

Questions and Answers ABOUT NUCLEAR TESTS

I. RADIOACTIVITY—ITS EFFECTS ON MAN

Why Do Scientists Disagree on Dangers from Radioactive Fallout?	8
What Do Scientists Agree Upon?	5
How Much Harm May Result From Nuclear Tests Already Held?	7
Is There a Safe Level of Nuclear Testing?	8
Do "Clean" Bombs Reduce the Danger from Nuclear Testing?	8
Is the Degree of Risk Strictly a Scientific Question?	9

II. BOMB TESTS AND THE ARMS RACE

Do Armaments "Prevent War"?	10
What Would Be the Destruction From a Nuclear War?	11
Would "Cleaner" Bombs Change the Nature of Nuclear War?	11
What Happens When the Ballistic Missile Carrying a Hydrogen Bomb is Perfected?	12
How Long Will It Be Before Other Nations Start Testing Nuclear Weapons?	12
Do We Have to "Trust Russia" to Keep an Agreement to Stop Nuclear Tests?	13
What Can Individual Citizens and Members of Organizations Do?	13
Practical Suggestions for Busy People	14
Glossary of Technical Terms	14
Footnotes	16

"There is general agreement among scientists concerning the scientific facts which relate to the tests of nuclear bombs. Public controversy has arisen when social and moral judgments, based on these scientific data, have led to opposing conclusions.

"The following discussion of the bomb test question gives an accurate account of the pertinent scientific material and its relation to the decisions which must be made by the public and its government." *MATTHEW SANDS, Ph.D., Physics

How can well-informed persons look at the same facts and arrive at entirely different conclusions? This question puzzles most of us as the great nuclear debate between scientists continues.

There are two major aspects of the debate: first concerns the biological dangers of atomic radiation; second, the general implications of the nuclear arms race, of which the tests are a symptom. Part I of this pamphlet discusses the biological dangers; Part II examines the arms race.

Those who want the tests to go on equate the tests with military security. Others urge a ban because of hazards to human health, or as a break in the arms race. The one sees danger to our military establishment, hence our "national security", if we stop. The other sees even greater danger to our security in the ever-spiraling arms race if we continue.

Most scientists believe that radiation, in any amount, is harmful to any creature. But they disagree on the amount of harm now being done by radioactive fall-out.

"Because we know there is harm, even though we disagree on the extent of the peril, we must stop, for the harm is irreversible", says the one.

"No", responds the other, "for if we do, we risk our lead in the arms race and invite attack by the Russians, resulting in damage far greater than any present physical or future genetic harm."

Neither conclusion is based on pure science. Those with scientific training do not, after all, discard other values, opinions and prejudices in making up their minds.

So in any discussion of The Bomb we cannot stop with the known or disputed scientific facts, just as we cannot ignore them. Each of us must arrive at a conclusion which is also based on other reasons and beliefs. We cannot know

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all, but neither can we leave the judgment to the experts alone, for beyond certain technical knowledge they may be no more expert than we.

We think that the following questions, answers and opinions will be of help to the reader in making up his own mind. And we pray that our collective decision will be the right one because, for the first time in history, we are making decisions for the race of man, for all and each of us.

I. RADIOACTIVITY—ITS EFFECTS ON MAN

Why Do Scientists Disagree On

Dangers From Radioactive Fallout?

There are several reasons:

1. **Structure of the Atomic Energy Commission:** The Atomic Energy Commission is responsible both for developing a crash program of nuclear weapons and evaluating the possible dangers resulting from nuclear weapons tests.

Since the AEC's primary responsibility is for nuclear weapons development, AEC spokesmen might logically be expected to emphasize the useful rather than the harmful effects of the program. This is not to question their integrity. But when statements must be reconciled with official policy, security regulations, and one's personal livelihood, the result is likely to be less than completely objective.

2. **Lack of Data:** Scientists agree that present knowledge is inadequate. Dr. Charles L. Dunham, director of the AEC Division of Biology and Medicine, before the Joint Congressional Committee on "The Nature of Radioactive Fallout and Its Effect on Man" (Holi-field Hearings), estimated that it would take 10 to 15 years to learn by experiment what precise effect strontium-90 has on dogs and therefore on human beings. Others at the hearings stressed that **under-estimating** the fallout danger now may wreak "irreparable havoc" on the human race.¹

3. **The "Threshold" Problem:** Is there a point, or "threshold", below which radiation doses are harmless? Geneticists agree that there is almost certainly **no** such threshold so far as genetic damage is concerned (see below, "Genetic Damage"). This means that, genetically speaking, there is no such thing as a "safe" dosage. The majority of experts at the Holi-field hearings made the same assumption for bone cancer and leukemia—that there is **no** "safe" dosage.²

Present government policy rests on the opposite assumption, that there is a "safe" dosage.³ This assumption was the basis of predictions made in May

1957 by Dr. Frank H. Shelton, technical director of the Armed Forces Special Weapons project. Dr. Shelton said that explosions totalling 30,000 megatons would be required to bring the average amount of strontium-90 in human bones up to the "danger point"; this "danger point," he added, would be 5 to 10 times below that necessary to produce a "barely detectable increase" in the rate of bone cancer or leukemia.⁴

Since only 50 megatons have been exploded in all bomb tests to date, Dr. Shelton obviously meant to minimize fallout danger. His words lose much of their reassuring quality, however, when it is considered that other scientists, including E. B. Lewis, Harrison Brown, Nobel Prize winners Hermann J. Muller and Linus Pauling, and the British Atomic Scientists Association as a group, base their deductions on exactly the opposite assumption — that there is no "safe" dosage, however small.

4. **Percentages or People?**: AEC statements concerning fallout often speak of "negligible", "average" or "barely detectable" effects. The terminology is significant, for it illustrates a tendency on the part of many scientists, including AEC spokesmen, to treat fallout damage in **statistical** rather than personal terms. Similarly, the comparison is often made between risks from fallout and the statistical risks of driving a car or smoking cigarettes, or from natural background radiation.

There are several objections to this way of thinking. In the first place, people are not statistics. To say that fallout will harm only a very small percentage of people, and that this percentage is negligible, is to say that the death of an individual (or several thousand) does not matter since he represents only a very small percentage of the total world population.

Secondly, to compare the risk of fallout to that of, say, smoking cigarettes is fallacious. We may choose to smoke or not to smoke, but we are given little choice in the matter of bomb tests, especially if we happen to live outside the countries conducting the tests.

Third, averages are deceiving because they ignore variation within the average. This point is particularly important with regard to fallout distribution patterns (see below).

To summarize, the man who calls fallout damage "negligible" or "barely detectable" is not so much stating the facts as **interpreting** them in the light of his own values. Harrison Brown has well illustrated this point:

"A person who subscribes to the AEC philosophy might phrase the effect of continued testing upon the incidence of leukemia as follows: 'This effect is so small that it cannot be detected with certainty in death statistics. Clearly the risk is far less than most other risks which we face as payment for our pleasure, our comfort, or our material progress.' Many of us, however, might prefer to phrase the consequences in other terms: 'Continued testing at the present rate may well result in the death each year from leukemia of nearly 10,000 persons who might not otherwise have died.'"⁵

5. **Variations of fallout patterns:** Various claims have been made that bomb tests are harmless because the average increase in radiation to the earth's surface is small. Such claims are misleading, since it is now known that even delayed fallout drifting down from the stratosphere is distributed **unevenly** on the earth. Dr. Lester Machta, director of weather bureau research for the Civil Defense Administration, confirmed this when he told the Holifield subcommittee that delayed radioactive debris is concentrating in the world's north temperate zone, with its heavy population centers.⁶ An AEC report submitted to the subcommittee said fallout in the United States is the highest in the world. And the Radiation Hazards Committee of the Federation of American Scientists stated last year: "It may well be true that **in certain areas of the world**, the strontium-90 hazard may have already passed the danger point, to say nothing of the additional production of this material in further tests."⁷ (our emphasis)

What Do Scientists Agree Upon?

Although there is considerable scientific uncertainty as to the precise effects of fallout, there are also, as has been indicated, several areas of widespread agreement. These may be summarized as follows:

1. **Genetic damage:** The National Academy of Sciences reported in 1956 that "no competent persons" doubt that radiation reaching the reproductive organs causes mutations (abnormalities) of the hereditary genes.⁸ These will be passed on to offspring. Other widely accepted points have been itemized in separate statements by Dr. James F. Crow⁹ of the University of Wisconsin and Dr. A. H. Sturtevant¹⁰ of California Institute of Technology:
 - a. Almost all mutations that have been studied are harmful (Crow and Sturtevant).
 - b. All radiation is harmful, whether natural or man-made. There is no such thing as a "safe" or desirable dose of radiation. (Crow and Sturtevant).

- c. The effects of successive exposures are cumulative (Sturtevant).
- d. The effects are permanent in the descendants receiving the mutant genes. There is no recovery. (Sturtevant)
- e. There is a store of undesirable genes already present in any population. What irradiation does is to add to this store. (Sturtevant)
- f. Slight genetic damage to large populations is in the long run actually more serious than great damage to a small group, since the mutations do not die out as readily and are passed on to great numbers of people for generations. (Crow)

This means that a small amount of radiation received by each of a large number of people can do a great deal of damage to the human race.

2. **Damage to body tissue:** The AEC's Dr. Willard Libby has written that there is no question that excessive dosages of radioactive strontium can cause bone cancer and leukemia in animals;¹¹ biologists generally agree that the same result occurs in human beings. While the number of persons in this generation who will be damaged by increased radiation is "roughly calculable," it is not possible to identify individual cases resulting directly from fallout. We know these cases occur, but they cannot be identified apart from diseases resulting from other causes.¹²

The majority, though not all, of the experts at the Holifield hearings assumed that there was no "safe" dosage of radiation, or no threshold with respect to bone cancer and leukemia.¹³

Some scientists, notably Dr. Hermann J. Muller, Nobel Prize Winning geneticist of Indiana University, believe that radiation in any amount also shortens life expectancy. Dr. Muller's conclusions are given below (see "How Much Harm May Result From Nuclear Tests Already Held?").

3. **Fallout Distribution:** The Holifield hearings brought out general agreement that the danger of fallout is world-wide, but that, contrary to previous AEC assumptions, distribution is not uniform.
4. **Lack of data:** There is unanimous agreement on the need for more information about such things as the nature and effect of strontium and a number of long-range research projects have been initiated.¹⁴

Generally speaking, the entire controversy about fallout effects centers on the question of **degree**: not whether any harm is being done, but **how much** harm is being done, and to whom?

How Much Harm May Result From Nuclear Tests Already Held?

The degree of danger from bomb tests already made is not clear. However, **deductions** have been made as to the numbers of additional cases of leukemia, bone cancer, and genetic damage:

Genetic damage: H. J. Muller, a Nobel Prize winner for his study of the genetic effects of radiation, has said that the number of lives "seriously curtailed or injured throughout the world in future generations as a result of the tests **already held** is in all probability in the hundreds of thousands, or millions."¹⁵ (our emphasis). Dr. Linus Pauling, a Nobel Prize winning chemist, estimated the increase in the number of serious mental and physical defects at 200,000 every generation.¹⁶

Leukemia: Harrison Brown, Professor of Geochemistry at California Institute of Technology, referring to a study by Professor E. B. Lewis¹⁷ showing a direct relation between the dose of radiation and the occurrence of leukemia, states that, "If testing continues at the present rate for the next few decades, the leukemia rate may increase by about 0.5 per cent", or 10,000 individual cases.¹⁸

Bone cancer: The British Atomic Scientists Association estimates that 1,000 persons all over the world will contract bone cancer for every megaton exploded in atomic bomb tests.¹⁹ Since testing nations have to date exploded about 50 megatons, it is probable that, based on the BASA estimates, 50,000 people will die of bone cancer as a result of fallout from past explosions.

It should be stressed that the above deductions are based upon statistical averages. The danger may actually be greater for children. British scientist C. H. Waddington says: "We know that strontium has a greater tendency to settle in their [children's] bones, and we think they are probably more sensitive to the damage it causes."²⁰

AEC Commissioner Libby indicated recently that a small but detectable level of strontium-90 (see glossary) now exists in children's bones.²¹ This is a direct result of atomic explosions, since strontium-90 does not exist in nature.

Shortening of life: Dr. H. J. Muller considers the shortening of the life span "by far the most serious of the long-term effects of radiation on the exposed person himself" (as distinguished from effects on his off-spring). He adds: "There is still some uncertainty about the exact quantity, but not about the principle. No one particular ailment is thereby induced in the exposed group; they are simply made a trifle more susceptible to all causes of death, much as if they had been aged by several days." Any exposure, he states, no matter how small, **exerts some permanent damage.**²²

Is There A "Safe" Level Of Nuclear Testing?

The previous sections of this pamphlet have indicated that all testing involves **some** danger from radioactive fallout. Therefore, if one considers as "safe" the level at which there is **no** risk of radiation damage then there is **no safe level of testing of nuclear weapons**.

The National Academy of Sciences in its summary report on the "Biological Effects of Atomic Radiation" stated that one of the "**major ways to reduce our present and future exposure to radiations would be — to reduce the testing of atomic weapons and hence to reduce radioactive fallout**"²³ (emphasis ours). Thus a determination of a "safe" level of testing would be dependent upon how many defective mutations, cases of bone cancer and leukemia we would be willing to undergo in order to justify the tests. This judgment is basically a moral and political one, rather than scientific.

The AEC plainly justifies continued tests, with **certain** harm to some people, in order to avoid the **possibility** of a **greater catastrophe** resulting from an attack by the Soviet Union. Another alternative — the stopping of nuclear tests as a first step toward international disarmament, thereby avoiding both the fallout harm and war — is not being seriously considered.

Do "Clean" Bombs Reduce The Danger From Nuclear Testing?

"Almost without realizing it, we are adopting the language of madmen. We talk of 'clean' hydrogen bombs, as though we are dealing with the ultimate in moral refinement. We use fairyland words to describe a mechanism that in a split second can incinerate millions of human beings — not dummies or imitations but real people, exactly the kind that you see around your dinner table. What kind of monstrous imagination is it that can connect the word 'clean' to a device that will put the match to man's cities?" Norman Cousins.²⁴

Nothing has so far been revealed officially as to the difference between a "clean" and a "dirty" hydrogen bomb. However, the statement of Dr. Edward Teller, often called the father of the H-bomb, that the attainment of a "**virtually clean bomb**" was still in the state of a "high hope"²⁵ would indicate that a "clean" bomb is years from realization. (our emphasis) The term "clean" bomb is apparently meant to describe a hydrogen bomb with **relatively** little radioactive fallout, but a bomb that can still kill millions of people and level their cities.

The talk of "clean" bombs has obscured the important question concerning nuclear testing. More than 50 scientists attached to the Los Alamos chapter of the Federation of American scientists, in a statement to the President, pointed out that the paramount objective is world peace.

"The choice which faces us now is not so much between 'clean' and 'dirty' bombs, but rather between a world in which war and, therefore, nuclear bombing will occur, and a world in which we shall be free of their scourge."²⁶

Reassuring statements about the "clean" bomb should not lead us into thinking that we are now safe from radiation danger. How much radiation fallout is produced from the bombs we are now testing? If the "virtually clean bomb" is still years off, how much radiation would be created by the testing necessary to develop such a "clean" bomb? These questions remain unanswered. But, there continue to be reports of radioactivity after each explosion in the current series of Nevada tests. The 1957 tests are more numerous and (in some cases) involve large "dirty" bombs.

Moreover, there are reports that the current tests are in part to measure the amount and duration of radioactivity from given sized bombs. And what about the Russians? And the British? And other nations which may start testing? Will their bombs be "clean"?

It has been claimed that the development of an absolutely clean hydrogen (fusion) bomb is necessary for the peacetime development of this type of atomic energy. On the face of it, this claim seems fallacious. It would appear that the best way to develop a nuclear reactor utilizing hydrogen energy would be to work **directly** on it rather than on a hydrogen bomb, even though a similar physical principle may be used for both. But even if this claim is true, why the rush to perfect a hydrogen reactor — especially at the cost of unlimited bomb tests? Would anyone seriously object if man were given a breathing spell to allow some of his outmoded political institutions to catch up with his scientific inventions?

"To call the H-bomb clean
Makes sound and sense divergent
Unless it's meant to mean
The Ultimate Detergent"

Punch

Is The Degree Of Risk Strictly A Scientific Question?

No. As we have said, both moral and political questions are involved, and the three aspects — scientific, moral, and political — must all be considered.

But the moral and political questions have been clouded by the emphasis on the scientific aspect in the current nuclear debate. We often think that the conclusions reached by scientists are based on their scientific findings **alone**.

When a scientist tells us that radiation can cause genetic mutations which in turn can lead to defects in individuals carrying the mutations, he is exercising (if a geneticist) his **scientific** judgment born of training and experience. He may also make estimates as to the number of such mutations, given a certain dosage of radiation, to the world's population. But when a scientist states that these mutations are "small" or "negligible", is making a judgment as to the relative value of human life. Here he moves from the scientific realm into the moral. Moreover, when he balances a possible risk from radiation against his evaluation of the need for continued testing, he is clearly making a political judgment.

Thus, we must not let the confusion of the scientific debate lead us to abandon our responsibility to make political and moral judgments on issues affecting our own lives and those of the human family all over the world.

II. BOMB TESTS AND THE ARMS RACE

Do Armaments "Prevent War"?

History provides no proof that armaments prevent war.

Reliance on nuclear weapons is increasing. The U.S. has now switched seven divisions to primary reliance on tactical, "small" atomic weapons and is converting other divisions presumably at an accelerating rate.²⁷ There is no doubt that the Soviet Union is doing the same.

We should question this reliance on nuclear weapons to prevent war. Today, events sliding out of control are more likely to be the cause of a general war than is a planned attack. Nuclear war might not be started deliberately, but might grow from a "brush fire" war in which one side resorts to nuclear weapons. The assumption that nations actually fear to use these weapons because of the devastating effects on their own country may also prompt diplomatic gambling followed by attempts to "call the bluff" until some power is goaded into acting — and starting a war.

Hans J. Morgenthau, director of the Center for Study of American Foreign Policy at the University of Chicago, states that the mechanics of mutual deterrence raise a most serious political dilemma: "No nation can afford to yield to a threat of all-out atomic war that is only a bluff; nor can it afford to stand up to a threat that turns out not to be a bluff."²⁸

The simple truth is that, even granted a temporary stalemate, there is no permanent peace in an arms race, nuclear or otherwise.

What Would Be The Destruction From A Nuclear War?

Here we find almost unanimous agrément among scientific, military and political spokesmen.

Major General Gavin: 110 super-bombs dropped on the U.S. would kill or maim 70 million persons and several hundred million more would die from the radioactive fallout, somewhere in the world, depending on which way the wind blew.²⁹

AEC Commissioner Libby: Radioactive fallout from a nuclear super-bomb could blanket an area as big as 100,000 square miles under windy conditions . . . and kill 85% of those living within 12 miles of target zero.³⁰

Civil Defense meteorologist Charles Schafer: If Russia hit 144 American population centers with 250 bombs, each with a power of 10,000,000 tons of TNT [less than 2/3 the force of the bomb exploded on Bikini in 1954] 82,000,000 American lives would be lost.³¹

President Eisenhower: There will be no such thing as a victorious side in any global war of the future.³²

Would "Cleaner" Bombs Change The Nature Of Nuclear War?

There is much talk about "limited war" employing "tactical", "small" and "clean" nuclear weapons. History gives little indication that military tacticians ever use weapons of less than full destructive capacity in the fury of warfare. The United States did not hesitate to use the then awesome atomic bomb in the 1945 invasion of Japan.

Peacetime testing and wartime use of nuclear weapons are two distinctly different things. The waging of warfare is basically an irrational act. It is brought about by the failure of men to arrive at rational agreement. And when agreement on arms limitation fails during peacetime, it is even more logical to conclude that there will be no limitation on the use of arms during wartime.

According to Newsweek of July 15, 1957:

"To many high officials . . . and especially to the Air Force, the idea of limiting a nuclear war seems preposterous. 'One side fires off atomic artillery,' says one top officer, 'and the other side comes back with a small clean A-bomb. Then the first one drops a bigger, dirty bomb, then it's H-bombs on supply depots in the rear areas, and soon both sides are dropping everything they have on factories and big cities.' . . . And Gen. Lauris Norstad says 'it would be extremely difficult to limit the use of atomic weapons. There would be a very rapid tendency for things to get bigger rapidly

... I believe that if you have an incident the assumption must be that great power will be used.' ”³³

Also, the clean bomb, looked at in the light of the foregoing, **increases** the probability that nuclear weapons will be used in a future war. It contains less fallout; therefore, it is less likely to harm the aggressor as well as the victim. Thus, this kind of bomb becomes less unthinkable to a desperate nation. **By this very fact it makes disarmament all the more imperative.** For to a small degree that deterrent of “mutual terror” is lessened by the “clean” bomb.

War was never “clean”.

What Happens When The Ballistic Missile Carrying A Hydrogen Bomb Is Perfected?

The H-bomb is now being married to the intercontinental ballistic missile (ICBM) which could streak through the air at speeds up to 16,000 miles an hour and at heights up to 600 miles. It would be able to span oceans and plummet down continents away to grind large cities to dust.

Military experts argue that further nuclear testing is necessary at least for the **rapid** wedding of ICBM's and hydrogen warheads: we must keep ahead of the enemy in weapons development.

To arguments of this type, the **London Times** comments: “If agreement has to wait on the last invention, there will be no agreement. Someone is always on the brink of discovering something.”³⁴

And if we permit its development which may be just around the corner, another terror-point lies just beyond when a 5th or 6th or 10th nation has the bomb and the missile. If this point is reached, what then? If all nations are testing, and the ground is honey-combed with hidden rocket-launching sites which cannot be certainly detected, it may then be impossible for all the good faith in the world on the part of 99% of humanity to gain assurance that 1% is not prepared to bring the whole world down about our heads.

An international agreement **could** be monitored **now**. And an international ban on nuclear testing could halt or seriously slow down the development of these missiles while they are still in the experimental stage.

How Long Will It Be Before Other Nations Start Testing Nuclear Weapons?

The U.S., Soviet Union, and Great Britain are now testing nuclear weapons. France will soon start. All European countries are actively pursuing atomic energy development. Brazil and India are not far behind them. Missiles with war-

heads were assured England and France by the U.S. at the Bermuda Conference in March 1957.³⁵ West Germany has requested assurances of atomic arms within the next 16 months.³⁶

Increasingly inexpensive processes of producing nuclear fission have been developed. The possibility that some nation may trigger a war with nuclear bombs increases. One way to control use of nuclear weapons is, first of all, to control testing; without testing, such implements cannot be perfected.

In short, as many countries come to have nuclear weapons, the problems of effective control increase at an accelerated rate. Time is not on our side.

Do We Have To "Trust Russia" To Keep An Agreement To Stop Nuclear Tests?

Any agreement between men and nations must rely somewhat on mutual trust, but not entirely: the ability to check on the stopping of nuclear tests decreases the need to rely on faith.

Our instruments now detect tests all over the world. In 1949, the Atomic Energy Commission reported detecting the first Soviet A-bomb test, "Joe I", which was nearly a thousand times smaller than our H-bomb test of March, 1954. Japanese scientists regularly detect our Nevada tests on their instruments.

An additional safeguard, according to President Eisenhower, would include "as a general first step toward disarmament . . . the necessary inspectional system to make certain that the whole scheme was being carried out faithfully on both sides . . ." ³⁷ Russia has proposed such a system for the test ban, and general agreement has been reached for both air and ground inspection.

What Can Individual Citizens And Members Of Organizations Do . . .

- to stop testing of nuclear weapons by all countries?
- to stop manufacturing and stockpiling by all countries?
- to prevent the use of stockpiles we already have?
- to prevent the development of intercontinental missiles with hydrogen warheads?
- and
- to encourage the first necessary steps toward universal, enforceable disarmament?

Policies are made by our President, his cabinet, and our Congressmen and United Nations representatives. Action stemming from these policies is taken in our name. Changes are often a reflection of the attitudes of the people. Our elected officials need to know that we want an end to nuclear bomb tests and guided missiles and a beginning toward security through disarmament. Wars are man-made. We can do something to prevent them.

Here Are Some Practical Suggestions For Busy People . . .

Select just one of these projects — and do it well!

- 1) Think of three or four likely prospects in your neighborhood. Give them a copy of this pamphlet. Then get together and draft a joint letter — or each write one to one or more of those listed below. Raise questions — ask what your representative is doing to find the answers.

. . . President Dwight D. Eisenhower
White House, Washington, D. C.

. . . your Representative or Senator
House or Senate Office Building, Washington, D. C. (if you don't know your Congressman's name call your local Registrar of Voters, tell him where you live)

. . . UN delegates Henry Cabot Lodge, Paul G. Hoffman, and Senators William F. Knowland and Hubert Humphrey.

- 2) Ask your Congressman when he's to be home next. Then make your letter writing group the nucleus, add 6-8 more, and plan a meeting to discuss these issues with him in person. It takes planning and preparation, but is a most rewarding experience.
- 3) Bring the facts before your organizations — service clubs, church social action committee, trade union. Ask your officers to plan a discussion.
- 4) Urge your organization to pass a resolution and forward it to the President, Congress and the U.N. officials. Circulate this to other branches or chapters in other towns.
- 5) Order more copies of this booklet from:

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Glossary Of Technical Terms

Fallout: Particles of matter (fission products, atomized rocks, building material, etc.) created or made radioactive by nuclear explosions. When an A or H-bomb is exploded close to the

ground thousands of tons of this matter are sucked upward to help form the mushroom cloud. These dust particles, coated with radioactive material and the fission products, drift down to earth in various stages. This is called fallout.

Fission: The act of splitting into parts; the nuclear process whereby the nucleus of an atom is split. When atoms of uranium split in the A or H-bomb explosion they release radioactive particles.

Fusion: A melting together; the nuclear process whereby nuclei of atoms are combined releasing energy. A temperature in the neighborhood of 100 million degrees is necessary to get the atoms to fuse. Although there is radioactivity created in the fusion process, relatively few long-lived radioactive elements are produced.

Genes: The hereditary material passed on from parent to offspring. Basis of the word "genetic."

Kiloton: When applied to an atomic bomb it means the explosive power equal to 1,000 tons of TNT.

Megaton: In atomic bombs it means the equivalent of In atomic bombs it means the explosive power equal to 1,000,000 tons of TNT.

Mutation: The change in the hereditary material (genes) passed on from parent to offspring. It is almost always a detrimental change and may cause defects through all generations carrying it. A mutation only dies out when the entire line of persons carrying the defect dies out.

Radioactivity: The process whereby atoms decay and emit radiation.

Strontium-90: A radioactive element produced as a product of the decay of certain products of fission. It has a half-life of about 28 years. It is dangerous because it can substitute for calcium and hence can be absorbed into the bones in place of its "twin", calcium, where it can cause radiation damage during its lifetime.

Strontium is absorbed by plants and can be taken into the body as food.

FOOTNOTES

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3. "Facts About Fallout," cited above.
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5. Harrison Brown, "What Is a Small Risk?" *Saturday Review* (May 25, 1957).
6. "Russ Attack Could Kill 82 Million," *San Francisco Chronicle*, (May 29, 1957)
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8. National Academy of Sciences, *The Biological Effects of Atomic Radiation*, Summary Reports, 1956, p. 29-30.
9. Friends Committee on National Legislation, "Fallout Hearings," *Washington Newsletter*, No. 166 (July 1957), p. 2.
10. A. H. Sturtevant, member of the National Academy of Sciences Committee on the Genetic Effects of Atomic Radiation, before the Holifield subcommittee (June 1957).
11. Willard Libby, "An Open Letter to Dr. Schweitzer," *Saturday Review* (May 25, 1957).
12. "Facts About Fallout," cited above, p. 16.
13. "Facts About Fallout," cited above, p. 16.
14. Warren Unna, "Fallout 'Showdown' Ends in Puzzle," *Washington Post*, (June 16, 1957).
15. Warren Unna, cited above.
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17. E. B. Lewis, "Leukemia and Ionizing Radiation," *Science* (May 17, 1957), p. 965-972.
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