CHERNOBYL:
A THEME TO INTEGRATE THE NATURAL AND SOCIAL SCIENCES

Lesson Plans

A Joint Effort of the Center for Russia, East Europe, and Central Asia (CREECA), the Wisconsin Teacher Enhancement Program in Biology (WisTEB), and Friends of Chernobyl Centers United States (FOCCUS)

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Security, Power, and Medicine: Advancements in Nuclear Energy and their Historical, Economic, and Political Effects

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1. NCSS Standards (Thematic Strands) and Wisconsin’s Model Academic Standards for Social Studies and Science

**NCSS Standards**: VIII. Science, Technology and Society

**Wisconsin’s Model Academic Standards for Social Studies**: B.12.9 Select significant changes caused by technology, industrialization, urbanization, and population growth, and analyze the effects of these changes in the United States and the world.

**Wisconsin’s Model Academic Standards for Science**: G.12.3 Analyze the costs, benefits, or problems resulting from a scientific or technological innovation, including implications for the individual and the community.

H.12.3 Show how policy decisions in science depend on social values, ethics, beliefs, and time-frames as well as considerations of science and technology.

H.12.5 Investigate how current plans or proposals concerning resource management, scientific knowledge, or technological development will have an impact on the environment, ecology, and quality of life in a community or region.

2. Introduction - Purpose/Rationale

Throughout the course of history, advances in science and technology have had social, economic, political, psychological, environmental, and other influences on society. Societal responses have ranged from overwhelmingly positive to destructively negative. In the majority of high schools, the natural and social sciences are studied in separate classrooms and treated as very distinct subjects. Students seldom are encouraged to make connections between advances in science and technology and the ways in which they impact society. Natural disasters most often show uncontrolled, unpredictable science and their destructive impact on a society and its economy. Less often addressed is the impact of unnatural disasters or controlled scientific research on a society and its economy.

This lesson will challenge students to find connections between a controlled scientific technology, nuclear energy, and its impact on society. Although the scientific community has been aware of the existence of nuclear energy for approximately a century, the world did not learn of its power until 1945 at the close of World War II. Since then, nuclear energy and its specific uses in medicine, security (weapons systems), and as an alternative power source have been a continuing controversy. In this lesson, students will examine the three areas of nuclear energy use by looking for technical advancements and their impact on society.
3. Recommended Grade Level/Course Placement

This lesson is designed for students in grades 9-12. The complexity and amount of teacher direction may need to be modified to fit the needs and abilities of the students. This lesson may work best in a variety of elective courses in the natural and social sciences (examples include Current Events and Science and Society). Nevertheless, with few or no modifications, this lesson would work in certain more general, often required, science and social studies courses.

4. Objectives

**Knowledge**—Students will:
- explain the major ways in which nuclear energy is used for security, power, and medicine and the scientific and technological advancements in each of these areas since 1945
- explain the significant historical, economic, and political effects of the scientific and technological advancements related to nuclear energy

**Skills**—Students will:
- Work cooperatively and productively in small groups, divide research and presentation tasks, and produce quality work with significant input from all group members
- Formulate a reasoned opinion on an open-ended question and justify that opinion based on information gained through research and listening to group presentations

5. Time Allotment

Three class periods is recommended although additional research days may be needed, especially if more challenging research requirements are given. A fourth class period also may be needed depending on the number of group presentations and the amount of time that the instructor wishes to spend on closing discussions and other activities. Extensions can be used with this specific lesson or integrated into the unit in general.

6. Resources Needed

- Appendix 1: Prereading packet
- Appendix 2: T-Grid

7. Procedure

A. Hand out the prereading packet (Appendix 1) several days in advance and have students read it by the first day of the lesson so that students have the necessary background information on the early history of nuclear energy.

B. Write the term “Nuclear Energy” on the board and ask each student to write down at least five terms, phrases, ideas, opinions, events, and/or people that immediately come to mind upon hearing that term. After 3-5 minutes, have students quickly share their lists with one nearby classmate. Then, ask for student volunteers to share one item on their list. The teacher should write the items on the board and use them as a springboard for beginning a brief introductory lecture on nuclear energy in general and the following assignment specifically. This introductory activity should provide the teacher with an understanding of the students’ knowledge and misconceptions about nuclear energy.
C. Introduce this activity to your students as follows:

1. Divide the class into groups of 4-5 students in the manner that works best for you and your students.

2. Assign each group one of these terms—Security, Power, or Medicine—and explain that each group will be responsible for researching the ways in which nuclear energy is used in their assigned area, for finding the advancements in their area since 1945, and for listing the known or likely historical, economic, and/or political effects of each advancement on the world or nation. Except in small classes, it is likely that more than one group will need to be assigned one or more of the three terms. Hand out the T-Grid (Appendix 2) and indicate that each group will be responsible for finding a minimum of 5 effects in their area and including the necessary information (including sources used) on the T-Grid. Source information must be provided in the generally accepted bibliographical format. The completed T-Grid will be handed in by the end of class on the second day.

3. Each group also will produce and hand in a list of 3-5 questions regarding the information that will be presented in the group's oral presentation to the class (explained below). The questions should relate to the “big picture” rather than be focused on small details. Put another way, the questions should relate to what students need to know about the group's assigned area of nuclear power or to the thought question that all students may be required to answer as homework after the presentations (see Assessment section). These questions will be compiled and made into a handout so that students can answer them while listening to the presentations. Although the questions may be turned in early, they are due no later than the day before the group presentations.

4. Give students any time remaining in the period and the class period the following day to research, complete their T-Grid, and to begin writing their list of questions. While there is no set list of scientific and technological advancements or resulting effects that the groups should be expected to come up with, especially for those groups having difficulty, the instructor may wish to steer the groups toward certain advancements and effects. Some of these would include the nuclear accidents at Chernobyl and Three Mile Island, disposal of nuclear waste, the development of the hydrogen bomb, the use of radioactive tracers as a diagnostic tool, the use of CAT scans, and advancements in radiotherapy. You may wish to ask your school librarian in advance to pull books from general circulation that may be useful to your students in conducting this research.

5. About 2-3 days after the full research day, each group will give a 5-10 minute oral presentation to the class hitting the highlights of their findings. Each presentation should include at least one visual aid. Groups should inform the teacher if they will need any audio-visual equipment in order to use their visual aid. Some of the time between research and presentations should be used by the groups outside of class to organize their presentations and create their visual aid. While listening to the presentations, the other students will answer the relevant questions on the handout referred to in 3 above.

D. After all of the presentations have been given, a concluding discussion should take place to provide closure to the lesson. Questions that you may wish to explore include, but are not limited to, the following: 1) Has your opinion about nuclear energy changed in any way? If so, how? 2) What else about nuclear energy would you like to know? 3) On balance, do you believe that nuclear energy is a good thing? Why or why not? 4) What other issues or topics can you think of that have an obvious connection between science and social studies? 5) How can this activity be changed to make it more effective? Explain.
8. Assessment

One or more of the following assessments may be used:

A. The T-Grids submitted by each group will be collected and may be assigned a grade that each group member would receive.

B. Questions submitted by each group may be collated and used as a graded worksheet to be completed individually during group presentations.

C. Group presentations could be graded by the teacher. If this is done, it is recommended that the teacher produce and distribute a grading rubric so that the students are aware of how their presentations will be evaluated.

D. The following question may be given as homework to be turned in the day after group presentations are completed or it may be used in class as part of a wrap-up discussion.

Based on the information about nuclear energy that you learned during this activity, state your opinion as to whether scientific/technological advancements in nuclear energy have been driven by societal/economic/political needs or whether economic, political, and societal institutions have reacted to scientific/technological advancements in nuclear energy. If given as a writing assignment, it is suggested that students write at least a page and include at least three examples from group presentations (including your own).

E. Students will be responsible for material presented by the groups on the next unit exam.

9. Extension and Enrichment

A. Using several sentences, finish one of the following statements providing examples to support your opinion:

1. Overall, I believe that nuclear energy is/is not (circle one) a good thing because...

2. Overall, I believe that nuclear energy is/is not (circle one) a good thing but...

B. Have students research and compare the nuclear accidents at Chernobyl and Three Mile Island. Challenge students to look for both the technological and societal impacts.

C. Invite a guest speaker to your class or arrange a panel of guest speakers with differing viewpoints on the advantages and disadvantages of nuclear energy. In addition to educational experts, some suggested guest speakers include:

1. an anti-nuclear activist
2. a former or current nuclear power plant worker
3. someone who is or was receiving radiation or chemotherapy treatment
4. an oncologist or oncology nurse
5. a nuclear medical technologist
6. a nuclear disaster survivor

D. Have students make informed predictions regarding the future of nuclear energy for the purposes of security, power, and medicine. This could take the form of a writing assignment, small group discussions, or a full class discussion.
E. Have students research the coverage by the news media of nuclear energy and its uses and how it influences society. Based on their research, students should draw one or more conclusions about the way or ways in which the news media covers this issue.

F. Individually or in groups, have students develop a questionnaire on nuclear energy to give to a representative sample of the student body. Students should analyze and interpret the results of their surveys and draw conclusions from the results. Students also could research other public surveys dealing with nuclear energy and compare and contrast the results of their survey to those of other surveys.

G. Students could research alternative energy forms with emphasis on cost-effectiveness, pros and cons, and the conditions that must be met for that energy form to become much more widely used.

H. As an introductory or closing activity (or both), students could be given the Radiation Survey (Appendix 3). Use of this survey would depend largely on whether this lesson is conducted with a science or social studies focus.
The First Fifty Years of Radiation Protection
By Ronald L. Kather and Paul L. Ziener

The science and art of radiation protection or health physics as it is more properly called grew out of the parallel discoveries of x-rays and radioactivity in the closing years of the nineteenth century. The x-ray, discovered by German physicist Wilhelm Konrad Roentgen on November 8, 1895, was reported to the world shortly after the first of the year 1896. Roentgen's discovery was a scientific bombshell, and was received with extraordinary interest by both scientist and laymen. Many scientist dropped other lines of research to pursue the mysterious rays, and the newspapers and magazines of the day provided the public with numerous stories, some true, others fanciful, about the properties of the newly discovered rays.

The public fancy was caught by the invisible ray with the ability to pass through solid matter, and, in conjunction with a photographic plate, provide a picture, albeit a shadowy diffuse one, of the bones and interior of the body. Scientific fancy was captured by an extraordinary new radiation, of shorter wavelength than light, that presaged new and great vistas in physics, and the structure of matter. Both the scientist and the public were enthusiastic about potential applications of the newly discovered rays as an aid in medicine and surgery. Thus, within a month after the announcement of the discovery, several medical radiographs had been made in Europe and the United States which were used by surgeons to guide them in their work.

Only two months after the general announcement of the discovery of the x-rays, Henri Becquerel, a French physicist, communicated to the world his discovery of similar penetrating rays emitted from salts of uranium. His discovery was, unlike that of the x-rays, virtually unnoted by the layman and scientist alike. Only a relatively few scientist were interested in Becquerel's findings, and it was not until the discovery of radium by the Curies two years later that interest in radioactivity became widespread.

The initial lack of popular interest in radioactivity was more than made up for by the enormous activity with regards to x-rays. Experimenters and physicians, laymen and the physicists alike set up x-ray generating apparatus and proceeded about their labors with a blithe lack of concern regarding potential dangers. Such a lack of concern is quite understandable, for there was nothing in previous experience to suggest that x-rays would in any way be hazardous. Indeed, the opposite was the case; for who would suspect that a ray similar to light but unseen, unfelt, or otherwise undetectable by the senses would be damaging to the person? More likely, or so it seemed to some, x-rays would be beneficial, both for the prophylaxis and therapy.

Inevitably, the widespread and unrestrained use of x-rays led to frank injury. Often, injuries were not attributed to x-ray exposure, in part because of the latent period before the onset of systems, and more so because there was simply no reason to suspect x-rays as the cause. Whatever some early experimenters may have thought about the skin effects they noted, others soon began to tie x-ray exposure and skin burns together. The first warning of possible adverse effects of x-rays came from Thomas Edison, William J. Morton, and Nikola Tesla who reported independently of eye irritations from experimentation with x-rays and fluorescent substances. These effects were most likely not attributable to x-rays but rather to eye strain, or possibly, ultraviolet from the fluorescence.

However, other reports, describing skin effects similar to those associated with a bad sunburn, began to appear. So frequent and persistent were these reports that in late 1896, less than a year after Roentgen's announcement, Elihu Thomson, an American physicist, deliberately exposed the little finger of his left hand to an x-ray tube for several days, half an hour per day. The resultant
effects - pain, swelling, stiffness, erythema and blistering - were convincing for Thomson and others, but not for all. Many prominent physicians still denied that x-rays were in any way harmful, although of times the denial was tempered by a qualification that the effects noted were attributable to misuse of the x-ray.

By 1900, four years after the discovery, it was apparent to most of the medical and scientific community that x-ray exposures, if too frequent or intensive, could produce skin burns. Reduction of exposure time and frequency were the most obvious ways to limit dose to patients, and experimenters sometimes used enclosed tubes or distance to protect themselves. Filtration of the x-ray beam was advocated prior to 1900 as was limitation of beam size (collimation). Other techniques, including the use of intensifying screens to reduce exposure time and higher x-ray generating voltages were also used about 1900 to minimize patient doses to x-rays. Impetus to providing patient protection was spurred by malpractice law suits decided in favor of patients who had been injured as a result of diagnostic x-ray exposure.

Although the basic techniques of x-ray protection were well known by 1905, ten years after the discovery, implementation was spotty. Thus, even during the 1920’s and into the 1930’s it was not uncommon to find medical x-ray units with virtually no safety precautions. The hazards of radioactivity were better controlled, primarily because of the high monetary value of the radium sources in use in medicine, coupled with their continuous output of very penetrating rays. Thus, storage of radium in locked shielded safes was common, and applicators, necessitated by sterile techniques and surgical application, were generally used.

1 Pioneer Era (1895-1905), briefly described above, in which recognition of the gross somatic hazard occurred, and relatively simple means devised to cope.
2 Dormant Era (1905-1925), in which the major concern was toward applications, but in which great gains were made in technical and biological knowledge which were later applied to protection.
3 Era of Progress (1925-1945), which saw the development of radiation protection as a science in its own right along with the birth of health physics in the Manhattan District.

The Pioneer Era has already been briefly described, and needs only mention of an extraordinary x-ray protection pioneer to complete the description. William Herbert Rollins was a Boston dentist, who, during the period 1896-1904, made numerous original contributions to the emerging science of radiology. Rollins also performed a series of experiments that showed x-rays could kill guinea pigs. His experiments included exposure of a pregnant guinea pig which resulted in killing of the fetus and which led to Rollins expressing concern about the use of x-rays in pelvic exams of pregnant women. He was a true pioneer of x-ray protection.

The Dormant Era (1905-1925) was a period of two decades in which applications of x-rays and radium along with the development of improved equipment seemed dominant. In the protection area, little overt progress was made, although latent effects of radiation exposures, particularly at low level, began to be recognized. However, gains in the radiation protection area were relatively slow and few, although in some respects highly significant.

One little known event that is of historical significance in health physics was reported at the October 1907 meeting of the American Roentgen Ray Society. At that meeting, Rome Vernon Wagner, an x-ray tube manufacturer, reported that in an effort to control his personal exposures, he had begun to carry a photographic plate in his pocket and to develop the plate each evening to determine if he had been exposed. This practice, which apparently did not come into widespread use until later, was clearly the forerunner of the film badge. Unfortunately, Wagner's concerns for his personal exposure came too late, for he had already developed cancer and died 6 months later in 1908.
The real gains were yet to come. The year 1925 marked the start of what might be termed "Era of Progress" (1925-1945). In that year(1), Arthur Mutscheller put forth the first tolerance dose or permissible exposure limit, equivalent to about 0.2 rem per day. Mutscheller, a German-American physicist, based this limit on 1/100 of the quantity known to produce a skin erythema per month noting that recovery would occur swiftly enough to obviate any untoward effects. Swedish physicist Rolf Sievert also put forth a tolerance dose - 10\(^2\)\% of the skin erythema dose - in the same year.

The 1920's saw other gains in radiation protection: the introduction of film badges for routine personnel monitoring, recognition of the genetic effects of x-rays (for which Hermann Muller won the Nobel Prize in 1946), and the adoption of a unit for measuring radiation by the Second International Congress on Radiology in 1928. The definition and adoption of the Roentgen, as this unit was named, provided a physical basis for the quantitative measurement.

It was the Manhattan District of U.S. Army Corps of Engineers that the name "health physics" was born, and great advances were made in radiation safety. From the onset, the leaders of the Manhattan District recognized that a new and intense source of radiation and radioactivity would be created, and thus, in the summer of 1942, asked Ernest O. Wollan, a cosmic ray physicist at the University of Chicago, to form a group to study and control radiation hazards.

Within the Manhattan District, the name "health physicist" seems to have been derived in part from the need for secrecy (and hence a code name for radiation protection activities) and the fact that there was a group of mostly physicists working on health related problems. Thus, their activities included development of appropriate monitoring instruments, developing physical controls, administrative procedures, monitoring areas and personnel, radioactive waste disposal, in short, the entire spectrum of modern day radiation protection problems. It was in the Manhattan District that many of the modern concepts of protection were born, including the rem unit, which took into account the biological effectiveness of the radiation, and the maximum permissible concentration (MPC) for inhaled radioactivity. In deed, it was in the Manhattan District that modern day radiation protection effects, born in the early days of x-ray and radium, realized their maturity.

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A Brief Chronology of Radiation and Protection

by J. Ellsworth Weaver III 1994, 1995

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Is it right to probe so deeply into Nature's secrets?

The question must here be raised whether it will benefit mankind, or whether the knowledge will be harmful. Radium could be very dangerous in criminal hands. Alfred Nobel's discoveries are characteristic; powerful explosives can help men perform admirable tasks. They are also a means to terrible destruction in the hands of the great criminals who lead peoples to war... -- Pierre Curie in his Nobel Prize Oration, June 6, 1905

The Beginning

1,800,000 BC First "reactor accident." Concentration of enriched uranium forms natural nuclear reactor at Oklo, Gabon and becomes critical: core burns for 200,000 years.

1900 Friedrich Ernst Dorn discovers radon (atomic number 86), a radioactive daughter of uranium.

1901 Becquerel confirms Crookes' statement about uranium not being the origins of the radiation but also shows that if uranium is left standing, its radioactivity increases.

1902 Rollins experimentally shows X-rays can kill higher life forms.

1904 Rutherford shows that alpha particles are helium atoms and works out the natural decay series.

1904 Radon and daughters identified as part of the uranium series. Work with animals begins, especially in Russia and France.

1904 "If it were ever possible to control at will the rate of disintegration of radio elements. an enormous amount of energy could be obtained from a small amount of matter." --Ernest Rutherford.

1904 Rutherford coins the term "half-life."

1905 (June 6) "Is it right to probe so deeply into Nature's secrets? The question must here be raised whether it will benefit mankind, or whether the knowledge will be harmful. Radium could be very dangerous in criminal hands. Alfred Nobel's discoveries are characteristic: powerful explosives can help men perform admirable tasks. They are also a means to terrible destruction in the hands of the great criminals who lead peoples to war..." Pierre Curie in his Nobel Prize Oration delayed from 1903.

Modern Physics Era

1910 Jesuit Father Theodor Wulf measures radiation at ground level and at top of Eiffel Tower. Radiation increases at higher elevation. Suspects extraterrestrial origins of this radiation. Suggests balloonists measure dose rates.
1911 (Aug) Rutherford and Geiger discover that atoms are mostly space using alpha particles to bounce off thin gold foil.

1911 Georg von Hevesy conceives the idea of using radioactive tracers. Leads to Nobel Prize in 1943.

1912 (July 16) Patent granted to the Radium Ore Revisator Co., 260 California St., San Francisco, CA for a device, the Revisator, that charges water with radon, ushering in a 20-year craze in radioactive health corks. Instructions read: "Fill jar every night, use hydrant or any good water, drink freely when thirsty and upon rising and retiring. Average six or more glasses daily. Scrub with stiff brush and scald monthly."

1913 (Jan 31) A. S. Russell put forward that in beta decay the position of the element in the periodic table changes by one place.

1913 Hans Geiger unveils his prototype gas-filled radiation detector.

1913 Soddy proposes the term "isotope" for atoms with the same number of protons and differing only in number of neutrons.

1914 H.G. Wells publishes The World Set Free set in 1956 predicts an alliance of England, France, and America against Germany and Austria. All the major cities of the world are destroyed by atomic bombs.

1914 Ernest Marsden, Rutherford's assistant, reports an odd result when he bombards nitrogen gas with alpha particles -- something is thrown back with much greater velocity. This is the first report of nuclear fissioning.

1915 (June) British Roentgen Society proposes standards for radiation protection workers; includes shielding, restricted work hours, medical exams; no limits because of lack of units for dose or dosimeters; voluntary controls.

1920 Luminous dial painting expanded to clock factories.

1920-1930s Much use of radon generators in hospitals for preparation of radon seeds.

1921 Suggestion that radium and radium emanation might be causative agent in cancer in miners taken seriously but not proven.

1923 "There is no likelihood man can ever tap the power of the atom. Nature has introduced a few foolproof devices into the great majority of elements that constitute the bulk of the world, and they have no energy to give up in the process of disintegration." --Dr. Robert Andrews Millikan

1925 Physician. Martland, describes pathology of bone changes and anemia in radium dial painters.

1925 William Bailey introduces Radithor, a quack radium potion to cure sexual dysfunction and everything else.

1927 H. Muller shows genetic effects of radiation.

1927 Herman Blumgart, a Boston physician, first uses radioactive tracers to diagnose heart disease.
1928 Description of basis for Geiger-Mueller counter by Hans Geiger and Walter Mueller at the Physics Institute in Kiel (Germany).

1929 "The energy available through the disintegration of radioactive or any other atoms may perhaps be sufficient to keep the corner peanut and popcorn man going in our large towns for a long time. But that is all." --Dr. Robert A. Millikan (hedging a bit on his statement of 1923).

1931 Van de Graaff electrostatic generator constructed.

1931 Linear accelerator is constructed by Sloan & Lawrence at Berkeley.

1931 "Alpha particles are probably the most potent and destructive agent known to science." --Martland

1932 "There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will." --Dr. Albert Einstein

1933 (Sept 12) "The energy produced by the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine." --Lord Ernest Rutherford (after splitting the atom for the first time)

**Atomic Era**

1936 First use of radioisotopes in therapy by John Lawrence (Berkeley)

1938 Hahn and Strassman split the atom repeating Fermi's work.

1939 (Jan 26) Fermi announces uranium releases a few neutrons on splitting. He speculates upon the possibility of a chain reaction.

1939 (March 16) Hitler annexes Czechoslovakia, richest known source of uranium, alerting him to the feasibility of building an atomic bomb and the threat of Germany building one.

1939 (Sept 3) Germany declares war on Great Britain.

1939 Igor Kurchatov alerts the USSR government of the military significance of nuclear fission.

1939 Enrico Fermi patents first reactor (conceptual plans).

1939 More useful count rate meter developed.

1940 (Nov 8) First contract is signed with Columbia University to develop bomb material.

1940 George Flerov of the USSR discovers the spontaneous fission of uranium.

1941 (Sept 18) Werner Heisenberg meets with Neils Bohr to try to convince Bohr and the Western Allies that atomic bomb production is unfeasible and should be stopped. Bohr is unconvinced and suspects Heisenberg's, now working for the Nazis, motives.

1942 (Jan 24) A. H. Compton, chairman of the Physics Department at University of Chicago, announces his decision to site the first self-sustaining chain reaction at University of Chicago. This is over the objections of Szilard (Columbia U.) and Lawrence (Berkeley).
1942 (June 23) Werner Heisenberg's fourth experimental atomic pile, the L-IV, explodes spewing burning particles of uranium twenty feet in the air and catching the lab on fire. Heisenberg and Robert Doepel are nearly killed.


1942 (Sept) The Manhattan Project is formed to secretly build the atomic bomb before the Germans.

1942 (Nov) Los Alamos is selected as site for atomic bomb laboratory. Robert Oppenheimer is named director.

1942 (Dec 2) First sustained and controlled chain reaction in an atomic pile at University of Chicago. Reactor is graphite moderated. Fermi oversees design and building. Fission products expected. Arthur Compton sends message to James Conant: "The Italian navigator has arrived at the shores of the new world and found the natives were friendly. It is a smaller world than he believed."

1942 Beginning of biomedical work at Chicago's Michael Reese Hospital on uranium (cells & whole organism).

1942-1945 Concern over possible use of fission products in radiological warfare leads to Projects Peppermint and Gabriel (secret study on fallout effects).

1943 (Apr) Ground broken for Hanford reactors. built to produce plutonium for Nagasaki bomb.

1944 Substantial group begins work at Met Lab (Chicago) on biomedical aspects of fission products.

1945 (June 6) Criticality accident at Los Alamos. 14 people exposed. some up to 3000 rem gamma and neutrons.

1945 (July) Szilard writes Roosevelt warning of arms race: "The development of atomic power will provide the nations with new means of destruction. The atomic bombs at our disposal represent only the first step in this direction, and there is almost no limit to the destructive power which will become available in the course of their future development. Thus a nation which sets the precedent of using these newly liberated forces of nature for purposes of destruction may have to bear the responsibility of opening the door to an era of devastation on an unimaginable scale."

1945 (Aug) Photographic film at Eastman Kodak fogged from contaminated packing paper (fallout from Trinity).

1945 (Aug 6 & 9) Hiroshima and Nagasaki atomic bombed.

1945 (Aug 21) Harry Daghlian, a Los Alamos lab tech, conducts an unauthorized experiment and is lethally irradiated, first North American to die of acute radiation sickness.

1945 (Sept) USSR occupies Czechoslovakia. Soviet commanders order all German plans, parts, models, and formulas regarding the use of atomic energy, rocket weapons, and radar be turned over to them. USSR infantry and technical troops occupy Jachimov and St. Jochimstal (the only European source of uranium.)
APPENDIX 1A2

1945 (Dec 24) An attaché at the US Embassy in Moscow warns that "the USSR is out to get the atomic bomb. This has been officially stated. The meager evidence available indicates that great efforts are being made and that super-priority will be given to the enterprise."

1945-1947 18 patients (one a five year old) injected with plutonium at Rochester, NY, Oak Ridge, TX, U. of Chicago, and UCSF. No informed consent; potential doses much greater than occupational limits.
PART I: The World's Worst Nuclear Accident

By Charles Recknagel

Prague, April 18 (RFE/RL) -- Ten years ago this month, the world received an alarming indication of what happens when nuclear power slips out of human control.

In the early morning hours of April 27, 1986, monitors in Scandinavia began to detect mysteriously high levels of radiation in the wind blowing out of the east.

As the levels increased, nuclear experts believed their worst fears had come true. Somewhere in the then-Soviet Union, a nuclear power station had malfunctioned, sending clouds of radiation into the atmosphere. But for two days Moscow denied anything was amiss.

The scale of the disaster then overwhelmed Moscow's attempts to hide it. Ninety kilometers north of Kiev, radiation was pouring from the fourth reactor at Chernobyl after a bungled procedure had blown off the building's roof on April 26.

For almost two weeks the radiation continued to escape. To slow the outflow, workers known as liquidators traversed the broken roof in relays to throw a shovelful of hot graphite into the hole before they were immediately evacuated to safety. Then, construction crews raced to seal the entire reactor within a 300,000 ton concrete-and-metal shield, or sarcophagus.

Meanwhile, the clouds of escaped radiation settled onto villages, towns, and forests across wide stretches of Ukraine, Belarus, and neighboring parts of Russia. More than 150,000 people were evacuated from the fallout areas in Ukraine. Some 130,000 more people were removed from the radiation's path in Belarus. As wind patterns changed, the radiation sometimes followed the evacuees, forcing thousands of people to be evacuated a second time from its path.

David Marples is a historian who is an expert on the Chernobyl accident at the University of Alberta in Canada. He says that few events have produced as much emotion as Chernobyl.

Marples says the Chernobyl accident "has caused perhaps more fears among the public, more let's say, stress, emotional anxiety, and tension than any other industrial accident in history."

From the beginning, Marples says, experts have disagreed over how many people have died or will ultimately die from the accident, and what health hazards the escaped radiation will continue to pose in the future.

Today, there is still little consensus on many issues, beginning with the estimates of the accident's ultimate death toll. The lowest prediction originally provided by Soviet authorities is that the accident will finally result in 2,500 deaths. The highest estimate, from a study by the University of California in the U.S., is half a million deaths.

Analysts say that such wide disagreements exist because the casualty toll has to be inferred from the amount of radiation escaping from the reactor into the atmosphere and eventually falling onto inhabited land. The inferences are complicated by scientific disagreements over how much radiation the human body can tolerate without falling ill.

The number of casualties has been estimated differently by competing interest groups. Officials have tended to downplay the accident, while anti-nuclear groups have dramatized it as the best argument for using alternatives to nuclear energy.
How much of a threat Chernobyl still poses to the environment is also an open question. Radiation settled onto surrounding agricultural land and forest, entering local food chains. Now, as most emergency aid programs which initially brought clean food into the contaminated areas have ended, residents are returning to eating locally grown food. But scientists disagree on the risks they run.

Chernobyl’s repercussions have been felt far beyond the areas it contaminated. The scope of the disaster shook the faith of people around the world in the capacity of nuclear energy to safely generate electricity. In the West, Chernobyl -- as well as earlier, smaller scale accidents like that at Three Mile Island in the United States -- sparked a powerful anti-nuclear movement that has dramatically reduced governments’ investment in nuclear power.

In Central and Eastern Europe and the former Soviet Union, Chernobyl initially led to widespread public questioning of nuclear energy. But as the countries’ economies recover from Communism, they lack the money for alternative energy sources and continue to build new reactors. They also continue to operate old facilities, including some units similar to those at Chernobyl. That raises the question of whether new nuclear accidents could occur.

At Chernobyl itself, the destroyed fourth reactor which so frightened the world remains sealed beneath its urgently built sarcophagus. In recent years, cracks have appeared in some walls of the concrete enclosure. Experts say the structure is unlikely to survive for 35-years, as originally planned, and that a permanent solution must be found in the decade ahead.

Meanwhile, two undamaged reactors continue operating at the Chernobyl, producing half the electricity used in Kyiv. Experts say those reactors are now no more dangerous than ones of the same design operating elsewhere in the former Soviet Union. But shutting down Chernobyl completely remains an international priority, and negotiations are under way for millions of dollars of aid to help Ukraine replace the plant with a safer energy source.

Belarusian President Alexander Lukashenko has described the effect of Chernobyl on his country as a "radioactive tornado never seen before." He told an international conference on Chernobyl in Vienna this month that a decade after the accident, his country is spending a quarter of its annual budget to cope with the aftermath of the accident.

Such costs are too much for any of the contaminated countries to face alone. Lukashenko says that to return the contaminated areas to full life Belarus needs financial help from the international community.

Alexei Yanilovok, head of Russia’s ecological safety commission, says that it is still too early to know what the final costs and health consequences from Chernobyl will be.

"Hiroshima and Nagasaki and other nuclear catastrophes showed us that the height of illness began only ten years afterwards. What we are seeing now is only what we could call the buds (from the Chernobyl accident), the real fruit will come later. The final consequences will be much worse than we ever thought because ... there are still so many things we don’t know about radiation."
Reducing Nuclear Dangers.
Building Cooperative Security

Project Description:

The Cooperative Security Project is an ambitious look at the obstacles to further reductions in global nuclear weapon arsenals that digs into policy makers’ assumptions about the nature of international threats, nuclear weapons’ contributions to meeting them, and the opportunity costs imposed by traditional views of the world and traditional foreign policy tools, when countries and their peoples face a whole array of new, often transnational, challenges to individual and collective security.

The enduring world views and assumptions of policy makers with regard to nuclear weapons and the character of threats to Americans’ well-being are prominent among the obstacles to change. Opponents of deep reductions or the elimination of nuclear weapons assume that international politics will continue to be typified by competition, and that the survival of states may require the unilateral use of military force, including, for some states, the threat or use of nuclear weapons. In the future, as in the past, they argue, nuclear weapons will continue to be valuable political and military tools, stabilizing relations among the major powers, deterring conventional and unconventional attacks or threats, enhancing regional and international political status, and ensuring the nuclear forbearance of key U.S. allies. Although some skeptics acknowledge that the United States could reap these benefits with fewer weapons, their complete elimination is considered both infeasible and undesirable, short of a major transformation of international politics, a possibility that is soundly rejected.

Do the policy makers, politicians, and organizations who hold and propagate these views have it right?

Will traditional threats dominate future security challenges to the well-being of the United States and its citizens? If not, and Washington’s focus remains fixed on traditional threats, the country will have wasted billions of dollars to save itself from the wrong set of problems, with correspondingly great opportunity costs inflicted on efforts to resolve or manage newly pressing problems.

Are states trending toward cooperative arrangements to enhance their security, or do they continue to prefer unilateral approaches? If cooperative and unilateral efforts coexist, what do their respective trend lines look like? Is cooperation on the rise and, if so, where and on what sorts of issues, and impelled by what sorts of factors? If there does seem to be movement toward greater cooperation in security, what does that imply for the proliferation, control, or elimination of weapons of mass destruction (WMD)?

Do nuclear weapons really play a unique and irreplaceable role in safeguarding (some) states’ security? What political and military missions do they perform that cannot be achieved by other means? Why have nuclear weapons been only selectively constrained, while chemical and biological weapons have been formally banned by international treaty? If nuclear weapons do not fill unique political and military roles, then why haven’t they suffered the same fate as chemical and biological weapons?
To answer these questions, the project will undertake parallel assessments of security threats, international cooperation, and specific obstacles to eliminating nuclear weapons.

The assessment of threats will build on work done by the Foreign Policy Project and examine old and new challenges to US security. It will look at both interstate and transnational security challenges.

The assessment of international cooperation will examine the degree to which states have worked together to meet security challenges in recent years, and whether there are any clear trends in such cooperation over time or subject matter. For example:

Is interstate cooperation confined to issues with particular characteristics?
Has interstate cooperation been supplemented significantly by commercial and NGO cooperative ventures, or have these hurt or helped states' stability and security, and how do they affect official cooperation?

The assessment of obstacles to reduction or elimination of nuclear weapons will build on the work of the Stimson Center's project on Eliminating Weapons of Mass Destruction. It will address several key questions:

If nuclear weapons are not "unique and irreplaceable," how do we explain the resistance of the nuclear weapons states to relinquish these arsenals and the desire of some states to acquire them?
What are the impediments to achieving progress toward deeper reductions; are they primarily technical (a question of sufficiently sophisticated tools to verify treaty compliance, for example)? political (and if so, domestic, regional, or global?), bureaucratic (stymied by institutional interests or inertia), or something else? How might solutions to overcome these obstacles be found?
APPENDIX 1 NUCLEAR ENERGY-MEDICINE-- What We Know About Radiation

1. What is radiation?

We live in a sea of radiation. There are many different types of radiation, some of which are visible light, ultraviolet rays from the sun, infrared from a heat lamp, microwaves, radio waves and ionizing radiation. Radiation is said to be ionizing if it has sufficient energy to displace one or more of the electrons that are part of an atom. This creates an electrically charged atom known as an ion. Common examples of ionizing radiation are x rays, which are generated by machines, and gamma rays, which are emitted by radioactive materials. Others include alpha and beta rays, which are also emitted from radioactive materials, and neutrons, which are emitted during the splitting (fission) of atoms in a nuclear reactor.

2. When do we encounter ionizing radiation in our daily lives?

Everyone who lives on this planet is constantly exposed to naturally occurring ionizing radiation (background radiation). This has been true since the dawn of time. The average effective dose equivalent of radiation to which a person in the United States is exposed annually is estimated to be about 350 millirem. (A millirem is a unit that estimates the biological impact of a particular type of radiation absorbed in the body.)

Sources of background radiation include cosmic rays from the sun and stars, naturally occurring radioactive materials in rocks and soil, radionuclides (unstable radioactive counterparts to naturally stable atoms) normally incorporated into our body's tissues, and radon and its products, which we inhale. Radon exists as a gas and is present in soil from which it seeps into the air. Radon gets trapped inside buildings, especially if the ventilation is poor. Levels of environmental radiation (World Wide Web address: http://www.epa.gov/radiation/) depend upon geology, how we construct our dwellings, and altitude. For example, radiation levels from cosmic rays are greater for people on airplanes and those living on the Colorado plateau. This low-level background radiation is a part of the earth's natural environment and any degree of risk associated with it has not been demonstrated to date.

We are also exposed to ionizing radiation from man-made sources, mostly through medical procedures. On the average, doses from a diagnostic x-ray are much lower, in dose effective terms, than natural background radiation. Radiation therapy, however, can reach levels many times higher than background radiation but this is usually targeted only to the affected tissues. Besides extremely small amounts of ionizing radiation from color televisions and smoke detectors, there are small amounts of ionizing radiation in many building materials and mining and agricultural products, such as granite, coal, and potassium salt. People who smoke receive additional radiation from radionuclides in tobacco smoke.

The discovery of x rays in 1895 was a major turning point in diagnosing diseases because physicians finally had an easy way to "see" inside the body without having to operate. Newer x-ray technologies such as CT (computerized tomography) scans have revolutionized the diagnosis and treatment of diseases affecting almost every part of the body. Other sophisticated techniques have provided physicians with low-risk ways to diagnose heart disease (World Wide Web address: http://www.nhlbi.nih.gov/nhlbi/nhlbi.html). For example, doctors can now pinpoint cholesterol deposits that are narrowing or blocking coronary arteries, information essential for bypassing or unclogging them.
Every major hospital in the United States has a nuclear medicine department in which radionuclides are used to diagnose and treat a wide variety of diseases more effectively and safely by "seeing" how the disease process alters the normal function of an organ. To obtain this information, a patient either swallows, inhales, or receives an injection of a tiny amount of a radionuclide. Special cameras reveal where the radioactivity accumulates briefly in the body, providing, for example, an image of the heart that shows normal and malfunctioning tissue. Radionuclides are also used in laboratory tests to measure important substances in the body, such as thyroid hormone. Radionuclides are used to effectively treat patients with thyroid diseases, including Graves disease—one of the most common forms of hyperthyroidism—and thyroid cancer.

The use of ionizing radiation has led to major improvements in the diagnosis and treatment of patients with cancer. These innovations have resulted in increased survival rates and improved quality of life. Mammography can detect breast cancer at an early stage when it may be curable. Needle biopsies are more safe, accurate, and informative when guided by x-ray or other imaging techniques. Radiation is used in monitoring the response of tumors to treatment and in distinguishing malignant tumors from benign ones. Bone and liver scans can detect cancers that have spread.

Half of all people with cancer are treated with radiation, and the number of those who have been cured continues to rise. There are now tens of thousands of individuals alive and cured from various cancers as a result of radiotherapy. In addition, there are many patients who have had their disease temporarily halted by radiotherapy. Radionuclides are also being used to decrease or eliminate the pain associated with cancer—such as that of the prostate or breast—that has spread to the bone.

Radionuclides are a technological backbone for much of the biomedical research being done today. They are used in identifying and learning how genes work. Much of the research on AIDS (World Wide Web address: http://www.niaid.nih.gov/factsheets/facts.htm) is dependent upon the use of radionuclides. Scientists are also "arming" monoclonal antibodies—that are produced in the laboratory and engineered to bind to a specific protein on a patient's tumor cells—with radionuclides. When such "armed" antibodies are injected into a patient, they bind to the tumor cells, which are then killed by the attached radioactivity, but the nearby normal cells are spared. So far, this approach has produced encouraging success in treating patients with leukemia. Most new drugs, before they are approved by the Food and Drug Administration (World Wide Web address: http://www.fda.gov/fdahomepage.html), have undergone animal studies that use radionuclides to learn how the body metabolizes them.

Another clinical and research tool, PET scanning (positron emission tomography), involves injecting radioactive material into a person to "see" the metabolic activity and circulation in a living brain. PET studies have enabled scientists to pinpoint the site of brain tumors or the source of epileptic activity, and to better understand many neurologic diseases (World Wide Web address: http://www.nih.gov/ninds/). For example, researchers were able to learn how dopamine—the chemical messenger (neurotransmitter) that's involved in Parkinson's disease—is used by the brain.

These are but a few of the many vital uses of ionizing radiation in medicine. About 70 to 80 percent of all research at the National Institutes of Health is performed using radiation and radioactive materials. NIH research has consistently produced results that have improved the health of the American people.

Ionizing radiation can cause important changes in our cells by breaking the electron
bonds that hold molecules together. For example, radiation can damage our genetic material (deoxyribonucleic acid or DNA) either directly by displacing electrons from the DNA molecule, or indirectly by displacing electrons from some other molecule in the cell that then interacts with the DNA. A cell can be destroyed quickly or its growth or function may be altered through a change (or mutation) that may not be evident for many years. However, the possibility of this inducing a clinically significant illness or other problem is quite remote at small radiation doses.

Our cells, however, have several mechanisms to repair the damage done to DNA by radiation. The efficiency of these repair mechanisms differs among cells and depends on several things, including the type and dose of radiation. There also are biological factors that can greatly modify the cancer-causing effects of large doses of radiation.

The severity of radiation's effects depends on many other factors such as the magnitude and duration of the dose; the area of the body exposed to it; and a person's sex, age, and physical condition. A very large dose of radiation to the whole body at one time can result in death. Exposure to large doses of radiation can increase the risk of developing cancer. Because a radiation-induced cancer is indistinguishable from cancer caused by other factors, it is very difficult to pinpoint radiation as the cause of cancer in a particular individual.

Other effects of large doses of radiation include suppression of the immune system and cataracts (World Wide Web address: http://www.nei.nih.gov/publications/cataract.html). Certain tissues of a fetus, particularly the brain, are especially sensitive to radiation at specific stages of development. However, the children and grandchildren of the atomic bomb survivors so far have shown no greater incidence of genetic problems than do unexposed populations. (7)

It is very difficult to detect biologic effects in animals or people who are exposed to small doses of radiation. Based on studies in animals and in people exposed to large doses of radiation such as the atomic bomb survivors, scientists have made conservative estimates of what might be the largest doses that would be reasonably safe for a person over a lifetime. But these calculations are estimates only, based on mathematical models. Low-level exposures received by the general public have shown no link to cancer induction. Even so, the U.S. Government uses these estimates to set the limits on all potential exposures to radiation for workers in jobs that expose them to ionizing radiation. International experts and various scientific committees have, over the years, examined the massive body of knowledge about radiation effects in developing and refining radiation protection standards.

Radiation (World Wide Web address: http://www.cic.nci.nih.gov/Radiation/radintro.html), surgery, and chemotherapy are the major ways in which cancer is treated; they are used singly or in combinations depending on the cancer. The effectiveness of radiation in killing cancer cells—and, at the same time, the potential for harm to normal tissues—depends on several things, including the type of radiation used, the extent of the body that is treated, and the patient's age or other medical problems. Doctors try to avoid exposure of large parts of the body to radiation because this can cause serious side effects like a secondary cancer—one that develops after treatment for the initial cancer. However, only about 5% of all secondary cancers have been linked to radiotherapy. The risk of leukemia after large doses of radiation to localized areas of the body often is surprisingly low, because the local effect is to kill cells that might, at smaller doses, undergo transformation—the changes that a normal cell undergoes as it becomes malignant—eventually leading to leukemia. Other side effects of radiotherapy range from
mild to serious. many are temporary.

With the development of better therapy machines and the use of computers to plan the
treatment, the safety and efficacy of radiotherapy have steadily improved. Radiologists
make every attempt to minimize harmful effects to normal tissues. Thus, a patient's risks
from exposure to radiation are far offset by the benefits from the treatment.

fields. must ensure that all risks to the participants are justified on the basis of potential
benefits either to them or to society and that their rights will be protected. This
regulation applies to all studies, including those in which the use of radiation is
proposed. It is also the IRB's responsibility to ensure that patients or volunteers are fully
and accurately informed of the risks and benefits of participation in the study, are not
coerced in any way into participating, and are competent to make the decision to
participate. (If the studies will be conducted in children, then parental consent and
assent by the child is required.) When the use of ionizing radiation is involved, nearly all
such institutions also have a group of radiation health experts (the radiation safety
committee) review the proposed research before it can be approved to proceed.

Most of the radiation that we are receiving is naturally occurring background radiation
over which we have little control. Some level of exposure to additional radiation is
unavoidable. It appears, however, that the cancer risk from very small-dose exposure is
quite low. It is prudent to avoid unnecessary exposure, but not if one loses more—in
money, time, convenience, or increased risks from other things—by avoiding radiation
rather than ignoring it.

The cancer risk associated with exposure to large doses of ionizing radiation is among
the best understood of any relationships involving environmental agents (World
Wide Web address: http://www.niehs.nih.gov) that cause cancer, this relationship
continues to be studied and reevaluated. This knowledge is constantly used in evaluating
the risks and benefits of the uses of radiation in medicine. In the overwhelming majority
of cases where it is used, the benefits of medical radiation far outweigh the risks
associated with it, but there is a tradeoff. In this sense, radiation is no different than any
other diagnostic or therapeutic agent, except that we have more information than usual.

Properly managed, radiation can be used for great benefit to humanity and with minimal
risk, a risk comparable to or lower than those commonly accepted as an ordinary part
of daily life such as driving to work.
APPENDIX 3

Radiation Survey -- How Much Do You Know About Radiation?

Key: A = Agree with the statement, B = Disagree with the statement, NS = Not sure

1. _____ There is only one type of radiation.
2. _____ Radiation is only manmade.
3. _____ A sunburn is a type of radiation damage.
4. _____ Radiation is always present.
5. _____ You are slightly radioactive.
6. _____ Everything is radioactive.
7. _____ The dead skin layer on your body stops some radiation.
8. _____ Fission is a splitting of atoms.
9. _____ The color in gemstones may have been created with manmade radiation.
10. _____ Uranium is radioactive.
11. _____ All radiation is deadly.
12. _____ Radioactivity is a naturally occurring process.
13. _____ Fusion is a combining of atoms.
14. _____ Albert Einstein discovered radiation.
15. _____ A TV emits radiation.
16. _____ Exposure to a radioactive substance can make you radioactive.
17. _____ Radiation could mutate you - say into Ninja Turtle or Spider Man.
18. _____ Irradiation of strawberries to retard spoilage causes them to be slightly radioactive.
19. _____ Before atomic bomb testing started, food was not radioactive.
20. _____ All cancer is caused by radiation.
21. _____ All bananas are radioactive and always have been.
22. _____ The radon problem is manmade.
23. _____ Nuclear radiation cannot be seen, heard, felt, tasted, or smelled.
24. _____ Flying in an airplane increases the amount of radiation you receive.
25. _____ Radiation can be used to treat cancer.

FROM: www.set.lanl.gov/programs/cif/History/HistoryBM.htm
Security, Power, and Medicine: Advancements in Nuclear Energy and their Historical, Economic, and Political Effects

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