determinable either in terms of medicines or in terms of observations. Hence it is a matter for the jurisprudence of modern times to determine, despite the fact that there is an absence of precedent in this matter,and to apply the traditional concepts of law and jurisprudence, in view of the fact that there is such a determination of the physical effects which are the results of biological mutation which have been proven scientifically to be inevitable as a result and the consequence of nuclear tests. Therefore, I submit for your consideration that we take a dynamic view of the legal consequences of this mutation on the biological effects of nuclear tests, particularly when we discover that these effects are no more determinable, not only in terms of nuclear tests, but also because we find to-day that the testing of basic strategic weapons is so comprehensive, so diversifying that we cannot any longer pinpoint one type of nuclear weapon only which has become known to us as it is no more scientifically proven that all nuclear weapons which have to be tested are indentical. We observe today, in the development of strategic weapons, a large measure of diversification, a large measure of testing of new weapons and new scientific discoveries, and therefore in the same manner as mutations are unforseeable but inevitable, by the same token we find the efforts on the part of various nations, particularly the big nations of the world, to contribute to the scientific discovery, by breaking-through into new kinds of thermonuclear weapons and it is this break-through which we cannot foresee nor even the scientists can foresee the consequences of this break-through into new horizons of scientific and technological discovery. That it has become very self-evident for us, particularly in Asia and Africa, to realise that the break-through which is unforeseen in terms of technological advance, in terms of nuclear weapons, a certain degree of test ban should be immediately imposed and all our political as well as diplomatic efforts should be mobilised in this direction. But what is even more important is the fact that each of the nuclear powers in the world considers it a preemptive advantage on its part to regard this as a suspicion of preparation for war and this is where the testing of nuclear weapons and new weapons becomes a very dangerous factor. The suspicion of preparation for war is no longer a suspicion, but a cause of war itself, and therfore both sides consider the vulnerability of either of their sides in terms of retaliatory forces to an attack by either side. Therefore it is important for us to realise, as the distinguished Representative of the United

Nations has just said, that we in terms of jurisprudence should acquire a more dynamic concept and realise that nuclear weapons and the new break-through into thermological advances in terms of destructive weapons have introduced a new dimension which should have its impact and should stimulate a new dimension in jurisprudence itself. Perhaps the Afro-Asian jurists, in particular, are in a position to extricate themselves into that position of neutrality, if we might say, or impartiality, and to provide the break-through not in terms of technological destructive weapons, but the break-through in terms of providing international law and jurisprudence a new dimension, which would take into consideration not only the hopes and aspirations and moral considerations that are pertinent and relevant to our very survival, but will take into consideration the necessity of reflecting new political and physical and biological considerations in terms of references which would be applicable to our new jurisprudence and legal precedent.

As the President, formulating the issues involved in this discussion, made it very clear in his last formulation, namely, "Can we not apply the accepted principles of civilised jurisprudence?" I am sure that the President, as well as many of us, consider the terms "civilised" as operative because the term "civilised" is a dynamic concept. Civilizations, of course, take into consideration the great heritage of mankind, the great contributions of the past, the great precedents in terms of jurisprudence that have been established and proven relevant and valid. But the term "civilized" must be accommodating for the new forces and the new factors that have been introduced as a static concept of civilization can be ultimately a negation of civilization. Therefore we are confident that, particularly in this Committee, it is necessary not only to accept the straight jacket of precedents, however important precedents are, but to bring about a formulation which would take into consideration the new factors, and that these new factors would constitute a new dimension in terms of modern and contemporary jurisprudence.

Therefore, I submit to you that it may be *a priori* on our part to state that nuclear tests are illegal in all phases. Of course, we must have a certain commitment to the tenets of jurisprudence and we must prove this and we can only prove it by the application of the rules of law, and these rules of law must take into considera-

tion the new factors that have been introduced. We in the Arab States and all the Arab Governments look forward to the proceedings in this field because we consider that your conclusions in this line not only will help provide new factors and new interpretations in jurisprudence, but will also help the efforts of mankind not only towards its survival but towards its purposes in existence and being.

Observer from Ghana:- Ghana's position on the question of nuclear tests has been quite clear. My President has made it clear in no uncertain terms that Ghana is completely opposed to nuclear tests in the Continent of Africa or in any other part of the world. The Distinguished Delegate from U.A.R. was right in stating that my country became a victim to the effect of French nuclear tests in the Sahara not so long ago. That these tests must of necessity be ceased cannot be overemphasised and I wish to take this opportunity of reiterating our *status quo ante* to the effect that this Committee, this year, take perhaps a more definite step in initiating some sort of international legislation to stop these nuclear tests. In conclusion, I wish to associate myself with the answers given by the majority of Delegates to the questionnaire before the Committee.

V. A STUDY ON THE LEGALITY OF NUCLEAR TESTS

(Prepared by the Secretariat of the Committee)

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INTRODUCTION

Object & plan of study

The object of this Study is to examine the question of legality of nuclear tests in time of peace. It is estimated that over three hundred atmospheric or surface tests have been carried out in various parts of the world. About one hundred and seventy atmospheric tests have been carried out by the United States, and the Soviet Union has carried out about one hundred and twenty atmospheric tests. The United Kingdom and France have also carried out some tests. The majority of these tests have been carried out in or near the Asian-African region and Asian-African States are therefore the countries most directly concerned with the question. The United States has used the Marshall Islands, Johnston Island and Christmas Island in the Pacific Ocean as the main sites for the testing of nuclear weapons, and some of these tests have had harmful effects on the people and territory of Japan. The Soviet Union has tested its nuclear weapons in Central Asia and Siberia, and the United Kingdom has carried out its nuclear tests in the Monte Bello Islands and in Australia. France has tested its nuclear weapons in the African Sahara and some of these tests have had harmful effects on neighbouring African States. The testing of nuclear weapons is therefore a matter of common concern among Asian African countries and the Asian-African Legal Consultative Committee has decided to give this subject top priority.

It will be observed that the subject under consideration is the legality of nuclear tests in time of peace and the Report of the Secretariat therefore confines itself to this question and does not deal with the question of the legality of the use of nuclear weapons in time of war. In order to examine the question of legality of nuclear tests, it is first necessary to study the effects of nuclear tests as the various legal questions on this subject would only arise if the effects are found to be harmful to the health and well-being of the peoples of the world. The scientific information on the effects of nuclear tests contained in Chapter I of this Report is essentially a summary of the information contained in the Reports of the United Nations Scientific Committee on the 'Effects of Atomic Radiation', the Reports of the British Medical Research

Council on the 'Hazards to Man of Nuclear and Allied Radiations' and Reports of Japanese Scientists on the 'Effects and Influences of the Nuclear Bomb Test Explosions'. Chapter II of the Study deals with the application of the principles of State responsibility and tortious liability to the problem of nuclear tests in order to determine whether the carrying out of nuclear tests amounts to the commission of an international tort and whether there is State responsibility for the damage caused by such tests. Chapter III of the Study consist of an examination of the question of the compatibility of nuclear tests on the high seas in time of peace with the principle of the freedom of the seas, in order to ascertain whether such tests interfere with freedom of navigation and freedom of fishing on the high seas and thus violate fundamental rule of customary international law. The Study concludes with an examination of the partial nuclear test ban treaty entered into by the United States, Britain and the Soviet Union.

CHAPTER I

The Effects of Nuclear Weapons

In order to examine the question of legality of nuclear tests, it is first necessary to study the effects of nuclear explosions and the damage that the nuclear tests have already caused. It is, therefore, necessary to commence with an examination of the relevant scientific data regarding the effects of nuclear explosions. While the technology of nuclear weapons is exceedingly complicated, the basic scientific facts regarding the effects of the explosions are now clear and can be stated for the present purpose in a very brief compass. These basic scientific facts have implications which bear directly on the problems confronting world statesmen today and have given rise to questions with which international law must concern itself.

Over three hundred nuclear tests carried out

It is estimated that over three hundred atmospheric or surface tests have been carried out in various parts of the world. The first nuclear test was carried out by the United States in Alamogordo, U.S.A., in July 1945 when a fission bomb was exploded for experimental purposes. In August 1945, two fission bombs were dropped by the United States on Hiroshima and Nagasaki in Japan. In June and July 1946, the United States carried out two nuclear tests in Bikini Atoll. In March and April 1948, three fission bombs were exploded by the United States in Eniwetok. In 1949, the Soviet Union is reported to have carried out its first nuclear tests, within its own territory. In January and February 1951, the United States exploded several fission bombs in its own territory in Nevada. In the spring of 1951, the United States exploded four fission bombs in Eniwetok. In September and October 1951, the Soviet Union exploded two fission bombs within its own territory. In October and November 1951, several nuclear tests were carried out by the United States in Nevada. From February to April 1952, the United States exploded eight fission bombs in Nevada. In October 1952, the United Kingdom carried out its first nuclear tests in the Monte Bello Islands. In November 1952, the United States exploded several fission bombs in Eniwetok. In March 1953, the United States exploded eleven

fission bombs in Nevada. In August 1953, the Soviet Union exploded several fission bombs within its own territory. In October 1953, the United Kingdom carried out several tests of fission bombs in Woomera, in South Australia. In March and April 1954, the United States exploded several hydrogen bombs in Bikini and Eniwetok in the Pacific Ocean. In September and October 1954, the Soviet Union exploded a number of hydrogen bombs in its own territory. From February to May 1955, the United States carried out several nuclear tests in Nevada. In August and November 1955, the Soviet Union exploded several fission and hydrogen bombs within the U.S.S.R. In April 1956, the United Kingdom carried out a test of fission bomb in the Monte Bello Islands. From October to November 1956, the United Kingdom tested several fission bombs in Maralinga, South Australia. In 1956, 1957 and 1958 the United States and the Soviet Union continued testing nuclear weapons within their own territories until the nuclear test ban conference commenced in Geneva in November 1958.

France carried out her first nuclear test on 13th February 1960 in the Sahara. Nuclear tests were carried out by France again on 1st April 1960, 27th December 1960 and 25th April 1961 in the Sahara. During the years 1959 and 1960, no nuclear tests were carried out by either the Soviet Union or the United States. On 30th August 1961, the Government of the Soviet Union announced that it was going to resume the testing of nuclear weapons and this announcement was immediately followed by a series of nuclear tests which was carried out in Central Asia and the Soviet Arctic. The first Soviet test in the new series was carried out on 31st August 1961, and on 23rd October 1961 the Soviet Union exploded a 50-megaton bomb in the Arctic island of Novoya Zemlya. The Soviet Union continued to carry out further atmospheric tests in various parts of its territory for several months. According to an announcement of the United States Atomic Energy Commission made on 25th September 1963, it has been estimated that the Soviet Union has carried out about 121 atmospheric or surface tests since the first nuclear weapon was tested in Soviet territory in 1949. No information is available regarding Soviet underground tests. On 2nd March 1962, the President of the United States announced that the United States would resume

nuclear tests in the Pacific Ocean regions, and the first nuclear test was carried out on 25th April 1962 in the vicinity of Christmas Island. This was followed by a series of nuclear tests which were carried out in the vicinity of Johnston and Christmas Islands for several months. In a statement issued on 25th September 1963, the United States Atomic Energy Commission announced that since the United States first began testing nuclear weapons, she has carried out altogether about 170 atmospheric or surface tests, 10 tests at altitudes over 100,000 feet, some of them actually in outer space, and 6 underwater tests. Apart from these it is estimated that the United States has carried out about 105 explosions underground.

The test explosions which have taken place in America, in Russia, in North Africa and in the Pacific Ocean are equivalent, in the aggregate, to more than 5,000 bombs of the type that fell on Hiroshima. Each atmospheric test has added its quota of radioactive material to the land, the sea and the air. The general contamination of the world with radioactive substances will multiply as the years go by if more bombs are exploded and the harm this will do and is capable of doing is already evident from the materials already published. Scientific data is now available regarding the effects of the atmoic bombs dropped by the United States over Hiroshima and Nagasaki and regarding the effects of the nuclear tests carried out by the United States in the Pacific Ocean. Some information is also available with regard to the effects of the nuclear tests carried out by France in North Africa. There is, however, very little accurate information available with regard to the effects of the nuclear tests carried out by the Soviet Union as these tests were often carried out in complete secrecy. There is however no reason to believe in the absence of evidence to the contrary that the effect of nuclear tests carried out by the Soviet Union would be any different from the test explosions carried out by other powers. The scientific data available on the effects of nuclear explosions carried out by the United States gives us an indication of the harm caused by such explosions and at any rate of the harm the tests are capable of causing. It would, therefore, be reasonable to proceed on the basis of such scientific evidence in examining the question of legality of nuclear tests from the point of view of international law.

The effects of the atomic bombs dropped on Hiroshima and Nagasaki

So much has been written of the effects of the two atomic bombs dropped on Hiroshima and Nagasaki in August 1945, that it is only necessary here to survey briefly the main facts. The first atomic bomb to be used in time of war was exploded at 8.15 a.m. on the morning of 6th August 1945 over Hiroshima. The effect was catastrophic. The communique issued by the General Commanding the U.S. Strategic Air Forces in the Pacific stated that the reconnaissance photographs showed that "the heart of the city had been wiped out with such awful thoroughness that it was as though some giant bulldozer had swept across the buildings and houses. The photographs showed that four and one-tenth square miles of the city's built up area of six and nineteenth square miles were completely destroyed by the atom bombing mission." When Western correspondents entered Hiroshima at the beginning of September, they found the city obliterated and desolated. On 5th September 1945, the London *Daily Telegraph* correspondent described the scene thus:

> "Only the vultures live now in Hiroshima, first city in the world to be atom-bombed. Today I drove in to this town, the most destroyed town in the whole of the war. Today, nearly a month after the first atom bomb fell, the stench of death was terrible—worse than the stench of the battlefields in Normandy. It was as if all the bombed towns in the world had had their devastated areas lifted out and all had been placed together here..... I stood in what was the exact centre of Hiroshima and looked around slowly in a circle. There was absolutely nothing for two miles in any direction."

On 5th September 1945, the London *Daily Express* correspondent also described the horror and devastation in the following words.

> "Hiroshima does not look like a bombed city. It looks as if a monster steamroller has passed over it and smashed it out of existence. In this first testing ground of the atomic bomb, I have seen the most terrible and frightening desolation in four years of war. It makes a blitzed Pacific island seem like an Eden. The damage is far greater than photographs can show. When you arrive in Hiroshima you look around and for 25 and 30 square miles yousn ac eehardly a building. It gives you an empty feeling in the stomach to see such man-made devastation.... In Hiroshima, 30 days after the first atomic bomb destroyed the city and shook the world, people are still dying, mysteriously and horribly—people who were uninjured in the cataclysm—from an unknwon something which I can only describe as the atomic plague. Many people had suffered only a slight cut from a falling splinter of brick or steel. They should have recovered quickly. But they did not. They developed an acute sickness. Their gums began to bleed. And then they vomitted blood. And finally they died."

A second atomic bomb was dropped on 9th August 1945 on Nagasaki. The results were again cataclysmic, one third of the city being destroyed. The plutonium bomb used at Nagasaki had a 15 per cent greater radius of destruction than the Uranium 235 bomb used at Hiroshima. At Hiroshima approximately 80,000 people, one quarter of the population, were killed, and at Nagasaki approximately, 40,000 people or one-sixth of the population were killed. The lower casualties at the latter city were due to the uneven terrain which shielded parts of the city from the effects of the bomb. At Hiroshima 4.7 square miles of the city were destroyed and at Nagasaki 1.8 square miles of the city were destroyed. The mortality rate per square mile destroyed in Hiroshima was 15,000 people, and 20,000 people per square mile destroyed in Nagasaki. Both at Hiroshima and Nagasaki the scale of the disaster brought city life and industry virtually to a standstill.[1].

The technical effects of the explosion when the atomic bomb was dropped on Hiroshima are described in the following passage of the Summary Report of the United States Stragetic Bombing Survey on the Pacific War:

> "At the time of the explosion, energy was given off in the forms of light, heat, radiation, and pressure. The complete band of radiations, from X and gamma rays, through ultra-violet and light rays to the radiant heat of infra-red rays, travelled with the speed of light.

1. *The Effects of the Atomic Bomb at Hiroshima and Nagasaki* — Report of the British Mission to Japan, 1946.

The shock wave, created by the enormous pressure, built up almost instantaneously at the point of the explosion but moved out more slowly, that is at the speed of sound. The superheated gases constituting the original fire-ball expanded outwards and upward at a slower rate.... The duration of the flash was only a fraction of a second but it was sufficiently intense to cause third degree burns to exposed skin upto a distance of one mile.... In the immediate area of ground zero (the point on the ground below the explosion), the heat charred corpses beyond recognition."

It is estimated that the temperature at the core of an atom bomb at the moment of the explosion is about one million degrees and the shock waves produced by escape of the compressed gases cause severe damage and destroy everything they encounter.[2] The explosive energy released by a nuclear weapon equivalent nominally to 20 million tons of T.N.T. is 8.4×10^{22} ergs. In comparison, the total energy release in recorded earth-quakes varies from 10^{22} ergs for a slight local tremor to 10^{26} ergs for a catastrophic earth movement. A blast wave is propagated through the air from the centre of the explosion of such a bomb. The radius of complete destruction would be at least five miles, that of severe damage at least eight miles and of partial damage at least eighteen miles. These figures will vary with the size of the bomb, being proportional to the cube root of the explosive power. It is estimated that the 20-megaton bomb, now possessed by the United States, would have 1,000 times the nominal explosive power of the bomb that devastated Hiroshima. The propagation of the blast wave through the atmosphere enables the occurrence of an explosion of a nuclear weapon to be detected from a distance of many hundred miles if the bomb explodes in the air. If the bomb is exploded underground in a cavern, a great deal of energy will be propagated as an earthquake shock wave through the ground, so that with an energy release of the order quoted above such an explosion underground is hardly likely to escape detection.

2. For scientific of the surveys effects of the atomic bombs refer *"The Effects of the Atomic Bombs at Hiroshima and Nagasaki."* Report of the British Mission to Japan, 1946; *The Effects of the Atomic Weapons*, United States Atomic Energy Commission, 1950.

The extreme temperature attained gives rise to an enormous radiation of heat and energy at the instant of the explosion. The instant heat flash persists for about twenty seconds, and fires and burns of exposed skin might be expected at a distance of twenty miles. The distance at which such effects are to be expected is proportional to the square root of the size of the bomb. An intense radiation of gamma radiation occurs for a minute during the explosion. However, the radiation is rapidly absorbed by the intervening air and at a radius of two miles would be reduced to 400 roentgens. Beyond a radius of four miles no immediate harmful effects are to be expected. Intense neutron radiations given off the same time will be less hazardous.

Local and global radioactive fall-out from nuclear test explosions

With regard to explosions in the megaton range, the most far-reaching hazard comes from the fall-out of radioactive fission products produced in the explosion. Indeed, in the case of test explosions carried out by the various powers, in view of the precautions that are taken to prevent casualties in the neighbourhood of the explosion, the fall-out constitutes perhaps the main hazard that requires serious consideration. The fall-out also provides a very sensitive method of detecting the occurrence of nuclear weapon test explosions from a great distance. It is reported that fall-out from the Soviet tests carried out in the atmosphere was detected over Japan and India[4].

If a nuclear weapon is exploded at low altitudes, the central mass of hot gases, the fire-ball, which may have a diameter of three miles or so, may reach to the ground. The intense heat produces a huge crater and as much as 10-100 millions tons of earth and rock may be vaporized and drawn up through the intensely radioactive cloud. The dust, when it condenses out from the vapour, will itself be intensely radioactive. The dust will be drawn up to a height of perhaps 30,000 or 40,000 feet. Then it will begin gradually to fall towards the ground again. As it falls

3. For accounts of the effects of nuclear weapons, refer *Nuclear Explosions and Their Effects*, Government of India Publication, 1956.
4. On fall-out from nuclear tests, refer, *Contamination of the World by Fall-Out from Nuclear Test Explosion*, 1957, St. Paul's University, Tokyo, Japan.

slowly, it will be drawn by the prevailing winds far from the point of the explosion. The larger dust particles may be drawn along by the wind for hundreds of miles before they fall out. A particle of dust of about 1/10 milli-metre in diameter will fall from 40,000 feet in about four hours, while a particle 1./100 milli-metre in diameter will take about two weeks to fall the same distance. The relative size of the particles of the fall-out will depend on the type of the surface that comes into contact with the fire-ball.

When a nuclear bomb is exploded under fixed conditions, the danger area due to local fall-out radiation would be expected to be approximately proportional to the amount of fissionable material contained in the bomb. The local fall-out consists mainly of short-lived fission products—Molybdenum 99, Tellurium 32, Iodine 131, Barium 140, Praesodymium 143 and Cerium 143.

If the bomb is exploded so high that the fire-ball does not strike the ground, the radioactive fission products will not condense on dust particles to anything like the same extent. They will be drawn to much higher altitudes, perhaps to 100,000 feet, and will gradually spread out over a large part of the world. They will settle down slowly, sometimes become attached to water drops and reaching the ground with rain and snow. Even when the fire-ball does touch the ground, a certain proportion of the fission products will go to great altitudes and contribute to the global fall-out.

The global fall-out may persist for about ten years after the explosion of a nuclear weapon, about 10 per cent falling out each year. This means that the global fall-out will consist almost exclusively of the long-lived fission products such as Strontium 90 and Caesium 137. In this respect if differs markedly from the local fall-out in which the greater part of the activity is contributed by short-and-medium-life fission product.[5]

It has been estimated that each of the thermo-nuclear weapons tested by the United States has yielded an amount of radioactive materials many hundreds of times greater than that from the ordinary atom bomb exploded in Hiroshima. A careful examination of the fall-out produced in one of these explosions has established that the main explosive force must have come from the fission of uranium 238. It is now believed that the large bombs so far tested have been the "three-decks" bombs consisting of a thermonuclear bomb surrounded by a shell of ordinary uranium. It has been suggested that it may eventually be possible to produce a hydrogen bomb completely free of fission products and thence a truly "clean" bomb. There is no evidence, however, that such a means of detonation has as yet been achieved. President Eisenhower of the United States stated in June 1957 that he had been assured by three of his scientific advisers that it might be possible to produce an absolutely "clean" bomb, after four or five more years of nuclear tests. On the other hand, other American scientists do not consider that it is possible to make clean bombs which release no radioactivity. Confirmation of this point of view is given by the report in the Journal *Science* (1957) that during explosion of even the 'cleanest' bomb part of the non-radioactive material of the bomb will pick up neutrons and be converted into manganese 54 carrying millions of curies of radioactivity. In any case, it appears that the search for a clean bomb will involve even the United States in four or five more years of tests during which bombs producing radioactivity will be tested. The testing of nuclear weapons has already significantly and irrevocably increased the background radioactivity in the world, in the same way as would an all out nuclear war, though to a lesser extent. Each test of nuclear weapon has so far added its quota of radio-active material to the land, the sea and the air. The tests carried out in the underground may minimise the risk of fall-out but what their other effects will be have yet to be seen.

5. Refer *The Long Range Fall-out from Nuclear Tests Explosions*, Medical Research Council, London.

In the foregoing pages it has been clearly shown that radio-active material carried into the atmosphere settles back on the earth as fall-out and that this is the most serious hazard to be faced after a nuclear explosion. It is now proposed to give a brief out-line of the ways in which such atomic radiations affect living crea-tures and to indicate what is now known about the hazards which may arise from the explosion of nuclear weapons. The chief sources of information which will be used are the Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation and the Reports of the British Medical Research Council on the Hazards to Man of Nuclear and Allied Radiations.

The effects of atomic radiation

Atomic radiations, more correctly called ionizing radiations, arise when radioactive atoms distintegrate and turn into new atoms, at the same time emitting one or more of the particles of which they are composed. These particles can have positive or negative electric charges, or be uncharged, and travel very fast or less fast, according to what kind of atom is disintegrating. In some cases, as in the Hiroshima explosion, energy is emitted also, not in the form of particles, but in the form of gamma rays which are very penetrating form of X-ray. All these forms of atomic radiation are similar to cosmic rays. In this survey all the forms of atomic radiation will be considered together because they all have similar biological effects, and an attempt will be made to give a sober, factual and reasonably simple account of the effects of atomic radiation on living creatures, especially on man. The survey will not be confined to radiation from fall-out, but it would be discussed in relation to natural background radiation and medical radiation, and an attempt will be made to assess the hazards of atomic radiation in the light of the information available up to July 1961 in the reports of the U.N. Scientific Committee and the British Medical Research Council.

The biological effects of atomic radiation

When atomic radiations pass through living matter, which is composed largely of water, they split the water and other constituents into chemically very active and unstable electrically charged parts or ions, hence the name 'ionizing radiation'. These ions are created along the track of the radiation, and they can react in turn with other important molecules in cells, causing chemical changes which alter or render completely inactive some of the cells. The biological importance of these effects depends upon how far the susceptible molecules are vital for the life of the cell, and whether they are in short supply or can be replaced. The effects have mostly been studied using large amounts or radiation, from 50 to 1,000 or more rads. Evidence is derived mainly from experiments on living cells in tissue culture, on plants, on insects, and on experimental animals such as mice; but direct information on the effects of radition on man is derived from the scientific observation of the victims of the atomic bombs dropped on Hiroshima and Nagasaki and also from studies of accidental exposures of

persons in industry or in atomic energy plants. Large doses of radiation (100,000 roentgens or more) kill any mammalian tissue in a few minutes, and doses of 3,000—10,000 roentgens do so in a few hours. At doses from a few hundred to 3,000 roentgens the main immediate effect is to stop cell division. Since cell division is the means whereby body cells are constantly being replaced as they wear out, a person or animal whose cells cannot divide will die. A dose of radiation received by the whole body has a much greater effect than the same dose applied to a part of the body; this is because undamaged cells from elsewhere can often replace the damaged ones. Thus a dose of 500 roentgens, which would have a negligible effect on the rest of the body if given, say, to one arm only of a man, would kill about half of those people who were exposed to it over their whole bodies after an atomic explosion. The pattern of events which follows exposure of the whole body or most of it to a large dose of atomic radiation is called "acute radiation sicknesses." It is vividly described in the following extract from the British Medical Research Council Report on the *Hazards to Man of Nuclear and Allied Radiations* (1956):

> "The first effect of exposure of the whole body to a heavy dose of gamma rays of the order of 500 roentgens is a sensation of nausea developing suddenly and soon followed by vomitting and sometimes by diarrhoea. In some people, these symptoms develop within half an hour of exposure; in others they may not appear for several hours. Usually, they disappear after two or three days. In a small proportion of cases, however, the symptoms persist; vomitting and diarrhoea increase in intensity; exhaustion, fever, and perhaps delirium follow; and death may occur a week or so after exposure.
>
> Those who recover from the phase of sickness and diarrhoea may feel fairly well, although examination of the blood will reveal a fall in the number of white cells. Between the second and fourth weeks, however, a new series of ailments, preceded by gradually increasing malaise, will appear in some of those exposed. The first sign of these developments is likely to be partial or complete loss of hair. Then from about the third week onwards, small haemorrhages will be noticed in the skin and in the mucous membranes of the mouth, which will be associated with a tendency to bruise easily and

to bleed from the gums. At the same time, ulcerations will develop in the mouth and throat, and similar ulceration occurring in the bowels will cause a renewal of the diarrhoea. Soon, the patient will be gravely ill, with complete loss of appetite, loss of weight, and sustained high fever. Feeding by mouth will become impossible and the healing wounds will break down and become infected.

At this stage, the number of red cells in the blood is below normal, and this anaemia will increase progressively until the fourth or fifth week after exposure. The fall in the number of white blood cells, noted during the first two days after exposure, will have progressed during the intervening symptomless period, and will by now be reaching its full extent.

The changes in the blood-count seriously impair the ability to combat infection, and evidence from Nagasaki and Hiroshima shows that infections of all kinds were rife among the victims of the bomb. Many of those affected die at this stage and, in those who survive, recovery may be slow and convalescence prolonged; even when recovery appears to be established, death may occur suddenly from an infection which in a healthy person would have only trivial results.

The radiation effects described above are the most severe which can follow a single whole-body dose of 500 roentgens of gamma rays and still allow some hope of survival; but at least half of the population so exposed would die."

Such would be the consequences of direct exposure to atomic bombs for those who were sufficiently protected to avoid being killed by the heat flash, which would kill all persons in the open over a wide area. Considerable doses of radiation would also be received by persons exposed to local fall-out down wind of an explosion, for distances which depend upon the wind velocity and the size and nature of the nuclear weapon, but might be a hundred miles or more. Lesser degrees of exposure have less obvious immediate consequences—150 roentgens would produce sickness, diarrhoea, fall in white blood cells, loss of hair, perhaps ulceration of the skin if it were directly contaminated with products of fall out, but probably no death; and 50 roentgens would have no obvious effect. The possible late effects of radiation will be discussed later.

These are the effects of atomic radiation which were seen at Hiroshima and Nagasaki in 1945 and were seen again in 1954 when the crew of the Japanese fishing vessel, *Fukuryu Maru*, were affected by radiation after the nuclear tests carried out by the United States in the Pacific Ocean. These were the horrors which were twice experienced by the people of Japan but which, if nuclear weapons were banned for ever, mankind may hope never to see again—except possibly as an occasional side effect of intensive radiation treatment for cancer, or in the presumably improbable event of a bad accident in a nuclear power station.

The effects already described are the consequences of large amounts of radiation which are only produced for a few hours or days after an explosion, before the short-lived fission products have had time to decay. The effects of small doses of radiation over a long period will now be discussed. The testing of nuclear weapons has already significantly and irrevocably increased the background radioactivity in the world. When a nuclear weapon is exploded, the radioactive fission products do not necessarily condense on dust particles and finally decay. The radioactivity is often drawn to much higher altitudes, to about 10,000 feet, and gradually spreads over a large part of the world. The radioactive fission products then settle down slowly on the earth usually reaching the ground in rain or snow. This global fall-out consists almost exclusively of the long-lived fission products, strontium 90 and caesium 137. In this respect it differs markedly from the local fall-out, in which the greater part of the activity is contributed by short-life fission products the effects of which have already been described. The effects of small doses of radiation from long-life fission products have been and will continue to be a great hazard to the human race. The greatest hazard from nuclear weapons is, of course, that more and more nations will come to possess them, and that sooner or later they will be used in a war, whose horrors and consequences would beggar description. The American, Russian and — to a lesser extent — British and French tests of these weapons have, however, already distributed sufficient extra radioactivity over the world to be detectable in all over bodies, and the importance of these consequences of nuclear weapon tests must now be considered.

The genetic effects of global fall-out from nuclear tests

In the global, as opposed to the local, fall-out from a nuclear explosion, the only elements which really matter are those whose rate of radioactive decay is slow enough for them still to be significantly radioactive when they return to earth from the stratosphere. The estimates of the time taken for this return to happen have recently been sharply revised. Whereas in earlier official discussions on fall-out the average length of time which the radioactive particles would spend in the stratosphere was reckoned at 10 years, actual time now appears to be nearer 2 or 3 years. Consequently, the radioactive materials from nuclear tests in the past five years have been and will be returning to earth sooner, and less spent, than was expected. In addition, fall-out of these materials, instead of spreading uniformally on this earth, has been found to concentrate in a band in the northern hemisphere between latitutdes 30° and 45° N. Such considerations, together with variations in rates of testing hydrogen bombs (which are most important where global fall-out is concerned) and new discoveries relating to the sorts of long-lived radioactive materials produced by them, have made prediction of fall-out rates very difficult. The latest attempt was made in the Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, published in 1958. This Scientific Committee estimated that if nuclear tests were stopped by the end of 1958, then fall-out from tests already carried out might increase the genetically significant radiation to the gonads by less than 1 per cent in our immediate generation, and by a diminishing amount in subsequent generations. At the same time the dose of radiation to the bone marrow in a person's life time in this generation might be increased by anything from 2 to 14 per cent over that due to natural sources—*the higher figure applying to countries whose inhabitants derive most of the calcium in their diet from rice* rather than milk, and thereby lose the partial protection afforded by the fact that the ratio of radioactive strontium to calcium is less in milk than in the herbage grazed by the cow.

Should nuclear tests continue at the same average rate as over the period 1954-58, then in about a hundred years' time the genetically significant radiation would be increased some 4 per cent, and the dose to bone marrow would be increased from 40 to

240 per cent over the current background level. The figures for the genetically significant increase are almost certainly unrealistically low, because the report of the United Nation Scientific Committee could not take into account the very recent discovery that hydrogen bomb explosions create large amounts of a long-lived radioactive form of carbon (Carbon 14) by interaction of neutrons with the nitrogen of the atomosphere.[8] Radioactive carbon is being steadily produced all the time by 7 similar action of cosmic rays, but bombs tested to date are now estimated to have increased the amount by about 0.5 per cent. The reason why carbon 14 must be regarded seriously is not only that it takes thousands of years for its radioactivity to decay, but that it can actually be built into the nucleic acid of which the chromosomes of the germ cells are made. In this case it has the maximum chance of causing damage, even though at present it only contributes 1 or 2 per cent of the radiation received by the germ cells.

Figures such as these mean little unless they are interpreted. The most optimistic interpretation is that fall-out does little biological harm as to be negligible in effect, and that radioactive strontium 90 in the human bone is unlikely to produce a single case of cancer. This is the view usually favoured by those who regard possession of hydrogen bombs as essential for defence or as a stabilising factor for world peace. A more pessimistic interpretation is that present fall-out levels, by producing several hundred thousand genetic mutations per generation in the whole world, do great biological harm, and that already sufficient strontium 90 has been released to be responsible for hundreds of new cases of leukaemia in this and the next generation. These interpretations are not so much at variance as they may appear, since they depend upon the size of the population and the period of time considered.

If radiation in very low doses produces effects in proportion to its effects in high doses—which is not certain, but must at present be considered as likely as the converse—and if the effect is considered over the whole world population (for one or two generations in the case of bone cancers and for many generations to come in

8 *"Ralio-carbon from Nuclear Tests,"* W. B. Broecker & Olson, E. A., *Science*, 1960.

the case of genetic damage) then it is a matter of simple arithmetic, based on reasonable conjectures about the rate and mode of incorporation of fall-out products into living creatures, to make the calculations arrived at by DR. G. W. BEADLE in the *Scientific American* in September 1959. These are that, even if nuclear tests cease, fall-out from already exploded bombs would result in very roughly 480,000 individuals being born with new mutations in the world in a generation, assuming that 2,400,000,000 new persons were born in that time; most, but not all of these new mutations would be undetected. By similar calculations, based on the estimates of the United Nations Scientific Committee on the Effects of Atomic Radiation, there might be 400 to 2,000 or so additional deaths in the world from leukaemia in a generation. Neither increase would be noticeable against the much larger number of mutations nor leukaemia deaths which will occur inevitably from other natural causes. It is important to realise that these estimates are only reasonable guesses, and could be wrong by quite a large factor in either case. In discussions about the genetic dangers from radiation produced by nuclear tests, there are many uncertainties and conflicts of opinion but one definite principle is however emerging—it is the people with the most knowledge of the subject who seem to be the most alarmed.

In the last few pages, an attempt has been made to objectively present the scientific facts regarding the effects of atomic radiation, so far as they are known. From what is known at present, it is possible that nuclear weapon tests will cause a significant number of deaths and deformities among the population of the world; it is also possible that they will cause only a few deaths and deformities. There is a natural tendency among those who value the tests to think only in terms of the lowest estimate, while those who oppose the tests emphasize the highest. But no one can deny that the tests have harmful effects. The testing of nuclear weapons therefore raises moral and legal problems of a new kind. It has not previously been possible for any one nation to alter global environment in a manner clearly harmful to other nations. A nation or government accused of such contamination is naturally reluctant to face the issue squarely. Even though the harm done is still small, now that it has been proved that nuclear tests have harmful effects, the issue can no longer be evaded, for rightness and wrongness are qualitative, not quantitative.

The effects of the nuclear tests carried out by the United States in the Marshall Islands

It is proposed to examine the effects of the nuclear tests carried out by the United States because more accurate scientific information is available of the effects of the hydrogen bomb explosions in the Marshall Islands by the United States than there is of any other tests. Accurate information is available regarding the effects of these tests because the hydrogen bomb is so very much more destructive than the simple fission bombs tested by the United Kingdom and France, and also because the United States Government has itself released some information regarding the effects of these tests and the Japanese Government and Japanese scientists have investigated every aspect of the damage caused by the nuclear tests in the Pacific Ocean. Japanese scientists spent nearly three years collecting the scientific information on the effects of the hydrogen bombs exploded in the Marshall Islands from 1st March to 6th May 1954, and all the scientific information collected has been published in two volumes entitled *Research in the Effects and Influences of the Nuclear Bomb Test Explosions*. This is a monumental work of 1,824 pages to which Japan's most eminent scientists have contributed and the following pages of this chapter will be essentially a summary of the scientific information on the effects of nuclear tests contained in these two volumes, which is the most comprehensive analysis of the effects of nuclear weapons yet published.

The injuries caused to the Marshall Islanders

On 31st January 1950, President Truman of the United States ordered the United States Atomic Energy Commission to proceed with the development of the hydrogen bomb. On 1st March 1954, the first hydrogen bomb was exploded at Bikini Atoll and altogether six thermonuclear tests were carried out by the United States in the Marshall Islands from 1st March to 6th May 1954. The Marshall Islands are a trusteeship territory of the United Nations with the United States as the administering authority. The United States Atomic Energy Commission chose Bikini Atoll and Eniwetok in the trusteeship territory as the main sites for testing nuclear weapons and all the inhabitants of these and neighbouring islands had to be removed from their land and homes and taken elsewhere. Soon after the United States began its trustee administration in

1947, the United States authorities removed the 137 inhabitants of Eniwetok and settled them on another island, Ujelong. The 167 inhabitants of Bikini Atoll were also removed from their land and homes and settled on Kili, an island in the southern-most part of the Marshall Islands group. Bikini and Eniwetok, where the hydrogen bombs were exploded, will almost certainly never again be inhabitable by these islanders, who have therefore been permanently exiled from their land and homes by the trustee authority.

The first hydrogen bomb was exploded at Bikini on 1st March 1954, which released radiation and radioactive material that contaminated with deadly amounts of radiation an area of 10,000 square miles. The 'warning area' set up by the United States covered 50,000 square miles of the high seas around Bikini Atoll, but as Admiral Strauss, the Chairman of the U. S. Atomic Energy Commission reported:

> "Unfortuntely the wind had failed to follow the prediction and had shifted southwards, so that the islands of Rongelap, Rongerik and Uterik were in the path of the fall-out." [9]

These islands are about 150 miles away from Bikini but the inhabitants of these islands were seriously affected by radiation. According to the United States authorities, 'the prevailing winds were westerly so the bomb cloud moved generally to the east and about 160 miles down-wind from the point of the burst the early fall-out was observed in the form of fine white particles which looked like snow. It began to fall about eight hours after the detonation and continued to fall for several hours. It was subsequently discovered by Japanese scientists that 'the coral island itself had been vaporised by the heat of the explosion, and blown into the air as a gas, and had then recrystallized.' It were these crystalline particles, heavily contaminated with radioactive material, that fell like snow on the Pacific Islands and on the Japanese fishing vessel, the Fukuryu Maru, which was engaged in fishing eighty miles away, outside the so-called 'danger zone'.

According to the U. S. authorities "two hundred and thirty-seven people from Rongelap and Uterik had to be evacuated from their homes to a hospital on Kwajalein. Twentyeight American

9 *The Times*, 31st March, 1954.

servicemen on another island were also affected. Sixtyfour of the people on Rongelap had a dose of external radiation of 175 roentgens. Eighteen who were away on a fishing trip at the time got only 69 roentgens and the 157 islanders on Uterik had an average of 14 roentgens each." In the section of this chapter on the biological effects of radiation it was noted that a dose of 500 roentgens would kill about half of those people exposed to it over their whole bodies after an atomic explosion and that even after a dose of only 100 roentgens about 15 per cent of the exposed population would be affected and a few would die. It may be said therefore that the exposure of the Pacific Islanders to radiation was considerable and symptoms of radiation sickness, described earlier in this chapter, developed in a large number of cases. According to a report in the journal, *Science* (1955) about three-quarter of the people affected by radiation developed the usual symptoms of nausea, vomitting and diarrhoea together with itching and burning of the skin. This was followed by loss of hair and painful skin ulcers, particularly in the group of sixty-four from Rongelap who had suffered the maximum exposure. The radioactive dust had fallen "in the open cisterns that were used to store drinking water. Some of the food that was eaten had also picked up radioactive dust. The woven mat houses of the area were readily penetrated by the dust; and thus practically everyone down to the tiniest babies was irradiated." Up to the present no cancer, leukaemia or cataract has been observed in any of the islands, but all the children under twelve years who were irradiated appear to be a year behind in height and weight.

In May 1954, the United Nations received an urgent plea from the Marshall Islands for an immediate cessation of nuclear weapon tests in this region. According to *The Times* of 15th May 1954, "the petition was signed by eleven members of the Marshallese Congress Committee and by hundred interested Marshall Islands citizens." The petition stated that "the lethal effect of the bomb tests had already affected the inhabitants of the two Marshall atolls, Rongelap and Uterik, who were suffering in various degrees from lowered blood count, burns, nausea and the falling out of hair. Apart from the danger to their persons in case of another miscalculation, the inhabitants were concerned about the increasing numbers of people being removed from their land. Bikini

and Eniwetok were evacuated and their inhabitants moved to Kili and Ujelong. Because Rongelap and Uterik were now radioactive, their inhabitants were being kept on Kwajalein for an indeterminate time." The petition concluded by requesting the United Nations to bring about an immediate cessation of nuclear tests in the Marshall Islands.

The United States delegate to the United Nations, Mr. Cabot Lodge, said that the United States Government was 'very sorry indeed' that some inhabitants of the Marshall Islands had suffered ill-effects from the nuclear tests and assured the United Nations that the United States authorities 'were doing everything humanly possible' to take care of everyone who was in the area. In 1956, a Mission from the United Nations Trusteeship Council, headed by Sir John Macpherson of the United Kingdom, visited the Marshall Islands and reported that 167 inhabitants of Bikini Atoll who had been evacuated to the island of Kili, in the southern most part of the Marshall Islands group, were experiencing hardship on the island of Kili, which did not possess lagoons abundant with fish as around Bikini. The United States authorities told the United Nations Mission that all efforts to find a suitable unoccupied atoll for the Bikini inhabitants had failed. The United Nations Mission, in its unanimous findings, stated that the grievances of the Bikini people appeared to be serious as they had been deprived of their homes and the extensive lagoons abundant with fish around Bikini Atoll on which they had depended for their livelihood and food. The United Nations Mission recommended generous treatment for these unfortunate people, who had suffered from the effects of the nuclear tests. It is difficult to see how the United States, which holds these islands on trust, can repair such damage. The test island in Eniwetok Atoll was practically obliterated and a cavity one mile in diameter and 175 feet deep was torn out of the ocean floor. The coral island in the Bikini Atoll was itself vaporized by the heat of the explosion and blown into the air as gas. The two islands on which the hydrogen bombs were tested have virtually disappeared from the face of this earth.

The question of nuclear tests in the Pacific Islands was raised again in the United Nations on 16th June 1961 when the United States delegate, Mr. Jonathan B. Bingham, told the United Nations Trusteeship Council that the United States had no immediate plans to resume nuclear tests in the trust territory of the

Pacific Islands, but declined to give the Trusteeship Council an absolute assurance that no further tests would be carried out in the Pacific Islands. The delegate of the Soviet Union had raised the question when the Trusteeship Council considered the Report of a U.N. Inspection Mission that visited the territory early this year. The U.N. Mission had said that it had a statement from the United States administering authority that there were no plans to resume tests there and had expressed a hope that no such tests would be "carried out in the future." [10]

On 21st June 1961, the subject was discussed again in the United Nations when India called for the establishment of a territorial legislative council in the United States administered Pacific Islands trust territory by the end of the year 1962. Mr. C. S. Jha, India's Permanent Representative at the United Nations, told the U.N. Trusteeship Council that the islanders, who were politically advanced, should not have to wait for the legislature until the scheduled period of 1965. India's statement was made when members of the Trusteeship Council were summing up their positions on the report of the visiting U.N. Mission and the answers of the United States authorities about political and welfare conditions in the islands. The delegate of India said that his country would like to hear from the United States that it would not in future carry out nuclear tests in the islands, a promise the United States had refused to make to the Soviet Representative in the previous discussion. The delegate of India said that in the meantime the United States Government should take steps to pay the islanders of Rongelap their money claims for radiation and fall-out damage caused by the tests carried out in the Marshall Islands in 1954. The Indian delegate, Mr. Jha, noted with concern the visiting U.N. Mission's Report that the people at Rongelap had not as yet recovered from the effects of the tests carried out in 1954 and were still seized by fear and anxiety lest the test series be resumed. [11]

Radioactive pollution of the Japanese fishing vessel and the death of a Japanese national

At the time of the explosion of the first American hydrogen bomb at Bikini on 1st March 1954, the Japanese fishing vessel

10. *The Times*, 17th June, 1961.
11. *The Times*, 22nd June, 1961.