Atoms at the Science Fair

EXHIBITING NUCLEAR PROJECTS

U.S. ATOMIC ENERGY COMMISSION / Division of Technical Information

Each year more students undertake science fair projects, many of which involve some aspect of nuclear science or technology.

The United States Atomic Energy Commission has prepared this booklet to help these young exhibitors, their science teachers, project counselors, and parents.

The booklet suggests also some of the numerous nuclear topics on which students can base meaningful science projects. It offers all exhibitors — regardless of age, experience, or project topic — advice on how to plan, design, and construct successful exhibits. It describes some rewards awaiting those who win their way to the National Science Fair-International, including 10 AEC Special Awards offered for the most outstanding nuclear exhibits.

Detailed advice on conducting science projects is omitted, partly because several earlier publications deal with the subject, but also because much of the personal satisfaction gained while doing a science project stems from the student investigator's opportunity to exercise his initiative, imagination, and judgment in solving a problem of his own choice, in his own way.

We trust this booklet will encourage students to enter science fair competition, and hope it will help their advisers guide them toward better projects and more successful exhibits.

Edward J. Brunenkant

Edward J. Brunenkant, Director
Division of Technical Information

Atoms at the Science Fair
Exhibiting Nuclear Projects

by Robert G. LeCompte and Burrell L. Wood

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United States Atomic Energy Commission
Division of Technical Information

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Interviews help AEC Special Awards judges identify the most outstanding nuclear-related exhibits entered in each National Science Fair-International. Here, Elizabeth Winstead of Jacksonville, Florida, explains her irradiated fruit flies to Dr. Paul W. McDaniel, AEC Director of Research and a Special Awards judge at the 1963 national fair, Albuquerque, New Mexico. Selected as one of the 10 winners, Miss Winstead and her science teacher spent a week at the Commission's Argonne National Laboratory near Chicago.

ROBERT G. LeCOMPTE majored in English (A. B., St. Benedict's, 1935) and has worked primarily as a communicator— reporter, house-organ editor and photographer, military-information officer and instructor, public-relations consultant, and information and exhibits specialist. He joined the Atomic Energy Commission's staff at Albuquerque, New Mexico, in 1951, transferring in 1957 to the AEC's Headquarters, where he is Exhibits and Education Officer in the Division of Technical Information. His concern with science stems from aviation writing, World War II service as an Air Force pilot and technical-intelligence officer, science-news reporting, and requirements for presenting AEC scientific–technical developments to the lay public. He has been involved in science fair activities since 1960, when he began the study which led to establishment of AEC Special Awards for outstanding nuclear-related exhibits at the National Science Fair-International.

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Atoms at the Science Fair
Exhibiting Nuclear Projects

by ROBERT G. LeCOMPTE
and BURRELL L. WOOD

SCIENCE PROJECTS, EXHIBITS, AND FAIRS

In almost every area of endeavor, we learn best by *doing*. Books and lectures provide background, but it is by putting theory into practice that we make knowledge truly our own. To learn a language, we read and speak it. Our knowledge of mathematics follows practice at problem solving, and so it is with science.

Science Projects

In conducting a good science project, we work in much the same manner as professional scientists. Like them, we observe, experiment, investigate, speculate, and check the validity of our speculations with more experiments, all in order to learn something. If our work is good, others may learn from it too, but only if we present it adequately.

Better understanding of an area of science is the least that we can gain from doing a science project. At their best, science projects foster habits of effective planning, attention to detail, careful work, and high performance standards that will serve us well throughout our lives. Moreover, there is always the promise that the project will open the door to a satisfying career.

Project Exhibits

More and more, scientists are called upon to share their work not only with other scientists but also with legislators, administrators, sociologists, artists—all kinds of people in all kinds of professions. To follow this lead, student scientists also must tell other people about their science projects.

When executed properly, exhibits are an effective way to do this. Exhibits which combine interesting visual materials with well-written messages can communicate much in very limited time and space. Good exhibits can speak clearly to a great variety of viewers. Those already generally familiar with the subject may absorb the entire message, but even the uninitiated will find something of interest.

Science Fairs

Fairs have been popular throughout history. Generally they have been occasions to display work or feats of which people are proud. Often they have stimulated progress and the exchange of goods and ideas.

Early in this century some teachers encouraged their students to undertake individual science projects, then exhibit them before their classmates and fellow students. Between the two World Wars some individual school systems developed citywide science fairs to show the most outstanding of these exhibits from each school. The science fair movement gained momentum rapidly after World War II, and in 1950 the First National Science Fair was held in Philadelphia, drawing exhibitors from 13 affiliated area fairs.

Today the national event draws exhibitors from more than 200 affiliated state and regional fairs. Recent entry of competitors from several other countries has produced its new title—National Science Fair-International (NSFI). It is the "Olympic Games" for science fair exhibitors, conducted by Science Clubs of America, an activity of Science Service, 1719 N Street N. W., Washington, D. C.

The growing international flavor of the national science fair is exemplified in contestants like Anders S. Brahme, Sweden's entrant at Albuquerque in 1963, and the first non-U. S. student to achieve Atomic Energy Commission Special Awards recognition. He was one of 10 alternates to the 10 winners and is shown receiving a Certificate of Achievement from Harry S. Traynor, AEC Assistant General Manager.

Usually state and regional science fairs are limited, like the national event, to the 10th, 11th, and 12th grades, but occasionally they have a division for junior high school entrants. In school districts where junior high schools hold fairs, the district fair frequently includes both senior high and junior high divisions. Some elementary schools conduct science fairs for their 4th, 5th, and 6th grade students. In both the elementary and junior high school divisions, exhibitors usually compete against entrants of their own grade level, for example, 5th graders against 5th graders, and 9th graders against 9th graders. In the senior division each entrant competes against all others. Although the overall quality of exhibits at local fairs is rarely up to that of regional, state, and national fairs, the local events are possibly the most valuable educational tools because they are viewed by so large a "grass-roots" audience of classmates, parents, teachers, and other local citizens.

In science fairs—as in athletics or music—top prizes are seldom won by first-time competitors. Almost all national fair exhibitors have participated in science fairs at various levels for a year or more before winning their way into the national event. Both experience in science projects and practice in display techniques are required to develop outstanding exhibits. Since this is true, the time to start the science project which will form the basis for your exhibit is now!

YOUR SCIENCE PROJECT

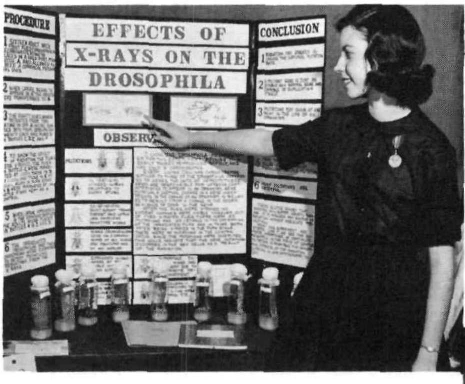
Choosing the Topic

Since you will necessarily spend considerable thought, time, physical effort, and (sometimes) money on your project, pick a topic from which you can expect to learn something. If you can avoid the temptation to pick one with which you are already familiar, you will probably get more out of it. Your project should be an adventure, not merely a drill!

On the other hand your science project need not be in utterly unexplored areas; to be successful you need not come up with data and conclusions which will confound professional scientists who have spent their lives in similar work. You are a student and a hobbyist, not yet a professional research scientist. Primarily your project should advance your personal knowledge, and your abilities to observe, speculate, hypothesize, experiment, deduce, and conclude.

You should choose a project which you can expect to follow to a successful conclusion, but which is enough above your current knowledge to make you "stretch" your abilities.

But it is important not to bite off more than you can chew. The project should not demand so much time that you neglect other responsibilities. However, you need not pass up an interesting topic because covering all of it would consume too much time. Instead, zero in on just those aspects which interest you most.

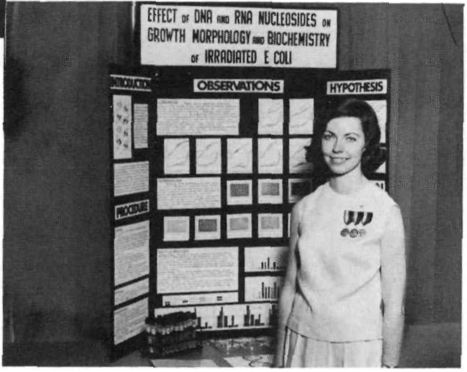


Sophomore Eileen O'Brien of New Dorp High School, Staten Island, New York, displayed this nuclear-related exhibit at the 13th NSFI at Seattle in 1962, but did not win any AEC recognition.

At the 14th NSFI at Albuquerque in 1963, junior Eileen O'Brien returned with a new and better exhibit of a related but more advanced project ...

... and found herself an AEC Special Awards winner invited, with her science teacher, to spend a week at Argonne National Laboratory.

At the 15th NSFI at Baltimore in 1964, senior Eileen O'Brien qualified again as an AEC Special Awards winner by exhibiting a more advanced project, but one still related to her earlier ones. Courtesy Science Service



You may be able to select a project which will be of continuing interest in later years. For example, a 9th-grade general-science student might begin by making an *overall survey* of a topic to discover what is already known about it and what remains to be discovered. As a 10th-grade biology student, he might investigate *biological* aspects of his topic, and then follow with investigations of *chemical* and *physical* aspects of it while studying 11th grade chemistry and 12th grade physics. Some outstanding science fair exhibits have resulted from such progressive development of a single project which the exhibitor undertook first in junior high school.

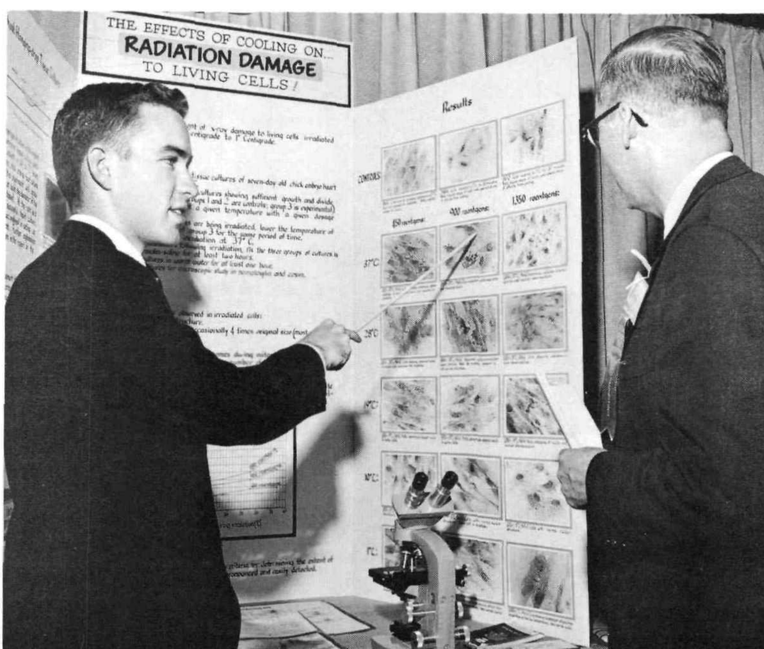
Whenever you ask a question about some aspect of nature you have a possible project topic. "How does a chicken hatch?" "What is the best way to treat a burn?" "How could nuclear energy be used in space travel?" You need only examine the questions that occur to you every day to find dozens of topics on which to base projects.

You might identify promising topics by reviewing the table of contents in your science text, noting chapters or topics of particular interest. Or you may find it helpful to consult the references listed in the appendix to this booklet. If you are interested in a project related to atomic energy, the appendix lists also many nuclear topics and research areas.

It is probably wise to select several potential project topics, do a little reading on each of them, and then pick one. Before reaching a decision, discuss them with your teachers and parents. Your science teacher can help you pick a topic that will relate closely to classroom work, and may be able to suggest interesting approaches you haven't considered. By talking your project topic over with your parents and advisers you can make sure that you will have the time, working space, moral support, and financial resources needed to complete it successfully.

After failing as sophomores to qualify for AEC Special Awards at Seattle, both these Texans came back as juniors to win at Albuquerque with better exhibits of similar, but more refined projects. James L. Ash (right) is from Dallas, and Michael A. Haralson (above) is from Abilene.


HISTORY
PHASE I
RESULTS
F2 MUTANT CONTROL
PHASE III


THE EFFECTS OF COOLING ON...
RADIATION DAMAGE
TO LIVING CELLS!
Results
1350 roentgens
37°C
28°C

At the outset, the exhibit possibilities of your chosen project may not be clearly apparent. You cannot predict exactly what procedures you will follow nor what conclusions you will draw. As you proceed, you will probably uncover many facts which you will want to tell people about. If you choose a good topic, work carefully and accurately, and cover the topic fully, you will produce a successful project which can form the basis for a good exhibit.

Where to Get Help

One mark of a truly educated individual is his willingness to discuss his problems with others and profit by their advice and help. One of the most important things that you can learn while doing a project is how and where to obtain information and assistance.

Your *science teacher* may be an excellent source. If he cannot provide specialized help himself probably he can direct you to those who can.

Your *school librarian* can point out specialized references such as scientific encyclopedias and "reserved" reference books. Scientific magazines and journals have good "survey articles" on recent developments. Don't overlook the public, college, and special technical libraries near you. Also, academies of science, technical societies, and science laboratories may have libraries or publications you can use.

It is to be hoped that your topic is one on which some expert local counseling will be available—from your science teacher or one of your parents, your family physician or the local pharmacist, your agricultural extension agent, or scientific and engineering personnel of a nearby manufacturing plant, defense installation, research laboratory, or college.

Select a *project adviser* and try to enlist his cooperation. Explain your choice of topic to him and how you plan to develop it. (If you have already done background reading you may find him more receptive and more helpful.) You may need to consult him on several different occasions. You will probably want him to check your project plan to make sure that you have not left out an important step, or included some potential pitfall. Also, you may want him to review the final written report in which you summarize your work and findings.

However, your project must rest upon work done by you. It is permissible to obtain assistance from others, but never to the extent that you are standing on the sidelines watching someone else do your work. Keep your interviews brief and approach each conference with a clear idea of what you are seeking and why, and always only after you have already done as much as possible—whether by way of reading or project work—to find the answer on your own. By doing this you will gain valuable habits of self-reliance, and added stature in your adviser's eyes.

Special equipment and materials may be obtained or borrowed through laboratories. College laboratories assist sometimes. Some industrial organizations may have surplus equipment and materials that they are willing to lend or donate.

Documenting Your Work

Project Notebook Every scientist worth his salt keeps detailed notes on each project on which he works. You should do likewise. This notebook, which could as well be a set of file cards, contains a running, day-by-day account of everything that concerns the project—observations, speculations, experiments, materials, expenses, procedures, data and observations, hypotheses, checks for validity, conclusions, and conjectures. From such notebooks comes the information for the scientist's formal report, or "paper", by which he advises his employers and colleagues of the progress of his work.

Since the notebook contains everything pertaining to your project, it may become disarranged, no matter how well you organize it in the beginning. If so, don't worry—just keep it up to date.

Project Report But there should be nothing haphazard about the final report on your project. In some science fairs, this report is displayed in the exhibit and considered in the judging. Even where not required, the project report belongs with your exhibit.

After writing your report you will find that much of your exhibit planning—and even some of the text which will appear in your exhibit—is already accomplished.

If you are doing your project as a classroom assignment, your teacher may specify the manner in which your report is to be organized. Otherwise, you can follow a format such as this:

1 TITLE Keep it short If accuracy requires more than a few words consider using a very brief main title and a more definitive subtitle

2 ABSTRACT This is a very brief condensation of the entire report summarizing the objectives of the project what you did and the conclusions you came to

3 INTRODUCTION Describe your topic and give some background information such as relevant work done by others Summarize your purpose scope and method of investigation State the questions or hypotheses you examined Include the most significant findings of your investigations

4 MATERIALS AND METHODS Describe in detail the materials equipment methods experiments controls unforseen difficulties and remedies

5 OBSERVATIONS AND DATA Describe your observations Include some of your observational data here as an example You may wish to put the bulk of it in an appendix

6 DISCUSSION OF RESULTS Give the main conclusions your observations tend to prove or deny (Disproval of your initial hypothesis may be as important as proof of it!) Include the evidence developed for each main conclusion and any exceptions or for opposing theories Offer possible explanations Compare your results and interpretations with those of other workers in the same field

7 NEW QUESTIONS POSSIBLE APPLICATIONS AND FUTURE PROJECTS IF ANY

8 APPENDIX Give more detailed and supplementary information often including graphs, tables photographs and drawings

9 BIBLIOGRAPHY Keep it brief listing only those books and periodicals which you actually used to provide background information

10 ACKNOWLEDGMENTS Both prudence and the best traditions of science require that you acknowledge all help which you receive Usually student scientists do not produce

laboratory work of professional quality, nor do student exhibitors match the skill of commercial designers and fabricators. Consequently, when judges encounter very exceptional unacknowledged work, they may reasonably wonder if the exhibitor received some professional help. And if on part, they speculate, on how much more? Result: they might be tempted to disqualify the exhibit entirely, whereas if you had acknowledged frankly—"Professor James Smith, Alpha University, for loan of four color transparencies", or "My father, who devised the lighting system"—you might lose a point or two on their scorecards, *but remain in competition.*

Your project notebook and your formal project report are important components of your exhibit to follow. If both are completed first, you will find planning the rest of your exhibit a much simpler task.

EXHIBITING YOUR SCIENCE PROJECT

Planning the Content of Your Exhibit

Try to organize your exhibit content so that it will be meaningful to viewers who know less about it than you do. The following outline may be followed, but is not the only one possible. Don't be afraid to let the unusual aspects of your project influence the organization of its exhibit.

Title The same title you chose for your project report may be an acceptable exhibit title. It should be brief and as nontechnical as possible. A subtitle may explain or amplify the main title.

The Summary Message (or Statement of the Problem) Give the viewer a capsule explanation of the project and its significance. You may use a simplified version of your abstract, eliminating information and language which is not meaningful to the average viewer. Keep it simple.

Hypotheses and Conclusions List these briefly in a manner understandable to the average viewer. (Those interested in details can find them in your notebook and project report.)

Method and Scope of Investigation Hit only the high points, but emphasize instances where you feel you displayed unusual imagination, ingenuity, or resourcefulness.

Observations and Data Both are important, but in an exhibit too many data can be dull. Select only those which are essential to the capsule story of your project.

Photographs and Illustrations Review the foregoing elements to see where pictures will tell your story as well as (or better than) words. List all photographs you have already taken of your project, ones you can still obtain, and drawings which will illustrate or help narrate your story. Don't be selective yet. Later, when you are designing your exhibit layout, space limitations will force you to choose.

Equipment and Specimens These also help narrate your story. Select objects and apparatus which will provide viewers a good grasp of your project work. Have you hit upon a low-cost substitute for expensive laboratory equipment? Do some of your specimens present clearly visible evidence of points you want to make? Are any of the experimental results or specimens particularly unusual, spectacular, or beautiful? List them for possible use.

Handout Brochure An important but frequently overlooked exhibit component is the "handout brochure" to be distributed to interested viewers. Even a single mimeographed page can supply more written information than should be displayed in the limited space of the exhibit. It can provide serious viewers a condensed version of the project report. The brochure provides all viewers a reference when they discuss the science fair and your exhibit with others. Consider the handout brochure while planning your exhibit's contents because it can contain data and graphs which might otherwise clutter and confuse your exhibit proper.

How Exhibits Are Judged

Rules for the judging of exhibits vary, but most science fairs stick fairly closely to the criteria and point values used by the National Science Fair-International, which are:

I. Creative Ability — Total 30 points

How much of the work appears to show originality of approach or handling? Judge that which appears to you to be original regardless of the expense of purchased or borrowed equipment. Give weight to ingenious uses of materials, if present. Consider collections creative if they seem to serve a purpose.

II. Scientific Thought — Total 30 points

Does the exhibit disclose organized procedures? Is there a planned system, classification, accurate observation, or controlled experiment? Does exhibit show a verification of laws, or a cause and effect, or present by models or other methods a better understanding of scientific facts or theories? Give weight to probable amount of real study and effort which is represented in the exhibit. Guard against discounting for what might have been added, included, or improved.

III. Thoroughness — Total 10 points

Score here for how completely the story is told. It is not essential that step-by-step elucidation of construction details be given in working models.

IV. Skill — Total 10 points

Is the workmanship good? Under normal working conditions, is the exhibit likely to demand frequent repairs? In collections, how skilled is the handling, preparation, mounting or other treatment?

V. Clarity — Total 10 points

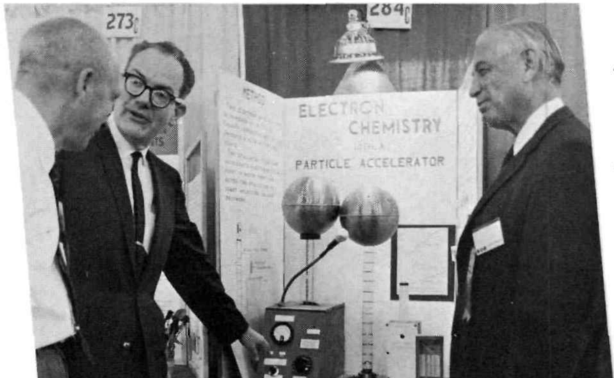
In your opinion, will the average person understand what is being displayed? Are guide marks, labels, and descriptions spelled correctly, and neatly yet briefly presented? Is there sensible progression of the attention of the spectator across or through the exhibit?

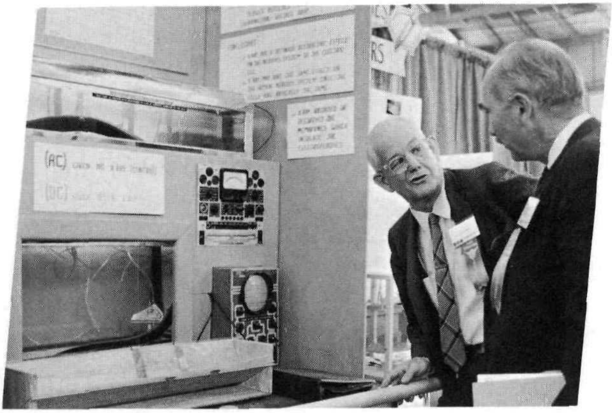
VI. Dramatic Value — Total 10 points

Is this exhibit more attractive than others in the same field? Do not be influenced by "cute" things, lights, buttons, switches, cranks, or other gadgets which contribute nothing to the exhibit.

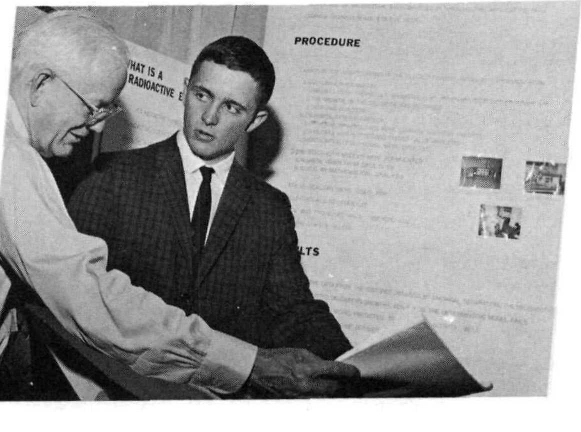
Such rules leave much to the individual discretion of the judges, particularly regarding the distinction between the science project itself and the exhibit. Be sure to study your local rules and judging criteria carefully. Since usually 60 points pertain to creativity and sound scientific thought, a

AEC Special Award competition is judged by a "blue-ribbon" panel composed of people who head research and development programs at AEC offices and laboratories throughout the United States. At the 14th NSFI at Albuquerque, these





judges spent the morning identifying eligible exhibits, "huddled" late in the afternoon to select semifinal choices, and then in the evening talked with each semifinalist before making the final choice of winners and alternates.



large part of your score depends on the original excellence of your science project. The remaining 40 points apply to the manner in which you develop your exhibit of that project.

Judges study criteria and point values before evaluating exhibits. Although your exhibit should speak for itself, at many fairs the judges chat with each exhibitor to determine how well he understands his project area. Be prepared to present details concisely and clearly, but avoid lengthy explanations unless asked.

Designing Your Exhibit

After you have finished your project, documented your work in a project report, planned and listed what must go into the exhibit, and familiarized yourself with the ground rules under which you will compete, you are ready to design your exhibit. The sections which follow suggest guidelines and construction hints on exhibit structure; ways of presenting information (text, photographs, transparencies, line drawings, captions, models, specimens, laboratory equipment, etc.); layout and location of exhibit items, exhibit materials, color, and lighting.

STRUCTURE

Size. National Science Fair-International rules limit exhibit size to 48 inches wide and 30 inches deep. The structure may rest on the floor, on its own supports, or on a table (normally about 30 inches high) supplied by the fair. Even if local rules permit more space, you may find it desirable to build to NSFI rules so your structure will be eligible at all fairs.

The overall height of your exhibit is limited by practical considerations to about 7 feet, since the passing viewer's eye encompasses most easily the area between 30 and 90 inches above the floor and the view of someone standing near is even more limited. Tabletop structures 48 inches or less in height work out nicely, and can conserve materials.

Shape. With few exceptions, science fair exhibitors can explain their projects adequately within structures similar to those shown in Figures 1 and 2. Such tabletop "booth" exhibits have these common features: (a) a large back wall which can be used for the introductory message, for featured illustrations or specimens, or for important conclusions; (b) two smaller side walls, angled outward for easier viewing, which can contain supplementary text and illustrations; and (c) horizontal display space at table height to hold specimens, apparatus, project notebook and project report, handout brochures, etc. Some exhibitors fit this space with a slanted- or stepped-shelf unit. If the back and side walls are fastened to such a base the structure is stronger.

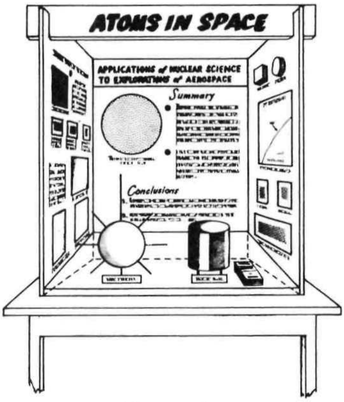


Figure 1

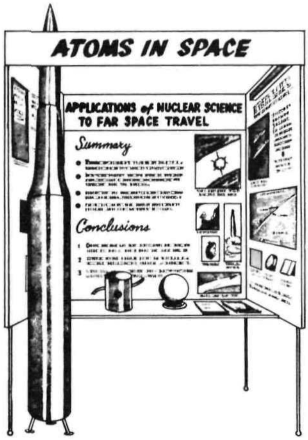


Figure 2

These two basic structures are designed for simplicity, flexibility, economy of materials, and repeated use in successive years of science fair competition. Both meet NSFI rules on maximum dimensions. The structure shown in Figure 1 is easiest to build. The one in Figure 2 is a modified Figure 1 designed to accommodate an outsize object which must rest on the floor.

Many variations are possible. Very tall objects might be handled by the self-supporting structure shown in Figure 2. Some exhibitors extend back and side walls to the floor, but this requires more panel material and tempts the exhibitor to mount text and illustrations below the level of easy viewing.

The title board can be functional as well as attractive, as in Figure 1. It puts your main title where it can be seen easily and it conserves wall space. It can brace the side walls and serve to shield lights.

Materials. Attractive exhibit structures can be built from artboard and similar paper products, so for one-time-only elementary school exhibits you may not wish to invest in more permanent materials. But if you look forward to other projects, exhibits, and fairs, you will be wise to consider materials which will hold up in repeated use. Even though most fairs do not permit you to compete in successive years with the same exhibit material, seldom do they require you to build a new structure each year to hold your changing displays.

"Masonite" and similar wood-fiber particle boards are relatively inexpensive, take paint and adhesives well, are fairly light, and in thicknesses of more than $1/8$ inch and lengths of less than 48 inches are sufficiently rigid when supported by adjoining panels. They are available with rows of holes pre-drilled to accommodate a multiplicity of "pegboard" hanger devices. If you hope to use your basic structure for other exhibits, pegboard allows you flexibility in rearranging three-diminsional exhibit items. Also, the holes facilitate wiring down display items that might be dislodged by careless viewers or filched by thoughtless souvenir hunters.

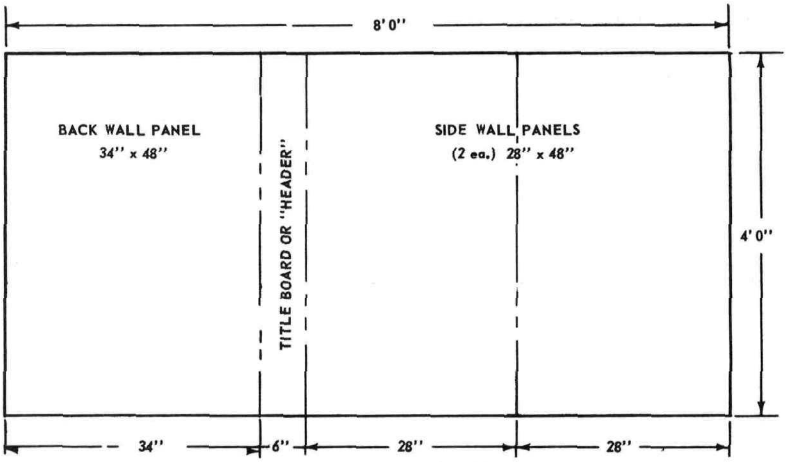
One standard 4-by-8 foot sheet of hardboard or plywood will suffice for the typical tabletop structure if you divide it as shown in Figure 3.

Plywood and untempered hardboard should be sealed with a primer coat before finish painting. If you seal the reverse side of the panels also, they warp less. For finish coats, the enamel now available in aerosol spray cans will save you some brush work. Always apply spray paints in several light coats while the surface is horizontal, to avoid unsightly "runs".

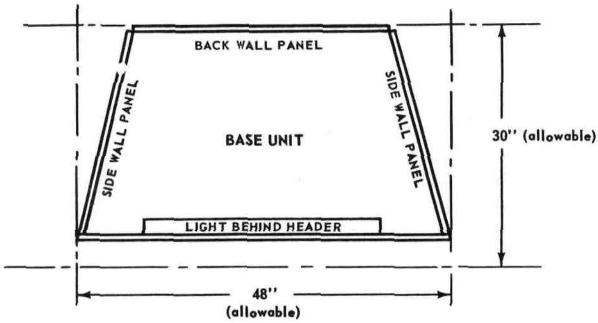
For bracing, framing, and other woodwork, white pine is strong, light, easy to work, and unlikely to warp if seasoned properly.

Hinges, washers, bolts, nails, or screws which will be painted may be of uncoated steel. Otherwise, you may find brass, stainless steel, aluminum, or chrome-plated steel better.

If your exhibit proves to be a winner, you may need to erect and dismantle it at several fairs. A little ingenuity



CUTTING 4' x 8' PLYWOOD OR HARD BOARD FOR MAXIMUM ECONOMY



OVERHEAD PLAN OF TYPICAL SCIENCE FAIR EXHIBIT STRUCTURE

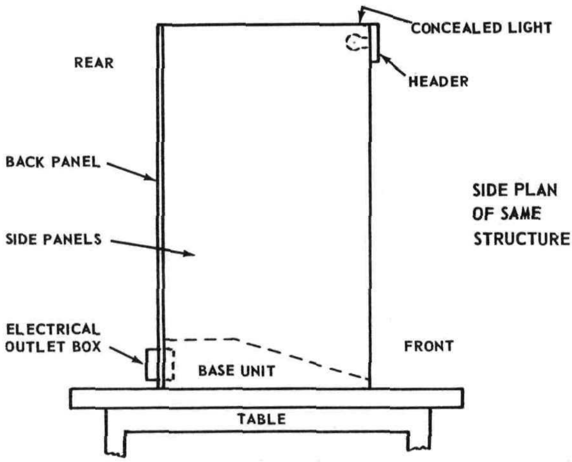


Figure 3

and foresight in the selection of removable-pin hinges, wing-nut bolt assemblies, and the like, may save a lot of time later and help keep your exhibit structure in good condition.

Lighting and Wiring. Fluorescent lighting is bulky and hard to conceal in the average science fair exhibit. Incandescent showcase lamps work well, take up less space, and are less expensive. If you need shielded light, consider inexpensive clip-on bed lamps.

Most fairs have rigid rules on electrical wiring and you should study them and those of the National Science Fair-International. If you will install a fused entry-outlet box on your back wall or base unit, as shown in Figure 3, you can run all fixture cords to that one location. Most fairs provide power cords reaching to the exhibitor's electrical inlet, but don't depend on it. Procure 25 to 50 feet of heavy-duty extension cord and keep it handy, just in case.

PRESENTING INFORMATION

After determining the shape and size of your structure, you can decide how best to present the information needed to explain your project. Some exhibitors prefer to build their structure first, so that they may try out different arrangements of illustrations and three-dimensional items on the finished display space. Or, you can measure off your back wall, side walls, and interior base areas, and then "try out" the size and placement of your display items on matching-size sheets of tracing paper.

There are many good ways to present the same information. Exhibit design is an art with some established principles but with few fixed rules. Here are some guidelines which may help you.

Preliminary Sketches. Make sketches of all possible layout ideas and study each for clarity of content and visual effect.

Text. Keep all text to a minimum number of words. Viewers come to see an exhibit, not to read it! A good illustration, specimen, or a graphic representation (see Figure 4) can save many words. Where text is needed, letter it clearly and large enough for easy reading. But

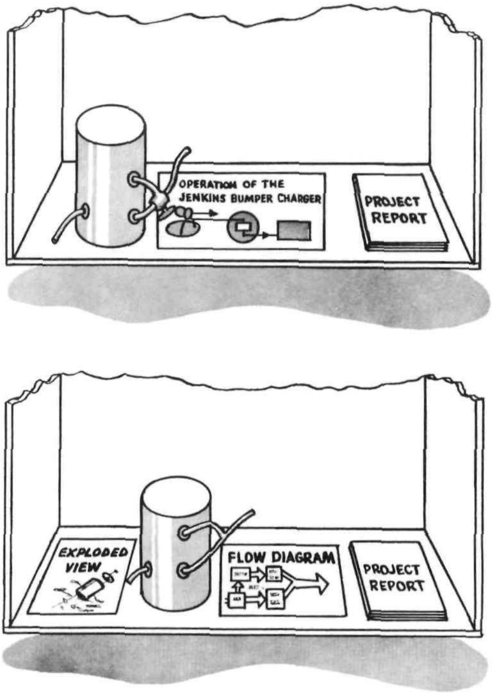


Figure 4

avoid unnecessarily large or garish lettering—titles and text should only explain your exhibit, never dominate it!

Text Placement. Some exhibitors place captions uniformly over or under all illustrations, but text blocks placed at the side may communicate as clearly, and help prevent visual monotony (see Figure 5).

Points of Emphasis. If you use a series of illustrations or specimens to tell a running story, consider enlarging or featuring one of the most significant items so it can serve as the focal point of the series, as in Figure 5.

Large Photos. Unless your photographs can be viewed in detail without stooping and squinting, either have them enlarged or discard them.

Color Photos. Color photos are expensive, but just one or two will add interest to a large group of black-and-white prints.

Charts and Graphs. If your exhibit contains charts and graphs, keep them simple. Avoid line charts if several

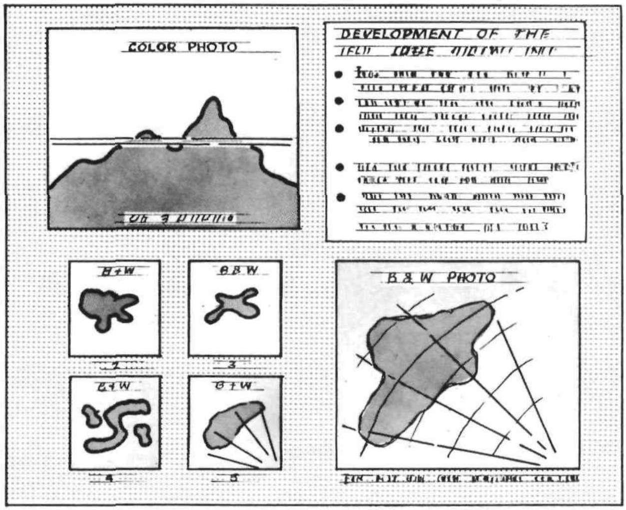


Figure 5

curves must cross and recross. Logarithmic charts, scatter diagrams, and similar ratio charts are confusing to the average viewer. Caption and explain charts and graphs adequately. Simple pie, bar, and representational charts, as shown in Figure 6, can be particularly meaningful. Often the use of colors will make the various factors more discernible.

White Space. Next to content, the exhibitor's most valuable tool is "white space"—those unoccupied areas of his display panels. Crowded, busy panels on which materials and text fill every inch of space are a hallmark of the amateur. Worse, they defeat their purpose, for viewers usually take one hurried glance, decide that understanding so cluttered an exhibit would be a chore, and move on to simpler displays. (As a rule of thumb, approximately 40% of your available display space should be occupied by absolutely nothing!)

Organization. Just as you organize words into sentences and paragraphs, your exhibit elements (textual and visual) should be organized into groups and subgroups. (See Figures 1 and 2.) Here again the "feature" technique may be employed. For example, if you are displaying several similar

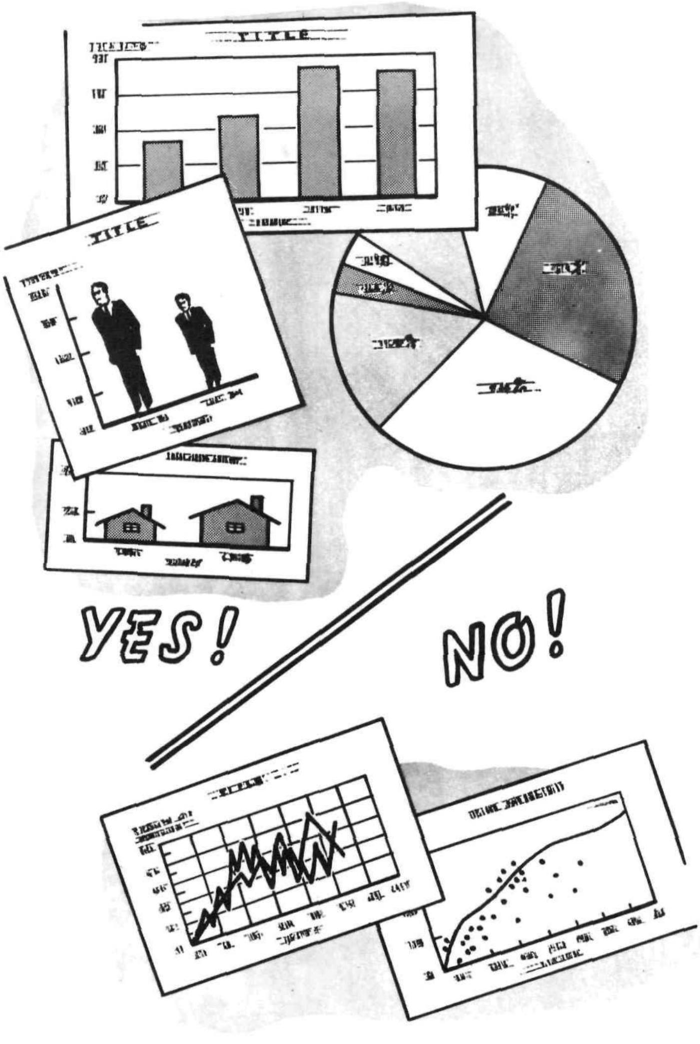


Figure 6

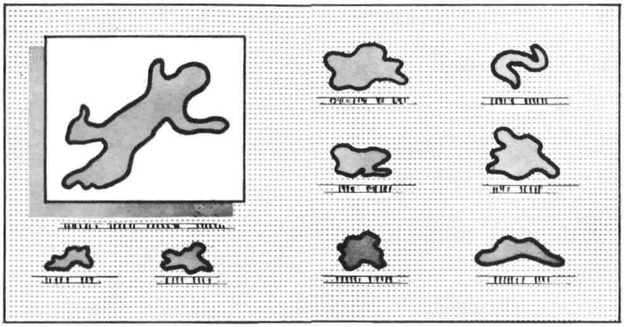


Figure 7

specimens you may emphasize the most unusual one by placing it on a raised or differently-colored background as shown in Figure 7.

Apparatus. Amateur exhibitors sometimes get carried away with enthusiasm for large arrays of mechanical apparatus which are both unnecessary and confusing. If your project involved development of a unique piece of equipment, consider whether you can display it alone, without the entire assembly into which it fits. Sometimes this can be done by displaying the featured part alongside a drawing or photograph of the complete assembly, as in Figure 4. Again, keep details to a minimum; leave them in the project report.

Mechanical Movement. Usually motion in a science fair exhibit is called for only when there is a clear need for it. Thus it is logical to use a turntable to revolve different fluorescing mineral specimens under "black light", or to present successive radioactive ore specimens to a Geiger-counter probe. But to use such a turntable to present a series of photographs would probably be unnecessarily contrived. Usually you may spend your efforts better on sound content, clean design, and clear text than on mechanical gimmicks.

Pushbuttons and Such. Few audience-participation devices in science fair exhibits merit the effort, money, and space expended on them. But if you do display equipment for viewers to operate, make certain it can be operated safely and dependably even when you are absent (as during the judging). Nothing frustrates an exhibit viewer more than a pushbutton that doesn't work!

Demonstrations. These can be informative and interesting, and you may want to include one. But since you cannot be on hand to demonstrate at all times, design your exhibit to "stand alone" without the demonstration. And when you are absent, you may avoid unsatisfied viewer curiosity either by removing the idle demonstration equipment, or by posting a "Next demonstration at ___ o'clock" sign.

Living Things. Plants or animals which have been employed in the science project can often be displayed to lend interest and meaning to the exhibit. But since the science fair follows the project, interim growth and aging may alter living specimens so that at fair time they are considerably less meaningful or attractive than at the peak of your project. Also, if you compete in several fairs, you may find transportation and special care of your living specimens difficult and onerous. If you do plan to exhibit living specimens, familiarize yourself with local and national fair regulations governing their use, make sure that animals can be housed attractively and comfortably, and protect both animals and plants from inquisitive fingers. Then be selective and employ the minimum needed to make your point in the exhibit.

About Color

Properly employed, color is functional as well as aesthetically pleasing. You may find the following suggestions helpful in deciding which colors to employ in your exhibit, and where.

In a space as small as your science fair exhibit, one or two basic colors, plus black and white, should suffice. Use your color in a few large blocks, not in many small patches. Different basic colors can be used to define different main areas of emphasis; then different shades of the basic colors can be used to define subareas.

Life-science project exhibits can rely most safely on pastel shades running heavily to greens and yellows, while physical-science projects are portrayed frequently against

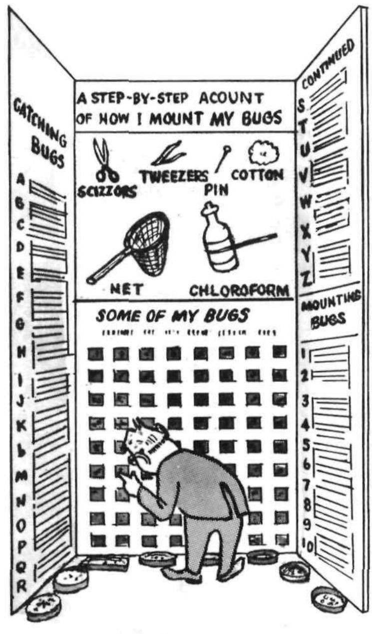


Figure 8

Far too frequently science fair judges are asked to evaluate very poor exhibits of what may have been very worthwhile science projects. Some of the more common mistakes they encounter have been included by our artist in the sketch above. Now that you have read our advice on designing science fair exhibits, how many shortcomings can you identify? (Answers below.)

Answers: Structure extends too high and too low for easy viewing, and width exceeds dimensions usually allowed. The main title is too long. Two words are misspelled. The best display space is wasted on ordinary objects which contribute little new understanding to topic exhibited. There are too many photographs which are too small and poorly positioned for viewing. Specimen boxes positioned on the floor as an afterthought where few viewers will attempt to inspect them. Endless text provides details of little or no interest to the average viewer. More text on introductory topic ("Catching Bugs") than on the exhibit topic. No logical progression from the original problem and hypothesis through experimentation and observation to conclusions. There is no project notebook, report, or handout brochure. No thought has been given to lighting. No points of emphasis in either text or illustrations. White space has not been exploited.

more intense colors. In either case, avoid violent contrasts and "paintpot" variety. Your exhibit should convey an air of handsome restraint, not flippant prettiness or carnival gaudiness. Your colors should attract and enhance, not shock or confuse!

Where desired, visibility and impact of illustrations and specimens can be increased by mounting them against contrasting background colors. Avoid the amateurish impulse to always tape or paint a border around illustrations, specimens, and blocks of type. Placed properly against a contrasting background, these provide their own best border.

The final test of color is how it looks in actual use, so experiment with your color schemes before making a final choice. And if you have any doubts, invite the reactions of your family and friends and also the advice of your art teacher.

Completing Your Exhibit

Before mounting your exhibit elements on the structure permanently, lay them out temporarily. (You will probably want to move them around several times to get the best position.) You can then pencil in your title, text, and caption blocks in actual size. Use separate sheets of paper for each, and try out various locations around the materials they explain.

Use of too many letter styles will detract from the attractiveness of your exhibit. Headings can be all in capital letters, and subheads in smaller "caps", or in initial caps and "lower case" letters. Statements and other text should use caps and lower case. Do not use all caps for a paragraph of descriptive material—a mass of capitals is harder to read.

Before completing the lettering, you should try out your layout and text on classmates, family, and perhaps your English teacher. Science fair exhibits should be understandable to intelligent laymen as well as to trained specialists. Technical jargon, pompous adjectives, and stilted sentence structure are not scientific. In scientific writing, as in any good writing, the simple, direct approach is usually best. Try to use short sentences, familiar words, and a minimum of technical terms and formulae.

Are your present photographs too small? You can experiment with desirable sizes of photos by clipping from old magazines any illustrations that appear about the right size, and trying them on your layout. You can then have your photos enlarged to the ideal sizes that you find most pleasing. Matte-finish photo prints are preferable since glossy prints produce "glare". Before mounting photographs, trim off the white border, which detracts from the impact of your pictures and the simple unity of your exhibit.

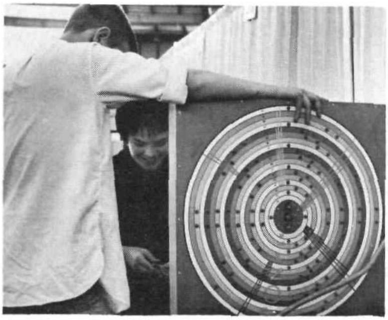
When fully satisfied with your layout, begin the final lettering of your text. For hand-lettering, sketch with a soft pencil first, using a ruler and eraser freely. A lettering guide, borrowed from your school's graphic arts department, will prove very helpful. Unless you are experienced you can save yourself trouble by not lettering directly upon the background. Instead, letter each copy block on a separate piece of art paper which can be glued into position later. Have a friend or teacher double-check your lettering for typographical errors.

With illustrations and copy blocks complete and trimmed to size, you are ready to start mounting. For paper products use "rubber cement", obtainable at stationery stores. Coat both surfaces completely, but do not press them together until each is dry. To avoid air bubbles, first separate the coated surfaces with a "slip sheet" of waxed paper or aluminum foil, which can be slipped out when the materials are positioned exactly. Then press into place with a soft cloth or rubber roller. (Excess cement will rub off when dry, without damage.) Also consider using double-coated adhesive tape for mounting. It is obtainable at art-supply stores.

Assemble your structure, mount your lighting fixtures, and plug them in. Install whatever equipment needs to be displayed. Put your project notebook, project report, and handout brochure in place. Your science fair exhibit is finished and you are ready to compete!

Typical arrival day activities at the 14th National Science Fair-International, Albuquerque, New Mexico, 1963.


National Science Fair




ALBUQUERQUE
MAY 6-12
NATIONAL SCIENCE FAIR
CHEMISTRY AND BIOCHEMISTRY
EARTH AND SPACE SCIENCES

COMPETITION AND ITS REWARDS

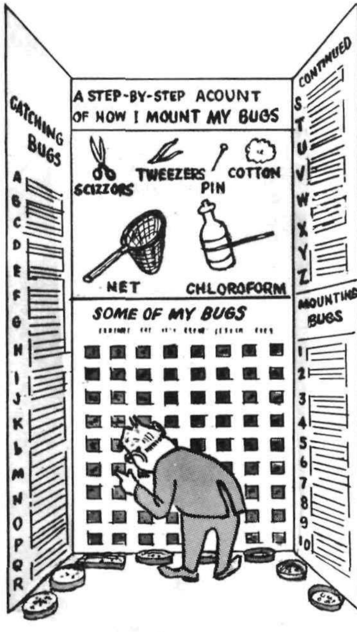
Some of you can look forward to enjoying within the next several years a thrilling experience.

Some morning in May you will bid your parents farewell, walk up the steps of an airliner, and touch down a few hours later in a distant city. For the next five days you will be caught up in the excitement and fascination of the National Science Fair-International!

The full impact of your nation's science fair hits you the morning you set up your exhibit in the auditorium. You knew that you had a good exhibit when you entered the district fair back home in March. (Since this is your second year of serious competition, and you have improved both your science project and your exhibit, you weren't too surprised to win there.) But regional and statewide competition is even tougher, so you were holding your breath until they finally called your name!

Now here you are, and as you appraise the 400 other exhibits going up besides yours, you realize this is the "big league". These guys and gals are really good. But some of your awe evaporates as you talk with your neighbors, and while you help the pretty blonde with the guppies position her heavy aquaria. Win or not, this is going to be fun!

And so it is—during the tension of the judging the next day, when you show your exhibit to the public the day after that, and throughout the tours of research laboratories and industrial processing plants that follow. In conversations with the judges, in the varied social contacts with more than 400 fellow exhibitors from the United States and several foreign countries, you get a fresh look at the rewards of serious scientific endeavor. One evening you listen enthralled by the startling concept being explained by one of the "big men" in science. You've seen his name and picture in newspapers, textbooks, and technical journals, and there he stands, talking seriously to you and your fellow exhibitors. As he explains a problem that has puzzled you, you begin to see science as a community of kindred minds where every serious truth-seeker is welcome, where there



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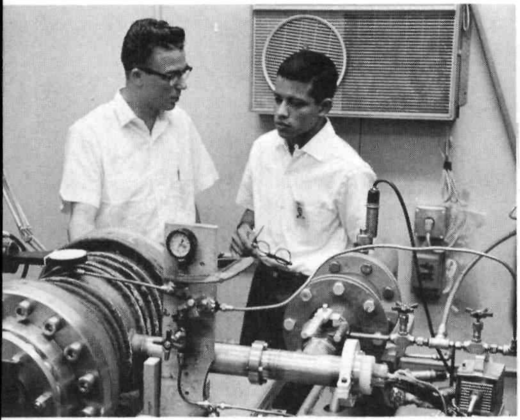
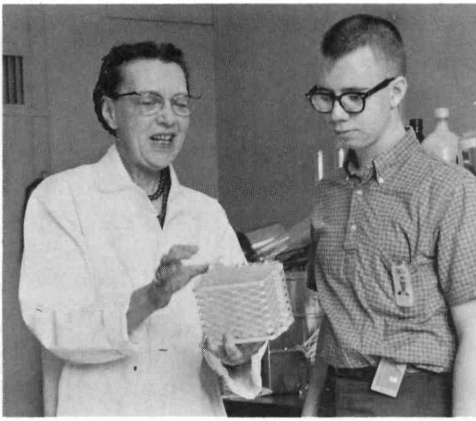
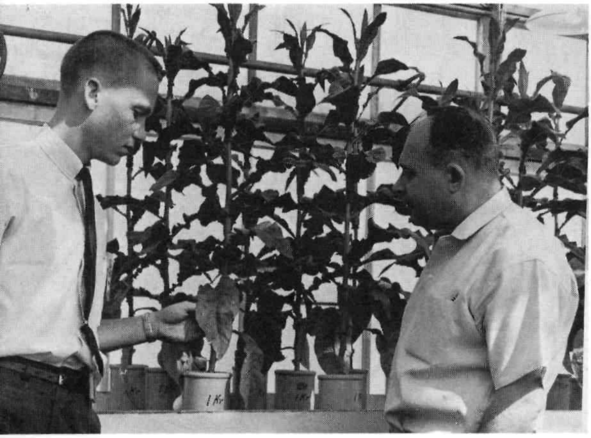
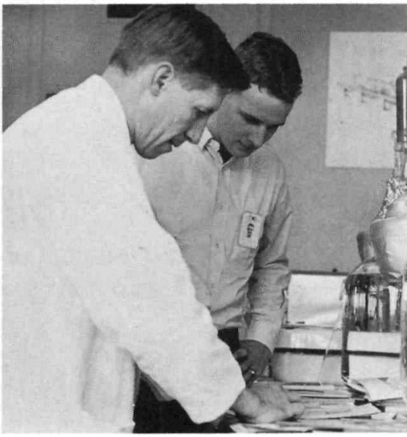
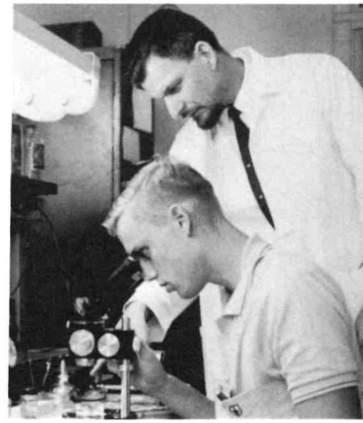




First Atomic Energy Commission Special Awards winners, selected at the 13th NSFI at Seattle, photographed during their Nuclear Research Orientation Week at the AEC's Argonne National Laboratory near Chicago in August 1962.

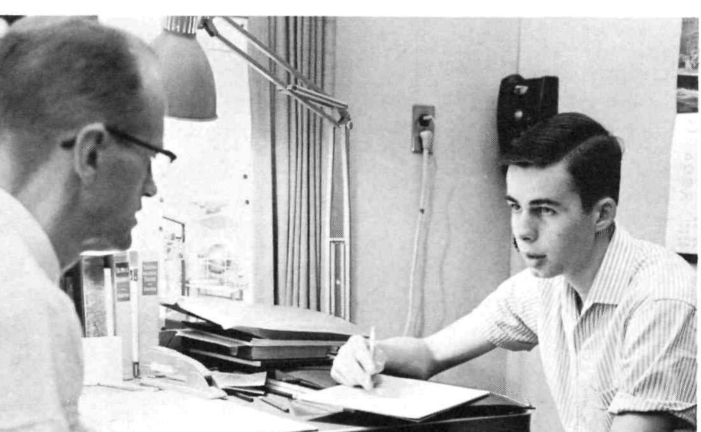


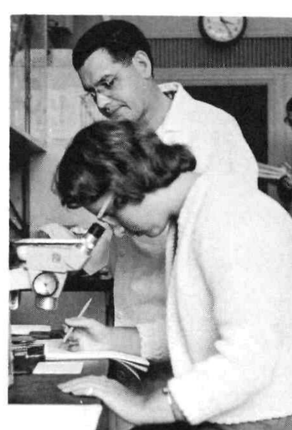


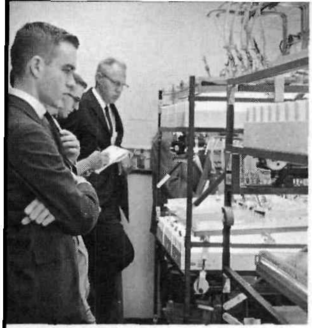
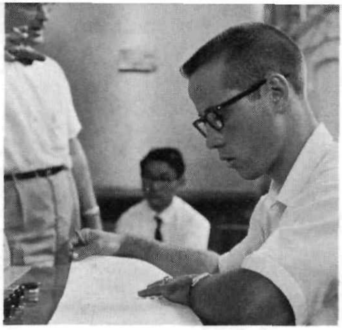
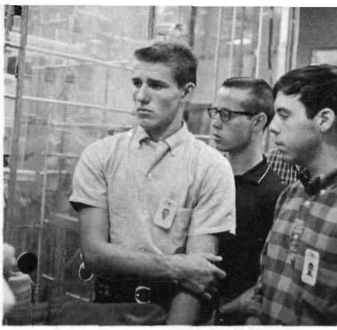


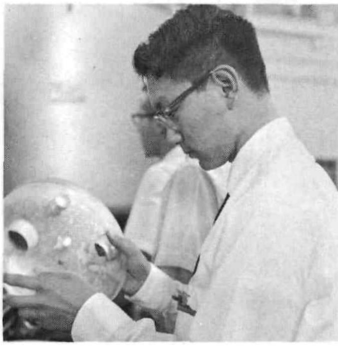
High point of the week, winners report, is the opportunity—pictured here—to talk face-to-face with Argonne scientists who are working in areas of research of particular interest to each student visitor.

Courtesy Argonne National Laboratory





QUO VADIS?

Or "where do you go from here?"

First, resolve now to enter science fair competition this year. You may not win, but at least you will have started, and you will gain some of the experience needed for victory in later years.

Next, choose a science project topic, and discuss your choice with your science teacher, science club adviser, or hobby counselor. Especially if this is your first attempt, choose a topic which can be investigated with materials and equipment available to you at school or at home, and which can be finished by mid-February. Also, allocate definite times—particularly on weekends and holidays—when you will work on your project. (Remember that exams and term papers will probably keep you very busy in late January and early February.)

Third, execute your project, keeping careful notes and consulting your project counselor from time to time. Then draft your Project Report, discuss it with your counselor,

1963 AEC Special Awards winners and their science teachers spent their Nuclear Research Orientation Week at Argonne National Laboratory. Top photograph is of Elizabeth Winstead of Jacksonville, Florida, whose prize-winning exhibit at Albuquerque is pictured on the cover. The photograph below hers is of William E. Murray, Jr., of Bethesda, Maryland, who was also an AEC Special Awards winner at Seattle in 1962.

Courtesy Argonne National Laboratory

revise and edit it as necessary, and get it typed in final form. Also verify the date your local science fair opens.

Fourth, plan your exhibit content, design and build your exhibit structure, select your exhibit components and draft your text, and make trial layouts until you arrive at the best possible design, including color. Prepare your color backgrounds, letter your text, and install text, components, and lighting. Get your handout brochure mimeographed.

Fifth, enter local science fair competition. If you don't win, find out why by comparing your project and your exhibit with the winners', and by discussing it with your parents, classmates, teachers, judges, and viewers. If you do win, attempt to understand what made your exhibit better than the others.

Finally, continue reading and thinking about your basic project topic, so that next year you will know whether you want to continue to work on the same topic or to shift your interest to another field.

Above all, have fun, and

GOOD LUCK!

APPENDIX I

NUCLEAR SCIENCE PROJECT IDEAS

The following projects related to nuclear science were exhibited at the National Science Fair-International from 1950 through 1963.

General and Theoretical Topics

The Review and Future of the Atom
Simplified Nuclear Physics
Approach to the Study of Nuclear Physics
Elementary Particles—an Investigation of the Fundamental Components of Matter and Energy
Odd Nucleon Effect
A Study of Binding Energies and Nuclear Reactions
The Integrated Theory of Atomic Structure Through Inductive and Deductive Reasoning
Tools of Nuclear Physics
$E = MC^2$—Energy Equals Mass Multiplied by the Speed of Light Squared
Downfall of Parity
How to Measure the Charge of the Electron
How Atoms Are Constructed
Formation of Heavy Nuclear Particles
Millikan Oil-Drop Experiment
Nuclear Magnetic Resonance
Third Electrons in Transition-Metal Complexes
Probability in Electron Position
Stability of Radioactive Equilibria
The Electron: Measurement of Its Charge and Mass
Experimental Study of Nuclear Structure
Fourth State of Matter
Project-Observation Satellite
Creation of Antimatter
Energy Loss of Beta Particles in Lead and Aluminum
Stochastic-Radioactive-Equilibria Models
Cosmology
Controlled Thermonuclear Reaction
Electron Chemistry
Plasma-Ion Engine

Plasma Production by Gaseous Ionization
Finite Calculus and Particle Physics
Two Applications of the Plasma Discharge
Increasing the Efficiency of a Plasma Jet Suitable for Space Propulsion
Prediction of Elements 99-118
Exact Evaluation of the Charge of the Electron
Three-Dimensional Periodic Chart of Atoms
Atom Mobiles
Weight of an Atom
Determination of the Charge of an Electron Using the Millikan-Stokes Effects
Atomic-Particles Detection and Analysis
Electron-Charge Determination by Oil-Drop Method
The Mineral That May Shape Our Destiny: Uranium
A Machine to Show Radioactive Materials
The Making of Active Metals
The Extraction of Uranium from Carnotite
The Chemistry of Thorium

Special Apparatus Topics

Construction and Operations of Wilson Cloud Chamber
Geiger-Müller Counter: Theory and Construction
Experiments with a Homemade Geiger Counter
An Experimental High-Voltage Geiger Counter
Design and Construction of a Scintillation Counter
The Construction and Theory of Radiation Detectors for Radioactive Experiments
The Underlying Principles of Accelerators for Positively Charged Particles
Electronic-Equipment Construction and Applications to Nuclear Theory and Techniques
A Germanium Linear Accelerator
Proton Accelerator
Construction of a One-Half Million Electron-Volt Proton Cyclotron
Construction of Apparatus for Accelerating and Detecting High-Energy Beta Radiation
Betatron
A Continuous Cloud Chamber
Van de Graaff Generator

The Mass-Energy Problem of Particle Accelerators
Mass Spectrograph for Determining the Mass of Atoms
A Liquid-Scintillation Spectrometer for Counting Natural Carbon-14 Samples
Proton Linear Accelerator
Magnetic Thermonuclear Chamber
Atom Smasher and Ionic-Drive Reaction Motor
Expansion Cloud Chamber for Observation of Tracks of Alpha Particles
Nuclear-Magnetic Resonance Spectrometer
High-Voltage Particle Acceleration
Linear Accelerator
Van de Graaff Generator Designed for an Accelerating Tube
Wilson Cloud Chamber
Low Energy Linear Accelerator
Nuclear-Magnetic Resonance and Spectrometry
Millikan's Oil-Drop Experiment
Theory, Design, and Construction of a $10\frac{1}{2}$-inch Cyclotron
Carbon-14 Counter
Proton-Free Precession Magnetometry
The Bubble Chamber
Electron Accelerator
Nuclear-Magnetic Resonance
Beta Synchrotron
Electrostatic Particle Accelerator with Van de Graaff Generator Power Supply
The Cyclotron
Linear Alpha-Particle Accelerator
The Plasma Jet
Beta-Ray Spectrometer
Freon-13 B1 Bubble Chamber
Wilson Liquid-Piston Cloud Chamber
Expansion-Type Cloud Chamber
Nuclear-Magnetic Resonance Spectrometer
Linear-Subatomic-Particle Accelerator
Experimental Linear Accelerator
New Design in Microwave Techniques Used in Electron Acceleration
Application of Relativity to the Phenomena of a Diffusion Cloud Chamber

0.5-Mev Electron Accelerator

Radio-Frequency Plasma Torch

Design, Construction, and Operation of a 3-inch Freon Bubble Chamber

Experiments in Plasma Physics

Studies with a 500,000-volt Electron Accelerator

An Experimental Plasma Generator

The Plasma Torch

Using Nuclear Emulsions to Track Ionizing Particles

Experimental Study of Nuclear Structure

Emission Studies of a Nitrogen Plasma

A Combination 3-Mev Neutron Source and Medium-energy X-ray Source

Van de Graaff Electron Accelerator

Cosmic Rays Studied with a Counter-controlled Cloud Chamber

Radio-Frequency Plasma Generator

Plasma Acceleration

Investigation of High-Temperature Plasma Techniques Necessary for a Controlled Thermonuclear Reaction

Atom Smasher—An Electrostatic Particle Accelerator

Design, Construction, and Use of a 0.5-Mev Linear Particle Accelerator in Study of Short DeBroglie Wavelengths by Crystal-Diffraction Method

Production of Plasma by a High-Frequency Magnetic Field

Radiation Topics

A Cosmic Ray

Beta- and Gamma-Ray Analysis

Calculating the Angle of Deflection for Beta-Ray Under Normal Atmospheric Conditions in Magnetic Fields of Differing Intensities

Effects of Absorption and Geometry on Beta Count Rate

Detection and Recording of Cosmic Radiation

A Study of Alpha Particles by Means of the Continuous Cloud Chamber

Visual Detection of Alpha Particles

Detection of Subatomic Particles

A Survey of Background Radiation Made with a Geiger Counter

^{51}Ne as a Radiation Detector
Detection of Atomic Radiation
Methods of Measuring Radioactivity
Preliminary Study of the Effect of Radiation from some Common Radioactive Materials on Photographic Film
Carnotite and Radioactivity
Study and Analysis of a Sample of Radioactive Sand from the Atomic Explosion at Alamogordo
The Use of Ion Exchangers in the Disposal of Radioactive Wastes
Radiation Effects on Fruit Flies
Effects of Radiation on *Drosophila melanogaster*
Investigating Radioactive Minerals with Thick-Emulsion Photography
Actions of Gamma Radiation on the Offspring of Irradiated Female Guppies
Influence of Beta-Particle Bombardment upon the Embryonic Development of the Chick
Autoradiographs of Brain Tumors
A Radiation Detector
A Study of Cosmic Rays
Effects of Atomic Radiation on Rats
Atomic Radiation and the Geiger Counter
Atomic Radishes
Effects of X-Ray Radiation on Plants and Animals
Radiation Demonstration
Nuclear Radiations
Radiation Sterilization
X Ray, Light's Cousin
Effects of Ionizing Radiations on Plants and Animals
Roentgen Rays and the Construction of an X-Ray Machine
Visual and Aural Detection of Cosmic and Atomic Radiation
Radioautography
Experimentation with Ionizing Radiation
Radiation Hazard?
Phosphorus Uptake by Autoradiography
Demonstration of Rutherford's Method of Separating Alpha, Beta, and Gamma Radiation
Radiation—Effects and Possible Protection
Tired Blood—Production of Anemia by Radioactivity

Techniques of Autoradiography
Cosmic Radiation and Life
Radiation in Plant Breeding
Experiments with Induced-Radioactivity Apparatus
Effects of Radiation on the Blood in White Rats
Radioautographic Study of Tryptophan Metabolism in the Rat
The Effects of Beta Rays from ^{32}P on the Tissues on White Rabbits
Radioactivity Around Us
Effects of Radiation on Mice
Experiment, Design, and Application of Solid Propellant Rockets to Radiation Studies of the Upper Atmosphere
Comparative Study of Radiation
Alpha and Beta Rays (Photographs)
A Laboratory-Scale Neutron Irradiator
Colchicine vs. Radiation
Mutations in German Millet Induced by Gamma Radiation
Cosmic Radiation
Cloud Chamber Study of Alpha and Beta Radiation
Effects of Radiation on Chick Embryos
The Protection of Cystamine and AET on X-Irradiated Mice
The Effects of X Ray on the Blood of Guinea Pigs
Measurement of Radioactivity in Milk
Chemical Modification of Radiation Effects
The Absorption of Alpha Particles in Air and Other Cases
Mass Absorption of Beta Radiation
The Danger of Radioactive Contamination of Kelp
Carnotite Radiation on Reproduction and Mortality Rates of *Daphnia magna*
Mutations Produced by the Irradiation of German Millet Seeds
Spectrometer Analysis of Beta Emitters
The Effects of Total-Body X-ray Radiation on the Hematopoietic System of the Guinea Pig
Energies of Nuclear Radiations
An Analysis of Tracks Formed by Atomic Particles in a Diffusion Cloud Chamber
Effects of X-Ray Radiation on the Bacteria *Serratia marcescens*

Effects of Prenatal Radiation on Postnatal Learning Behavior of Mice
Color Changes in Gemstones by Radiation and Heat Induction
Studies in Effects of the Protection from Ionizing Radiations
Temperature Variation and Effects of Radiation on Reproduction and Mortality
Effects of Irradiated Neoplasmic Extracts on Carcinoma in Cottontail Rabbits
Determining Locus of Irradiated Mutant Drosophila "bl-pt-rd"
Effects of Radiation on Bacteria
Effects of Total-Body Irradiation on Longevity of Tissue Homografts in Rabbits
Radiation—Why Be Concerned?
Radiation Effects on Drosophila
Effect of X rays on Drosophila
Effect of Irradiation on Black Shank Fungus
Comparative Determination of Radioactivity in Rowan County Soils
Lethal and Mutagenic Effects of Radiation on Penicillium
The Teratogenetic Effects of X ray on Hamsters
Protection from Total-Body Irradiation
Effects of Ionizing Radiation from a ^{60}Co Source on Ascorbic-Acid Concentration in *Raphanus sativus*
Drugs vs. Radiation
Radiation Effects on Selected Botanical Specimens
Energy Loss of Beta Particles in Lead and Aluminum
Radioactive Uptake of ^{32}P in Animals and Subsequent-Recovery Period
Effects of X rays on Living Cells
Radiation Effect on Chick Embryos
Dietary Defense Against Radiation
Irradiation Effects on Gene Mutations in Drosophila
A Study in Radioactivity
Bacteria Protection from Radiation
Damaging Effects of Radiation
Effect of X-irradiation on Titration of Influenza Virus
Effect of Vitamin-K1 Analogue on Coagulation Time of Cobalt-60-irradiated Mice

Effect of Gamma Radiation on Regeneration Rate of Planaria

Spirogyra and Cobalt-60

Effects of Blood Serum from Irradiated Guinea Pigs on Tissue Cultures

Chemical Protection from Radiation in Planaria

Induced Mutations in Drosophila

Effects of Gamma Rays on Yeast and Aspergillus

Radiation-Protective Effects of RNA

Radiation, Hematology, and Biochemical Study of Molt-Control Hormones of Crayfish, and Possible Importance to Man

Radiation and Mutations

Aromatics Possibly Help Determine Plant Radiosensitivity

Bone Marrow Transplantation and Recovery

Mutation in Tomato Plants Produced by Gamma-Ray Radiation

Dietary Control of Ionizing Radiation

Effects of Cooling on Radiation Damage to Living Cells

Rate of Regeneration of Eyespots in Planaria

Effects of Radiation on Transmission of Nerve Impulses

Irradiation of Amino Acids

Radioisotopes Topics

Use of Radioactive Salts in Plant and Animal Nutrition Studies

The Radioactive Isotopes: Its Uses in Medical Research and Treatment

Chemical Activity of Deuterium as Compared with Hydrogen

Radioisotopes in Medicine

Pinpointing the Past with Carbon-14

Algae Uptake of ^{32}P

Radioiodine and Construction of a Geiger-Mueller Counter

Radioiodine in Guppies

Uses of Radioisotopes

Radioisotopes

Chelation of a Radioactive Isotope in Rats

The Role for Radioactive Testosterone on Hematopoieses

Phosphorus-32 Tracer Studies Conducted with the Coleus Plant

Tracing the Organ Uptake of Radioisotopes in Animal Tissue

Carbon-14 in Photosynthesis

Transfer of Radioactive Elements on Succeeding Generations

Corrosion and Adsorption Studies Using Radiochemical Techniques

The Radioactive Elements—Separation, Detection, and Properties

Experiments with Radioisotopes

Translocation of Radioactive Phosphorus

Assimilation of Radioactive Isotopes in Fish

Use of ^{32}P by Plants

Comparative Studies of Isotope Utilization in Tomato Plants

Detection of Strontium-90 in Backbones of Fish from Areas of the United States

The Circulation of Iodine (^{131}I) in the Parabiotic Rat

Radioactive Zinc and Zinc-Chelates in the Hormone Metabolism of Plant-Tissue Culture

Effect of Dietary Calcium on Deposition of Calcium-45 and Strontium-90

Autoradiographical Evidences of Cytological-Radioisotope Deposition

Tracing the Development of a Chick Embryo with ^{32}P

Radioactive Isotopes as Tracers

Beware! Strontium-90 Everywhere

Plant Research with Radioactive Phosphorus

The Kettleman Hills Formation (Carbon-14 Dating)

Radiobiologic Investigations of Contractile Activity and ATP-induced Pinocytosis *in vitro*

Determination of the Half-life of ^{65}Zn

Atomic Farming

Nutrient Passage Through Plant Grafts as Tested with Radioisotopes

Study of the Period of DNS Synthesis Using Tritiated Thymidine

Absorption of Radioactive Iodine by Molds and Bacteria

Radioisotopes as Tracers

Translocation of ^{32}P in Plants

Nuclear-Change Topics

Demonstration of Chain Reaction
A Study of Chain Reactions
The Theory and Construction of an Inexpensive Neutron Source of Moderate Strength
A Study of the Reaction $_5B^{10}(n,a)_3Li^7$ with the Aid of Nuclear Research Plates
How Fission and Fusion Take Place
Uranium Fission and Isotope Production
From Uranium to Energy
Atomic Transmutation
Atomic Disintegration
Conversion of Atomic Power to Electric Power
Interactions Between Subatomic Particles
A General Study of Atomic Energy: Its Fundamentals and Its Uses
Atomic Power Plant
Construction of an Atomic Reactor
Atomic Power for Space Travel
Atomic Weapons
Model of Atomic Power Plant
Bikini Bomb-Explosion Model
Destruction by the Atom Bomb
Demonstrated Principles of Nuclear Physics
The Sun—Our Chief Source of Energy
Uranium—Radioactivity and Fission
Atomic Power—The Servant of Man
Power from the Sun
The Process of Nuclear Fission
Fusion—Source of Solar Energy
Electricity from Atomic Power
Effects of Thermal Neutrons on Mammalian Systems
Fusion
Nuclear-Powered Electric Generator
Particle Characteristics and Reactions
Fusion Theory of the Universe
Project Fusion
The Magnetic-Mirror Machine
Plasmatron
The Heating and Confinement of a Thermodynamically Stable Plasma

Controlled Thermonuclear Reaction
The Stability of Radioactive Equilibria
Determination of the Half-life of ^{60}Zn
Subatomic Particle Research
Nuclear Disintegration and Density
The Theory of the Plasma Torch

APPENDIX II

NUCLEAR ENERGY-RELATED INVESTIGATIONS AND APPLICATIONS

Listed below are a number of areas in which nuclear knowledge or atomic energy products may be used to achieve investigative, developmental, or engineering data and results which would have been unattainable a few years ago. Science fair exhibits may be based on projects in which these nuclear "tools" are employed to help solve problems of a non-nuclear nature. Such exhibits receive consideration for AEC Special Awards at the National Science Fair-International.

Biology

Biosynthesis of Compounds; Plant Genetics; Plant Metabolism; Plant Nutrition; Effects of Soil Density and Water Content; Disease Control; Pollination Agents; Crop Improvement; Photosynthesis; Ecological Cycles; Pest Control; Action of Pesticides; Ecology of Wildlife; Dispersion of Pesticides; Nutrition of Domestic Animals; Milk Production; Mammalian Aging; Animal Physiology; Genetic Chemistry.

Medicine

Blood and Water Volume Studies; Cardiac Output; Blood Flow; Measurement of Physiological Functions; Location of Appetite Control Centers; Formation of Blood Cells; Metabolic Processes; Cancer Study; Leukemia Study; Antibody Therapy; Study of the Central Nervous System; Vitamin Studies; Behavior of Viruses.

Chemistry

Reaction Mechanisms; Catalysis; Exchange; Kinetics; Corrosion; Dilution; Diffusion; Mineral Flotation; Detergent Action; Mirror Formation; Metal Plating; Analysis.

Physics

Standard Length Measurements; Film Thickness; Nuclear Structure; Vapor Pressures; Elementary Particles.

Geology

Sedimentation; Ocean Currents; Underground-Water Resources and Movement; Geological Dating.

Industry

Thickness Gauging; Process Control; Inspections for Defects; Volume Gauging; Leak Detection; Sterilization; Electron Printing; Flow-rate Gauging; Tool-wear Gauging; Dye-migration Measurement; Oil-well Acidizing Control; Lubricant Studies; Cleansing Efficiencies; Measurement of Oxygen in Metals; Food Preservation; Power Sources; Self-luminous Light Sources.

APPENDIX III

SUGGESTED REFERENCES

The following is a partial listing of publications on science projects, science fairs, and atomic energy. Many of these publications also contain bibliographies which readers may use to multiply their source of knowledge.

Science and Science Projects

Science Projects Handbook, Shirley Moore (Ed.), Ballantine Books, Inc., New York, 1960, 254 pp., $0.50.

Ideas for Science Projects, V. Showalter and I. Slesnick, National Science Teachers Association, Washington, D. C., 1962, 53 pp., $1.00.

Wonderful World of Science, Shirley Moore and Judy Viorst, Science Service, 1719 N Street N. W., Washington, D. C., 1961, 246 pp., $0.50.

How To Do an Experiment, Philip Goldstein, Harcourt, Brace and World, Inc., New York, 1957, 260 pp., $2.60.

Science News Letter, published every week by Science Service, 1719 N Street N. W., Washington, D. C., single copies, $0.15; $5.50 per year.

Scientific American, published every month by Scientific American, Inc., 415 Madison Avenue, New York, single copies $0.60; $7.00 per year.

Science Projects and Science Fairs

Project Ideas for Young Scientists, John Taylor, Phoebe Knipling, and Falconer Smith, Joint Board on Science Education, Washington, D. C., 1962, 173 pp., $1.25.

Ideas for Science Fair Projects, Ronald Benrey and other winners of the National Science Fair-International, Fawcett Publications, Inc., Greenwich, Connecticut, 1962, 144 pp., $0.75.

Science Fair Projects, Science and Mechanics Publishing Company, Chicago, Illinois, 1962, 162 pp., $0.75.

Your Science Fair, Arden Welte, James Diamond, and Alfred Friedl, Burgess Publishing Company, Minneapolis, Minnesota, 1959, 103 pp., $2.75.

Scientific Exhibits, Thomas Hull and Tom Jones, Charles C. Thomas, Publisher, Springfield, Illinois, 1961, 126 pp., $6.50.

Atomic Energy and Nuclear Science Experiments and Projects

Sourcebook on Atomic Energy, Samuel Glasstone, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1958, 641 pp., $4.40.

Annual Report to Congress of the Atomic Energy Commission, available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. (January 1964), 512 pp., $1.75.

Fundamental Nuclear Energy Research (annual report), available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. (December 1963), 412 pp., $2.50.

Atomic Energy (including experiments), Irene Jaworski and Alexander Joseph, Harcourt, Brace and World, Inc., New York, 1961, 218 pp., $4.95.

Laboratory Experiments with Radioisotopes for High School Science Demonstrations, Samuel Schenberg, available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 1958, 59 pp., $0.35.

Teaching with Radioisotopes, U. S. Government Printing Office, out of print but possibly available in school libraries or science departments.

Experiments with Radioactivity, National Science Teachers Association, Washington, D. C., 1957, 20 pp., $0.50.

Atomic Energy, Boy Scouts of America Merit Badge Series, available from Official Boy Scout Distributors (at local retail stores) or from Boy Scouts of America, National Supply Service, New Brunswick, New Jersey 08903.

Scientific Instruments You Can Make, Helen M. Davis, Science Service, 1719 N Street N. W., Washington, D. C., 1959, 253 pp., $2.00.

Experiments with Atomics, Nelson Beeler and Franklin Branley, Thomas Y. Crowell Company, New York, 1954, 160 pp., $2.50.

Atomic Experiments for Boys, Raymond F. Yates, Harper and Row Publishers, Inc., New York, 1952, 132 pp., $2.50.

Atomic Energy and Civil Defense (Price List 84) a listing of related publications available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., free.

Preparation of Scientific and Technical Reports

How to Write Scientific and Technical Papers, Sam F. Trelease, Williams & Wilkins Company, Baltimore, Maryland, 1958, 185 pp., $3.25.

Writing Useful Reports, Robert E. Tuttle and C. A. Brown, Appleton-Century-Crofts, Inc., New York, 1956, 635 pp., $4.75.

Technical Reporting, Joseph N. Ulman, Jr., and J. R. Gould, Holt, Rinehart & Winston, Inc., New York, 1959, 289 pp., regular edition $6.75; textbook edition $5.00.

Report Writers' Handbook, Charles E. Van Hagan, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1961, 276 pp., regular edition $9.35; textbook edition $7.00.

APPENDIX IV

WORKING WITH RADIATION AND RADIOACTIVE MATERIALS

No scientist worth his title ever exposes himself needlessly to any potential hazards which confront him in his investigations. Thoughtful student scientists also will avoid any unnecessary exposure to ionizing radiation, particularly since bad habits acquired while doing student projects may be difficult to overcome later.

Before undertaking experiments with radioactivity, consult your science teacher or project counselor. Any materials to be irradiated should be processed with professional equipment by persons trained and authorized to operate it. Use of radioisotopes, even in quantities exempt from license requirements, usually involves special laboratory facilities, techniques, and instruments, as well as the isotope itself. Make certain that all these will be available to you before you embark on your project.

If possible, conduct all work with radioisotopes under the supervision of a trained, experienced isotope technician. At the very least, familiarize yourself with the specialized handling techniques required (see *Experiments with Radioactivity* or *Laboratory Experiments with Radioisotopes for High School Science Demonstrations*, listed in Appendix III). Then follow them to the letter!

APPENDIX V

SUPPLIERS OF RADIOISOTOPES

Your science teacher or project counselor may know of a nearby laboratory from which you can obtain the radioisotopes required for your investigation. If you wish to write direct to a commercial source, some of the suppliers of application-exempt quantities are:

Atomic Corporation of America
14725 Arminta Street
Panorama City, California

Bio-Rad Laboratories
32nd & Griffin Avenue
Richmond, California

U. S. Nuclear Corporation
801 N. Lake Street
Box 2022
Burbank, California

Abbott Laboratories
Box 1008
Oak Ridge, Tennessee

Nuclear Consultants Corporation
9842 Manchester Road
St. Louis 19, Missouri

Nuclear-Chicago Corporation
333 East Howard Avenue
at Nuclear Drive
Des Plaines, Illinois

New England Nuclear Corporation
575 Albany Street
Boston, Massachusetts

ChemTrac Corporation
130 Alewife Brook Pkwy.
Cambridge 40, Massachusetts

Union Carbide Nuclear Company
Oak Ridge National Laboratory
Isotope Sales Department
P. O. Box X
Oak Ridge, Tennessee

Nuclear Consultants, Inc.
33-61 Crescent Street
Long Island City 6, New York

APPENDIX VI

INTERNATIONAL SCIENCE FAIR RULES

Finalists who enter the ISF must follow these rules without exception.

The following code refers to the ISF rules listed below:

S—School Fairs (recommended)
R—Regional Fairs (recommended)
I—ISF (required)

S-R-I

Categories* established for grouping and judging science projects at the ISF are:

Botany
Zoology
Medicine and Health
Biochemistry
Chemistry
Pure Physics
Applied Physics and Engineering
Mathematics and Computers
Earth and Space Sciences

S-R-I

Project exhibit size is limited to 30 inches deep (front to back), 48 inches wide (side to side), and 12 feet high (floor to top). Any project exceeding these dimensions is oversize and does not qualify for entrance in the ISF.

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*Entries in any of these categories, if nuclear-related, will be considered for AEC Special Awards at the International Science Fair.

R-I

Each exhibitor must assemble his or her exhibit without major outside help, except for transportation and unpacking.

S-R-I

A typed abstract of the project, using not more than 250 words, is required and must be displayed with the project.

S-R-I

Anything which could be hazardous to public display is prohibited. This includes:

Live poisonous animals may not be displayed.

No dangerous chemical substances such as caustics, acids, highly combustible solids, fluids or gases may be displayed. If such materials are required, inert substitutes should be used.

No open flames are permitted.

Any project producing temperatures exceeding 100° C must be adequately insulated from its surroundings.

Highly flammable display materials are prohibited.

Tanks which have contained combustible gases must be purged with carbon dioxide. No combustible fuel may be displayed.

High voltage equipment such as large vacuum tubes or dangerous ray-generating devices must be shielded and safety checked by a qualified inspector. Students should be cautioned in advance about the dangers of experimenting with such equipment and their work carefully supervised.

S-R-I

No live, warm-blooded animals may be displayed at the ISF. Projects involving the use of such animals may display photographs, drawings, charts or graphs to illustrate the conditions, developments, and results of the investigations. This eliminates the needless shipping, housing, care, harm, discomfort or loss of animals.

S-R-I

During judging the exhibit area is closed to all except judges and authorized personnel. Exhibitors may be present only at a specified time during which they are to remain at their exhibits.

S-R-I

All exhibitors must be interviewed at their projects by at least one judge. The purpose of all interviews is to determine the exhibitors' familiarity with the project, the science involved, and to give the student an opportunity to meet the judges, react to questions and to discuss their work with a recognized leader. Care must be taken to allow a reasonable interview time within the time limits alloted for judging.

I

Not more than two students, male or female, may be certified as finalists to the ISF from an affiliated science fair. They must be students in 10th, 11th or 12th year classes in a public, private or parochial school.

I

A student who will have reached age 21 on or before May 1, preceding the ISF is not eligible to participate as a finalist in the ISF.

I

A student may enter only one project and it must be his own work. Group projects involving two or more students give experience to beginners and are acceptable in S or R fairs but may not be entered in the ISF.

I

The identical repetition of previous year's project is not permitted. However, a student may again exhibit work on a continuing problem provided the work demonstrates considerable progress when compared with the previous year.

I

Finalists must be accompanied to the ISF by an official adult escort designated and/or sponsored by the regional fair. Responsibility and liability for entry in the ISF rests with the affiliated fair organization which finances the entry, provides transportation for the finalists and their projects, and living expenses during ISF.

I

Students planning to enter exhibits in the ISF which contain materials that may be regulated by a quarantine should first consult with a Federal or State plant pest control or animal health inspector, a county agricultural agent, or write to the Director, Plant Pest Control Division, U. S. Department of Agriculture, Federal Center Building, Hyattsville, Maryland 20782.

S-R-I Regulations for Experiments With Animals

This guide was prepared and approved by the National Society for Medical Research, the Institute of Laboratory Animal Resources (National Research Council), and the American Association for Laboratory Animal Science (1968).

1. The basic aims of scientific studies involving animals are to achieve an understanding of life and to advance our knowledge of

life processes. Such studies lead to respect for life.

2. Insects, other invertebrates and protozoa are materials of choice for many experiments. They offer opportunities for exploration of biological principles and extension of established ones. Their wide variety and the feasibility of using larger numbers than is usually possible with vertebrates makes them especially suitable for illustrating principles.

3. A qualified adult supervisor must assume primary responsibility for the purposes and conditions of any experiment that involves living animals.

4. No experiment should be undertaken that involves anesthetic drugs, surgical procedures, pathogenic organisms, toxicological products, carcinogens, or ionizing radiation unless a trained life scientist, physician, dentist or veterinarian directly supervises the experiment.

5. Any experiment must be performed with the animal under appropriate anesthesia if pain is involved.

6. The comfort of the animal used in any study shall be a prime concern of the student investigator. Gentle handling, proper feeding, and provision of appropriate sanitary quarters shall be strictly observed. Any experiment in nutritional deficiency may proceed only to the point where symptoms of the deficiency appear. Appropriate measures shall then be taken to correct the deficiency, if such action is feasible, the animal(s) shall be killed by a humane method.

This booklet is one of the "Understanding the Atom" Series. Comments are invited on this booklet and others in the series; please send them to the Division of Technical Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

Published as part of the AEC's educational assistance program, the series includes these titles:

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Animals in Atomic Research
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Nuclear Terms, A Brief Glossary
Our Atomic World
Plowshare
Plutonium
Power from Radioisotopes
Power Reactors in Small Packages
Radioactive Wastes
Radioisotopes and Life Processes
Radioisotopes in Industry
Radioisotopes in Medicine
Rare Earths
Research Reactors
SNAP, Nuclear Space Reactors
Sources of Nuclear Fuel
Space Radiation
Spectroscopy
Synthetic Transuranium Elements
The Atom and the Ocean
The Chemistry of the Noble Gases
The Elusive Neutrino
The First Reactor
The Natural Radiation Environment
Whole Body Counters
Your Body and Radiation

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USAEC, P. O. BOX 62, OAK RIDGE, TENNESSEE 37830

Complete sets of the series are available to school and public librarians, and to teachers who can make them available for reference or for use by groups. Requests should be made on school or library letterheads and indicate the proposed use.

Students and teachers who need other material on specific aspects of nuclear science, or references to other reading material, may also write to the Oak Ridge address. Requests should state the topic of interest exactly, and the use intended.

In all requests, include "Zip Code" in return address.

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