The Use of DU Weapons in War

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1.0 Introduction:

The use of DU weapons in war has been widely opposed by scientists, legal experts and concerned persons both within and outside of the U.S. and U.K. Individuals from many countries have joined their efforts to bring this issue to the Human Rights Tribunal of the United Nations, and have formed global organizations to support victims of DU and work toward a ban of its use. Yet millions of dollars have been spent sending fact finding teams of experts from respected international agencies, and in general no cause for the widespread sickness has been found. It is important that this Hiroshima World Tribunal address the questions: (1) Who shall we believe? (2) Is DU a poison gas or a radiological weapon of indiscriminate or mass destruction? (3) Have the warriors among us violated the basic Treaties designed to protect civilians from the ferocity of wars? Some official studies need to be reviewed first, and then an effort will be made to draw together a reasonable picture of the hazards and health effects of DU as we know it today.

2.0 Official Reports on DU:

One of the first reports, often quoted, is the **Rand Report,** [Ref 1] sponsored by the Office of the U.S. Secretary of Defense in response to a mandate from the U.S. Congress. The preface of this document contains a Disclaimer seldom quoted:

> "The reviews are intended principally to summarize literature on the known health effects of given exposures to these risk factors. Where available evidence permits, the reviews also summarize what is known about the range of actual exposures in the Gulf and assess the plausibility of the risk factor at-hand [DU] as a cause of illness. Statements related to the Gulf War experience should be regarded as suggestive rather than definitive, for much more research both on health effects and exposures remains to be completed before definitive statements are made.
>
> "These reviews are limited to literature published or accepted for publication in peer-reviewed journals, government publications, and conference proceedings."

Since the literature contains no studies of DU used on the battlefield, the authors used reports on uranium mining and milling exposures. As was pointed out by the World Health Organization (WHO) report, uranium dust is considered to be particles, of approximately five micron in size. It is not able to travel into the deep lung or the alveoli. For this reason, the lung cancers which miners or millers experience are attributed to radon gas. As will be discussed later, Gulf War exposures to DU are in the one micron, or less, particle size range. These small particles are fully capable of entry into the deep lung and alveoli.

2.1 The report of the **Institute of Medicine of the U.S. National Academy of Science** [Ref. 2] recognized the problem of DU and the absence of information on its toxicology and radiological properties. It urged:

> "continuation and expansion of efforts to model potential exposures to DU in various military settings (e.g. inside and outside vehicles damaged by DU munitions, and other areas potentially contaminated by the dispersion of DU particles). Such efforts may result in a quantitative assessment of Gulf War veterans' exposure to DU. Further, the committee urges publication of the results in the peer-reviewed literature so that studies may receive broad review."

Besides indicating that the Rand review of non-existent literature is not helpful, the Medical Institute was perhaps indicating that such information belonged in the public sector and not in classified military archives. In general, this report stressed the lack of knowledge available on the health effects of DU used in battle.

2.2 The work of **Dr. Melissa McDiarmid**, [Ref 3] reporting on the small sample of veterans with fragments of DU in their bodies, due to friendly fire accidents, has been helpful. However, it is on too small a sample, with a different type of exposure, to provide conclusive information helpful to the majority of the veterans suffering from inhalation of micro- and nano particles of ceramic DU. It is more likely to be a study of the slowly dissolving particles from the shrapnel.

Based on her studies, one can conclude that shrapnel of DU is slowly oxidized in situ, and gradually eliminated through urine without major damage (to date) of the kidney tubules. This slow mobilization and excretion would be expected to avoid the consequences of fast dissolving and elimination of inhaled uranium dust, which quickly overwhelms the kidney tubules is some uranium mining experiences. McDiarmid found no chromosomal aberration differences between high and low exposure groups for internal fragment deposition, but she did find statistically significant increase in Sister Chromotid Exchange tests (SCE) in the high exposure group after ten years of follow up. These are generally recognized as indicators of exposure to exogenous mutagens. It likely also indicates somatic genotoxicity.

2.3 The **U.K. Royal Society** has also published a Report [Ref 4] which considered the radiological and chemical toxicity of DU. While quoting the literature on uranium exposure in the workplace, this report does suggest: "the typical form of the inhaled particles in industrial settings and on the battlefield will be different, and these alternative forms might not have the same adverse effects." They also summarize:

> "There are no data on the long term effects of the use of DU munitions on humans and the environment because they were first used in a military conflict in 1991 during the Persian Gulf War. Consequently the long term risks to health and the environment have been evaluated in the absence of data over appropriate time-scales."

The Royal Society used a standard ICRP approach to radiological damage and a standard toxicological approach to uranium renal toxicity. These methodologies determine that

only the risks of "radiation induced fatal cancer" and uranium induced "kidney disease" be considered. The Tribunal can judge later the inappropriateness of these tools in the face of this new hazard.

In Chapter 3 of Part II of the Royal Society Report, [Ref 5], they assume, using worst case scenario, the excess risk of fatal lung cancer estimation to be about 15 per 100. The worst case scenario is 130 mg DU inhaled each day for three months, giving a peak of 100 micrograms per gram of kidney tissue. This would also probably result in kidney failure before a cancer could develop. It is likely that exposures were below this extreme scenario because there were no known immediate fatalities from renal failure.

2.4 These studies do not represent the best choices of biological endpoints (cancer death and renal failure) for addressing the wartime DU exposure health effects. They do not effectively address the veterans' problems, and do not provide appropriate answers to the veterans' questions. Veterans have asked for an explanation of their symptoms, and suggested cures or medical mitigation. This problem is not one of calculating risks of artificial "health endpoints" chosen by researchers.

2.5 Another document of interest is the **UNEP Report** of investigations after the war in the Balkans.[Ref 6]. This mission had five elements.

1. Environmental assessment of the worst damaged industrial sites.
2. Complementary measurement, to assess the environmental impacts of the conflict on the Danube River.
3. Assessment of damage to the biodiversity in nature conservation areas.
4. Assessment of the potential long term health and environmental effects due to the conflict (including DU)
5. Assessment of the human settlement situation in Kosovo.

The small part of this study, part of mission (4), is devoted to DU. The UNEP study was self-proclaimed to be a "desk study", as opposed to a field study.

UNEP reported on the Specific Activity of DU (U235 0.2%) as 39.42 Bq/mg. Analyzed particles contained U238, U235, U234, and traces of Th234, Pa234 and Th231. In the case of skin contamination, through contact with solid pieces of DU, there is at most a beta dose of about 2 millisieverts per hour. According to the UNEP report [ibid 4.1] levels in the ambient air, outside of war zones, ranged from 0.02 to 0.76 nanograms per cubic meter, implying that the daily background intake of uranium from the air is about 1 nanogram (ng) or less per day.

With respect to the metabolism of DU, UNEP points out the rapid (less than 24 hours) clearance of systemically available uranium. It points out, however:

> "if the pH is low, the complex dissociates to a variable degree, and the uranyl ion may then bind to cellular proteins in the tubular wall of the kidney, which may then impair tubular function."

The affinity of uranium for the DNA molecule is worrisome for both somatic and genetic problems.

One scientist who worked on the UNEP Report prepared a separate report on DU nanogram size particles to which we will refer later.

2.6 The inclusion of health in the UNEP Study was provoked by veteran concerns that the DU weaponry used during the Gulf War in Iraq may have been responsible for an increase in cancer, birth defects (congenital anomalies) and diseases of the immune system. These concerns were raised at **The Commission for Pollution Impact by Aggressive Bombing (CPIAB)**, a Conference sponsored by the U.K. government and held at Whitehall, London, in 1999. [Ref 7] The research of Um-Al Ma'arek, 1991-1999, was. presented by M. Kammas at: **Roundtable Conference Opinion on Depleted Uranium and Cancers in Iraq (CPIAB)** demonstrating the scientific research done in Iraq on the question of after effects of the use of DU in Iraq**.** Kammas reported on a substantial rise in leukemia, lymphoma and bone cancer in Iraq. He noted that the relative risk for other diseases was elevated significantly, including infertility, congenital abnormalities, and kidney failure.

Such findings were also reported by Professor Gunther [Ref 8] of Germany, who had visited Iraq after the war and been concerned about the extraordinary birth defects which he had seen there.

2.7 The health question was also raised by an article in the **Lancet**: "Does Iraq's depleted uranium pose a health risk?" by K. Bichard. [Ref 9]

2.8 Moreover, a report to the **European Commission DG-XI** [Ref 10] describes that several toxic compounds released after the bombings in Yugoslavia, could cause chronic health problems. "Perhaps the most dangerous is depleted uranium."

2.9 A study of the birth defects in the children of veterans in the U.S. [Ref 11], undertaken by Han Kang, **U.S. Department of Veteran Affairs**, focused on the first pregnancy which veterans of the first Gulf War had after returning home. Slightly less than 21,000 service men, from all four branches, active and retired were included in the study (about 70% of those to whom questionnaires were sent). Male veterans were two times as likely, and female veterans were almost three times as likely, to report children with birth defects than their counterparts who did not serve in the Gulf. Likely birth defects included webbed fingers and toes, heart murmurs, chromosomal abnormalities, and brain tumors. These researchers excluded developmental disorders, perinatal complications and pediatric disorders. Male veterans reported miscarriages more often, and the increase, 1.62 times, was statistically significant. Females also reported more, but the sample size of female veterans was too small for reaching statistical significance.

2.10 The International Atomic Energy Agency (IAEA) has prepared a "Fact Sheet" on DU. [Ref 12] The IAEA, together with the International Labour Organization, the Food and Agriculture Organization and the World Health Organization, have established Basic

Safety Standards (BSS) based on the recommendations of the International Commission of Radiological Protection (ICRP) and The United Nations Scientific Committee on Atomic Radiation (UNSCEAR).

Essentially, a small group, from the thirteen men on the Main Committee of the ICRP, the decision making body, serve on UNSCEAR, and using both "hats" advise all of the UN Agencies which were designed to protect the people! ICRP is a self-appointed and self-perpetuating non-governmental organization of users of radiation (physicists and radiologists) and medical administrators from the nuclear nations. By their membership rules, they exclude persons trained in oncology, pediatrics, public health, and occupational health. ICRP and UNSCEAR are not public health organizations. The ICRP decides on the trade-off in health allowable for the benefits of nuclear activities, and UNSCEAR confirms that these choices are acceptable to "society".

If a member nation makes a formal request of the IAEA, to study a radiological situation, it will:

- Determined the source term through environmental monitoring program.
- Model potential pathways from the environment to humans.
- Assess the radiation dose to representative groups of individuals.
- Check for compliance against it Basic Safety Standards.

Intervention, in the way of clean up of the environment, "is almost always justifiable, if an individual effective dose exceeds 100 mSv per year". It "may be necessary, if the dose exceeds 10 mSv per year".

When dealing with facilities emitting radiation, the BSS requires the doses to the public be less than 1 mSv per year. [Ref 13] These changing radiation protection standards reflect changing costs, not changing human sensitivity to radiation injury!

2.11 A highly publicized paper by S. Fetter and F.N. von Hipple, published in **Science and Global Security** [Ref 14] using what they assumed to be maximum assumptions, estimated theoretically that doses of ionizing radiation to the military or civilians from DU in battle would be between 30 and 100 micro Seiverts in a year. They used the standard ICRP methodology [Ref 15] for internal contamination from uranium, assuming S, or slow, dissolution in body fluid. They did not seem to consider implications resulting from the ceramic glass-like nature of the DU fraction which might change the properties of uranium oxide, or increase the possibility of life-time retention. Nor did they discuss the nature and intensity of the DU fire, and the release of nano particles of all materials exposed to it. They seem not to be aware of the physical difference between the fire-polished smooth spheres of mixed non-organic particles and the rough surface of uranium dust in a mine. The calculation is correct but it is an inadequate explanation of the battlefield phenomenon.

2.12 The last official report of interest is that prepared by **WHO: "Depleted Uranium: Sources, Exposure and Health Effects"**, [Ref 16] In addition to discussing the specific activity of DU, as did most of the other studies, WHO noted that, as well as decay

through the emission of alpha particles, atoms of U238 may also decay through spontaneous fission, an energetic process that releases approximately 40 times more energy per nuclear decay [Ref 17]

The spontaneous fission half-life of U238 is estimated to be 8.5 X 10^{17} years [Ref 18], which, although much longer than its alpha half-life, results in approximately two atoms of U238 in every milligram of uranium decaying by this process each year. Similarly, spontaneous fission rates for the other natural or anthropogenic isotopes of actinides associated with DU, are available, but they are of low probability relative to the rates of other decay modes. Fissioning of DU, inside the delicate tissues of the body can be devastating to the victim.

2.11 Some of the estimations used in these official reports will be of use later. The WHO estimates natural ambient levels of uranium in air, in non-war situations, to range from 0.01 to 0.2 ng per cubic meter. This is more conservative than the UNEP Report, which estimates that uranium in the ambient air, outside of war zones, in Bosnia, ranges from 0.02 to 0.76 nanograms per cubic meter. WHO estimates that the daily background intake of uranium from the air is about 1 nanogram (ng) per day Higher levels are due to smoking of cigarettes, or the presence of a range of industrial processes such as mining of uranium ore, gas releases from coal-fired power stations and nuclear fuel manufacturing facilities.[Ref 19] WHO estimates that smoking two packs of cigarettes a day (which WHO does NOT recommend) contributes about 25 ng per day, and it is clear that this is exposure is harmful to health.

In the WHO summary [Ref 20] it is reported that the uranyl nitrate is cytotoxic and genotoxic in Chinese hamsters ovary cells. The genotoxic effects were thought to have occurred through the binding of the uranyl nitrate to the phosphate groups of DNA.

> "It was suggested that these results provide a possible mechanism for observed teratogenic effects. [Ref 21]

WHO notes:

> "The database for the toxicity of uranium is limited, most of the studies are old, meaning that not all present methods available to assess renal toxicity were available at the time of these studies. Information, especially on long-term affects of different uranium species, is based on studies from a limited number of researchers. Information is very limited for many uranium species, especially for those with limited water solubility."

The WHO Report identified two important information gaps: biokinetics data on DU aerosols, with emphasis on the effect of variable physical-chemical composition resulting from the use of DU munitions, and bio-availability of uranium after dispersion and re-suspension of DU dusts and aerosols.

Although the WHO uses ICRP methodology, mentioned above, and although it is careful to note that protection limits set by ICRP are not borders between what is safe and not safe, but rather reflect an ICRP judgment about the balance between the risks and the

benefits. [These benefits range from medical uses to uses in nuclear power and nuclear war] ICRP methodology approaches the health effect problem by setting permissible dose limits, and assuming that both the individual and society accept the health effects which will occur below this limit in exchange for the benefit of the activity. The military have been known to say that, given the other hazards of the battlefield, the risk from using DU is acceptable. Researchers, administrators and judges frequently consider exposures below ICRP recommended limits as "safe". So, for example, workers and atomic veterans, whose exposure to radiation does not exceed permissible levels, find it impossible to obtain worker or veteran compensation, in spite of serious disability and cancer.

With respect to the using the permissible limits recommended by the ICRP, it has never been clear whether veterans are to be considered nuclear workers or civilians, or whether, in foreign countries, the U.S. or the I.C.R.P. guidelines for exposure should be used. Similarly, should military decisions to introduce hazardous munitions, be allowed to threaten the health of children, infants and pregnant women? These are questions for the Tribunal to answer.

The WHO report called attention to the biokinetics not only of U3O8, UO2 and UO3, but also mixed uranium-iron oxides which may also be present on the battlefield. As default absorption parameters for DU, WHO recommends using 0.2, because of the presence of "ultra fine metal or oxides particles". This will be discussed later.

3.0 Historical, Political and Scientific Context of DU Reports:

3.1 Apparently radioactive powder was first proposed, in the U.S., to General Leslie Groves, Director of the Manhattan Project, by senior scientists in the project. In this memo, dated 30 October 1943, these scientists noted that radioactive material, including uranium, could be used to contaminate air, water and terrain [Ref 22]. The letter stated that inhalation of radioactive materials would result in bronchial irritation "coming on in a few hours to a few days".

> "The material was to be ground into particles of microscopic size to form dust and smoke, and distributed by a ground-fired projectile, land vehicles or aerial bombs. In this form it would be inhaled by personnel. The amount necessary to cause death to a person inhaling the material is extremely small. It has been estimated that one millionth of a gram [1 microgram] accumulating in the person's body would be fatal. There are no known methods of treatment for such a casualty. Two factors appear to increase the effectiveness of radioactive dust or smoke as a weapon. These are, it cannot be detected by the senses, and it can be distributed in a dust or smoke so finely powdered that it will permeate a standard gas mask filter in quantities large enough to be extremely dangerous." [Ref 23]

The grinding into microscopic particles is no longer necessary, since a uranium fire produces many levels of non-soluble respirable and ultra-fine particles, sometimes called metal fumes.

3.2 Following World War II, the U.S. began testing nuclear bombs in the Pacific, and continuing the research into larger and more effective bombs. Because the fissile material blew apart in the explosion of the atomic bomb, it was limited in size. When the hydrogen bomb was developed, and the first large bomb had been tested in the Marshall Islands of the Pacific, 1954, President Eisenhower went to the United Nations and declared the opening of the Nuclear Age "Peaceful Atom Program", promising unlimited electrical energy too cheap to meter! The hydrogen bomb was unlimited in size, and the U.S. immediately began to convert its arsenal into this new technology. A "peaceful atom" program assured the military of the support services which it needed: uranium mining and milling, transportation of radioactive materials, University education for nuclear physicists and engineers, and toleration of the intractable nuclear waste problems by an accepting public. The nuclear arms race followed, as is well known history.

3.3 The United Nations responded by creating in 1955, The United Nations Scientific Committee on the Effects of Ionizing Radiation, UNSCEAR, [Ref 24] to "assess and report levels and effects of exposure to ionizing radiation". According to the UNSCEAR website, "governments and organizations throughout the world rely on the Committee's estimates as the scientific basis for evaluating radiation risk, establishing radiation protection and safety standards, and regulating radiation exposure." UNSCEAR was envisioned as an organization of physicists, who at that time were the only ones who could measure radiation since it escapes our senses and requires specialized instruments for detection. Establishing standards eventually (in the non-professional society) became understood as decision making power on whether or not an exposure to radiation was legally permitted or an observed cancer or illness was radiation related.

3.4 UNSCEAR became primarily a reporting agency, detailing the measurement of radioactive fallout, worker exposures and eventually emissions from nuclear power plants. I would assume that legislators saw this agency as providing independent monitoring of nuclear activities, as a check on predicted pollution and theoretical estimates of harm. Unfortunately, UNSCEAR incorporated into its midst the same scientists who were making the predictions, members of the Main Committee of the International Commission on Radiological Protection (ICRP), and who were estimating which levels of low level radiation exposure caused "no harm". ICRP is a self-established and self-perpetuating non-governmental agency which has given itself the mandate to recommend radiation protection standards to nations [Ref 25].

ICRP has never claimed to be a public health agency. Rather, it makes the decisions as to how much risk of ill health in workers and the general public, should be acceptable for the benefits of radiation-related activities (on which their income and national security depended) No other industry is allowed to monitor itself. We do not ask the tobacco companies to tell us about tobacco's harm, or the pesticide companies to tell us the effects of their products on children. More will be said on this point later.

3.5 In 1957, the World Health Organization, which had been established by the U.N. in 1948, became alarmed about the atmospheric nuclear testing and the proposed expansion of this nuclear technology for "peaceful uses". It called together eminent geneticists to

consider the threat this exposure would pose to the human and ecological gene pool. Prof. Hermann Muller, the geneticist who received a Nobel Prize in Medicine for "the discovery of the production of mutations by means of X-ray irradiation" in 1946, was a participant at this conference. Although the United States had not sent him as its delegate, he received a standing ovation at the conference for his work, and he consistently opposed extension of nuclear technology into civilian uses because of the danger it posed to the gene pools of plants, animals, and humans. The conclusion of this expert group was that there was not enough information available in the scientific community to assure the integrity of future generations, should the burden of ionizing radiation exposure be increased.

They called for extreme caution and further genetic investigations, especially in Kerala, India, where there is a high natural background radiation, and people have lived in this environment for hundreds of years. Governments never implemented these recommendations because they were anxious to get on with nuclear activities. The first serious study of the genetic effects of ionizing radiation in Kerala's environment will be published in autumn, 2004. [Ref 26]

3.6 After the Chernobyl disaster, 1986, the ICRP developed a protocol for use after a radiation accident. [Ref 27] According to this new policy, the status quo is considered after the accident to be the "norm". Any proposal for clean up must determine that there is sufficient benefit to warrant the expenditure. The WHO document adheres to this ICRP policy, namely that unless the radiation exposure of the public exceeds 100 mSv per year, there is no presumed need to clean up a site. If the dose to the public per year will be 10 mSv, then a risk v benefit judgment should be made. This is in contrast to the policy of ICRP for uncontaminated land, which proscribes environmental activities, involving exposure of citizens, to cause no more than 1 mSv dose per year to individuals.[Ref 28].

3.7 Natural Uranium (NU):

Uranium is a natural product found in the Earth's crust. In ordinary soil, it occurs as about one to three parts per million (ppm). Certain rocks have a higher concentration of uranium, about 0.05 to 0.2% by weight (five parts per 10,000 to two parts per thousand).

After the uranium is mined, milled, and processed, uranium oxide (sometimes called yellow cake) is formed. This is about 88% uranium (88 parts per hundred). The uranium oxide is then combined with fluorine gas to form uranium hexafluoride, and then enriched, to concentrate the U235 isotope of uranium, and the "extra" U238 is discarded. The uranium with enhanced U235 is called enriched uranium (EU), and it is used for either nuclear weapons or nuclear reactor fuel rods. The uranium which is discarded is called Depleted Uranium (DU), not because it is not radioactive but because the prized (and rare) U235, used for nuclear fission, has been removed.

3.8 Uranium is distributed globally, with concentrations in soil of about 1 to 3 parts per million (1 to 3 ppm, or 1 to 3 micrograms per gram soil). If the human body had no

filtering ability, we would expect to find roughly the same concentration in the body as in the environment. However, the reduction in humans is significant. According the International Commission on Radiological Protection (ICRP) the human body in general (the Standard Man) contains the following amounts of natural uranium [One microgram = one thousand nanograms]:

Total	0.0012 ppm or 1.2 nanograms
Skeletal tissue	0.008 ppm or 8 nanograms
Kidneys	0.023 ppm or 23 nanograms

The human body does not need uranium for any beneficial purpose, and it is always considered to be a contaminant. Other metals may be needed by the body in trace amounts.

The daily intake of natural uranium in food and water is about 1.9 microgram, but only about 1 to 2% is absorbed through the intestines, between 0.019 and 0.038 microgram (19 to 38 nanograms). The output of natural uranium in feces is 1.881 to 1.862 microgram daily. The 19 to 38 nanograms of natural uranium, which is absorbed by the intestinal wall and screened by the liver, goes either directly to the kidneys and is excreted through urine, or circulates in the body, is stored in bone and is excreted at a later time.

The daily excretion rate in urine, for non-occupational exposure, ranges from 0.003 to 0.310 nanograms. In this way, the body maintains steady state, and the estimates of internal contamination remain fairly stable. [Ref 29] They are well below the one microgram estimated to be “enough to kill the person” in the Manhattan Project letter.

3.9 Depleted Uranium (DU):

The Biokinetics of the DU aerosol generated in combat has not yet been entirely determined, and is one of the urgently needed pieces of information for predicting the complete health effects of DU inhalation. Although the biokinetics of uranium oxide found in uranium mining and milling, is well known, the DU produced on the battlefield is a ceramic version, practically insoluble in body fluid, together with a mixture of particle sizes from 10 micron down to nanogram size which can only be detected by electron microscopy.

U238 decays into thorium 234 (which has a half life of 24.1 days), and thorium 234 decays into protactinium 235 (which has a half life of 6.75 hours). Protactinium decays into U234 (which has a half life of 247 thousand years). Effectively, in four to six months, because of these continuous radioactive transformations, freshly produced DU, composed mostly of U238, becomes a mixture of U238, Th238, Pr235, and U234 in equilibrium proportions. The first two decay products along with U238 account for most of the alpha and beta radioactivity of the mixture.

Globally there is more than one billion tons of DU as a waste product of uranium enrichment for nuclear weapons and nuclear reactors. It is available at little or no cost to

weapons manufacturers, and it provides a valuable replacement for the costlier tungsten. It has some military advantages. When exposed to friction in air, or when it hits a hardened target it creates a very hot metal fume, 3000 to 6000 degrees Centigrade, which burns away the point of weapon, keeping it sharp. This allows it to penetrate deeply into the object it hits. Tungsten, on the other hand, blunts against the target and does not penetrate as well.

Many scientists and radiation specialists have pointed out the danger of inhalation of the invisible ceramic like DU aerosol. They strongly recommend applying the Precautionary Principle. There has been no indication of the military halting its use and engaging in (or declassifying) a serious study of the detrimental effects of DU on health. In fact, we find the U.K., Russia, and perhaps other nations now producing DU weapons. It appears to be an ongoing serious problem which must be dealt with by the international community.

Global Storage and Production Rate of Depleted Uranium
Metric Tons

Country	**Stored DU**	**DU Produced Yearly**
United States	560,000	20,000 per year
France	135,000	12,000 per year
Urenco: Germany, Netherlands and U.K.	29,000	4,000 per year
U.K. (BNFL)	30,000	0
Russia	430,000	10,000 per year
Japan	2,600	500 per year
South Africa	2,200	0
China	20,000	1,000 per year
Others	<1,000	Unknown

[Ref 30]

Most of the DU stockpile is in the form of UF6 or UF4, which are highly unstable gases. In the U.S., this radioactive and toxic gas is stored in 10 to 14 ton cylinders, out of doors, piled two high on a macadam surface. They are gradually being converted to uranium oxide, uranium metal and uranium metal alloys, which are more chemically stable. [Ref 31].

3.10 There are two more isotopes of uranium which are of concern: U234 which is 0.0055 %, in natural uranium (NU), and 0.0008 % in DU; and U236, which does not occur in natural uranium, and is 0.0030 % in DU. The presence of U236 in DU indicates that the uranium from which the DU was extracted, was from uranium obtained in the chemical reprocessing of spent nuclear fuel rods from a nuclear reactor, rather than from natural uranium ore. Such uranium will also have trace particles of transuranics (like, plutonium, americium and neptunium).

3.11 Comparison of NU and DU:

In both natural and depleted uranium, the isotope U238 predominates: 99.2745 % of natural uranium and 99.7947% of depleted uranium. Given the same amount of concentrated uranium, the specific activity of the depleted form is approximately 60% of the specific activity (number of nuclear transformation per second) from natural uranium. (The reduction is due mostly to reduction of U235 and U234). However the alpha radioactivity in DU is increased over that in NU, because of the increase proportion of the alpha emitter U238. Reduction of the gamma portion of radiation makes DU less of an external radiation hazard. The increased proportion of alpha radiation, which has a biological effectiveness factor of at least 20 over gamma radiation, makes DU a greater internal hazard. Although an alpha particle does not have as long a track through the body, its 20-fold increase in biological effectiveness makes it more damaging to cells when it is lodged inside of the body.

Compo-sition	Activity (%)			Specific Activity			Specific Activity of the total
	234U	235U	238U	234U	235U	238U	
NU	48.9	2.2	48.9	12.3	0.6	12.3	**25.2**
DU	15.5	1.1	83.4	2.3	0.2	12.3	**14.8**

Note: This Table includes the contribution from short lived progeny.

DU is orders of magnitude more radioactive than natural uranium in soil or ore, and must be handled by persons with special training in handling radioactive materials. The physical half-life of U238 is 4.51 billion years.

One microgram of pure U238 has 1.24 atomic transformations (sub-microscopic explosions) every second, each giving off one alpha particle with energy between 4.15 and 4.2 MeV [million electron volts]. It only requires 6 eV to 10 eV [electron volts] to break the DNA strand in a cell. In one day, one microgram of DU would release 107,000 alpha particles, each with more than a million electron volts of energy; into whatever organ of tissue it was lodged. These emissions cover a sphere with radius of about 7 cells. To assume that no harm is done to tissues and cells is ridiculous! To be concerned only if the damage results in a fatal cancer ten or twenty years from now is equally ridiculous. It should be obvious that DU is a significant hazard when inside of the human body. However, the possibility of cancer is not trivial.

> The International Agency for Research on Cancer (IARC) has identified "internally deposited radionuclides that emit alpha particles" as Group I carcinogens, meaning substances known to cause cancer in humans. [Ref 32].

4.0 Scientific Identification of DU Poisoning in Recent Wars::

4.1 According to the work of **Dr. Hari Sharma**, [Ref 34] who did the 24-hour urine sample analysis for veterans and civilians exposed to DU in the First Gulf War, the range of U235 in a 24 hour sample of urine for Gulf War veterans, measured in 1998 was 1.23 to 9.4 nanograms. The range of U238 in the same samples was 1.814 to 4.65 micrograms.

All samples were mixtures of NU and DU. Of 22 veterans tested, 17 had mostly DU, one had about 33% DU, and 4 were indeterminate.

Finding DU still present in the bodies of the veterans after the war was surprising, and it indicates that the particles inhaled or ingested were not soluble in body fluid.

Dr, Sharma tested another group of 18, urine samples, for 2 Iraqi veterans, 3 Iraqi citizens residing in Basra 1991-1994, one British veteran, 2 Canadian veterans, 5 Iraqi civilians who resided in Baghdad 1991-1994; and 5 U.S. veterans.

Of the two Iraqi veterans: 33% of the uranium in the first one's urine (1.34 micrograms) was DU, 4.34% of the uranium in the second one's urine (81 nanograms) was DU.

Of the three Iraqi residents of Bosra, Iraq: 15.8% of the uranium in the first one's urine (147 nanograms) was DU; the second had no DU; and 9.52% of the uranium in urine for the third (426 nanograms) was DU. Of the five Iraqi residents of Baghdad, 19.9% of the uranium in urine was DU and in the second, 64.2% of the uranium in urine was DU; the other three had all natural uranium only. Microgram content could not be calculated because no measurement of the total uranium in the urine was made.

Of the five U.S. veterans tested, the fractions of the uranium which were DU were: 15.2%, 55.2%, 38.6%, 84.1% and 59.3%. The DU content in nanograms was: 252, 924, and 844, with the last two, indeterminate.

Some samples of soil in Kuwait were also taken and analyzed. In Kuwait City and Jahra, no DU was found. In the beach area, uranium in three soil samples had about 24% DU. In the other soil sample, the uranium was natural. Four samples of soil taken from the Iraq battlefield each had about 24% of the uranium as DU.

4.2 The scientific methodology used by Dr. Sharma is based on the following facts: because of the different proportions of U238 and U235 in NU and DU, a simple ratio of these isotopes will identify the form present:

Pure NU: [U235]/[U238] = [0.720/99.2745] = 0.00725
Pure DU [U235/U238] = [0.2015/99.7947] = 0.00202 [Ref 33]

Enriched uranium (EU) would have more U235 and less U238, so its ratio would greater than 0.00725. When the fraction of U235/U238 is between 0.00725 and 0.00202, the uranium being analyzed is a mixture of NU and DU. Dr. Hari Sharma has published a table which can be used to determine the fraction of each:

U235/U238	**% DU**
0.00202	100
0.003	81
0.004	62
0.005	43
0.006	24
0.007	4

0.00725 0 [Ref 34]

4.3 Biological half-life is the time it takes for one half of the inhaled or ingested DU to be excreted from the body. One normally assumes seven half-lives to rid the body of the particulates. The biological half-life of ceramic DU, i.e. DU exposed to the extremely high temperature in battle, is unknown. However, based on Dr. Sharma's studies, it may be in the range of ten years. This means ceramic DU may contaminate the human body for roughly 70 years. The measurable amount excreted in one 24-hour urine sample represents only a very small part of the original uptake of DU, but with more accurate estimates of the biological half-life, and the exact time of exposure, one could calculate from the daily excretion the original ingestion/inhalation amount. [Ref 35]

The biological half-life of uranium could not be determined accurately by Professor Sharma because of unfortunate disruption of his valuable work. This determination is very important to completing the scientific analysis of the health effects of DU, but for now we will have to assume that a reasonable estimate is 10 years.

4.4 Dr. Sharma's research established the fact that Gulf War Veterans from the 1991 War, were excreting measurable amounts of DU in urine, eight and nine years after their return from the Middle East. Meaning that each small micron or nano size particle of DU had been inside the body, whether in the lungs or elsewhere in organs and tissues, releasing 4.2MeV of alpha energy into 7 or 8 cells in a spherical area located around it, at least 800,000 times (about 100,000 nuclear events per year). This long lasting fraction of the originally deposited DU is likely the ceramic (glass-like) fraction produced in combat from the intensely hot fire produced by friction with air and hardened surfaces of buildings and armored tanks.

5.0 Uranium Weapons:

5.1 The effectiveness of uranium weapons is due not only to the high density of uranium, which is more dense than lead, but also to its ability to form inter-metallic compounds with iron. This combination melts through armor plating, and is air oxidized into very fine iron and uranium particles. Jim Phelps, former worker at Oak Ridge (National Nuclear Laboratory), reported a DU experiment conducted at Oak Ridge with varying amounts of U235. He reports "it was very obvious that as the U235 content went up, the brilliance and energy of the fire cone from hitting a steel plate went up dramatically." This means that the energy from a uranium projectile is not produced solely from the chemical oxidative (pyrophoric) properties, but is also related to the U235 content. [Ref 36]

There is some confusion about this point, and about the presence of trace fission products, and residual U235 found in the DU after the war in the former Yugoslavia. One theory, mentioned earlier, was that the impurities were in the uranium because it was derived from reprocessed fuel rods. A second theory is that a small amount of U235 was added, and some fissioned during the impact fire. Because much of the information is classified, it is impossible to clarify this distinction.

Samples of dust resulting from live-fire impacting an armored target, was analyzed for physical, chemical, and biological properties at the Atomic Energy of Canada Ltd., Chalk River Laboratories. [Ref 37] Mass spectroscopic analysis indicated that the average uranium used was DU. There were also present elements of iron, aluminum and silicon. About 47% of the total mass was particles with diameters less than 300 microns (0.3 milligrams), of which about 14% was less than 10 microns (i.e. respirable). The uranium oxides in the samples examined were mainly U3O7 (47%), U3O8 (44%) and UO2. (9%). [Ref 38]

5.2 A DU friction fire, or DU explosion, as at Doha during Gulf War I, reaches temperature between 3000 degrees and 6000 degrees Centigrade. For comparison:

Ordinary glass cracks at 150 to 200 degrees Centigrade
TNT explodes at 575 degrees Centigrade
Waste Incinerators destroy organic particles at 590 to 650 degrees Centigrade
Commercial Incinerators operate at 870 degrees Centigrade
Hazardous Waste Incinerators operate at 980 to 1,200 degrees Centigrade
The Twin Tower 9/11 fire was estimated to be 2,000 degrees Centigrade
Nuclear explosion outer shock front is about 60,000 degrees Centigrade
Core of a nuclear fireball is about 400,000 degrees Centigrade

Note: Most steel has other metals added to tune its properties, like strength, corrosion resistance, or ease of fabrication. Steel is just the element iron that has been processed to control the amount of carbon. Iron, out of the ground, melts at around 1510 degrees C. Steel often melts at around 1370 degrees C. The 2000 degree temperature of the Twin Tower disaster on 9/11 was hot enough to melt the steel bolts, holding the braces which held the building together. Uranium melts at 1132 degrees Centigrade, and reacts with nearly all non-metals.

At the high temperature of friction fire, most of the DU particles created are converted to a ceramic like form:

> "DU projectiles hit very different targets, but especially buildings and armaments, like, for example, tanks, and when they do, the temperature in the core of the explosion exceeds 3,000 degrees Centigrade, which is more than enough to have all solid matter sublime, and, in some case, form new metal alloys. The gas expends over a large volume of atmosphere, then, rapidly, the matter becomes solid again, taking the shape of small spheres, stays suspended in the air and is carried away over distances depending on atmospheric conditions like wind, rain, snow and air pressure. This phenomenon was studied in 1977-78 at the U.S. Air Force Base of Leglin, Florida, U.S.A...
>
> "After some time, all air-borne particles fall slowly down and settle on grass and vegetables, fruit or expanses of water where they become inevitably a guest of food and drink to animals and [people] alike. Even if the unwanted presence is known in advance - but very often it is utterly ignored - getting rid completely of inorganic particles can be very difficult".[Ref 39]

Particles of 1 nanometer in diameter, can float in air indefinitely due to Brownian action or thermal motion of its molecules. How far it travels will depend on wind, air currents, and obstacles in its path. [Ref 40].

5.3 Professor Gatti participated in the investigation, after the war in the Balkans, sponsored by UNEP (The United Nations Environment Program). The diseased tissues of soldiers and civilians affected by the war in the Balkans, was submitted to Dr. Gatti for analysis. The soldiers, who served in the former Yugoslavian Territory, had an unusually high incidence of Hodgkin's and non-Hodgkin's lymphomas. The civilians, and staffs of the Humanitarian Missions, were suffering from the same diseases. Moreover, the Head of the Pediatric Clinic of Sarajevo, Professor Edo Hasanbegovich, reported an increase of leukemia among children, especially in towns located close to the Croatian border.

Although many strict followers of the ICRP methodology protested that there was not sufficient latency period for these cancers to be radiation related, they failed to consider the classic paper on the formation of tumors, by Peter C. Nowell. Radiation can initiate cancers, and also promote cancers which are hereditary or have been initiated by some other carcinogen.[Ref 41] Promotion of cancers already initiated requires no latency period.

In March of 2000, NATO revealed that DU shells had been used in the Balkans, and in 2001 traces of DU were found by UNEP, not far from Sarajevo, and in several other places in the area. Although the evidence pointed strongly to the DU shells, Dr. Gatti looked for another cause of the problem. She noted the shared experience of all soldiers was serving on firing ranges.

By using an innovative technique using an electron microscope developed at their Institute, Dr. Gatti examined tissue from Balkan soldiers, Italian Soldiers and Yugoslavian residents who were experiencing similar symptoms. Astonishingly, all samples contained micro- and nano- size particles. She did not find DU or uranium, but that is understandable since she did not examine the urine, where the DU would be expected to be most concentrated. She reported finding compounds of: iron and selenium; copper, chlorine and zinc; selenium, titanium, iron and aluminum; silicon and bismuth; silicon and lead; iron, copper and zinc; chromium, iron and nickel; iron and manganese, and one sample of zinc alone. These particles had been formed under a very high temperature, as could be determined because of their spherical shape, hollow in the larger sizes. This was compatible with a high temperature caused by a DU fire or a rapid fire friction exercise.

The focus of Dr. Gatti's research has been solid inorganic particles of sizes one nanometer to 0.1 micron, i.e. ultra-fine particles or metal fumes. According to her:

> "Once the debris that size enters the body, be it via the digestive or respiratory system, they can easily negotiate the luminal (cavity of a tubular structure) tissues and either be captured by the tissue itself, which acts as a filter, or be transported by the blood or lymph until they end their journey in some organ (for instance the

kidneys and the liver). Lymph modes, for example, are the organs where lymphoma's start and develop, and where, in all pathological cases checked, we found the presence of inorganic particles. But also the other pathological specimens we had the possibility to observe show clearly and without any single exception the presence of debris". [Ref 42]

5.4 Nano-pathologies are not unknown to the medical profession. For many years physicians have dealt with silicosis, asbestosis, and inflammatory reaction to debris from worn out hip prostheses, and dental fillings. When humans are invaded by micro- and nano-particles which are chemically inert and non-biodegradable, they induce a reaction through which the body tries to defend itself against the invasion. This reaction may become clinically observable. The body's reactions opposing the presence of small-sized foreign particles less than 0.1 micron in diameter, constitutes the focus of a new discipline called Nanopathology.

The body's reaction starts with a mild irritation, which, if it becomes chronic, can lead to granulomatosis, a fibrosis and later, in some cases, a cancer. In the pathology of granulomatosis and sarcoidosis, the tissue often (always for granulomatosis) contains minute particles encapsulated, or even within a cell or nucleus, surrounded by inflammatory tissue. In patients suffering from deep vein thrombosis, extremely small particles have been found within the thrombi, with a variety of chemical compositions: talc, barium-sulphate, zirconium compounds, steel, iron, lead or silver compounds, some bound with mercury, tin and copper (composition typical of dental amalgams). Technically speaking, these compounds, some never seen before, can travel in the blood forever. They are so small that they can avoid the two methods of excretion from the body: feces and urine.

5.6 Nearly all of the first responders at the World Trade Center towers have had respiratory problems - Wheezing, shortness of breath, sinusitis and asthma. Now, three years after the disaster, many are suffering from a new syndrome called "WTC cough", a persistent cough with severe respiratory symptoms. Hundreds on the fire fighters have had to end their careers because of this syndrome according to a new U.S. Government Accounting Office Study. [Ref 43].

This syndrome is being blamed on the dust, debris, smoke and various chemicals released into the air when the Towers collapsed.

According to Sally Ann Lederman, Ph.D., of Columbia University's Mailman School of Public Health, who studied 300 non-smoking pregnant women in the New York Metropolitan area, pregnant at the time of the disaster, about 44% of the women who lived or worked within two miles of the World Trade Canter had babies who were smaller and with significantly lower birth weight than infants born to those further away.

Infants born to these mothers who were in their first three months of pregnancy during the attacks were born significantly earlier than infants whose mothers were at a later stage of pregnancy during the attacks. The authors say the studies suggest that there may be

health and developmental implications for children exposed to the World Trade Center attacks.

5.7 The Belgian group, at the University of Louvain, has demonstrated the inorganic particles of a size less than 100 nanometers (0.1 micron) can cross the alveolar barrier in the lung and enter the blood within one minute of inhalation. An hour later, that material was found in the liver. [Ref 44]

The British researchers have demonstrated that the curve describing cardio-vascular disease episodes increases and decreases with the increase and decrease of particles less than 2.5 microns in the air. Talc and asbestos are well known pollutants, and tobacco smoke carries fine inorganic particles which fell on the tobacco leaves during their growth and drying process, and which are practically impossible to remove. [Ref 45]

5.8 In the Chalk River experiment, previously discussed, researchers identified a 14% fraction of ceramic DU of size less than 10 micron (PM10). A fraction of this will include PM 2.5 micron and PM 0.1 nano-particles. Since this science is independent of geographical location, these size particles were undoubtedly present in the DU used in Iraq, and in the Doha explosion. Based on the research of Dr. Gatti, other inorganic debris will likely also be inhaled and ingested on a DU battlefield, and other places where high speed weapons are fired.

5.9 Given that the Hiroshima nuclear bomb was principally composed of uranium, this nano-pathology, though not identified by either the Atomic Bomb Casualty Commission (ABCC) or its successor, the Radiation Effects Research Foundation (RERF), must have been present among survivors after the atomic bomb explosion. It may account for many of the unexplained pathologies of survivors, which have been ignored by the ABCC and the RERF.

It should also be easy to see why physicists, using the ICRP methodology derived from the Hiroshima and Nagasaki experience, based their calculations on the mass of DU converted to oxides and inhaled, calculated a small dose, and assumed that the use of DU in war was not a serious health hazard. They may have ignored the complexity of the situation, discounted the biomedical experiences in the literature or failed to be concerned about the non-fatal cancers and the secondary and tertiary effects of the atomic bomb. This will be discussed later.

5.10 From a physical hazard point of view, microscopic glass-like particles of any material are subject to breaking, and producing sharp pointed edges. Human cells are, on average, 10 microns in diameter, and could be easily breached by such sharp objects.

The physical characteristics of DU fragments released in combat include: their ceramic smooth surface, fragility, nanoparticle size, foreign body irritation, and potential to stay in the body for very long periods of time.

Internal contamination means exposure of sensitive tissues and organs inside of the body to ionizing radiation, but the dose from that exposure requires knowing how long the exposure lasts. Uranium dust in a mine stays in the body for a few days, other uranium compounds stay for weeks, but at a significant fraction of the ceramic DU must stay in the body for 10s of years.

5.11 All of the isotopes of uranium are chemically toxic, especially to the kidney. This toxicity has been studied in the uranium miners and millers, and is based on particle size with diameter of about 5 micron, and with uranium having high solubility in body fluid. The biological half life of uranium dust is measured in days, for the largest fraction. The retaining fraction is sequestered from the circulatory system by its capture in the bone. For these reasons, the Rand Report, which was a search of the literature, was rather useless. This report, so widely circulated and quoted, did not deal the DU used on the battlefield, so its conclusions are pertinent only to literature on those health effects of uranium in the mines and mills which have been researched.

The chemical toxicity of uranium, more broadly discussed, can be found in Encyclopedia of Occupational Health:

> "Uranium poisoning is characterized by generalized health impairment. The element and its compounds produce changes in the kidneys, liver, lungs and cardiovascular, nervous and haemopoietic systems, and cause disorders of proteins and carbohydrate metabolism……Chronic poisoning results from prolonged exposure to low concentrations of insoluble compounds and presents a clinical picture different from acute poisoning".[Ref 46]

Because of the long half-life in the body, DU contamination with micro and nano-particles would be considered to be "chronic".

> "The outstanding signs and symptoms [of chronic poisoning] are pulmonary fibrosis, pneumoconiosis, and blood changes with a fall in red blood count: haemoglobin, erythrocyte and reticulocyte levels in peripheral blood are reduced. Leucopenia may be observed with leukocyte disorders (cytolysis, pyknosis, and hypersegmentosis). There may be damage to the nervous system. Morphological changes in the lungs, liver, spleen, intestines and other organs and tissues may be found, and it is reported that uranium exposure inhibits reproductive activity and effects uterine and extra-uterine development in experimental animals. Insoluble compounds tend to be retained in tissues and organs for long periods".[Ref 47]

Toxicology based only on the amount of uranium required to damage the kidney tubules, is less than adequate in the face of the known health problems which have, by experience, been demonstrated with uranium exposure. In the face of this prior knowledge, the failure of the military of both the U.S. and U.K. to keep records of the pre-exposure clinical data of all military, for comparison with the post-exposure data, is unconscionable. The ILO material is in the public domain, and is a common reference for concerned physicians.

5.12 Animal experiments have demonstrated that uranium exposure results in damage to the entrance portals: namely, respiratory and gastro-intestinal systems; and to the exit portals: the intestinal and renal systems. Uranium oxide was associated with fibrosis and other degenerative changes in the lungs, proteinuria, and increased non-protein nitrogen and slightly degenerative changes in the kidney tubules, in animals. Uranium oxide is associated with focal necrosis of the liver, and with hematological changes, lymph node fibrosis, severe muscle weakness and lassitude at doses inhaled in polluted air with concentration between 0.2 and 16 milligram per cubic meter. Damage to body organs of animals occurred at concentrations as low as 5 microns per cubic meter of air. [Ref 48]

5.13 In vitro studies on human osteoblast cells have indicated that they may be transformed to the tumorigenic phenotype, including induction of tumor when implanted into mice, differences in *ras* oncogene expressions, and phosphorylation by DU administered as uranyl chloride. The interaction of uranium with phosphorus containing groups in DNA is well documented [Ref 49]

5.14 The history of radiation protection is also important for understanding the DU issue. As early as 1921, 23 years after the discovery of radioactivity by Wilhelm Conrad Roentgen, medical radiologists came together to address the problem of working with radioactive substances. [Ref 50] By this time, a book on radiogenic cancer had been published, and several experiences of radiation burns, and even amputation, were well known. The famous physicists, Professor W.V. Mayneord, Head of the Physics Department at the Royal Cancer Hospital, London, UK, addressed a Conference, convened by the Institute of Biology and the Atomic Scientists Association, on Biological Hazards of Atomic Energy, at Oxford in October 1950.[Ref 51] His paper was called: “The organization of Protective Measures Against Radiation Hazards”, and he began the discussion with an historical record of broad concern and the series of International Radiological Congresses, hosted by the British X-ray and Radium Protection Committee, formed in 1921, together with the Royal Society of Medicine, the British Association for the Advancement of Radiology and Physiotherapy, the Institute of Physics, the Radium Institute (London) and the National Physical Laboratory. “The personnel of the Committee was afterwards widened to include representatives from other bodies” [Ref 52] One is taken back by the breadth of the early attempts to deal with radiation health problems! It was clearly a multi-disciplinary problem. Even the American Philosophical Society held a symposium to address and overcome the various problems posed by the expanded use of nuclear materials [Ref 53]

5.15 This group of radiologists in London took the initiative and organized a series of meetings in London, 1925, called International Radiological Congresses, which set up two Commissions, on Units and Protection, respectively. In 1928, at Stockholm, at the Second International Congress of Radiology, the British recommendations were accepted, and the radiological protection committees were accepted as committees of this organization of Radiologists. In 1952, the physicists of the Manhattan Project, who had been meeting between 1945 and 1951, approached the Radiologists, seeking to belong to the radiation protection committees of the International Congress of Radiology. This merger was called the International Commission on Radiological Protection (ICRP).

Since this time, the membership of the Main Committee, which makes all decisions on recommendations, has been 51% physicists. Radiologists have been reduced to about 15%, and Medical Administrators from nuclear nations were added, making up about 25 %. The other 10% of the Main Committee is made up of medical physicists, geneticists, a pathologist from Oak Ridge and other sub-specialties.

5.16 From this broad beginning, focused originally on the protection of Radiologists and their patients from X-ray, the Main Committee of ICRP - 13 men - have reduced the complex health effects of exposure to ionizing radiation to risk estimates for fatal cancer, and eliminated all other health effects as "not of concern". As physicists, they have elaborated the complexity of the source of radiation, the pathways to humans, and the various weighting formula for partial body exposures, internal and external radiation, radiation from alpha, beta and gamma radiation, etc. However, the biological endpoint is ridiculously simple: cancer death, adopted because it was relatively easy to count. Actually, the death rate of cancer is subject to several other variables: early detection, medical interventions, the patient's health at time of diagnosis, competing causes of death, whether the cancer had been diagnosed or not (many are found on autopsy), etc.

Several other biological endpoints were considered, including congenital malformation, miscarriages, obesity, autoimmune disease, and immune suppression. These other effects, although experienced by those exposed, have fallen away out of sight of the press, governments, and physicists. Many now think that only cancer death is caused by ionizing radiation exposure.

5.17 The term "Health Physics" made its first appearance in 1942 and meant: "that field in which physical methods are used to determine the existence of hazards to the health of personnel".[Ref 54] Mayneord pointed out that:

> "The problems now faced [in1950] seemed infinitely more complex than those previously dealt with. For example, although there had been accidents in the handling of radioactive sources, generally the radium in use had been completely enclosed in platinum containers, and the gamma and beta radiations were all that had to be guarded against. Now, with open sources, and the necessity for cooling of chain reactions, the problem of contamination of the atmosphere either by gaseous or particulate matter became of prime importance. Again, where as previous radioactive wastes were unimportant, except in a very few locations, the radioactive wastes both from the atomic piles themselves and from the associated chemical extraction plants became problems of the first magnitude." [Ref 55]

A health physicist was usually trained in mathematics, physics or engineering. He then took courses in measurement of radiation, and radiation regulations, which he would be expected to keep. Rarely has the Health Physicist taken basic course in biology or biomedical sciences. This discipline, which began as measuring of radiation in the work place to protect workers, has developed into the sole arbiter of radiation health problems!

5.18 The ICRP gradually moved away from the International Association of Radiologists. Today it is an independent Non-Governmental Organization which had declared itself to

be the authoritative source of all radiation protection advice. When the IAEA was asked by the UN to set radiation protection standards, the IAEA turned to ICRP, rather than the WHO. The problem dates from a 1959 agreement between the two Agencies, [Ref 56] which has, in effect been interpreted that IAEA is the lead agency for researching or assessing radiation health problems and the WHO can take care of healing the victims of exposure. ICRP is now a self-constituted and self-perpetuating organization, advisory to nations and to the IAEA, with no professional accountability to anyone in the global community. It is a very powerful organization, with the power to disregard scientists who challenge their premises and assumptions. The IAEA is also a powerful U.N. Agency, which reports directly to the Security Council, while all other Agencies report to ECOSOC (the U.N. Economic and Social Council).

5.19 Hermann Muller, the 1946 Nobel Prize winner in Medicine, stated in 1952:

> "It is not well to have the mathematical computations run so far ahead of their biological and chemical bases as they have in this [nuclear radiation] case…. When this happens, comparatively simple basic issues too easily become submerged and distorted under masses of calculations. Especially are such calculations misleading when given in such a mathematically technical and elided form that most of the biologists reading them - and they must be intended primarily for biologists - tend to take the conclusions in faith."

This is precisely what has happened to both the majority of biologists the physicians. The whole complex field of radio-biological-medicine has been abandoned to the physicists, who produce complex formula, accurate and important in themselves, but serving to quiet the contribution of every other discipline to understanding and resolving the questions most urgent to those who experience radiation damage.

5.20 Marie Woolfe, Chief Political Correspondent for The Independent, in the UK, reported that Michael Meacher, the former U.K. Environment minister, accused the British Government (7 September 2004) of covering up the risk to human health from nuclear power.

> "Mr Meacher said government lawyers had tried to suppress a report by experts on a committee he set up three years ago to assess the cancer risk from radiation. The Committee Examining Radiation Risks from Internal Emitters was to advise ministers on the effects of low-level radiation. He said two members of the committee had warned that the cancer risk of radiation could be 300 times higher than previously believed - findings he said the Government had tried to stop being published. [Ref 57]

This has happened over and over since 1950, and the disputed findings are inevitably decided by governments by appealing to ICRP recommendations. On the other hand, ICRP describes itself as only a recommending organization, claiming that nations must set their own standards. Thus no one is responsible for errors in judgment which affect many human lives and the health of large groups of people, like those exposed to DU.

> "The minority report, co-written by Richard Bramhall, of the Low Level Radiation campaign, also won the support of the committee's secretary, Dr Paul Dorfman, who has investigated leukaemia clusters around nuclear plants. Dr Dorfman said yesterday that the committee's decision to in effect block two of the expert views had severe implications for public trust." [Ref 58]

6.0 Analysis:

6.1. Although about 12,000 veterans from the first Gulf War in the U.S., and another 600 veterans in the U.K. are deceased, neither country has initiated systematic autopsy studies. Neither country, seems willing to withdraw the use of DU weapons, until scientists and physicians clarify the long term health and environmental problems. They continue to use these weapons, and at least by example, are promoting the use of DU by other nations. Neither the U.S. nor the U.K. have conducted an epidemiological study to determine which symptoms and illnesses, if any, are attributable to DU exposure. From a medical point of view, this constitutes deliberate endangerment of the life and health of both military and civilians, and reckless endangerment of future generations and the life supporting environment.

6.2. The question of the health effects of DU used on the battlefield, has been confused and substantially hampered by the minimalist methodology of the physicists, who have assumed responsibility for ultimate decision-making on all human health problems related to radiological hazards. The Medical Profession knew a great deal about radiation before the Manhattan project brought the physicists into the fore. Medical studies of Radiologist, relative to colleagues of other medical specialties had revealed that not only that radiologists die of leukemia and other cancers at a higher rate than did other medical specialists, but thy also died at higher rates of cardio-vascular diseases, and "all other causes". Medical studies had determined significantly increased health problems in the children of radiologists, especially diseases of the cardio-vascular system. Because these studies did not have accurate measurements of the radiation dose, they are ignored by physicists, bent on finding dose-response estimates. This is only the tip of the iceberg of research rejected by the physicists because it is lacking precise dose data. There are other methods of validating suspicion of causality! For example, when the radiologist became more careful of radiation exposures in their work, the rate of occurrence of leukemia significantly decreased. [Ref 59]

Something unusual happened in the first Gulf War, leaving more than 200,000 formerly healthy men and women on medical disability, and more than 11,000 dead in the U.S. alone. The most startling change in the war environment was the DU metal fume produced in the high temperature friction and impact fires. Although there were other suspected exposures to toxic chemicals, vaccinations and infectious diseases, none can account for the ubiquitousness of the Gulf War Syndrome. A best guess would be an air pollutant of potent toxicity. Moreover, many of the so called Gulf War Syndrome symptoms have also occurred after the high intensity fire at the World Trade Center, 11 September 2004.

7.0 Conclusions:

7.1 Governments have tried to silence protests against the use of DU weapons, especially by the U.S. and U.K., and protesters have been discredited by sarcasm and appeals to ICRP methodology, but not with scientific studies or well based medical information. After thirteen years of DU use in war, citizens are still being challenged to undertake scientific research and produce evidence of harm without access to technological, professional and financial resources.

7.3 The millions of dollars spent on official studies of DU done by the official international agencies, UNEP, WHO and IAEA, have done more to blur the science than to clarify it. Meanwhile many veterans and citizens are left to suffer without assistance.

7.4 National Studies in the U.S. and U.K. have been based on irrelevant situations or simply made by applied mathematical formula, replying on the ICRP methodology.

7.5 The useful information provided by these studies is limited to confirming the presence of DU in the contaminated environment, and comparison of the levels found with ICRP recommended maximum levels of exposure. It is not even clear which radiation standards apply, ICRP or U.S.; worker or members of the public. No attention has been given to those exposed, who are now sick and disabled.

7.6 Enough is known, in the medical literature, about the toxicity of uranium, and the potential for harm when it is used in war, to call for a complete ban on its use. Of prime concern is its known affinity for phosphorus containing groups in the DNA. It appears to be a clear violation of the Geneva Protocol of the use of Gas in War, Geneva 1925, which was ultimately signed, with reservation (i.e. use for crowd control) by President Ford for the U.S. 22 January 1975. This Protocol was proclaimed on 29 April 1975. The U.K. signed this Protocol on 9 April 1930. The commitment to this Geneva Protocol was clearly known by the U.S. and U.K. prior to the 1991 war against Iraq. [Ref 60]

7.5 World Health Assembly Resolution 12-40 between the WHO and the IAEA needs to be amended. The United Nations must seek basic radiation protection information from the WHO and not the non-governmental organization, ICRP.

7.6 Micro and nano particles are able to contain tens of thousands of uranium atoms, each particle capable of nuclear transformations at a rate of hundreds or thousands a year, each transformation emitting more the 4 MeV of energy. Nano particles can enter into the cell and its nucleus. They can also pass through the lung-blood barrier, the blood-brain barrier, the placenta and reach other sensitive tissues and organs. The nuclear bond between atoms in the long proteins, and the DNA of the cells can be broken with a force as small as 6-10 eV. Moreover, given the long residence time in the body, there is potential for an occasional fission of some uranium atom. It is not possible that these energy bursts will not do biological damage to cells, and to the individual.

7.7 DU friction and impact fires cause the sublimation of metals and other materials in the range of the fire. These will produce inorganic nano and micro particles which are injurious to humans and animals. This debris will continue to pollute the food web for many years after the end of hostilities.

7.7 Damage from ceramic radioactive particles and the fire related debris produced when DU impacts a hardened target can cause damage to humans and animals across national boundaries because of its aerosol properties.

7.8 The ICRP has no authority or scientific backing for claiming that people must only be concerned if radiation causes a fatal cancer or serious genetic disease in a live born offspring. Most normal people care about **all** cancers, whether fatal or not, benign tumors and autoimmune diseases which are radiation related. They also grieve over miscarriages, still births, congenital malformations or diseases and all teratogentic damage caused by radiation, whether it is inheritable (genetic) or not.

7.9 Because of its radiological properties, DU would be expected to effect women and children more than men. Women are more susceptible to radiation related cancer because of their radio-sensitive breast and uterine tissue. Children are more sensitive to radiation because of their growth metabolism, and also because of their long prospective life-span, which allows for the latency period of most cancers. Leaving DU debris in the environment is very much like leaving land mines, which continue to kill long after the war is over.

7.10 Perhaps some of the concerns which I raise are beyond the jurisdiction of the Tribunal, however, I believe that a strong judgment and recommendations from the Hiroshima Tribunal will go a long way toward righting the 50 years of disastrous leadership the world community has endured, in matters of radiation health, from the physicists. Perhaps a recommendation for multidisciplinary bodies dealing with these complex problems, and a caution to professionals to keep their remarks to their area of expertise, is in order. Certainly a recommendation coming from Hiroshima, where for almost 60 years the victims of the first atomic bomb have endured this misuse of science, to oppress the victims, would be very effective.

7.11 Given the current methods of waging war, a total ban on pre-emptive and defensive war needs to be the goal of the world's citizens. This goal presumes a strong Court system to adjudicate problems, and a U.N. Peacekeeping Force of some competence. It will also require the steadfast will of the people, and their constant vigilance and assistance.

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