukemia, a blood tumor, responds, he said, because it turns out that leukemia needs to form new blood vessels in the bone marrow to grow. Leukemia tumors grow on these blood vessels, “like berries on a bush,” Dr. Folkman said, shedding cancer cells into the blood.

But Dr. Folkman is the first to urge caution in leaping to conclusions about what might happen when patients try the drugs. “Going from mice to people is big jump, with lots of failures,” he said.

Hopes were high for the chemotherapy drugs that worked well in mice but turned out to be less successful in people. Therapies that used the immune system to rid the body of cancer also worked in mice but were disappointing when they were tried in people. Gene therapy treats mouse cancer, but has had limited success in people.

From bitter experience, most cancer researchers have learned to be leery of what one called “that four letter word”—cure.

Meanwhile, Entremed is working as fast as it can to produce angiostatin and endostatin for studies in humans. Dr. John Holaday, Entremed’s president and chief executive, said his company was working with the Bristol-Myers Squibb Company to develop angiostatin and had not yet decided on a corporate partner to develop endostatin. The drugs are being made in genetically engineered yeast growing in 20-gallon vats.

Dr. Pluda, of the cancer institute, said the first patients to get the drugs would have cancers that were growing quickly and were essentially untreatable. The institute will start by giving the drugs separately by the end of the year, he said, and then hopes to combine them.

Already, Dr. Folkman, in an interview on Friday, said one call had come from an old friend from medical school with prostate cancer that had spread to his bones.

“He’s terrified,” Dr. Folkman said. But there were no strings Dr. Folkman could pull. He said he had to tell his friend what he told all the other callers: “You can’t get it because it isn’t being made.”

Correction: May 8, 1998, Friday

A front-page article on Sunday about two promising new anti-cancer drugs included an imprecise paraphrase of a comment by Dr. Richard D. Klausner, director of the National Cancer Institute. As noted in the next paragraph, he said he was “putting nothing on a higher priority” than clinical trials of the new drugs with patients. He did not say the drugs were his highest priority.

The article also misstated the title of Dr. James D. Watson at the Cold Spring Harbor Laboratory. He is its president, not its director.

Sources: Dr. Michael O’Reilly, Dr. Judah Folkman, Dr. Thomas Boehm and Dr. Timothy Browder, pg.34

Science Appendix 2 Overhead Transparency for CBS's 60 Minutes Video
or for Further Research Example Questions

Analyze and Compare Video and New York Times Article
"Could It Be True?" — Angiogenesis Inhibitors for Cancer

1. What is the key idea being tested? (Purpose)

2. A. Is there hope? If so what? (Hypothesis)
 - B. Are there cautions and concerns for the future?

3. A. What is the data in animals? (Form and Complete?)
 - B. What is the data in humans? (Follow-up Data)
[Jim Harbeson, Pat Grains, Scott Campbell, Ricki de Maria]
What is the form of the current data? Is it complete?

4. Is this video a reliable source?

5. Are the researchers, those commenting, and the UCLA Medical Plaza reliable?

6. Has the research proven anything? Consider how the testing was carried out. (Conclusion possible?)
Are there control groups?
Is it double blind? Prospective? Randomized?
For whom are the tests relevant (Compare with article)?

7. When you are dealing with human life, is it possible to have an adequate size test group and the proper controls?

8. If a family member of yours were dying of cancer, how would you respond? What is your thinking regarding health care for this very sick person? What would your thinking be and what would you do? What are the risks and hope with your decision? What is the community thought regarding the search for cancer patient care?

9. What are the required numbers and data to actualize your hope?
What kind of project might improve cancer research and treatment?
If this is a concern of your community, prepare your recommendations from information gathered by local health agencies and apply for financial support.

Angiogenesis Inhibitor Follow-up Article Analysis

A great deal of information follows the cancer research of Judah Folkman. As an alternative to the movie “Could It Be True?”, students can generate a computer, newspaper, and magazine search for the latest information. Then they use the “Scientific/Medical Article Analysis” questions and terminology list to encourage a deeper analysis and decisions that are based on more sophisticated approaches than the first lesson on the article reading.

The discussion of the questions can be emphasized to include current information such as:

- What are follow-up studies?
- Who has produced results and who has had troubles reproducing them?
- Why might there be differences in the results?
- Are there variables?
- What are other major researchers saying about the research?
- Did the *New York Times* present a balanced and truthful article? What is its reputation? Was this a media-driven frenzy?
- How can the same research be hyped as “miracle cure” and yet reported a “failure”?
- Look at what is said about the data. Is it true? Do headlines match data?
- Why do people react with such hysteria and unbelievable persistent interest?
- Has angiogenesis research taken new paths since the Folkman announcement? If it has, is it hopeful? Analyze.

Be sure class discussion on the cancer research finally links with grant needs on question #8 in the student paper “Scientific/Medical Article Analysis” questions.

Note: This type of discussion emerging from the use of the “Scientific/Medical Article Analysis” can turn any article into a lesson! The resulting lesson can be used for the culminating project!

Scientific/Medical Article Analysis

What do the numbers mean?

Refer to this list to determine the status of the study and therefore its reliability. Remember that larger size groups make for greater reliability.

Terms

Data: Recorded quantitative (preferred) or qualitative observations about a substance, event, organism, subject or group.

Theory: Well tested explanation of observations and facts that can make predictions about the outcome of other tests and facts.

Hypothesis: A reasonable guess that explains an observation. A good hypothesis is a statement that leads to a prediction that can be tested.

Opinion: A point of view or judgment that presents an unsubstantiated feeling about something or someone.

Observational Study: Observations recording facts, but there is no intervention.

Cross-sectional Study: Data are recorded of people who are asked about symptoms at a particular time. Example: Survey the number of cancer patients in your hometown. The shortcoming of this type of study is it will not provide any idea of why they have cancer or a cure.

Cohort or follow-up Study: Observe a group of people for a period of time. Depending on length of time and group size, you might be able to determine at what age and who is at the greatest risk for example for cancer. But note that an observational study still does not influence who gets the cancer medicine. This might follow people **retrospectively** (their past medical histories) or **prospectively** (medical histories forward in years from a particular point such as a group who has taken a medicine).

Case Control Study: Observe a group with a condition versus a group without a condition, who are similar in other ways. For example: observe the number of melanoma cases of a certain age working at a lab with radiation research versus the number of cases in the general population. Note: the melanoma condition might be found in people with a certain life style or genetic differences that the lab jobs entice. Still an observational study cannot intervene with a causal agent, and a control from an identical population can point to a conclusive cause.

Clinical Trials or Interventional Studies: Treat one group to see what happens.

Control Group: Two groups are identical except that the control does not receive the treatment (may be in the form of a placebo, a pill without the treatment).

Randomized: Each person in the group had an equal chance to be chosen or not for the study or for treatment. For example: A random computer selection would prevent a melanoma study group from all being sunbathers just because they were more interested in the subject and therefore more interested in volunteering.

Double-blind: Neither the researchers nor the subjects know who is taking the medicine so the groups can not be treated differently. For example: There is no temptation to perform more mammograms on the group taking estrogen.

Note: Look for prospective randomized double-blind controlled studies for the gold standard on which to base health decisions. Good data showing a good theory, a must!

Reference: *Dr. Susan Love's Hormone Book*

Science Appendix 3a

Questions to Answer for Article Analysis

Answer the following questions to analyze a health article of your choice. Choose some topic relevant to your community or to you. The source may be the Internet, newspaper, magazine, or technical journal. Scrutinize the data and narrative thoroughly to avoid developing false hopes as occurred to the readers of the *New York Times* article.

1. What was the information, and why do they think it important?
2. How was the information reported—by a narrator, in an interview? Was a graph or chart used? Was some other visual presentation made? Did this make a difference? Was there more than one source for the information? If yes, how many sources and did the sources agree? If not, how did that make you feel about the information?
3. What do you know about the source(s) that makes you decide whether the information is true or not? (Is the source a scientist or doctor; and if so, what effect did this have on your belief that the information was true? Does the information check with what you have learned in class or in other research? What evidence was given to show that the source is knowledgeable? Who are the scientists or what is the institution?)
4. How would you classify the information? Data? Theory? Hypothesis? Opinion? Observational study? Clinical trial? Discuss why.
5. Are there other sources that can be consulted to check the information? State them.
6. Was this a good source of information? Why or why not?
7. How do you think the article would affect someone reading it? Would you recommend it for them and for the good of your community?
8. Does this critical analysis identify an authentic community concern that needs grant money for improvements? Put into numbers why the community has this need or how the community reacts. What data is needed beyond what the article shows in order to provide a viable treatment? What could the project be that would actualize hopes for the health concern? What organization could meet the needs of this health concern? Use your analysis as a litmus test for a viable topic and then use the information to build a grant proposal.

Note: Link this with the “Community Health Issues in the News” activity you are doing in your social science and health careers classes. Use this science information for the criteria for choosing a health issue. Then you will be able to support it with facts and logic because you have critiqued the subject in a sophisticated way.

Science Appendix 4

Role Cards

New York City's Assistant Commissioner for Communicable Disease

You will play the role of the person in charge of disease in New York City where many people are reporting strange illnesses in humans as well as in animals. Although it has never been done before, you are arranging a meeting of some victims and some responsible observers, a very diverse group. You sense communication might shed some light on the disease(s) and will direct what can be done for these horrendous outbreaks. Act as moderator for the group you selected. (The class acts as a prestigious group of investigators including doctors, Centers for Disease Control representatives, lab technicians and public health officials who interview the victims and observers). You guide the interview session and tell the investigators the problem:

1. What is the cause of the outbreak? (What is it; where did it come from?)
2. How does it spread?
3. Will it settle down to stay?

You facilitate communication between investigators and interviewees. From this point you turn the work over to the investigators to make a plan to combat illnesses and deaths.

New York State Wildlife Pathologist

You play the specialist to whom New York state reports wildlife disease. You are trying to explain why hundreds of crows are dying and being picked up off the streets. When the investigation team asks, tell them the first crows arrived the first week of August. You performed over a hundred autopsies. Toxicology tests showed no poisoning by lead or a range of pesticides. You predict invading diseases will increase in frequency since we have fast travel and trade from all over the world. For example: a duck plague from Europe killed off 10,000 ducks in the US. Is the crow outbreak similar?

Place 100+ yellow dots on the map in the New York City area.

Horse Veterinarian from Long Island

You will play the role of a vet from a rural part of Long Island who has seen 9 of 23 stricken horses die. On August 26 a horse collapsed and thrashed, unable to get up. Another neurological disorder? But he died immediately! In the same week another horse walked with a tilted head, leaning against a fence for balance. Another staggered and tripped. Some were four years old. Some were elderly. Some fell fast. Some lingered. Some bounced back.

Develop a character to tell these stories of a dedicated vet working long hours and having a sick horse himself.

Place two red dots in New York (race track) and 21 on North Fork of Long Island (70 mi E of NYC). Perhaps is it rabies? Or Equine Protozoal Myelitis since five tested positive. But could they have just survived EPM and then contracted something else? But so many so fast, clustered within 5 miles? Normal is four to five per year for the entire territory! **After** the human report, say it is not the same disease as in humans since there are no horses with it in New York City.

Bronx Zoo Pathologist

You will play the specialist who must determine why by Labor Day strangely ill birds were dying. A cormorant swam in circles. A bald eagle had tremors. Flamingos died. A snowy owl died. Thousands of crows were on the zoo grounds. A trumpet swan swam backwards, but recovered.

Tell investigators your intuition says there is some novel disease, but every one says you are crazy. You found hemorrhage in brains and therefore it could have been Eastern Equine Encephalitis since it can also attack birds. But EEE also attacks emus and they were fine. So it is not EEE. After the announcement that it is St. Louis Encephalitis, you ask why we are losing so many species if it is something that has been here so long? You send bird samples for further testing. Place thousands (as many as you can place in one area) of blue dots at Bronx Zoo in New York City.

Centers for Disease Control and Entomologists

You will play the role of representative of CDC who is on the job of identifying and curtailing the strange illnesses attacking humans in New York City. On Sept. 3 you reported people probably were having an outbreak of St Louis Encephalitis even though it has never been this far north. Mosquitoes spread it. Queens appears to be the hot zone of the outbreak so our helicopters sprayed every swimming pool and mound of abandoned tires. A debate flared over the safety of sprays, but the epidemic died down after we sprayed just as we had predicted for a mosquito-borne disease.

Place 60 green dots to represent people in New York City. Seven of the 60 afflicted with the disease died.

Lab Technician and Gene Sequencer

(present tests from National Vet Services Iowa, Centers for Disease Control Colorado, UC Irvine & CDC in NY)

You will play the role of bringing the lab test results. That proved to be some new virus. Give the results of sequencing a region to each of the investigators to determine which virus it is. Let them identify from their own data.

Place 100 black dots scattering over the entire map. Tell the investigators that this similar virus has been identified in 23 species, including humans! At least three species of birds show no symptoms, but have tested positive with the disease. That includes starlings, house sparrows and pigeons. Common birds have tested positive even in New Jersey and Connecticut. These are healthy and flying everywhere with enough blood for mosquitoes to suck out. This is unlike the animals that die and can no longer support the virus for very long. Testing continues in other species.

Victims

You will play the role of a victim of a disease that can be deadly, although not always. You do not know the name of the disease or how you contracted it even though many have it nearby to where you live. You are to be interviewed by a group of investigators so they can determine a plan to combat the disease. Develop a character that shows them how sick you are, what you were like when you went into the hospital and what you were like when you first realized you had it. Symptoms are:

Mild—fever, headache, body aches, skin rash, swollen lymph nodes

Severe—high fever, neck stiffness, stupor, disorientation, coma, tremors, occasional convulsions, paralysis, death

Give a scenario of what you did and how you felt. Include activities and where you went a week or two before you became aware you were ill, where and what you ate, who you were with (ill or not?). Were you in a swampy area or outdoors in mosquito season?

Investigators

You are selected to be in a prestigious group of investigators (doctors, epidemiologists, lab technicians, public health officials) who are trying to determine the hot zone of an outbreak(s?) People and animals have been ill and many have died. It is unknown what the problem(s) is. It is unprecedented for human and animal specialists to meet together, but communication during this New York City urgent public health problem might help. NYC's Assistant Commissioner for Communicable Disease has brought together victims and responsible observers of the disease. He/she will let you ask questions of them. Arrange the interview so you can:

1. Identify the cause of the outbreak (What? from Where?)
2. Discover how it spreads.
3. Determine if it will settle down to stay.

From this information you should make a **plan** to combat the illness now and make sure it does not spread. We are counting on you!

Science Appendix 6

Transparency Master



**Extended
Science
Activities:
Chemistry,
Anatomy,
Physics**

Extended Science Activity #1

Chemistry: Mercury Madness

Students will conduct research and investigate incidents of mercury exposure and its affects on human health for use in the grant proposal.

Rationale

Mercury was one of the metals known to the Greeks and Romans, as apparent by its elemental symbol Hg (hydrargyrum, which comes from the Latin meaning quick silver or h silver). In being the only metal that is liquid at room temperature, they found it quite interesting.

Mercury can occur naturally in the environment, however; in this activity students will investigate situations where mercury is caused primarily by human activities. Specifically, the health effects of mercury exposure will be addressed.

The mercury studies will model a student-driven investigation in preparation for the project. Students will then choose and research a community health topic for their grant proposal that includes scientific information and critical thinking.

Basic Health Services Connection

This is foundational for the effective completion of the culminating project. Health services career connections will naturally occur in the process.

Standards Addressed

Science: Investigation & Experimentation 1; Chemistry 1

Objectives

The student will:

- Learn about the effects of mercury exposure on human health;
- Apply the investigation techniques to the grant proposal.

Process

The student will:

- Research causes of mercury poisoning in humans;
- Utilize the Internet to research current mercury-related exposure incidents and resulting health effects;
- Complete “Mercury Madness” assignment sheet; utilize “Nightmare on White Street”;
- Research environmental issues as possible community health issues;
- Decide on a topic (environmental or other);
- Gather scientific information that will give a basis for the reasoning process from real data, providing a strong grant application.

Assessment

- Evaluation of student work on the assignment sheet;
- Completion of grant topic, and related science research.

Bibliography/Resources

- Approved Chemistry text
- Encyclopedias
- Internet
- Local medical and research scientists

*Refer to Extended Science Appendix 1 & 2 following this section.

Extended Science Activity #2

Anatomy/Physiology: Blood and Lymph Circulation Lab, Angiogenesis Inhibitors

(Process with Social Science/Language Arts/Health Careers Activities 1 & 3)

Rationale

Studying blood and lymphatic systems with their vessels and cells unveils the structure/function link in an interesting way. The lab reveals the action area of new research with microscopic studies. Critical thinking in more depth than the previous *Times* article experience develops real substance to decisions and proposals of medical science for the community grant. This activity goes into more depth as to how to assess a variety of research designs, in this case an enzyme inhibitor that might contain answers to a variety of cancers. This is a model of how to assess any research topic for its reliability and accurate data and to use these facts in building a needed community project.

Basic Health Services Connection

This is a foundational skill-development activity in research design methods. This activity is designed to process with Social Science/Language Arts/Health Careers activities 1 & 3.

Standards Addressed

Science: Investigation & Experimentation 1; Biology/Lifesciences 1, 9

Objectives

The student will:

- Compare structural and functional differences among arteries, veins, capillaries;
- Observe blood movement through capillaries, arterioles, venules and lymph vessels;
- Explain possible means of transporting of angiogenesis inhibitors;
- Envision the cells and vessel action of the enzyme blocking mechanism;
- Use the knowledge of the subject and/or this model for a grant proposal.

Process

The student will:

- Attend teacher lecture on anatomy and function of blood vessels and link the understanding to the “Cancer Hope Analysis” which the students should have completed;
- Refer to text or charts to review the anatomy and function of arteries, veins, capillaries;
- Follow directions and answer all questions on the student lab sheet which directs microscopic observations, drawings and thoughtful insights on the path and mechanism of angiogenesis inhibitors;
- Use this depth of scientific analysis to choose a good project with good scientific research that can support a solution you propose in the grant proposal.

Assessment

- Lab procedures and lab write-up;
- Analysis of medical research with links to the community needs culminating project.

*Refer to Extended Science Appendix 3 following this section.

Extended Science Activity #3

Anatomy/Physiology: Genetic Vaccines: Transformation for Immune Response

Design a community project using a vaccine as a model for the group project.

Rationale

The research progress on genetic vaccines is dealing with the basics of the immune system as well as the basic understandings of DNA and the cell. Relating breaking medical advances to the anatomy and physiology system of immunity and the cell workings can be a very important part of the grant application (and therefore authentic life) in that it could be the base solution to nearly all infection and even cancer.

Objectives

The student will:

- Describe the immune response and how the genetic vaccines will intervene in disease;
- Conduct a transformation (using plasmids) and relate how genes transferred can transform a cell that may contribute to immunity;
- Design a reliable research study.

Standards Addressed

Science: Investigation & Experimentation 1; Biology/Life Sciences 1, 4, 5, 10

Teacher Preparation

The teacher will:

- Prepare a transparency from the “Immune System Response to Foreign Antigens” and define the concept step by step for the students;
- Demonstrate plasmid transformation: A plastic tube or a hose can be placed in a circle about 1 to 2 feet in diameter. (A pencil inserted in the two ends of the tube connects it.) This represents a plasmid, circular DNA that is present in bacteria. Show that the ends of the tube can separate and let the new plasmid segment into the circle. This new DNA can be a gene for a vaccine as well as any of numerous other genes. The vaccine plasmids entering the targeted cell can be shown by tossing the tube with the insert into an area drawn on the board or on a table that represents a cell. Tell students that the transformation they will perform (in our case on bacterium) is this tube circle toss that carries the inserted genes into the bacteria. It could also be delivered into cells (for instance muscle cells) by a gene gun or by an injection.
- Prepare for transformation lab.*

Process

The student will:

- Review lecture notes and text to describe the immune response. Imagine a gene that is inserted in the cell that produces antigens capable of producing immunity. Describe step by step what happens in cell processes (mRNA, translation into antigenic proteins and fragmentation of proteins) after the immunity gene enters. Then describe what happens

to the humoral and cellular immune response. (The basic concept may be drawn from fusing the technique inserting the gene for the antigen with basic textbook cell and immunity knowledge or in more detail from *Scientific American*, "Genetic Vaccines," July 1999);

- Perform a genetic transformation on cells students have made competent to accept the plasmids. The bacteria are thereby transformed (see transformation lab *or* teacher may also demonstrate). (Kits also can be ordered from BioRad Lab, Wards, or Carolina Biologicals.)
- Design a reliable medical study;*
- Complete the model: 1) decision regarding a disease that demonstrates a great community need, and 2) research of an effective clinical trial that has promise to prevent or cure the disease;
- Use the experience for the grant proposal first as a class model and then for ideas in preparing the group grant proposal.

Assessment

- Descriptions of the immune system response;
- Lab write-up;
- Class grant proposal model project discussion and student grant proposal.

*Refer to Extended Science Appendix 4, 5, 6 & 7 following this section

Extended Science Activity #4

Physics: Human Work and Power: Assessing Fitness Technique

The student will test mathematical formulae for work and power by setting up an experiment. This knowledge will empower the student to propose a grant dealing with the needs of physical fitness or other physics applications.

Rationale

Most modern research work requires multi-disciplinary collaboration. This unit demonstrates that collaboration, since it involves:

- Biology—how the human muscles work
- Chemistry—the conversion of chemical molecules into energy
- Physics—the measurement of power and work
- Mathematics—algebra, formulas and integrals
- Computer Skills—Spreadsheet and graphing software
- Health—work and energy expenditure for fitness

Most physics laboratory experiments involving force, work, and power deal with inanimate objects: the tension in a string attached to a pulley, the power output of an electrical circuit, etc. Measurement of these quantities in humans is both difficult and intriguing. An ergometer coupled with suitable timing instrumentation and a laboratory microcomputer makes it possible to measure instantaneous work and power output for people. Measuring work and power in people enables us to take care of major health needs of our communities and this service can be the center of an assembly proposal.

Objectives

The student will:

- Determine whether human power output agrees with a mathematical model by setting up an experiment with a bicycle riding volunteer and comparing the resulting data to the equation with an exponential form;
- Demonstrate understanding by explaining data and making further proposals;
- Apply knowledge by proposing a grant related to fitness or other physics instrumentation or equipment applications.

Standards Addressed

Science: Investigation & Experimentation 1; Physics 2, 3

Process

The student will:

- Explain work and power formulae, insert the proper units of measure and simplify
- Make an Excel spread sheet and graphs using given data from a bicycle volunteer
- Compare graphs to hypothesis
- Explain data outcomes and propose further data collection
- Organize a model grant proposal to serve the community by setting up a fitness testing center. (Or brainstorm ideas to serve some other community health needs which physics instrumentation or equipment applications can facilitate.)

Assessment

Lab report and grant (either class discussion of fitness service project or individual ideas for health needs that require the expertise and applications of physics).

*Refer to Extended Science Appendix Activity 8 following this section (white out teacher's guide answers that appear embedded in the lab).

Extended Science Appendix

Mercury Madness

Nightmare on White Street

**Blood and Lymph Circulation Lab and Angiogenesis Inhibitors
Analysis**

Transformation Teacher Instructions

Transformation Lab Student Instructions

Overhead Transparency Master for Immunity

Scientific American Article on Genetically Engineered Vaccines

Human Work and Power Lab Student Instructions

Mercury Madness

Although mercury is a naturally occurring metal in the environment, it has been released into the atmosphere through human involvement. In this activity, you will research and investigate historical and current incidents of mercury contamination. In addition, you will investigate human health effects that result from mercury exposure. Then you will use your Internet browsing skills to explore some environmental health issues and decide if one of the issues is a possible grant proposal topic. Finally, you will decide on a health topic and apply research to gain scientific information that will make a strong grant proposal.

Using a web browser, complete an Internet search on mercury to answer the questions below. A good starting place: <http://www.metroactive.com/papers/metro/12.04.97/mercury-9749.html>.

Too Close to Home!

1. Explain how the mercury contamination came about in the Almaden Quick Silver County Park.
2. Why is the location and proximity to waterways, residential communities and recreational facilities a danger?
3. Do you think it appropriate for people to be recreating in an area designated by the EPA as one of California's Superfund Sites?
4. How is the San Francisco Bay affected by the New Almaden site contamination? Why is nothing more being done?
5. What is the meaning of "mercury" and the history of the name?
6. To what does the term "Mad Hatter" refer?
7. Explain bioaccumulation.
8. While it is no longer hatters who are at risk, explain how finger print photographers, dentists, hospital technicians and workers are exposed to airborne mercury.
9. Describe the most extensively documented case of mercury poisoning from fish consumption. Use the Internet to find out more on this tragedy. Read and analyze the information found on <http://vm.cfsan.fda.gov/~dms/mercury.html>

Is there a cause for concern of mercury contamination in fish?

1. From where do the mercury vapors in the atmosphere come?
2. How do fish absorb methylmercury?
3. Briefly explain safety studies that have been used to set safety levels in fish.

4. What is the best index of exposure to methylmercury?
5. List the type of symptoms of mercury poisoning.
6. How can exposure to methylmercury affect prenatal life?
7. What advice does the FDA offer consumers?
8. In the Chloralkali industry, the major process is electrolysis of aqueous NaCl solution to produce NaOH and chlorine. Upon electrolysis, aqueous sodium chloride solutions liberate chlorine gas at a carbon anode. The anode oxidizes the chloride ion to chlorine:

$$2\text{Cl}^- + 2\text{e}^- \rightarrow \text{Cl}_2(\text{g})$$
 The mercury or carbon cathode is the site of reduction of water to hydrogen with concomitant production of hydroxide: $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^-(\text{aq}) + \text{H}_2(\text{g})$

How is mercury contamination a problem with this process?

- Mercury combined with an organic group, such as methylmercury (CH_3Hg) and other organomercury compounds such as the mold preventive phenylmercury acetate used in fertilizers ($\text{C}_6\text{H}_5\text{-Hg-OcoCH}_3$) are much more dangerous than inorganic forms. Why is pollution by organic forms of mercury a concern? (Hint: bacteria)
- Read “Nightmare on White Street” and describe what a nightmare this toxic ion can cause.
- Research a local environmental- and health-related issue. Issues to consider: how waste is disposed in the local area; what happens to medical waste; the health of local waterways and wildlife refuges; the types of chemicals used to eliminate pests; residential disposal of hazardous chemicals, etc. Investigate what effects the problem has on us. Use the exploration of mercury as a guide to how you approach the chosen topic. Include information on the symptoms, concerns for unborn children, bio-accumulation, remediation, etc. How does your new toxin or potential risk affect the body? What reactions at a chemical level take place?
- With your grant-writing team, discuss whether this is a potential project topic *or* is there one that is strictly health/chemical-related that might warrant the same type of search? Keep in mind the rigor needed to research a community problem. Use the completed model to challenge your information gathering to gain understanding as a means to develop a powerful grant.
- Use this research to complete the grant application with the logic of scientific reasoning centered on chemistry and data presented for visual clarity.

Nightmare on White Street

MYSTERY MATTERS

by Tim Graham

From all indications, Donald Nagle was an energetic, healthy 68-year old man. Others in his hometown of Lincoln Park, Michigan, described him as a good neighbor and a kind-hearted man. They noted that Nagle had taken in his 88-year-old mother-in-law, Theresa Haupt, to live with him. The neighbors were concerned when, on August 7, 1989, they heard the wail of a siren and watched an ambulance stop at Nagle's house on White Street. They wondered whether it was Nagle or Haupt who was ill.

Onlookers were surprised to see the emergency medical team wheel both Donald Nagle and Theresa Haupt into the ambulance and head off to Heritage Hospital. The neighbors' initial concern would soon turn to fear as the story unfolded.

Earlier that day, Nagle and Haupt experienced extreme nausea, diarrhea, and vomiting—classic symptoms of food poisoning. Because the refrigerator had not been working properly, Nagle suspected that spoiled food was causing food poisoning, and he called for the ambulance. While they waited, their symptoms grew more severe. The short five-mile trip to the hospital seemed like an eternity for the elderly pair who were now suffering chest pains and labored breathing.

Doctors at the Heritage Hospital emergency room quickly discovered that both patients had extensive damage to the esophagus and lungs. As technicians collected tissue cultures and blood samples, doctors agreed that the situation was extraordinary and life-threatening. The doctors decided to transfer the two patients to Henry Ford Hospital in Detroit where epidemiologists could evaluate the unusual symptoms. All the while, Nagle and Haupt were slowly dying.

Symptoms spread

As doctors prepared their patients for transfer, the situa-

PHOTO BY JO GUNCEY

CHEM MATTERS, DECEMBER 1996 9

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tion took an interesting twist. Another man and woman checked themselves into the same emergency room suffering from similar symptoms! Paul Stewart and his wife, Sandy, lived in Taylor, Michigan. As the emergency room staff interviewed the Stewarts, a connection emerged. Sandy Stewart's father was none other than Donald Nagle! Doctors didn't know what the four were suffering from, but it seemed likely that they all had been exposed to the same source. Was this the outbreak of an infectious disease? Now all four would be transferred to Detroit hospitals for thorough evaluation.

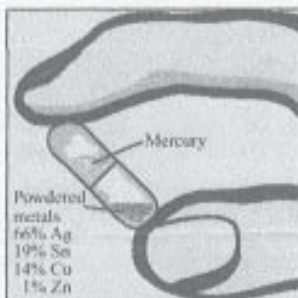
Although the symptoms were not specific to one particular cause, the severity of the inflammation in the esophagus and lungs of all four people led the medical team at Heritage to suspect exposure to a caustic chemical. Hospital officials contacted the Lincoln Park Fire Department and recommended that they search for hazardous chemicals. The investigation was now underway.

On August 9, police and fire investigators entered Donald Nagle's house at 866 White Street. In the basement, they discovered a crude laboratory with a furnace for melting metal, several pounds of silvery metal bars, a large quantity of powdered metal, and several liters of hydrochloric and nitric acid. Samples of the metals were taken to the Michigan State Police Crime Laboratory in Northville for immediate analysis. In the meantime, fire officials also found evidence that the metals may have come from the KM Corporation. A call to KM revealed that Nagle's son-in-

law, Paul Stewart, worked at KM as a maintenance man.

KM Corporation makes the capsules of amalgam that dentists use to fill teeth. KM says that their company tests every batch of capsules it makes and rejects those that don't meet standards. The rejected capsules are broken apart, and the mercury is separated and recycled. During this process, it is not unusual for some of the metal powder to become contaminated with mercury. Because this material cannot be used to make new capsules, it is stored and later sold to a metal recycler who further separates and recycles the metals.

KM believes that Paul Stewart stole this mercury-contaminated metal powder and was smelting it (refining by heating) to extract the silver, and planned to sell the silver. Donald Nagle permitted Paul Stewart to set up the laboratory in his basement.



A dental amalgam capsule contains two chambers that keep the ingredients separate. When the ingredients are mixed, they form a paste that begins to harden into solid metal in just a few minutes. For this reason, the final mixing must be done in the dentist's office, just before the drilled cavity is filled. The capsule is placed in a machine that shakes it back and forth vigorously. The vibration ruptures the barrier between the two compartments and thoroughly mixes with mercury with the powdered metals.

To purify the silver, Stewart removed the mercury by heating the mixture of metals in a casting furnace. Mercury vaporizes at a relatively low temperature and separates from the mixture as a colorless, odorless, but extremely toxic gas (see box Toxic Ion). An atmosphere contaminated with mercury vapor would be deadly to everyone who breathed it!

The following day the Michigan State Police Crime Laboratory confirmed the presence of silver, copper, and tin in the cast-metal bars. The same metals plus large amounts of mercury were found in the powdered metal samples. It was obvious to investigators that someone in the residence was indeed smelting the dental amalgam, thus driving off large amounts of mercury in vapor form. The mercury vapor entered air ducts in the basement, circulated throughout the house, and contaminated everyone and everything in the home. It is possible that the victims were unaware that they were breathing a dangerous atmosphere.

Because mercury is a hazardous material, health and environmental officials were called in from the U.S. Environmental Protection Agency (EPA), the Michigan Department of Public Health, and the Wayne County Health Department. The residence at 866 White Street was sealed and placed under guard until officials could determine the severity



of the contamination and determine how to clean it up.

On August 11, doctors started each patient on chelation therapy using Dimercaprol. Dimercaprol belongs to a chemical family of substances called chelates (pronounced key-lates), organic molecules that "bind" metal atoms and remove them from the system. This therapy is most effective within 48 hours of exposure, and all four patients were in their fifth day of hospitalization. Although doctors could now take a reasonable course of action, they held very little hope for success. During the next three weeks, all four died. Paul Stewart lived the longest, dying on August 30, 1989.

Postmortem tissue and blood samples revealed extreme levels of mercury in the vital organs of all four people. Each had died from acute mercury poisoning, which resulted in respiratory distress syndrome and ultimate respiratory failure.

Aftermath

Measurements made by EPA showed the mercury levels in the White Street house to be

Blood and Lymph Circulation Lab and Angiogenesis Inhibitors Analysis

In order to follow where the blood goes carrying angiogenesis inhibitors and how the inhibitors work, make the following lab preparations with the microscope and answer the questions. To assist in this lab, use information and charts from your teacher or drawings from your textbook.

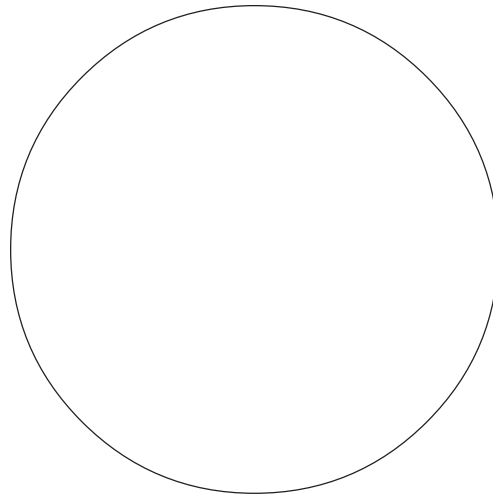
Materials

- Prepared microscopic slides of cross-sections of artery, vein, capillary
- Microscope
- Charts of circulatory system
- Text & lecture notes
- Live gold fish
- Clear microscopic slide
- Dropper
- Paper towel

Procedure

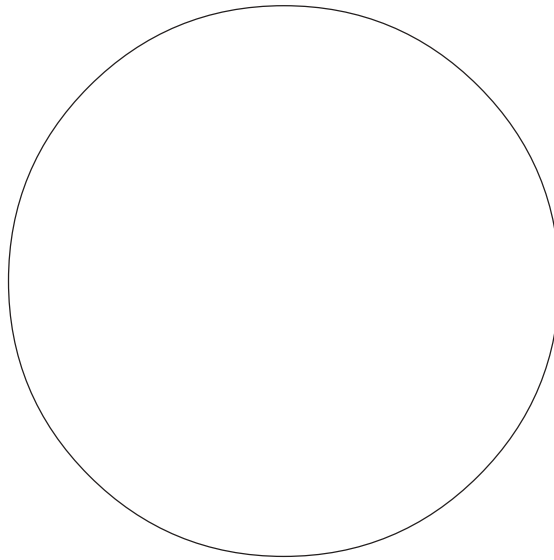
- ① Review the network of vessels and the means of transport out to the cells and back.
- ② Examine the prepared slides showing cross-sectional views of arteries, veins, and capillaries. Compare the diameter and thickness of the walls. Locate the three layers: tunica adventitia, tunica media, and tunica intima in the arteries and veins. Notice that the capillaries' thin walls contain only endothelial cells. Draw an artery, a capillary, and a vein. Label endothelial cells, circular smooth muscle, internal elastic membrane, external elastic membrane, tunica adventitia, tunica media, tunica intima.

Microscopic Drawing



Name and describe the two circuits of blood vessels.

- ③ To see capillary circulation, saturate paper towels with water. Place some water on a clean glass slide and lay a goldfish on the slide. Wrap a moist paper towel around the middle of the fish extending around the slide in order to moisten the fish and yet anchor the fish firmly so it remains immobile during viewing. Drop water with a dropper on the towel in the gill area during the procedure so it will remain moist. Place the slide and fish on the microscope stage and then place a slide over the spread tail fin. If the fish is longer than the slide, you may place the entire set-up in a petri dish to keep the stage dry. Observe under focused low power. Identify arterioles, venules and capillaries and observe blood flow. Draw and label arterioles, venules, capillaries and place arrows for direction of blood flow. Place the fish back into the water immediately after you have adequately observed.



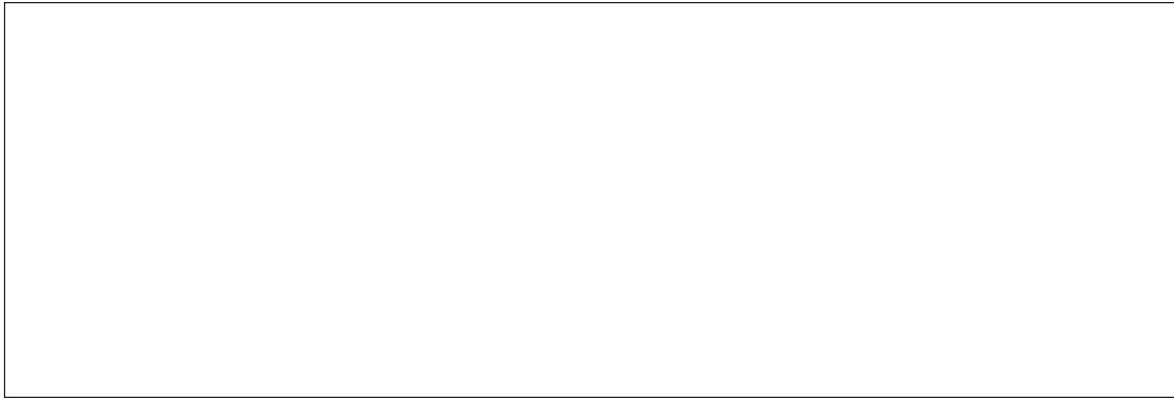
A. Describe the fish fin appearance and the direction of blood flow. _____

B. Why are capillaries structurally suited for diffusion of fluids? _____

C. How is blood pressure maintained? _____

D. How are the supplies that let cells grow delivered? Follow the path and describe how the vessels are designed to accomplish this task. _____

④ Now that you have seen the vessels and the cells where the action of Judah Folkman’s research takes place, try to envision what is happening. Folkman tells us there is proof that there is an enzyme (ATP synthase) on the endothelial cells’ membrane surface that must be inhibited for blood vessels to be stopped from growing, thereby stopping the supplies that let cancer grow. Endothelial cells grow unless inhibited, but this growth must occur at sites where tumor vessels hook up to the surrounding vessels. Folkman’s theory is that blocking that growth may be enough to starve cancer. Draw your vision of tumor vessels and cells that need to be blocked by angiogenesis inhibitors.



A. *The Proceedings of the National Academy of Sciences*, Mar 16, 1999, say that the ATP synthase (enzyme) activity could be an answer to why endothelial cells grow at low oxygen environments such as tumors. The enzyme allows ATP production. What would ATP give to this area you have drawn? If ATP production were stopped, what would happen to the malignant tumor? _____

B. Describe questions you have that are not answered. Are there any “whats” that you would like to have answered?

Suggested lines of thought from your previous course learning could include:

- What could a plentiful amount of ADP in endothelial cells do? Normally oxygen-deprived cells acidify the insides of their cells. Therefore, what kind of studies would help us know what is happening? Data of levels of what substances would be helpful?
- If enzyme production is genetically controlled in these particular cells, what suggestions of studies do you have? _____

C. In *Science* Feb 26, 1999, Folkman is portrayed as having a reputation for his ethics and scientific rigor and he himself says the article in the *Times* was “destructive” to him and people with cancer. “It’s hard for the public and media to understand that when something doesn’t work, it’s not scientific manipulation, it’s the way science is. All of our papers for 30 years have been reproduced, but they all took time and it usually was 1 to 2 years.”

How do you now feel about the cancer research? Is this the type of research you will select for your culminating project? What have you learned about real needs, reproducible research and real obtainable data?

Search for some health issue research needed by the community that is reproducible, gives good data and good hope for the future. Do not just take what somebody promises. Actually find the real facts to the research. Link this research with a possible community health needs project that the grant could support. Consider this for your culminating project.

Transformation

Advance Preparation

Luria-Bertani (LB) agar: LB agar can be made up at any time. It must be autoclaved and kept sterile in the refrigerator. Simply follow the directions on the bottle being sure that you pre-order an ample supply of distilled water. To avoid serious problems when remelting the agar later, it is best to place only 350 ml of agar solution into a 500 ml bottle. Autoclaving (sterilizing) can be done using a pressure cooker at 15psi for 20 minutes. It is simpler but more expensive to buy pre-made, sterile LB agar from any biological supply company.

LB plates: Preparing the LB plates is the most demanding part of the preparation. Since each team requires six plates and there are three different types of plates per team and sterile conditions must be maintained, this needs to be done by the teacher **or** students under very close supervision. This may be an opportunity to work closely with other department members or your best students as an after-school or weekend project.

- ❶ **Sterilizing plates:** Empty glass petri dishes (15 mm X 100 mm) can be sterilized ahead of time by heating them in an oven at 400° F for 30 minutes (Caution: Hot). Be sure to let them cool several hours before removing from the oven and handle only with hot gloves. If you can afford them, buy pre-sterilized plastic petri dishes from any biological supply company.
- ❷ **Marking plates:** Sterilized petri dishes should be marked on the bottom close to the edge. Each student team will have two plates labeled “LB”; two plates labeled “LB/AMP”; and two plates labeled “LB/AMP/X-gal.” In addition to team sets of dishes, you will need one extra dish per lab station labeled LB. This dish will be sub-cultured with bacteria 2–3 days before the lab is done and will be the source of bacteria at that lab station for each student team throughout the day.
- ❸ **Pouring plates:** Since ampicillin and X-gal are both heat sensitive, it is essential that you have hot water baths capable of holding temperature at approximately 60° C. These can be made using pans or large beakers over hot plates with variable heat settings. The pre-sterilized agar must be melted. This can be done with a hot water bath or microwave oven. The temperature needed is 100° C and you must **loosen the caps** on the agar bottles before heating.

When using a microwave, heat at the medium power setting and remove the caps, completely replacing them with sterile cotton or tissue. Once melted, the agar must cool to 60° C (this can take as long as 20–30 minutes). This temperature can be approximated by feel. If you can hold both hands around the bottle and not get a burning sensation, the agar is at the correct temperature. The agar can be placed into the hot water bath and kept at this temperature for hours. There must be enough water in the bath to completely cover the agar in the bottles when they are placed in the bath.

Once at this temperature, the Ampicillin and X-gal solutions can be added to the appropriately marked agar bottles. **DO NOT ADD AMPICILLIN OR X-GAL** to agar above 65°. When pouring the plates, place the sterilized, pre-labeled plates along the edges of your lab tables and lift the lids just enough to get the neck of the agar bottle into the space between the lid and the bottom of the plate. Pour enough agar (15 ml or less) to

BARELY cover the bottom of the plate and replace the lid immediately. **BE SURE THE AGAR IS Poured INTO THE CORRECTLY LABELED PLATE.** To reduce the amount of condensation inside the plate, you can leave the lid propped at an angle (just the slightest opening) instead of placing it down flat on the bottom half of the petri dish. After the agar in the plates cools and solidifies, close the plates, turn them over and stack them. They can be stored in plastic bags in the refrigerator until lab day. Leftover agar labeled LB can be saved in the refrigerator and re-melted for later use. Agar labeled AMP or AMP/X-gal **CANNOT** be saved for future use. Re-melting this agar would destroy the AMP and X-gal molecules. Once you begin this preparation, you cannot leave until all of the AMP, X-gal plates are poured. Be sure to plan plenty of time for this portion of the preparation; several hours are usually required. You might consider pouring LB plates one day and then the AMP and AMP/X-gal plates on another day.

Sub-culturing bacteria: Two or three days before the activity is planned, you need to take the extra LB plates poured (the ones you determined would be the source of bacteria for the lab station) and streak them with E. coli bacteria.

Transformation Kit: The transformation kits need to be ordered 6 weeks in advance of their planned use. They can be ordered from Carolina Biological Supply Company catalog # F6-21-1146. (Also, Bio Rad Labs has a kit that transforms bacteria to a green glow.) Each kit comes with enough supplies and consumables for **SIX TEAMS**; you need to divide your classes accordingly. If the LB broth or calcium chloride comes in large containers, you will have to transfer these to 1.5 ml microcentrifuge tubes. Since most students on first try do not measure very accurately with dropping pipets, you should make a double set of these tubes. This will prevent your having to try to transfer into these tubes during a class period.

Sterile technique: You should explain to your students the meaning of “sterile” and review those parts of the procedure that require using sterile technique. The procedure for this lab is written to save materials. In doing this, some sterile technique is sacrificed. If you have ample materials, instruct your students to discard all pre-sterilized pipets and loops after one use. You may choose to use a glass-spreading rod for spreading bacteria rather than the sterile loop technique in the procedure. If so, be sure to place the ethyl alcohol (used to flame the glass rod) in petri dishes or beakers and keep it and the glass-spreading rod away from the open flame of the Bunsen burner. You will have to demonstrate how to flame and use the glass-spreading rod.

Preparation time: Estimated time for making LB agar and marking plates is 1½ hours. Estimated time for sterilizing plates is 1 hour. Estimated time for pouring plates is 2–3 hours. Estimated time for sub-culturing bacteria is 10 minutes. Total estimated preparation time for 5 classes is 6 hours.

Introduction

This exercise allows students to learn the basic technique of inserting a piece of foreign DNA into a host organism. They will perform a transformation upon the bacteria *Escherichia coli* by inserting a plasmid containing two genes not normally found in the bacteria. By using pre-selected growth media, they can distinguish the bacteria cells that were transformed. This technique gives the students insight about one basic method used in genetic engineering.

Class Time Needed

Four to five 50–55 minute periods are required to do this activity.

1. The first day is for transforming and plating bacteria. Some teachers may wish to spend 1 day just reviewing and practicing the procedure and the second day actually performing the lab.
2. The second day is for discussions, predictions and gathering the data.
3. The third day is for analysis of results and calculation of efficiency.
4. The fourth day is for designing a reliable research design and link the drug research and therapies to the project.

Recipes for Consumables

- 10% Bleach: Add 10 ml of bleach (household variety) to 90 ml of tap water.
- 50 mM Calcium chloride: Add 50 ml of 1 M Calcium chloride to 950 ml of distilled water. Pre-rinsed filter. Transfer Calcium chloride to small, sterile tubes and store refrigerated until used.
- Other consumables are mixed according to directions on the stock bottles or are provided in the correct concentrations by the vendor.

Procedure

The most important thing for students to understand is the idea of **sterile technique**. If they think that they have contaminated a pipet or loop, it is essential that they discard that tool and get a new one. You should have an ample supply of sterile pipets and loops at each station. These can be placed in an empty beaker or jar.

The transfer of plasmid DNA from its stock tube to the pUC+ tube is crucial. Students must look carefully at the loop to see if there is a film of plasmid solution across the ring. This is similar to seeing a soapy film across a wire ring for blowing soap bubbles. If you prefer, you can have your students transfer 10ml of plasmid DNA with the micropipet. This will require extra materials and preparation if you choose this method.

It is essential that the students follow the directions regarding time. The pUC tubes are placed on ice for 15 minutes; the heat shock, for exactly 1½ minutes; and the recovery in ice, for 2–3 minutes. These times are designed to maximize the number of transformants. The most critical part is getting the shocked tubes **back in ice immediately**.

Transforming bacterial suspension from the pUC tubes to the petri dishes requires some care. The bacteria will settle to the bottom, so be sure that students stir the suspension with the pipet before drawing it up. Also, make sure that they don't open the petri dish to the air when placing the bacteria on the agar or when spreading the bacteria across the agar surface.

Disposal

- All loops and pipets can be placed in a 10% bleach solution for sterilization
- Sterilize petri dishes by covering the agar with the 10% bleach solution. Let it stand for 10 minutes or more. Once sterilized, the agar can be placed in double zip lock bags and placed in the garbage.

Source: Lawrence Livermore National Lab's Biotechnology Education Program (BEP)

Transformation Lab

Introduction

In this lab, you will put a small circular piece of DNA, called a plasmid, into a bacterium called *Escherichia coli* (*E. coli* for short). This process, in which a new piece of DNA is placed into an organism, is called transformation. It is a part of the new “genetic engineering” technology. Transformation can be used to introduce useful new genes from other species into a species that normally doesn’t have those genes. For example, plants and animals can be made resistant to certain diseases by this process. Some transformation experiments have produced interesting and strange results. In one famous case, the gene that makes a firefly glow is put into a plant. This results in a plant that can glow in the dark! On a more practical basis we are looking to do transformations within a species for gene therapy in such areas as cystic fibrosis and muscular dystrophy.

In this experiment, the bacterium *E. coli* cannot normally grow in the presence of the antibiotic ampicillin, nor can it break down the sugar-like molecule “X-gal”. However, the DNA plasmid pUC19, which will be put into the bacteria, contains two important genes. The first gene codes for resistance to the antibiotic ampicillin, and the second gene codes for an enzyme which can break down the X-gal. After undergoing transformation, the bacteria that successfully takes in the new DNA will be identified by their ability to grow on ampicillin, and also by their ability to break down X-gal. Bacteria that can break down X-gal will turn a bright blue color, and so they will be especially easy to see.

Sterile Technique

If you are not careful, other bacteria and even a fungus or two may grow on your petri plates and contaminate your experiment. Do not leave the petri plate lids off any more than you have to. If you are using a sterile tool, such as a pipet or plastic loop, do not touch the tip or allow the tip to touch **anything** except the designated bacteria, agar or sterile surfaces. Never assume a surface is sterile unless it has been specially prepared. If you make a mistake and you think the tool is no longer sterile, don’t take chances. Get another tool.

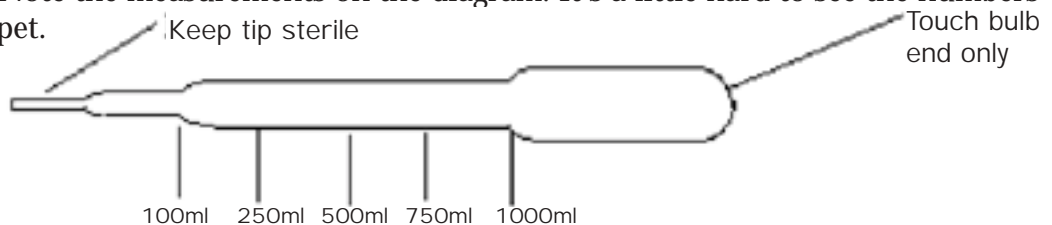
Objectives

The student will:

- Transform a bacterium;
- Complete sterile technique;
- Interpret and analyze experimental results using comparisons with controls;
- Design an experiment using transformation technology;
- Calculate transformation efficiency.

Materials

1. Sterile pipet. Note the measurements on the diagram. It’s a little hard to see the numbers on the actual pipet.



2. Sterile plastic “inoculating loop”. The loop end must remain sterile. Touch this instrument only on the handle.

Keep this part sterile.



Hold it on this end.



- | | |
|---|-----------------------------|
| 3. Culture <i>E coli</i> | |
| 4. pUC19 plasmid | 10. test tube holder |
| 5. Calcium Chloride | 11. ice bucket |
| 6. 2 plain Luria Broth agar petri plates | 12. Luria Broth |
| 7. 2 Ampicillin Luria Broth agar petri plates | 13. Disposable gloves |
| 8. 2 X-gal/Ampicillin Luria Broth agar petri plates | 14. 42[[ring]] C water bath |
| 9. 2 15 ml sterile culture tubes | |
| Optional: Incubator | |

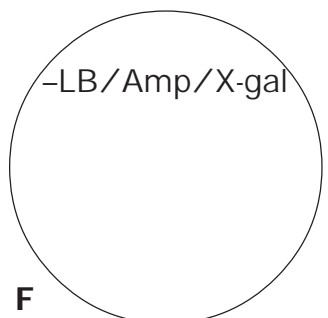
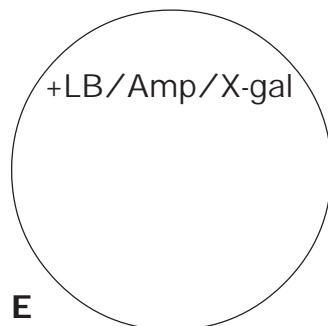
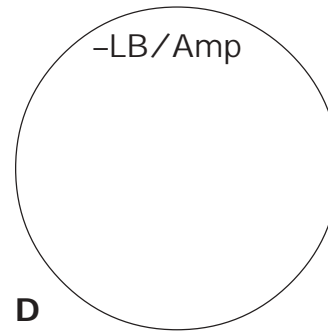
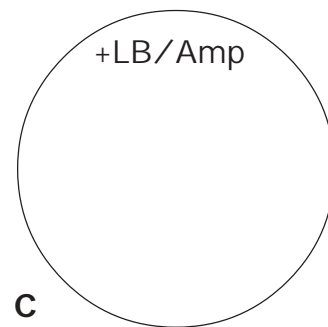
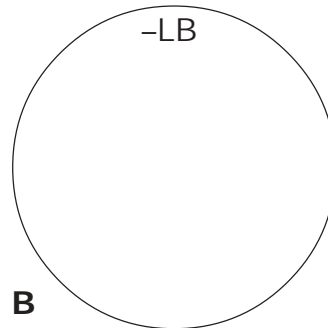
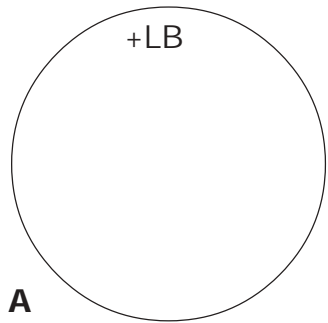
Procedure

1. First label one 15 ml test tube “+ pUC” and the other “-pUC”.
2. Use a sterile transfer pipet to add 250 ml of ice-cold calcium chloride to each of the two tubes. If you then put the pipet carefully back into the package it came from, being careful not to touch the tip on anything but the inside of the package, it should stay sterile.
3. Place both test tubes in the ice bucket.
4. Use a sterile plastic loop to transfer some of the *E. coli* bacteria from the starter plate culture to the -pUC tube. Be careful not to scrape up any of the agar along with the bacteria; slide the loop smoothly over the surface to pick up the bacteria. You don't need tons of bacteria, but get enough so that you can see a small clump sticking to the loop. When you put the loop into the calcium chloride solution in the tube, tap it against the tube wall so that the bacteria fall into the calcium chloride. Store the loop carefully on the lab bench **with the tip hanging over the edge so it doesn't touch anything**. This will keep it sterile.
5. Now use the saved pipet to suck the suspension in and out a few times, so that the bacteria mix completely. No clumps of bacteria should be left in the tube. Place the pipette back into its wrapper.
6. Put the test tube back in the ice. Now take the + pUC tube and put some bacteria in it by following steps 4 and 5. You can use the same loop and the same pipet, as long as they have not touched anything that is not sterile.
7. Both tubes should now be on ice. Throw away the plastic loop **and** the pipet.
8. Use a NEW sterile plastic loop to transfer a loopful of the pUC19 plasmid solution into the + pUC tube. Swish the loop in the tube to mix the DNA. Throw away the loop according to teacher instructions.

9. Return the + pUC tube to the ice. Leave both tubes on the ice for 15 minutes.
10. While the tubes are sitting on ice, label the six petri plates as follows:
 Label one LB/Amp/X-gal plate “+ ” and the other one”-”.
 Label one LB/Amp plate “+ ” and the other one “-”.
 Label one LB plate “+ ” and the other one”-”.
 By the way, LB refers to the nutrient mixture that the bacteria grow on. Amp means the plate also contains the antibiotic ampicillin, and X-gal means it contains the sugar-like molecule X-gal.
11. Now that the test tubes have been on ice for 15 minutes, they need to be “heat shocked.” This pulse will cause the cells to take up the DNA. To do this, remove the tubes from the ice and **immediately** put them in the 42^o C water bath for one and a half minutes. Watch the time carefully; don’t let them sit longer in the hot water.
12. Then **immediately** put the tubes back in ice for 1 minute (at least).
13. Use a **new** sterile transfer pipet to add 250 ml of LB broth to each tube. Put the pipet back in the package carefully to keep it sterile. Gently tap the tubes to mix them. Set the tubes in a test tube rack for a 10-minute recovery.
14. Now you are ready to put the bacteria on your labeled plates. To do this, use the same sterile transfer pipet to take 100 ml from the -pUC tube and put it on the - LB. Use the same pipet to add another 100 ml from the -pUC tube onto the -LB/Amp plate. Then use the same pipet again to add 100ml from the -pUC tube to the -LB/Amp/X-gal plate. Tilt lid over the plate only as much as necessary and replace it. Now all three of your plates labeled “-” should have 100 ml of -pUC suspension on them. Put the pipet carefully back in the package to store it.
15. Next you have to spread the bacteria over the surface of the plates. You can do this by quickly moving a new sterile loop back and forth across the plate surface. Be careful not to dig it into the agar. It should slide over the surface as if it were an ice skater. Use the same loop for all three plates and in the same order that you have done so far (LB, then LB/Amp, then LB/Amp/X-gal).
16. Now use the sterile transfer pipet (the same one previously used as long as it has not touched the agar or any other object) to take 100 ml of bacteria suspension from the + pUC tube and put it on the + LB plate. Then add 100 ml suspension to each of the other two plates (+ LB/Amp and + LB/Amp/X-gal). You can use the same pipet for all three. Use the sterile loop to spread the suspension around on the three plates as described in step 15.
17. Tape the lids down on the plates (you can stack them all together). Put your name on the plates and place them **upside down** in the 37^o C incubator until the next day (or at room temperature for several days).

Data

1. Observe, draw and describe each of the six plates carefully and write down observations for each one. How much bacterial growth do you see on each, relatively speaking? What color are the bacteria? You may be able to count how many bacterial colonies (the spots you see) that there are on each plate. This will depend on how many there are and how spread out they are.



Analysis

1. Why was one test tube labeled “+ ” and the other “-”?
2. Why do you suppose the CaCl_2 (Calcium Chloride) was added to the test tubes?
3. Why did you add the same bacteria to each tube?
4. Why did you add pUC19 (the plasmid or ring of DNA) to the “+ pUC” test tube **only**?
5. Why did you heat shock the bacteria?
6. Why did you add LB broth to each test tube? (HINT: What is a broth?)
7. Why do you suppose you needed to let the bacteria sit in the test tube racks for another 10 minutes after heat shocking and adding broth?

8. For each of the plates listed below describe what the label means and give a prediction of growth:

Plate	Description of Label	Growth/No Growth
+ LB		
-LB		
+ LB/Amp		
-LB/Amp		
+ LB/Amp/X-gal		
-LB/Amp/X-gal		

9. Were you successful in transforming the bacteria? How do you know? Give possible explanations for **any** results that did not come out as expected. (Hint: Review question #8 in procedure.)

10. In this experiment, how many traits were placed into the bacteria? What are they and how are they expressed?

11. For each of the following pairs of plates, directly compare the results that you see. What does each pair of results tell you about the experiment?

- A and B
- A and C
- A and E
- B and F
- B and D
- C and D
- C and E
- E and F

Conclusions

Describe how a transformation can be performed and methods in which to test the success of a transformation.

Design a Reliable Research Study Proposal

- ① Assume that the DNA for the vaccine that was described previously was inserted as you did in this transformation lab. Therefore instead of turning bacteria blue and antibiotic - resistant as in your lab results, the trait is DNA working as a vaccine. Describe a clinical research study that will determine if the vaccine is effective.
 - Lean on your knowledge of good scientific method to design the lab proposal.
 - Decide what kind of vaccine you are using such as the cold, flu, AIDS, Ebola, Encephalitis etc.
 - Choose a type of observational study or clinical trial/interventional study that will have the most scientific rigor. Consider who is in the study, what is really being studied and how big the study is. Remember “prospective randomized double-blind controlled” studies are the “gold standard” of the medical research world. Refer to “Scientific/Medical Article Analysis”.
 - Use the most data for needed reliable research. Notice the mathematics the transformation lab has.
 - Remember these are real people in your experiment! And the results are for real needs!
- ② Analyze another person’s creative clinical research design. Comment on the following to each other:
 - Scientific Method
 - Mathematical data
 - Terminology of the “Scientific/Medical Article Analysis”
- ③ Use the information you have learned on vaccines and clinical studies for the class design of a community disease need project. Investigate medical research! Listen to community cries. Dream away! What is possible in today’s research world?

Project

Use the information you have learned on vaccines and clinical studies for the design of a community disease or body system malfunction project. Investigate medical research! Dream away! What is possible in today's research world? What one class could do if one family can create "Project ALS" (Lou Gehrig's Disease)!

Doctors now credit Project ALS for starting the real research for ALS. A family with an ALS inflicted family member (1. Identify your community's need) has creatively managed research collaboration (2. Bring together proper players) and fund raising (3. Propose grant and matching funds) to set up centers for a cell replacement discovery (4. Decide on a body system that needs research). This family was asking what it would take to speed up finding a neuron replacement therapy or a therapy to prevent other motor neurons from dying. Their hospital doctors were suddenly involved in intensive research and testing because the family had raised funds. The family raised awareness by enlisting help from the communications and arts industries. They put together doctors who had never met each other and launched research at all levels of the lab. The doctors were focused and accomplished in six months what would have taken several years to do previously. Now there is money in their hospital to pay a post doc to research each important area of concern. The researchers say all this is possible because a family passionately asked the right questions, connected the proper players and supported the research financially.

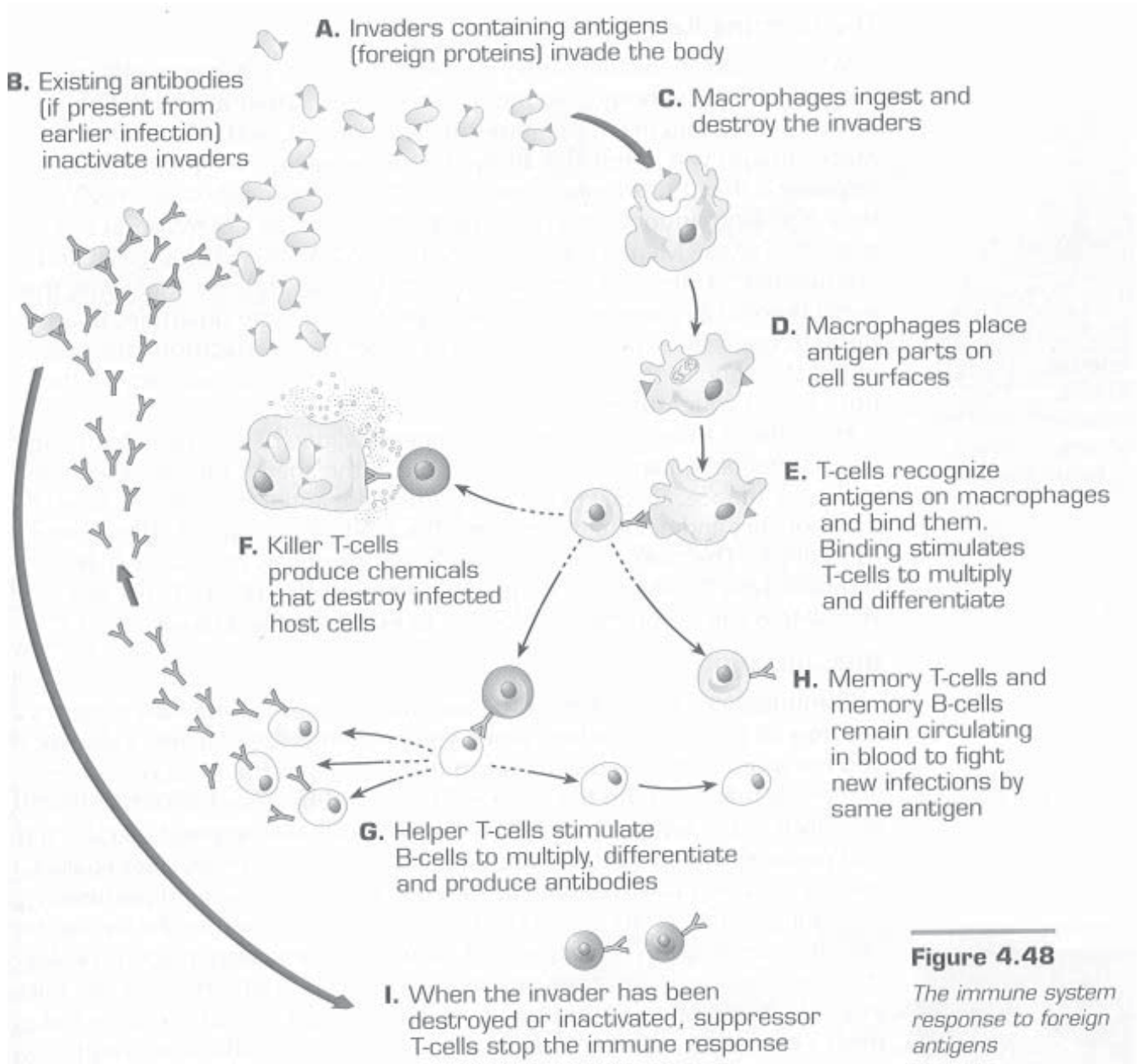
The patient says: "she is not in an illusion." She is "not just in it to save one life". Their work will change medicine even if it is not done in time for herself!

You are to find need for which a process can touch the lives of the people involved. Perhaps you wish to organize a test center for a medicine that is on trial and that your analysis says to be good. There are doctor's offices and centers that respond to needs through clinical trials. One community's hospital became a test center for a new heart drug and the death rates for heart disease dropped. You must search out the community need, find and analyze good medical research and finally connect those with the right expertise for collaboration.

There are many new drug therapies for you to analyze such as the following: mimicking the genetic code of a virus; stimulating the body's immune system; preventing the virus from entering the cell membrane. From your research choose a study to support. Your support could be efficient use of a vaccine or drug therapy. Or you could help with flu clinics, especially in getting word out to the elderly, to children's families or to targeted socio-economic groups. You could help with building a strong pandemic plan and being a part of community education to prevent the devastating potential of killer viruses that are breaking out. You could choose to educate the community on antibiotic resistance prevention. Then incorporate your science analysis and findings to the grant planning and decipher the money needed.

Find drug therapy for a malfunction of a human body system or an infectious disease and design a project that will touch the lives of people in your community. **Propose a grant to support it. Change medicine!**

Immune System Response to Foreign Antigens



Genetic Vaccines

Vaccines crafted from genetic material might one day prevent AIDS, malaria and other devastating infections that defy current immunization technologies. They may even help treat cancer

by David B. Weiner and Ronald C. Kennedy

Vaccines arguably constitute the greatest achievement of modern medicine. They have eradicated smallpox, pushed polio to the brink of extinction and spared countless people from typhus, tetanus, measles, hepatitis A, hepatitis B, rotavirus and other dangerous infections. Successful vaccines have yet to be introduced, however, for too many deadly or debilitating disorders—among them, malaria, AIDS, herpes and hepatitis C. This gap exists because standard immunization methods work poorly or pose unacceptable risks when targeted against certain illnesses.

Clearly, alternate strategies are needed. One of the most promising creates vaccines out of genetic material, either DNA or RNA. In the past 10 years such vaccines have progressed from a maligned idea to entities being studied intensively in academia and industry and in early human trials.

Vaccines at Work

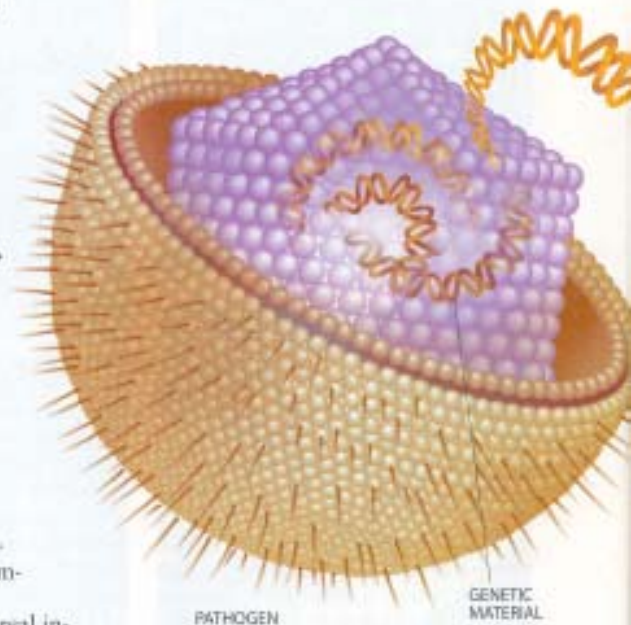
The merits of genetic immunization become most apparent when the actions of traditional vaccines are understood. Traditional preparations consist primarily of a killed or a weakened version of a pathogen (disease-causing agent) or of some piece (subunit) of the agent. As is true of most genetic vaccines under study, standard types aim to prime the immune system to quash dangerous viruses, bacteria or parasites quickly, before the pathogens can gain a foothold in the body. They achieve this effect by tricking the immune system into behaving as if the body were

already beset by a microorganism that was multiplying unabated and damaging tissues extensively.

When responding to a real infection, the immune system homes in on foreign antigens—substances (usually proteins or protein fragments) that are produced uniquely by the causative agent and not by a host. Two major arms can come into play, both of which receive critical help from white blood cells known as helper T lymphocytes. The humoral arm, led by B lymphocytes, acts on pathogens that are outside cells. These B cells secrete antibody molecules that latch onto infectious agents and thereby neutralize them or tag them for destruction by other parts of the immune system. The cellular arm, spearheaded by cytotoxic (killer) T lymphocytes, eradicates pathogens that colonize cells. Infected cells display bits of their attacker's proteins on the cell surface in a particular way. When cytotoxic T lymphocytes "see" those flags, they often destroy the cells—and the infiltrators within.

Beyond eliminating invaders, activation of the immune system against a specific pathogen leads to the creation of memory cells that can repel the same pathogens in the future. Vaccines confer protection by similarly inducing immune responses and the consequent formation of memory cells.

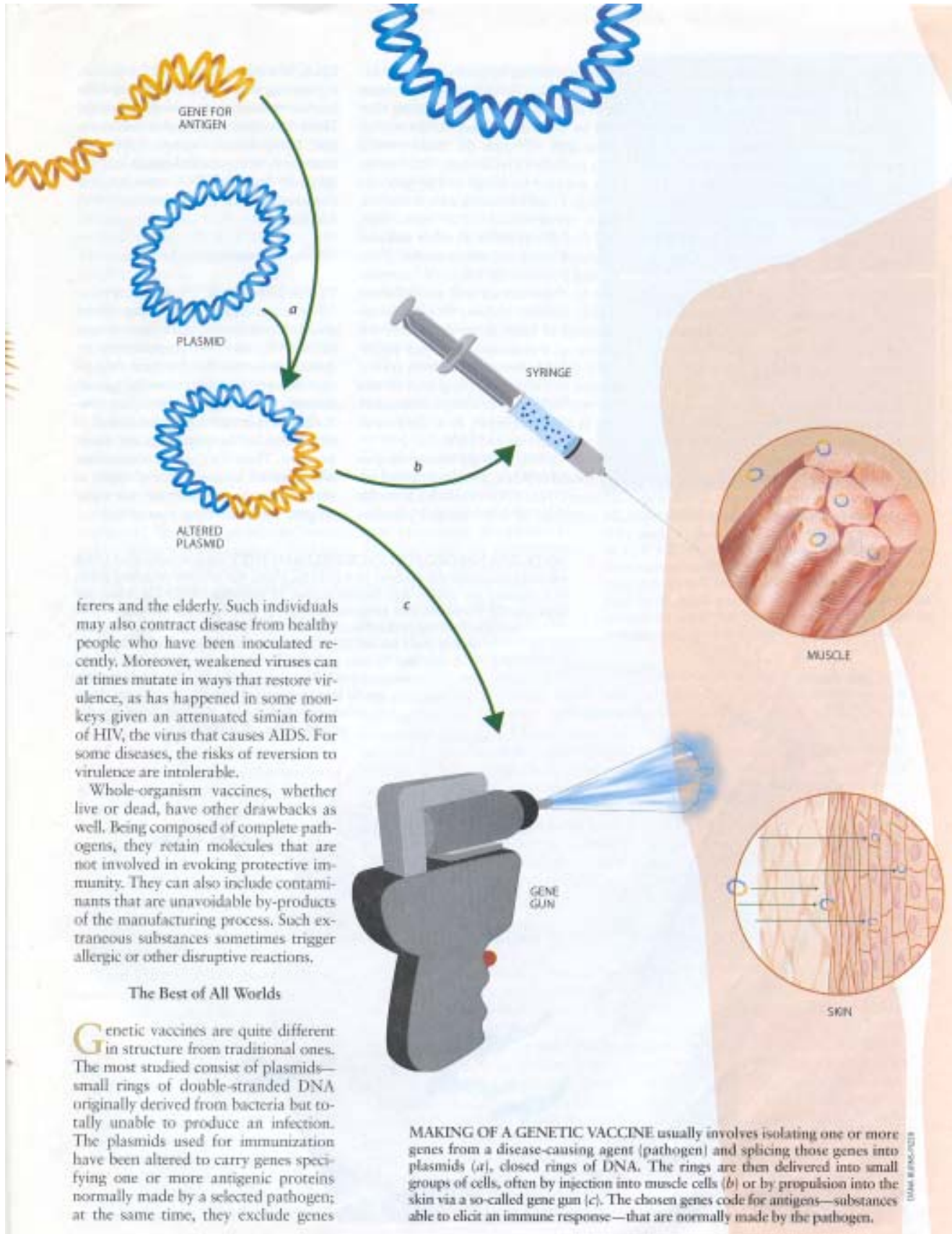
But standard vaccines vary in the kind and duration of security they provide. Those based on killed pathogens (such as the hepatitis A and the injected, or Salk, polio vaccines) or on antigens isolated from disease-causing agents (such



as the hepatitis B subunit vaccine) cannot make their way into cells. They therefore give rise to primarily humoral responses and do not activate killer T cells. Such responses are ineffective against many microorganisms that infiltrate cells. Also, even when nonliving preparations do block disease, the protection often wears off after a time; consequently, recipients may need periodic booster shots.

Attenuated live vaccines, usually viruses, do enter cells and make antigens that are displayed by the inoculated cells. They thus spur attack by killer T lymphocytes as well as by antibodies. That dual activity is essential for blocking infection by many viruses and for ensuring immunity when investigators do not know whether a humoral immune response would be sufficient by itself. What is more, live vaccines—such as the measles, mumps, rubella, oral polio (Sabin) and smallpox types—frequently confer lifelong immunity. For those reasons, they are considered the "gold standard" of existing vaccines.

Live vaccines can be problematic in their own way, however. Even they can fail to shield against some diseases. Those that work can cause full-blown illness in people whose immune system is compromised, as in cancer patients undergoing chemotherapy, AIDS suf-



ferers and the elderly. Such individuals may also contract disease from healthy people who have been inoculated recently. Moreover, weakened viruses can at times mutate in ways that restore virulence, as has happened in some monkeys given an attenuated simian form of HIV, the virus that causes AIDS. For some diseases, the risks of reversion to virulence are intolerable.

Whole-organism vaccines, whether live or dead, have other drawbacks as well. Being composed of complete pathogens, they retain molecules that are not involved in evoking protective immunity. They can also include contaminants that are unavoidable by-products of the manufacturing process. Such extraneous substances sometimes trigger allergic or other disruptive reactions.

The Best of All Worlds

Genetic vaccines are quite different in structure from traditional ones. The most studied consist of plasmids—small rings of double-stranded DNA originally derived from bacteria but totally unable to produce an infection. The plasmids used for immunization have been altered to carry genes specifying one or more antigenic proteins normally made by a selected pathogen; at the same time, they exclude genes

MAKING OF A GENETIC VACCINE usually involves isolating one or more genes from a disease-causing agent (pathogen) and splicing those genes into plasmids (a), closed rings of DNA. The rings are then delivered into small groups of cells, often by injection into muscle cells (b) or by propulsions into the skin via a so-called gene gun (c). The chosen genes code for antigens—substances able to elicit an immune response—that are normally made by the pathogen.

DAVID BECKER/PHOTOFEST

that would enable the pathogen to reconstitute itself and cause disease.

The vaccines usually are delivered by injection or by a device known as a gene gun. Injection, commonly into muscle, puts genes directly into some cells and also leads to uptake by cells in the vicinity of the inserted needle. The gene gun propels plasmids into cells near the surface of the body—typically those of the skin or mucous membranes. Once inside cells, some of the recombinant plasmids make their way to the nucleus and instruct the cell to synthesize the encoded antigenic proteins. Those proteins can elicit humoral (antibody-type) immunity when they escape from cells, and they can elicit cellular (killer-cell) immunity when they are broken down and properly displayed on the cell surface (just as occurs when cells harbor an active pathogen).

Such features raise hopes that, once perfected for use in people, DNA vaccines will preserve all the positive as-

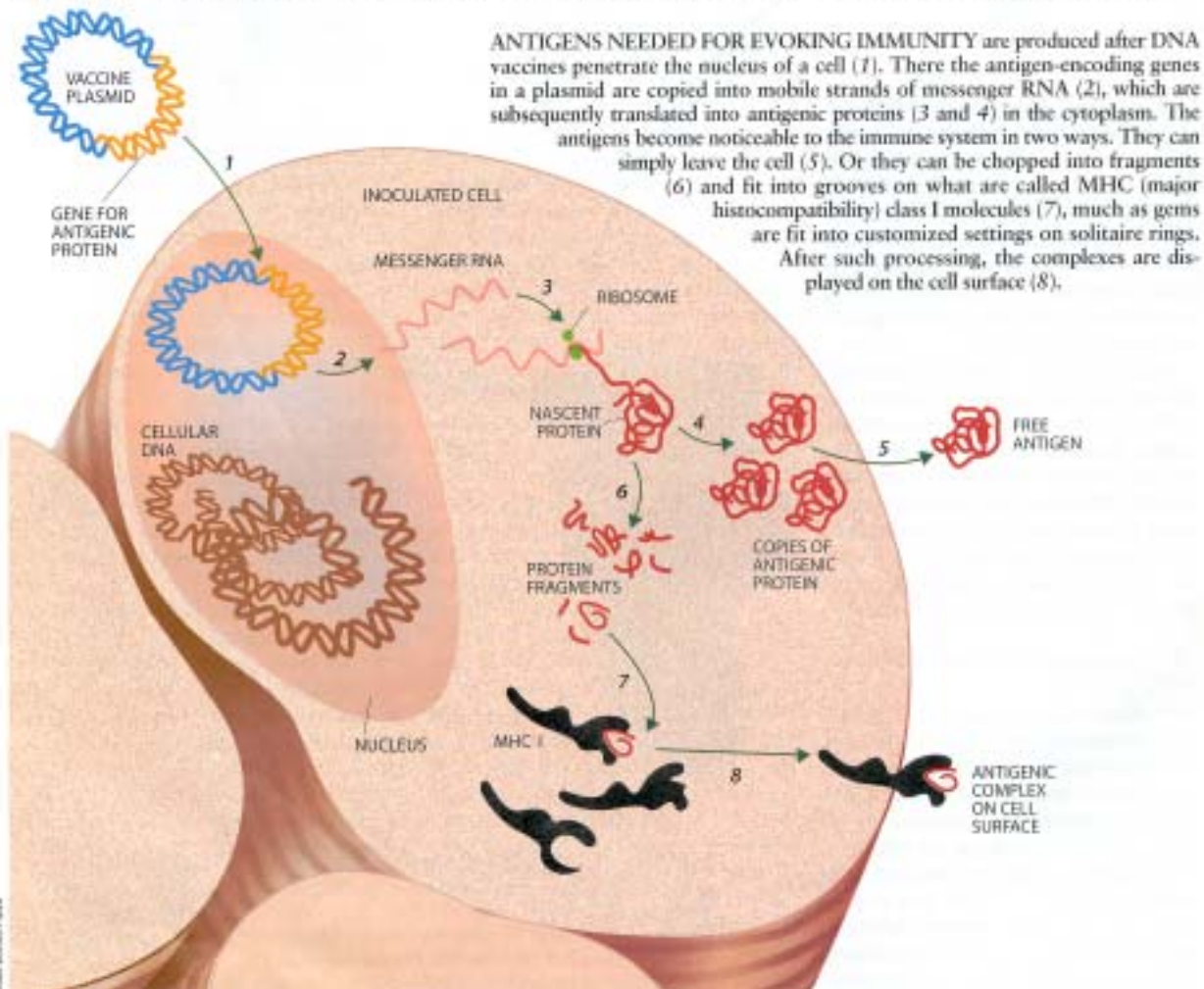
pects of existing vaccines while avoiding their risks. In addition to activating both arms of the immune system, they will be unable to cause infection, because they will lack the genes needed for a pathogen's replication. As a bonus, they are easy to design and to generate in large quantities using now commonplace recombinant DNA technology, and they are as stable as other vaccines (perhaps more so) when stored. They should therefore be relatively inexpensive to manufacture and to distribute widely. Further, because they can be engineered to carry genes from different strains of a pathogen, they can potentially provide immunity against several strains at once, something that should be very helpful when the microorganism is highly variable, as in the case of influenza viruses and HIV.

Some investigators are testing vaccines composed of RNA, a single-stranded relative of DNA. RNA in cells leads readily to synthesis of any encoded proteins.

RNA, however, is less stable than DNA, a property that can be problematic for vaccine manufacture and distribution. These difficulties are probably surmountable. Nevertheless, because RNA vaccines have been studied much less extensively than the DNA types, we will concentrate our discussion on DNA vaccines.

Lemonade from Lemons

The idea that genes might serve as vaccines grew in part out of research begun almost half a century ago. In the 1950s and 1960s experiments unrelated to vaccine development showed that delivery of genetic material into an animal's cells could trigger some synthesis of the encoded proteins as well as of antibodies targeted against those proteins. Thereafter, workers occasionally assessed antibody manufacture as an easy way to demonstrate that a given gene was generating a protein.



ALAN MARSH/PODAR

In the 1970s and early 1980s the ability of inserted genes to prompt an immune response gained attention from other researchers, this time as a disappointing phenomenon. Scientists trying to develop gene therapy (the delivery of genes to correct inherited and other disorders) noted that proteins made from therapeutic genes were sometimes destroyed in animals receiving the genes. The reason: an immune reaction to unfamiliar proteins.

By the early 1990s a handful of laboratories had begun exploring whether the unwanted immune responses to the protein products of foreign genes might be put to good use—for vaccination. Many others were dubious at first, skeptical, for instance, that the immunity elicited would be strong enough to spare people from infection by a living pathogen.

Yet in 1992 a cluster of animal studies done by independent groups demonstrated resoundingly that the concept was sound. Those groups included teams led by Stephen A. Johnston of the University of Texas Southwestern Medical Center in Dallas; by Philip Felgner of Viral in San Diego and Margaret Liu, then at Merck in West Point, Pa.; by Harriet L. Robinson, then at the University of Massachusetts; and by one of us (Weiner) at the University of Pennsylvania.

Collectively, those studies and a host of others conducted over the next few years revealed that DNA vaccines delivered into cells could stimulate the immune system of rodents and primates to generate B cell, cytotoxic T cell and helper T cell responses against many different pathogens and even against certain cancers. The research showed as well that immune responses and disease protection could be elicited when different routes of administration were used. The responses, moreover, could be enhanced by a variety of methods for facilitating DNA uptake by cells.

Since the mid-1990s many more researchers have turned their attention to DNA vaccines, and the technology has advanced to the first rung of human trials, focused on safety. The earliest trial began in 1995, when plasmids containing HIV genes were delivered to patients already infected by that virus. Bigger trials initiated in 1996 made history in another way. For the first time, physicians put new genes (coding for HIV or influenza proteins) into healthy people, instead of into those afflicted by some disorder.

So far human tests are examining vaccines designed to prevent various infections (by HIV, herpes, influenza, hepatitis B and *Plasmodium*—the parasite responsible for malaria), to bolster the impaired immunity of patients already infected with HIV and to treat a number of cancers (among them lymphomas and malignancies of the prostate and colon). Although cancer is not an infectious disease, much evidence indicates that harnessing the body's immune defenses may help combat it.

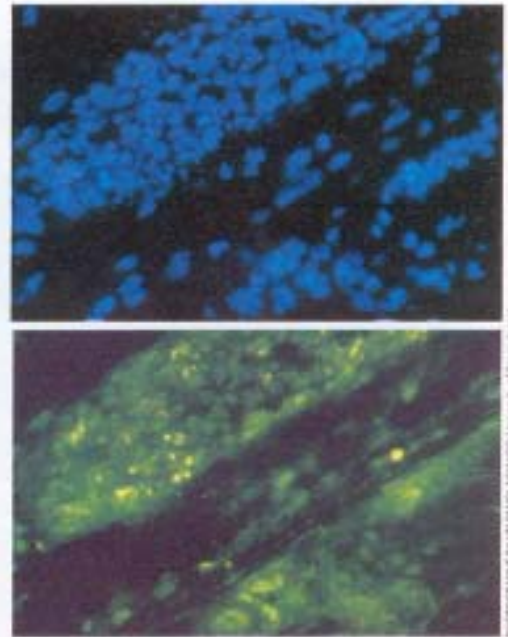
The safety trials ask such questions as, are the plasmids toxic, and does DNA delivered as a drug incite an immune response against the body's own DNA? Encouragingly, the studies have not identified any serious side effects to date.

Such trials do not assess disease prevention or amelioration, but many are monitoring the vaccines' effects on the immune system. Preliminary findings hint that useful immune responses can be achieved. Notably, HIV vaccines have generated both humoral and cellular responses; plasmids bearing *Plasmodium* antigens have evoked significant cellular immune responses; and a vaccine against hepatitis B has resulted in levels of antibodies that should be high enough to prevent infection. In common with traditional vaccines, though, current genetic approaches will probably have to be combined in many cases with generalized immune stimulators (adjuvants) in order to elicit the strong immune responses required to shield recipients from future infections.

How Do the Vaccines Work?

As clinical trials continue, bench scientists are seeking deeper insight into exactly how genetic immunization stimulates immunity, especially by the often crucial cellular arm of the defensive system. A detailed understanding should offer clues to enhancing effectiveness.

In truth, for many years immunologists faced a paradox. DNA vaccines obviously activated killer T cells. Yet simply putting DNA into skin or muscle cells and prompting those cells to display fragments of the encoded antigens should not have produced that

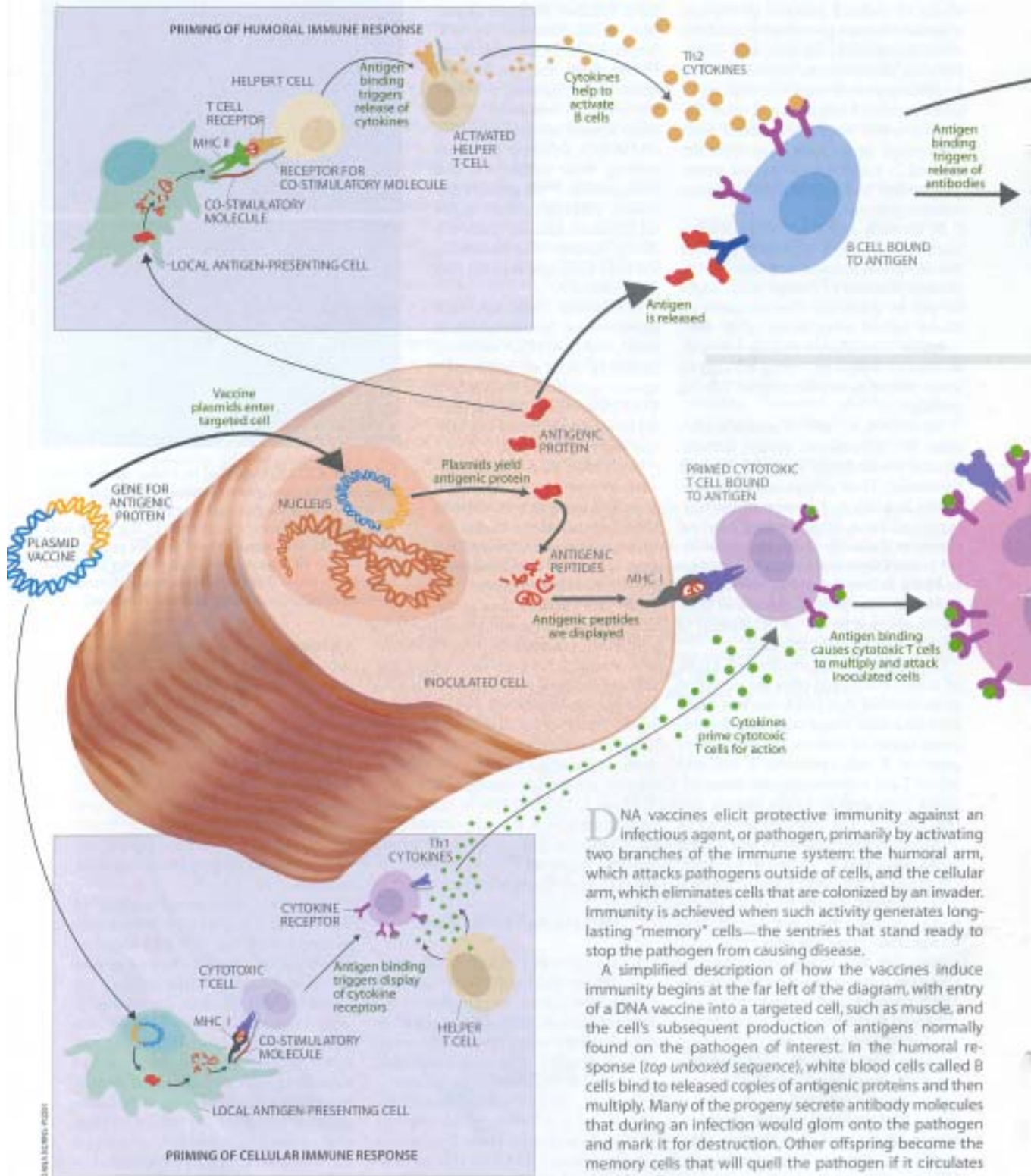


MUSCLE CELLS, identified by a blue marker (top), were made to glow green (bottom) after being injected with a DNA vaccine carrying a gene from the human immunodeficiency virus (HIV). The green indicates that the cells manufactured the HIV protein specified by the viral gene. Such micrographs constitute some of the proof that DNA vaccines can generate the proteins needed for evoking immune responses.

outcome. Before such display can activate cytotoxic T cells, the killers must be primed, or switched on, in part by interacting in a specific way with what are called "professional" antigen-presenting cells. In particular, the T cells must bind to the same antigenic fragments they will detect on inoculated nonimmune cells (such as muscle) and, simultaneously, to a second, co-stimulatory molecule (a "second signal") ordinarily found only on antigen-presenting cells.

At one time, biologists thought DNA vaccines had no way of getting into antigen-presenting cells and therefore that those cells had no way of synthesizing and displaying the antigens encoded by those vaccines. Recent discoveries by several groups have shown, however, that the original view was mistaken. Some of the plasmids do in fact make their way into professional antigen-presenting cells. These cells then display antigens alongside the critical co-stimulatory molecules and help to prepare the T cells for action [see illustration on next two pages]. Such findings indicate that to induce a powerful cellular immune response, DNA vaccines must be deliv-

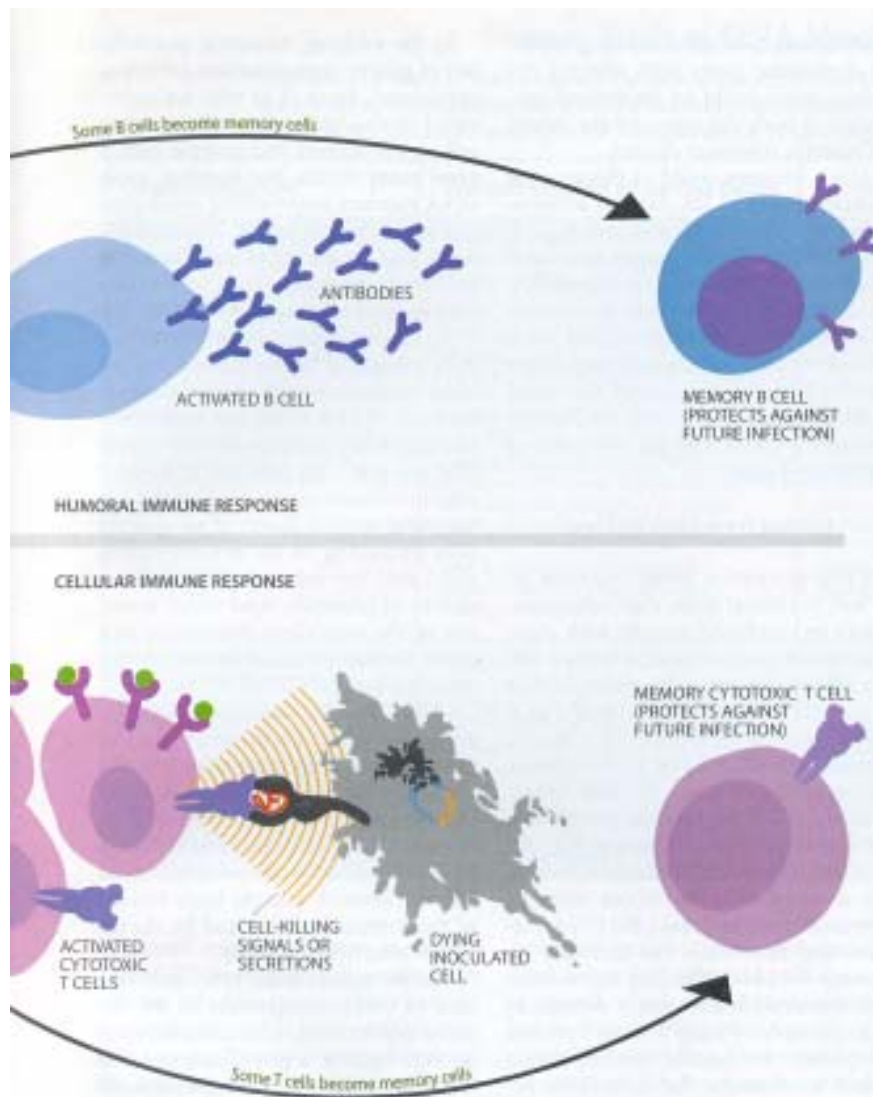
How DNA Vaccines Work



DNA vaccines elicit protective immunity against an infectious agent, or pathogen, primarily by activating two branches of the immune system: the humoral arm, which attacks pathogens outside of cells, and the cellular arm, which eliminates cells that are colonized by an invader. Immunity is achieved when such activity generates long-lasting "memory" cells—the sentries that stand ready to stop the pathogen from causing disease.

A simplified description of how the vaccines induce immunity begins at the far left of the diagram, with entry of a DNA vaccine into a targeted cell, such as muscle, and the cell's subsequent production of antigens normally found on the pathogen of interest. In the humoral response (top unboxed sequence), white blood cells called B cells bind to released copies of antigenic proteins and then multiply. Many of the progeny secrete antibody molecules that during an infection would glom onto the pathogen and mark it for destruction. Other offspring become the memory cells that will quell the pathogen if it circulates outside cells.

Meanwhile display of antigenic protein fragments, or peptides, on inoculated cells (within grooves on MHC class I



molecules) can trigger a cellular response (bottom unboxed sequence). Binding to the antigenic complexes induces white blood cells known as cytotoxic (killer) T cells to multiply and kill the bound cells and others displaying those same peptides in the same way. Some activated cells will also become memory cells, ready to eliminate cells invaded by the pathogen in the future.

In actuality, several preliminary steps must occur before such responses can arise. To set the stage for B cell activation (top box), "professional" antigen-presenting cells (APCs) must ingest antigen molecules, chop them and display the resulting peptides on MHC class II molecules. Helper T cells, in turn, must recognize both the peptide complexes and "co-stimulatory" molecules found only on the professional antigen presenters. If those steps occur, the helper cells may secrete signaling molecules known as Th2 cytokines, which help to activate B cells bound to antigens.

Priming of cytotoxic T cell responses involves APCs as well (bottom box). Before the cytotoxic cells can respond to antigens on inoculated cells, APCs have to take up vaccine plasmids, synthesize the encoded antigens, and exhibit fragments of the antigens on MHC class I molecules along with co-stimulatory molecules. Then the killer T cells must recognize those signals and also be hit by cytokines (this time of the Th1 type) from helper T cells. In steps not shown, DNA vaccines also yield memory helper T cells needed to support the defensive activities of other memory cells.

—D.B.W. and R.C.K.

ered in a way that will yield good uptake by antigen-presenting cells, not only by other cell types.

Separate work suggests that the plasmid DNA surrounding antigenic genes is more than a mere gene-delivery vehicle; it strengthens the immune response evoked by the antigens. This effect apparently stems from the high frequency of CG sequences in plasmids. Each strand in the DNA double helix is built from units called nucleotides that are distinguished by the bases they contain—either adenine (A), cytosine (C), guanine (G) or thymine (T). Plasmid DNA, derived from bacteria, has a greater frequency of CG sequences than does the DNA in vertebrates. Moreover, the CG units in bacterial plasmids tend to have no methyl group attached, whereas those in vertebrates generally are methylated.

Investigators have proposed that the vertebrate body interprets a high frequency of unmethylated CG pairs as a danger signal. In response, a relatively primitive part of the immune system (one not dependent on antigen recognition) attempts to destroy or wall off the foreign intruder.

Engineering for Optimal Effect

Along with analyzing the natural behavior of genetic vaccines in the body, immunologists are looking ahead, exploring ideas for increasing overall immune reactivity and for optimizing the ratio of cellular to humoral responses. One proposal for amplifying responsiveness has emerged from studying the DNA around CG sequences. Researchers have demonstrated that plasmid DNA yields the most potent immune response when CG sequences are flanked by two purines (adenine or guanine) to their "C" side and two pyrimidines (thymine or cytosine) to their "G" side. In mice, plasmids containing such "immunostimulatory sequences" induced more vigorous antibody and cytotoxic T cell activity than did an otherwise identical vaccine. Hence, increasing the number of immunostimulatory sequences in plasmids might well amplify the immunogenicity of the antigenic codes in a DNA vaccine.

A different approach is incorporating genes for signaling molecules called cytokines into antigen-carrying plasmids or into separate plasmids. Cells of the immune system release these molecules to regulate their own, and one another's, activities. As an example, a molecule named granulocyte-macrophage colony-

stimulating factor stimulates the proliferation of antigen-presenting cells, among other actions. Inclusion of its gene has been shown to boost overall responses to DNA vaccines.

To ensure that genetic vaccines trigger a strong cellular response when needed, researchers are experimenting specifically with genes for cytokines that are known to promote killer-cell activity. In mice, scientists have found that helper T cells called Th1 cells secrete cytokines that favor cellular responses at the expense of humoral (antibody) ones, whereas other helper cells (Th2 cells) secrete cytokines that favor humoral activity. In humans, helper T cells seem to come in more varieties, but a preponderance of Th1-type cytokines still promotes a cellular response, and a preponderance of Th2-type cytokines stimulates a humoral response.

One such project showed that a vaccine including genes for HIV antigens and for interleukin-12 (a classic Th1 cytokine) reduced production of anti-HIV antibodies in mice and markedly enhanced the responsiveness of cytotoxic T cells to HIV antigens. This bias toward a cellular response is particularly encouraging, because recent findings by HIV researchers indicate that a potent killer T cell response to HIV is critically important for combating HIV replication.

Genes for substances known as chemokines might be incorporated as well. Chemokines are small molecules that attract both antigen-presenting cells and T cells to damaged or infected tissues. Like cytokines, these substances differ in the mix of cells on which they act and in the precise effects they exert. As their individual actions are better

understood, carefully combining specific chemokine genes with selected cytokine genes could go far toward customizing both the type and the extent of immune responses elicited.

DNA vaccines could in theory even sidestep the need for classical antigen-presenting cells to prime cytotoxic T cells. If a gene for an antigen were bundled with a gene for a co-stimulatory molecule normally made by an antigen-presenting cell, then inoculated skin, muscle or other cells would themselves display both the antigen and the crucial "second signal," thereby facilitating both the priming and the activation of cytotoxic T cells.

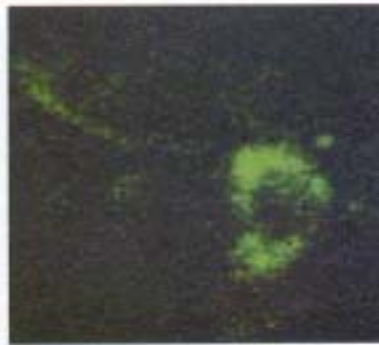
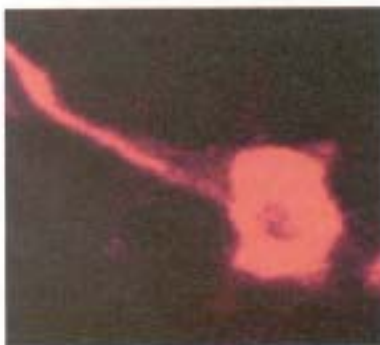
Getting from Here to There

If first-generation genetic vaccines do well in clinical trials, they may sometimes be combined initially with more traditional vaccines to achieve even better effects. Let us say, for example, that a subunit vaccine (consisting of a protein) evoked a good antibody response against a pathogen but that a cellular response was needed as well. Meanwhile a new DNA vaccine proved able to induce a cellular response but did not excite an ideal antibody response. In a so-called prime-boost strategy, physicians might deliver the DNA vaccine and then boost the antibody response by later delivering the subunit vaccine as well. Eventually, though, as vaccine makers learn how to optimize responses to genetic immunization (such as through the techniques described above), manufacturers may be able to achieve the needed effects by constructing genetic vaccines alone.

As the exciting, futuristic possibilities of genetic immunization are being considered, those of us who are captivated by this technology also have to roll up our sleeves and grapple with a great many details. For instance, most DNA vaccines stop yielding much protein after about a month. Would finding a way to extend plasmid survival lead to stronger immunity, or would it backfire and encourage attacks against unvaccinated, healthy tissue? How long does immunity last in human beings? How much do people vary in their responses? Which doses are most effective and what kinds of delivery schedules are best? We also need to know which substances are most useful for targeting genetic material to specific cells (including to antigen-presenting cells) and for enhancing the cellular uptake of plasmids. And which genes, out of the sometimes thousands, in a given pathogen should be selected for maximal power?

Clinical trials answering these questions and assessing the effectiveness of the first generation of DNA vaccines may not be completed for five or 10 years. Whether those specific versions reach the market, though, genetic immunization technologies are likely to prove extremely valuable for research into the basic biology of the immune response and for the design of even better vaccines.

Vaccine makers today often have little idea of which components of the immune system need to be activated most strongly against a given pathogen and which antigens and other substances can achieve that stimulation. Now, however, they can readily mix and match antigenic and other genes (such as those for



PHOTOGRAPHS BY MICHAEL DUFFIN/UCSD
University of Pennsylvania

UPTAKE OF DNA VACCINES by antigen-presenting cells, a crucial event in the induction of immunity, has now been demonstrated by several groups. In one approach, scientists added two kinds of labels to cells in a snippet of tissue that was exposed to a DNA vaccine—one tag (*red at left*) marked anti-

gen-presenting cells; another (*green at center*) denoted any cells making an antigen specified by the vaccine. When images of the cells were superposed, the appearance of an orange color (*right*) signified the presence of antigen-presenting cells that had taken up the vaccine and produced the encoded protein.

Human Trials of DNA Vaccines

This table lists many of the human tests known to the authors. All candidate vaccines are in early-stage trials examining safety and immune responses, and all have been well tolerated. No trials of effectiveness for disease prevention or treatment have begun. Most of the studies are ongoing.

Vaccine Objective	Proteins Encoded by Vaccine Genes	Immune Results So Far
Hepatitis B prevention	Hepatitis B surface antigen	Humoral and cellular responses
Herpes simplex prevention	Herpes glycoprotein	Immune analyses in progress
HIV prevention	Envelope and regulatory proteins; or core proteins and enzymes involved in HIV replication	Cellular responses (ultimately, all the genes will probably be tested in one vaccine)
Influenza prevention	Hemagglutinin	Immune analyses in progress (trial has ended)
Malaria prevention	Circumsporozoite protein	Cellular responses
HIV therapy	Envelope and regulatory proteins; or tat, nef and regulatory proteins	Humoral responses in first trial in list (which has ended); cellular responses in other trial
HIV therapy	Envelope, regulatory and core proteins and enzymes involved in HIV replication	Vaccine was combined with aggressive drug therapy (HAART); immune analyses in progress
Therapy for adenocarcinomas of the breast and colon	Carcinoembryonic antigen (CEA)	Cellular responses
Therapy for B cell lymphoma	Immunoglobulin	Humoral responses
Therapy for cutaneous T cell lymphoma (CTCL)	T cell receptor	Immune analyses in progress (trial has ended)
Therapy for prostate cancer	Prostate-specific membrane antigen	Immune analyses in progress

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cytokines and chemokines) in experimental DNA vaccines and compare the success of different combinations in small animals quite quickly. In that way, they can simultaneously gain a handle on the immune responses that are needed for protection and on the antigens and other proteins that can generate them.

As part of this testing, some researchers are creating "libraries" of a pathogen's genes; an individual library contains every gene in the organism, with

each gene spliced into its own plasmid. They then deliver subsets of such libraries to animals, which are also exposed to the live pathogen. Next, they identify the subsets that work best, further subdivide the groups and do more testing, until the most useful mix of antigens emerges.

As the years go by, the inherent manipulability of DNA should make it a vehicle of choice for teasing apart the body's complex immune responses to different disease-causing agents. With such infor-

mation in hand, vaccine makers should be able to design vaccines that will channel immune responses down selected pathways. In the past, manufacturers had no way to custom-tailor their products easily and inexpensively. In the future, such "rationally" designed genetic vaccines are likely to provide new immune therapies for cancer and powerful ways to prevent or minimize any number of devilish infections that elude human control today.

The Authors

DAVID B. WEINER and RONALD C. KENNEDY have each contributed significantly to the development of genetic vaccines. Weiner, a pioneer in the study of antiviral DNA vaccines, is associate professor of pathology and laboratory medicine and a member of the Institute of Human Gene Therapy at the University of Pennsylvania. Kennedy, professor of microbiology and immunology and of obstetrics and gynecology at the University of Oklahoma Health Sciences Center, studies genetic vaccines against cancer as well as those targeted against infectious agents.

Further Reading

HETEROLOGOUS PROTECTION AGAINST INFLUENZA BY INJECTION OF DNA ENCODING A VIRAL PROTEIN. J. B. Ulmer et al. in *Science*, Vol. 259, pages 1745-1749; March 19, 1993.
 PROTECTION AGAINST MYCOPLASMA INFECTION USING EXPRESSION-LIBRARY IMMUNIZATION. M. A. Barry, W. C. Lai and S. A. Johnston in *Nature*, Vol. 377, pages 632-635; October 19, 1995.
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 MODULATING THE IMMUNE RESPONSE TO GENETIC IMMUNIZATION. Adam D. Cohen, Jean D. Boyer and David B. Weiner in *FASEB Journal*, Vol. 12, No. 15, pages 1611-1626; December 1998.
 NEUTRALIZING ANTIBODY-INDEPENDENT CONTAINMENT OF IMMUNODEFICIENCY VIRUS CHALLENGES BY DNA PRIMING AND RECOMBINANT POX VIRUS BOOSTER IMMUNIZATIONS. Harriet L. Robinson et al. in *Nature Medicine*, Vol. 5, No. 5, pages 526-534; May 1999.

Human Work and Power Lab

In studying human power output, one experimenter¹ suggests that we are dealing with a saturation phenomenon, as with a charging capacitor. This might be anticipated from the knowledge that the time to complete one cycle of work increases as the subject tires. Accordingly an equation with an exponential form is the mathematical model most used in this field.

Among the questions this kind of investigation can answer are the following:

1. Does the phenomenon of “second wind” exist?
2. Can a person’s relative conditioning for sports be quickly and accurately determined this way?
3. Does a person’s power output decrease with time in an exponential fashion as one mathematical model predicts?
4. Can maximum power output and total work in 60 seconds be predicted from the initial slope of a power vs. time graph?
5. Does total work output depend upon whether one begins with a no-load or a gradual-load start up?

Introduction and Hypotheses

Mathematical Model Based on Chemical Energy Conversions

The Scientific Method proceeds by formulating a hypothesis, and then testing whether the results predicted by that hypothesis can be verified in experiments. The hypothesis here is:

In muscular activity there are two energy sources, aerobic (or oxidative) and anaerobic. For prolonged exercise the aerobic mechanism prevails, and there is a definite maximum rate of energy release. During the early stages of exercise, and under conditions of supreme exertion, the aerobic mechanism is insufficient, and the anaerobic mechanism prevails. This is the energy source which is vital in sprint events and which we will draw upon in this experiment.²

Chemists have determined that, in human muscles, the fundamental source of chemical energy is the exergonic reaction during which adenosine triphosphate (ATP) splits into adenosine diphosphate (ADP) and phosphoric acid. Since muscle contains only a very small amount of ATP, it has to be continuously resynthesised, at the same rate at which it is split. The energy for this is provided by the cleavage of creatine phosphate into creatine and phosphoric acid. Since the two reactions are in series and their energy contents are roughly the same, it is convenient to introduce the term phosphagen to describe all the substances containing high-energy phosphate. The cleavage of phosphagen can therefore be regarded as the primary energy source in muscular activity. For extended muscular exercise phosphagen must be resynthesised continuously utilizing the energy from food combustion and/or glycolysis.

Initially the power is supplied by the above described phosphagen cleavage, but when the phosphagen is depleted down to about one-half of its initial level, the glycolytic mechanism, characterized by the production of lactic acid, is activated. This is associated by consid-

erable physical discomfort and quickly leads to diminished levels of performance. It is for this reason that athletes in middle and long distances races avoid excessive exertion in the early stages of a race, delaying activation of the glycolytic mechanisms to the final stages of a race. A knowledge of the maximum rate at which energy can be extracted from the anaerobic mechanism is not only important to the calculation of sprinting performance, but is also important to the understanding of the strategy employed by athletes in races over long distances.

It is hypothesized that in the anaerobic period of exercise (prior to the activation of the aerobic, glycolytic mechanism) the rate of energy release due to oxidation is dependent upon the amount of split phosphagen and can be expressed by the formula:

$$P_t = P_0 e^{-Lt}$$

where P_t is the power at time t (power is the physics term for rate of energy release) available from the alactic mechanism, P_0 is the power at time 0, and L is the time constant.

Students are reminded that Work in physics is the product of Power multiplied by Time:

$$W = P * T$$

Since the instantaneous power p changes during the time of the experiment, mathematicians express this as an integral:

$$W = \int p \, dt$$

Integrating the power equation gives the energy, W_{an} as a function of time:

$$W_{an} = \frac{P_0}{\Lambda} (1 - e^{-Lt})$$

These measurements may be tested in our laboratory. Margaria³ cites values of Λ in the range 0.023 – 0.030 s⁻¹.

We wish to test this hypothesis by setting up an experiment, with a volunteer riding an exercise bicycle, which is instrumented to measure work performed.

Equipment and Equipment Function Formulae

1. Exercise bicycle, Monark Ergomedic, Model 818E
2. Photogate, #6576, Pasco Scientific Co.
3. Digital multimeter with RS232 output, Model M3850, Metex
4. Meter stick or tape
5. Spreadsheet program, Excel
6. Personal computer
7. Printer capable of outputting graphics (any modern inkjet or laser printer)

In this experiment, an exercise bicycle is equipped as follows: A belt on the front wheel provides a friction force retarding the turning of the wheel. A pendulum attached to the belt is calibrated to provide a measurement of the tension of the belt, T , in Newtons. The work performed during one revolution of the wheel is simply the tension times the circumference of the wheel C . It is easier to measure diameter D than circumference.

Question 1: What is the formula for the work W done in one revolution of the wheel, expressed in terms of the tension T and the diameter D ?

The volunteer's pedals drive the bicycle chain, whose holes interrupt the infrared beam of a photogate. The resultant signal is sent to the frequency input of a multimeter, which reads out the frequency f in kilohertz (KHz). Count the number of chain links N , which make the wheel turn one revolution. Because energy is lost between the pedals and the wheel, we have determined that we have to multiply the wheel's power by 1.09 to calculate the power expended by the volunteer.

Question 2: What is the formula for the power P expended by the volunteer as a function of the frequency of the multimeter signal f :

We must always be careful to measure all variables in the same units of measurement. In science, we normally use the metric MKS system (Meter, Kilogram, Second). In the United States, the English units of measurement FPS (Feet, Pounds, Seconds) are used in everyday life. Catastrophic results happen if they are inadvertently mixed—the \$160 million Mars Lander crashed into Mars partly for this reason.

A very powerful way to check a formula in physics is to insert the units of measurement for each variable and by algebraic manipulation show that the right hand side of the equation is expressed in the same units as the left hand side.

Question 3: Insert the units of measurement into the formula in Question 2 and show that the left side is in the same units as the right side (Power in MKS units is measured in Joules which is equal to Newtons * meters / seconds. Frequency is measured in cycles per second, and cycles have no units, neither does the count of chain links N).

In experiments, we cannot determine the exact value of the instantaneous power at each tiny instant of time, so we make some simplifications and assume that over a short period of time, $\Delta\tau$, the power is a constant Π . We then approximate the integral with a sum Σ over all the periods. Spreadsheets make this calculation easily:

$$\Omega = \Sigma (\Pi * \Delta\tau)$$

The measurements for this bicycle are as follows: D , the wheel diameter = 88 cm,
 T , the tension on the strap = 73.05 Newtons,
 N , the number of chain links for one revolution of the wheel = 15.

Question 4: Insert this data into the equation for power and simplify it as possible. Use 3.14 as the value of pi. Be careful of your units—convert centimeters to meters!

Procedure

A volunteer mounts the exercise bicycle, and pedals at maximum effort for almost a minute. The data recorded from this instrumented bicycle is given in the following table:

Time (sec.)	Freq. (Khz)	Time (sec.)	Freq. (Khz)	Time (sec.)	Freq. (Khz)
1	0.003	20	0.101	39	0.103
2	0.003	21	0.105	40	0.101
3	0.021	22	0.109	41	0.101
4	0.043	23	0.111	42	0.099
5	0.065	24	0.112	43	0.096
6	0.077	25	0.112	44	0.094
7	0.086	26	0.11	45	0.093
8	0.092	27	0.11	46	0.091
9	0.097	28	0.108	47	0.089
10	0.103	29	0.108	48	0.087
11	0.106	30	0.11	49	0.085
12	0.108	31	0.113	50	0.084
13	0.108	32	0.116	51	0.083
14	0.107	33	0.116	52	0.079
15	0.104	34	0.115	53	0.071
16	0.101	35	0.112	54	0.064
17	0.099	36	0.11	55	0.053
18	0.099	37	1.107	56	0.04
19	0.099	38	0.105	57	0.031

Question 5: Enter the data above in your Excel spreadsheet. Be sure that Time is the left A column, since Excel’s graphing software takes the data in the first column as the abscissa (horizontal axis). Format the columns for easy reading by setting the A column, Time, to a whole number, the B column, Freq, to a number with 3 digits right of its decimal point, and all other columns to have 2 digits to the right of the decimal point.

Question 6: Create the C column for Power (Joules/sec), inserting the formula you derived above to convert Freq (Khz) into Power.

Question 7: Create the D column for Work (Joules) by inserting the correct formula for it. Remember that Work is Power times Time. This is where the sum is substituted for the integral, so that to get the total work from the start of the exercise you must add that period's work to the total work calculated before. The first period of time will have a different formula than all the subsequent ones. Why? All of the readings have an elapsed time of 1 second, but that may not always be true, so do not assume in your formula that all readings are 1 second apart.

Question 8: Create the E column for natural logarithm of power, $\ln(\text{Power})$ by inserting its formula in each cell. The function in spreadsheets for natural logarithm is usually named LN.

Now is a good time to set up your spreadsheet so that it will print out on a single page. First select all data and choose a small font, Times New Roman 9 pt. Then select each column one at a time, pull down FORMAT select COLUMN and make WIDTH as narrow as possible. Finally pull down FILE, select PAGE SETUP, and choose PORTRAIT and ADJUST TO 1 Page high by 1 Page wide. Click OK.

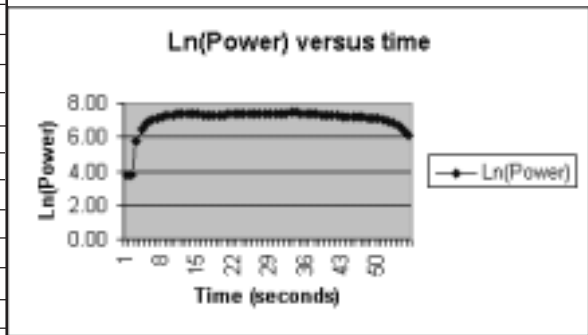
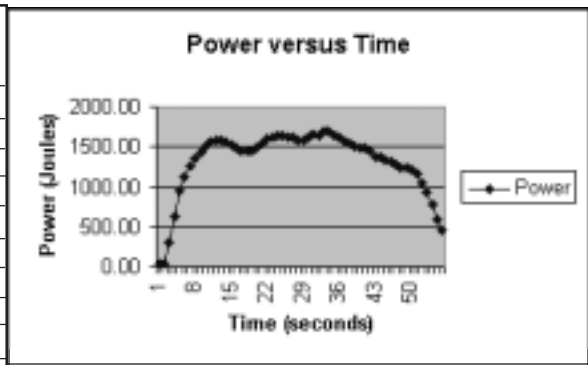
Question 9: Now create a graph of Power vs. Time and place it on your spreadsheet. In Excel, select the entire Power column C (click at the very top of column C). Pull down INSERT, select CHART, choose the LINE Chart option and click NEXT. When the chart appears, click NEXT. Fill in the labels for the title (Power versus Time) and the x and y axes. Include the units in parentheses for each axis. Click FINISH and position the resulting chart at the top, just to the right of the columns.

Question 10: Create the graph of $\ln(\text{Power})$. Place it below the graph of Power.

Question 11: Create the graph of work. Place it below the graph of $\ln(\text{Power})$.

Question 12: Your spreadsheet should now look like the next page. If it does not, review your steps and correct any errors.

Time (sec)	Freq (Khz)	Power (J/sec)	Work (Joules)	Ln (Power)
1	0.003	44.00	44.00	3.78
2	0.003	44.00	88.01	3.78
3	0.021	308.03	396.04	5.73
4	0.043	630.72	1026.76	6.45
5	0.065	953.42	1980.18	6.86
6	0.077	1129.44	3109.62	7.03
7	0.086	1261.45	4371.06	7.14
8	0.092	1349.46	5720.52	7.21
9	0.097	1422.80	7143.32	7.26
10	0.103	1510.80	8654.12	7.32
11	0.106	1554.81	10208.93	7.35
12	0.108	1584.14	11793.07	7.37
13	0.108	1584.14	13377.22	7.37
14	0.107	1569.48	14946.69	7.36
15	0.104	1525.47	16472.16	7.33
16	0.101	1481.47	17953.63	7.30
17	0.099	1452.13	19405.76	7.28
18	0.099	1452.13	20857.90	7.28
19	0.099	1452.13	22310.03	7.28
20	0.101	1481.47	23791.50	7.30
21	0.105	1540.14	25331.64	7.34
22	0.109	1598.81	26930.45	7.38
23	0.111	1628.15	28558.60	7.40
24	0.112	1642.82	30201.41	7.40
25	0.112	1642.82	31844.23	7.40
26	0.110	1613.48	33457.71	7.39
27	0.110	1613.48	35071.19	7.39
28	0.108	1584.14	36655.33	7.37
29	0.108	1584.14	38239.48	7.37
30	0.110	1613.48	39852.96	7.39
31	0.113	1657.48	41510.44	7.41
32	0.112	1636.95	43147.39	7.40
33	0.116	1701.49	44848.88	7.44
34	0.115	1686.82	46535.70	7.43
35	0.112	1642.82	48178.51	7.40
36	0.110	1613.48	49791.99	7.39
37	0.107	1569.48	51361.47	7.36
38	0.105	1540.14	52901.61	7.34
39	0.103	1510.80	54412.41	7.32
40	0.101	1481.47	55893.88	7.30
41	0.101	1481.47	57375.35	7.30
42	0.099	1452.13	58827.48	7.28
43	0.094	1378.79	60206.27	7.23
44	0.093	1364.12	61570.40	7.22
45	0.091	1334.79	62905.18	7.20
46	0.089	1305.45	64210.64	7.17
47	0.087	1276.12	65486.75	7.15
48	0.085	1246.78	66733.53	7.13
49	0.084	1232.11	67965.64	7.12
50	0.083	1217.44	69183.09	7.10
51	0.079	1158.77	70341.86	7.06
52	0.071	1041.43	71383.29	6.95
53	0.064	938.75	72322.04	6.84
54	0.053	777.40	73099.44	6.66
55	0.040	586.72	73686.16	6.37
56	0.031	454.71	74140.87	6.12



Analysis and Conclusion

Question 13: In the first 7 seconds, the cyclist is trying to work as hard as possible but the power measured is not as high as after that time. Why? Where is the energy going? What would we need to know to calculate it?

Question 14: From 8 seconds to about 41 seconds, the power measured is nearly constant. But the theory says that it should be decreasing exponentially. Why do you think the measurement is constant? Does this disprove the theory?

Question 15: Assume that starting at 52 seconds, the subject has used all reserves and that while still trying to exert maximum power, is now into the exponentially decreasing phase predicted by the theory. A convenient characteristic of exponential functions is that any point in time can be selected as the initial point. Let us now see if the data is behaving as predicted. In the formula:

$$W_{an} = \frac{P_0}{L} (1 - e^{-Lt})$$

at 52 seconds the value of P_0 is = 1041.43. Assume a value for L of 0.030. Take the data at the 56th second and show that the calculated work over these four seconds is “in the ballpark” of the measured work.

Class Project

Community fitness related to: Weight? Heart? Sports Condition? Work? Self Image? Depression? Social Acceptance?

Fitness is a great need in most communities in the United States today. Lack of fitness leads to many health problems. Therefore, analyzing the community's fitness, educating and setting up fitness testing centers can be a great aid in overcoming grave health problems.

- Continue to research and use math calculations for determining the fitness of your community and to make a convincing presentation of needs. The students themselves can be used as subjects for determining fitness of different groups. Next, research parents and the community fitness. Compare the fitness of different groups: age, gender, ethnic, socio-economic. Compare different speeds and times. The project can be tied in to physical education to determine if the mathematical models can determine conditioning for sports. Or determine what can be done to increase the work/power output. Use your imagination to pose and answer questions, allowing solid research to determine the health of your community.
- Produce brochures to educate the public about the areas of lack of fitness and the need for a fitness program in the community.
- Set up fitness centers and fitness testing centers. Consider partnering with hospitals and sport clubs/gyms. The school can be a place to administer testing of the progress.
- Use the power of physics theory and mathematical calculations to make a proposal on why research shows there is a need for fitness, for public education, for fitness centers and for tests on attainable goals.

This can be used as a model of what student projects can attain.

Contributors:

Charles Shaw, Cadence Design Systems, San Jose, CA

Tom Hall, Amador High School, Pleasanton CA

Bob Lum, Florin High School, Sacramento CA

Resource: University of San Francisco lesson and workshop

Human Work and Power Lab

Answer Sheet

1. $W = 3.14 * D * T$ or $\pi * D * T$

2. $P = 3.14 * D * T * 1.09 * 1000 * f$

N

Explain why Kilohertz must be multiplied by 1000 to convert to Hertz

3. $P(\text{Newtons} * \text{meters/sec}) = D(\text{meters}) * T(\text{Newtons}) * 1000(\text{cycles/sec}) * f(\text{Kilohertz})$
 $\text{N (no units)} * 1 (\text{Kilohertz})$

Doing cancellations, and noting that cycles has no units:

$$\text{Newtons} * \text{meters} / \text{sec} = \text{meters} * \text{Newtons} / \text{sec}$$

4. $P = (3.14 * 0.88 * 73.05 * 1.09 * 1000 / 15) f = 14668 f$

5. Check that students have set up their Excel spreadsheets correctly. Encourage them to label each column and to set titles for printout.

6. Each cell in column C, for example cell C15, should have the formula: $= 14668 * B15$. If the frequency in that row is 0.101, the calculated value should be 1481.50 if the number of decimal places has been set correctly to 2.

7. Except for the first cell in column D, each cell such as cell D15 should have the formula: $= D14 + (C15 * (A15 - A14))$. If row 3 is the first row of measurements (1 & 2 will probably contain titles), D3 should have the simpler formula: $= C3 * A3$. Explain why it is necessary to subtract the time of two rows.

8. Each cell such as cell E15 should have the formula $= LN(C15)$.

9–12 See individual work.

13. The entire system is being brought up to speed. The subject's energy is going into increasing the kinetic energy stored in the system. We would need to know the mass of the wheel and its radius of rotation, and perhaps similar information on the gears, the chain and the pedals.

14. Although the anaerobic reaction could release energy much faster, exercise bicycle cannot be pedaled safely faster, or the subject has been instructed to maintain a constant speed for as long as possible. The maximum anaerobic reaction rate is not occurring, but it is using up its reserves and that rate cannot be the subject either is not trying to expend the maximum energy every second, the maintained indefinitely. Experiments must be carefully designed, and all assumptions as well as limitations well understood. A single test should never be expected to prove or disprove a theory.

15. Teacher's guide:

$$W = \frac{1041.43 * (1 - e^{-0.030 * 4})}{0.030}$$

$$= 34714.3 * (1 - \frac{1}{e^{0.12}}) = 34714.3 * (1 - .887)$$

$$= 3923 \text{ joules}$$

From the data, work expended between 52 and 56 sec = $74140.87 - 71393.29$
 = 2758 joules

Lead a discussion on "in the ballpark," \ that experience is the only measure of it. Also discuss how many significant figures should be used in calculations, to show that 1041.43 could be set to 1040 since the readings from the frequency meter are at best good only to 3 significant figures.

Assessment

Rubrics for Culminating Project

A. Program Summary

The first component of the prospectus is the program summary. Each group will begin its presentation by handing each panel member a one-page summary of its proposal. This component is worth five points and should be scored as follows:

____Award **4** points if summary:

- Thoroughly narrates and summarizes program;
- Includes focus of program that is clearly identified, defined, and described;
- Accurately describes and details any special features of proposal;
- Has no factual implausibilities or inaccuracies.

____Award only **3** points if summary:

- Partially narrates and summarizes program;
- Includes focus of program that is somewhat identified, defined, and described;
- Describes any special features of proposal;
- Has one minor implausibility or inaccuracy.

____Award only **2** points if summary:

- Partially narrates and summarizes program;
- Includes focus of program that is somewhat identified, defined, and described;
- Describes any special features of proposal;
- Has more than one minor implausibility or inaccuracy.

____Award **1 or 0** points if summary:

- Partially narrates and summarizes program;
- Ignores focus of program;
- Contains no special features;
- Has major implausibility or inaccuracy.

____Award an **additional** point if summary:

- Is typed, double-spaced, uses a 12-point professional font;
- Has one-inch margins;
- Does not exceed one page, no binders or folders;
- Contains no additional information.

____**Total Points Awarded for This Page**

B. Description of Target Group Need

The second component of the prospectus is an oral presentation that describes the target group and its needs. The length of this portion of the presentation should be between three to five (3–5) minutes. This component is worth up to five points and should be scored as follows:

_____Award **4** points if presentation:

- Thoroughly and accurately describes the group or segment of the population that is being targeted by program;
- Shows attention to detail as to what the needs of the group are;
- Shows substantial evidence of organization;
- Is well focused with a well-defined thesis.

_____Award **3** points if presentation:

- Somewhat describes the group or segment of the population that is being targeted by program;
- Has minor mistakes in details as to what the needs of the group are;
- Shows sufficient evidence of organization;
- Demonstrates a focus and thesis with minimal narrative gaps.

_____Award **1 or 0** points if presentation:

- Inadequately describes the group or segment of the population that is being targeted by program;
- Has no details as to what needs of group are;
- Demonstrates little evidence of organization;
- Shows little focus and no thesis.

_____Award an additional point if presentation includes:

- Eye contact;
- Clear enunciation;
- Enthusiasm;
- Appropriate attire.

_____Total Points Awarded for This Page

C. Mathematical Support

The third component of the prospectus is the mathematical support. Each group must demonstrate orally and with the use of a visual component evidence that supports the need for its program. There is no time limit on this portion of the presentation. This component is worth up to fifteen points and should be scored as follows:

_____Award **12 to15** points if presentation:

- Identifies and logically organizes all relevant evidence;
- Uses appropriate and comprehensive critical thinking skills to analyze, evaluate and synthesize evidence;
- Reaches informed conclusions based on evidence;
- Utilizes a clear visual aid that provides outstanding support and is easy to interpret;
- Employs advanced mathematical concepts.

_____Award **8 to11** points if presentation:

- Identifies and organizes some of the relevant evidence;
- Uses partial critical thinking skills to analyze, evaluate and synthesize evidence;
- Reaches informed conclusions based on evidence;
- Utilizes a clear visual aid that provides support and is somewhat easy to interpret;
- Employs advanced mathematical concepts.

_____Award **4 to7** points if presentation:

- Identifies some of the relevant evidence but omits other evidence;
- Uses incomplete critical thinking skills to analyze, evaluate and synthesize evidence;
- Reaches incomplete conclusions or conclusions not linked with evidence;
- Utilizes a visual aid that provides some support;
- Employs mathematical concepts.

_____Award **3 or fewer** points if presentation:

- Does not identify important evidence relevant to the problem;
- Lacks critical thinking skills;
- Does not reach clear or any conclusions that are based on evidence;
- Lacks clear visual aid;
- Employs no mathematical concepts.

_____Total Points Awarded for This Page

D. Evaluation of Expected Outcomes

The final component of the prospectus is the evaluation of the expected outcomes of the program. This oral presentation should be limited to three to five (3–5) minutes. This component is worth up to five points and should be scored as follows:

_____ Award **4** points if presentation:

- Clearly identifies goals of program;
- Describes, utilizing significant facts and evidence, how success of program will be measured;
- Demonstrates with significant longitudinal data benchmarks that determine effectiveness of program.

_____ Award **3** points if presentation:

- Clearly identifies goals of program;
- Describes, utilizing some facts and evidence, how success of program will be measured;
- Demonstrates with some longitudinal data benchmarks that determine effectiveness of program.

_____ Award **2** points if presentation:

- Partially identifies goals of the program;
- Describes, utilizing some facts and evidence, how success of program will be measured
- Demonstrates with some longitudinal data benchmarks that determine effectiveness of program.

_____ Award an **additional** point if presentation includes:

- Eye contact;
- Clear enunciation;
- Enthusiasm;
- Appropriate attire.

_____ **Total Points Awarded for This Page**

Rubric for Scoring Presentations Communication

Demonstrates knowledge and reasoning through oral, written, visual, dramatic, or mixed media presentation:

6

- All ideas in the presentation are expressed in a way that provides evidence of the student's knowledge and reasoning process.
- The presentation is well focused with a well-defined thesis.
- The presentation shows substantial evidence of organization.
- The presentation shows attention to the details of specific performance conventions.

5

- Most ideas in the presentation are expressed in a way that provide evidence of the student's knowledge and reasoning processes.
- The presentation demonstrates a focus and thesis with minimal narrative gaps.
- The presentation shows sufficient evidence of organization.
- The presentation has minor mistakes in attention to the details of specific performance conventions.

4

- Some ideas in the presentation are expressed in a way that provide evidence of the student's knowledge and reasoning processes.
- The presentation demonstrates a focus and thesis with several narrative gaps.
- The presentation demonstrates adequate evidence of organization.
- The presentation lacks attention to the details of specific performance conventions.

3

- Few ideas in the presentation are expressed in a way that provide evidence of the student's knowledge and reasoning processes.
- The presentation demonstrates an adequate focus and thesis.
- The presentation demonstrates inadequate evidence of organization.
- The presentation lacks attention to the details of specific performance conventions.

2

- Most ideas in the presentation are not clearly expressed.
- The presentation demonstrates insufficient focus and a poorly defined thesis.
- The presentation demonstrates insufficient evidence of organization.
- The presentation lacks attention to the details of performance conventions, and includes multiple mistakes.

1

- Expression of Ideas in the presentation is unclear.
- The presentation demonstrates little focus and lacks a thesis.
- The presentation demonstrates little evidence of organization.
- The presentation lacks attention to the details of specific performance conventions.

