Depleted Uranium: All the questions about DU and Gulf War Syndrome are not yet answered

For 15 years, the debate about depleted uranium (DU) and its detrimental effects on the health of veterans of the Gulf War of 1991, on the Iraqi people and military (and subsequently on the people of Kosovo, Afghanistan, and Iraq during the second war) has remained unresolved.
21 November 2006 - Dr Rosalie Bertell

Meanwhile, the number of Gulf War veterans who have developed the so-called Gulf War syndrome has risen to about one-third of the 800,000 U.S. forces deployed, and unknown proportions of those involved in the subsequent wars. Uncounted civilians and personnel of other nations that fought in Iraq and other wars since 1991 have also been afflicted. The veterans have suffered from multiple serious physiological disorders and have received little or no official recognition, medical relief, or compensation. We need to take another look at this issue, using a holistic and interactive model for the toxic matrix of exposures, identifying the major roadblocks to resolving the scientific questions, and finding appropriate medical and political responses. This commentary is such an attempt.

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The following is a summary of the paper written ICBUW Science Team member Gretel Munroe:

A Commentary on "Depleted Uranium: All the Questions About DU and Gulf War Syndrome Are Not Yet Answered" by Dr. Rosalie Bertell, a paper published in The International Journal of Health Services 36(3), 503-520, 2006

In this paper, Dr. Rosalie Bertell, an epidemiologist with 30-years experience in the field of low level radiation, discusses the radioactivity and the high chemical toxicity of depleted uranium, its potential for harm and various disease states that DU exposure may lead to. She does this against the background of the methodology of the International Commission on Radiological Protection (ICRP) which has advised governments and agencies on radiation standards. Central to Dr. Bertell's paper are the physical ailments oft veterans from the 1991 Gulf War and the possible role that DU exposure has had in these illnesses.

The ICRP methodology is based on a mathematical model which predicts risk of cancer deaths through the analysis of radiation dose-response. The model estimates damage to cellular DNA as created by the uniform spreading of ionizing radiation over a tissue or organ. Once having determined the average radiation spread over, say, an organ, the ICRP gives that organ a certain weight allowing the model to approximate whole body exposure. A risk formula then estimates the number of cancer deaths that will result. If the formula gives a small number of expected cancer deaths, this is deemed of little importance. Bertell says, "This ICRP methodology assumes the affected persons care only about cancer death, that they have normal physiological health and intact cellular repair systems, and that no other life-threatening exposures confound the radiation experience". (DU causes harm through its

chemical toxicity as well as its radioactivity, and the former is not taken into account in determining risk of cancer deaths by the ICRP model).

Bertell deals first with DU's radiation. DU is primarily an alpha emitter. The full radiation effect of DU occurs six months after its production, when together with two chief decay products DU gives off its maximum amount of alpha, beta and some gamma radiation – although Uranium 238 (of which DU is mainly composed) –gives off most of the alpha radiation.

One milligram of U-238 can give off 1,071,000 alpha particles in one day. Each alpha particle releases over 4 MeV (million electron volts) of energy, in a spherical direction, which will hit cells randomly up to 6 or so cells away in an organ or tissue. Just 6-10 eV (electron volts) are needed to cleave the nuclear DNA strand in a cell.

U-238 also sustains spontaneous fission; that means that approximately two atoms of U-238 in each milligram of uranium reacts this way every year. Decaying by spontaneous fission leads U-238 to give off approximately 40 times the energy normally released.

Alpha particles typically randomly hit as far away as six cells. Beta particles, though far fewer in number travel further as is also the case with gamma rays. The radiation effect of these particles does not therefore affect the entire surface of the organ or tissue homogeneously as is hypothesized in the ICRP model.

Bertell says, "The radiation dose-response methodology, developed from studies of high-level radiation, seems to work by masking the low-dose effects. It is not appropriate for understanding low-dose DU exposures, because radiation, heavy metals (DU is a heavy metal), and other toxic chemicals can destroy the functionality of the cellular respiratory system (the mitochondria, which is the powerhouse of the cell), disrupt the chemistry of enzymes and hormones, frustrate normal cellular detoxification and repair, and leave the person alive but chronically ill". (p. 507) Here Bertell is alluding also to DU's high chemical toxicity and the other toxic metals to which the veterans were exposed in the First Gulf War.

In the section, **"Toxic Chemical and Radiological Damage to Cells"**, Bertell mentions the invisible metal fume created at extremely high temperatures when a DU shell hits a tank. DU ignites pyrophorically on impact and at temperatures reaching 3,000-6,000 degrees Centigrade. DU and all other metals at the struck area of the tank are sublimated, forming a gas or aerosol. To put this in perspective, the heat of the jet fuel which imploded on the World Trade Center in 2001, has been estimated to be 2,000 degrees Centigrade whereas the heat of the surface of the sun is approximately 6,000 degrees Centigrade.

The sublimated particles of DU and the other metals are nano-sized particles. Nanoparticles are a billionth of a meter in size, and are smaller than microns. They act more like a gas than a particle. These nanoparticles can cross the lung-blood barrier and gain entrance to cells. There they create free radicals– an electron is either knocked out of orbit in a molecule or a molecule that has lost one of a pair of electrons but in either case, an electron is lost and the molecule wants to gain another electron as quickly as possible. It will take an electron randomly from the nearest molecule, which in turn needs an electron to make up for the one it has lost.

Free radicals are generated by ionizing radiation while the heavy metal toxicity attacks the proteins in the cell which normally fight the free radicals. (The heavy metal toxicity of DU also creates free radicals). Bertell says, “Some scientists believe that the oxidative stress (when there are too many free radicals and not enough antioxidants to neutralize them) caused by uranium’s heavy metal properties is even more damaging than its radiological properties.

Total oxidative stress causes failure of protective enzymes, leaving cells vulnerable to viruses and mycoplasmas (bacteria without a cell wall). Damage to the cellular communication system and the mitochondria (where cellular respiration takes place), heavy metal replacement of magnesium in molecules that normally function as antioxidants, and destruction of the body’s repair mechanisms have serious consequences, including chronic disease and tumorigenesis”. (p. 507)

Bertell discusses how a protein is sequenced by DNA which is then manufactured by the RNA, after which it goes through a process of folding. The way it is folded influences its function. The folding process is complex. Bertell says, “Free radicals can totally disrupt this process, forming unusual molecules; and in the presence of heavy metals, the process may use trace amounts of toxic metals to replace the normally used zinc and manganese.” (p. 507)

Proteins that are not correctly folded may not be sent to cell membranes or glands where they are needed. Bertell says, “Some diseases caused by misrouted proteins include cystic fibrosis, diabetes insipidus and cancer” (p. 508).

Bertell adds that the amassing and accumulation of misfolded proteins leads to neurodegenerative diseases, Parkinson’s Disease and early- onset Alzheimer’s Disease. In these diseases, amyloids (pathological aggregations of nonbranching fibrils in bundles or forming a felt-like meshwork made from protein or protein fragments) are formed from protein fragments and dysfunctional proteins and that “Misfolded proteins are a central pathogenic mechanism, and Gulf War veterans have manifested many of the symptoms of these neurodegenerative diseases”. (p. 508)

Lou Gehrig’s disease is twice as commonly diagnosed in Gulf War veterans as expected. A disease of older people, it has attacked young veterans. Although Lou Gehrig’s disease (or ALS) is considered to have no known cause, Bertell says, “it seems clearly related to the failure of anti-inflammatory and antioxidant enzymes together with mitochondria dysfunction”. It is more complicated than this but oxidation or the production of free radicals in lipids (fats) in the brain can cause faulty regulation of cytokines, small proteins that communicate between neurons and glia cells (brain cells made of lipids) which become toxic through “neuro-inflammation”, killing neurons.

In the section, **“Immune and Hormonal Systems Damaged in the Gulf War”**, Bertell notes that “The DNA of mitochondria is 16 times more sensitive to radiation than is nuclear DNA”. She goes on to define the action of free radicals, adding, “free radicals can effect dramatic and destructive changes in the cell and in the intercellular fluid.” (p. 509)

The body has endogenous antioxidants which neutralize free radicals. One is glutathione (GSH). One function of GSH is the repair of cellular structures damaged by free radicals. Bertell says, “This antioxidant function of GSH is normally credited as having anti-cancer properties, since it neutralizes free radicals. Cellular repair mechanisms depend heavily on the presence of GSH in cells.” (p. 509). GSH also binds to heavy metals and is removed from the

cell where the complex of GSH and heavy metal is excreted in the bile. This is both good and bad, as the binding of the GSH to a heavy metal, reduces the amount of GSH remaining in the cell where it is needed to neutralize free radicals.

Another endogenous antioxidant – and anti-inflammatory – enzyme (a protein) is superoxide dismutase (SOD). SOD also is part of the cellular immune system. SOD is produced in the mitochondria of cells as well as in the liver. SOD needs zinc, manganese and copper to function. Manganese in SOD can be replaced by toxic metals such as nickel, which becomes part of the DU aerosol when the DU shell hits the metal of the tank – nickel being a component of steel. Nickel can reduce zinc stores in the body. This effect of toxic metals can make the SOD dysfunctional. Many free radicals in the cell can also deplete the cell of its SOD. SOD can be damaged by a number of different chemicals as well.

A decrease of manganese which is also required by protective enzymes in the cell lessens the ability of the cell to keep out viruses and bacteria.

In a section, **"Disturbance of Thyroid Function"**, Bertell discusses how tiny amounts of aluminum taken in through inhalation or food or water, can combine with fluoride to form a pseudo-hormone that can replace thyroid stimulating hormone (TSH) which can damage the thyroid and pituitary glands. These glands regulate metabolism and this "has severe repercussions for every organ system in the body, including the brain". Aluminum from food packaging, salt, etc. can combine with fluoride, found in oil well fires, soft drinks made with fluoridated water etc. to form aluminum fluoride. This compound can also interfere with cellular repair mechanisms. A further problem is that these compounds are not excreted as TSH is, and can bind to the TSH receptor sites of cells. One effect of this is the overworking of GSH in cells as well as sleep deprivation. Bertell states that, "At Oak Ridge, the U.S. Department of Energy nuclear weapons facility, illnesses similar to GWS are increasingly encountered. These illnesses have not been diagnosed and many go untreated. Aluminum and hydrofluoric acid, as well as DU waste, are part of the pollution of this and other Department of Energy facilities. Victims of the environmental disasters at the weapons facilities report muscular and skeletal problems, nervous system disorders, anemia, rashes, irritability, high blood pressure, and thyroid problems."(p. 511).

Bertell adds, "Heavy metal exposure (including uranium) can cause loss of cellular immunity, autoimmune diseases, joint diseases such as rheumatoid arthritis, and diseases of the kidneys, circulatory system, and nervous system. Heavy metals supplant the normal calcium and other minerals in enzymes (which make chemical reactions happen) and cause these molecules to lose their important function in the body". (p. 511) She mentions another toxic compound, peroxynitrate, created from the free radicals nitric oxide and superoxide which reduce the effectiveness of respiratory enzymes and the manganese-SOD enzyme, She states, " Decline in functional mitochondria (where cellular respiration takes place) is most damaging to those organs that have the highest energy demands per gram of tissue - namely, the heart, kidney, brain, liver, and skeletal muscle, in that order. These organs become poorly protected against irradiation from circulating uranium particles, as well as various other pathogens" (disease-causing entities). (p. 511).

In a section, **"Mycoplasmal Invasion Related to Depleted Uranium Exposure"**, Bertell discusses how DU's negative effect on cellular immunity can allow mycoplasms, (bacteria lacking a cell wall) into some human cells. Their presence can only be found through use of a sensitive genetic marker analysis. Several laboratories in the U.S. have found mycoplasms in

patients with chronic fatigue syndrome as well as Gulf War Syndrome. Bertell says, "The percentage of positive findings for mycoplasms ranged from 60 to 80 percent of patients examined." One research team found mycoplasm incognitos (a toxic form created in the military biological warfare laboratory) in their daughter suffering from GWS on her return from the Gulf War.

Bertell says, "Mycoplasma incognitos causes chronic fatigue syndrome, recurring fever, night sweats, joint pain, stomach upsets, stomach cramps, headaches, skin rashes, heart pain, kidney pain, thyroid problems, and, in extreme cases, autoimmune-like disorders." (p. 512)

Bertell has a section on the **differences between DU dust created in war and the uranium oxide found in uranium mines and mills**. This is important because most of the research on uranium has been done on uranium dust in mines and mills, and these have been applied to potential health effects of the DU aerosol. A principal difference is the metal fume (DU aerosol) that is produced at temperatures between 3,000-6,000 degrees C and the resulting particles made of DU, steel, aluminum, whatever materials are near the point of impact of the shell. are between 1 nanometer and 2.5 microns in diameter. These particles can make their way into the deep lung. They are largely insoluble. Furthermore, the creation of the DU aerosol also causes the sublimation of all nearby metals (like steel) and materials, into nanosized molecules. Bertell says, "The small size of these particles facilitates uptake into cells and transit across epithelial and endothelial cells into the blood and lymph circulation, thus reaching potentially sensitive targets. These targets include lymph nodes, spleen, and heart". (p.512-513). She goes on to say that the particles can gain access to the nervous system as well. Dust particles from mines and mills are much larger, about five microns, and are not invisible like the minute DU aerosol particles. They also contain radium and radon, which are basically absent from the DU aerosol. Particles greater than 2.5 microns don't penetrate the deep lung as particles from the DU aerosol do.

This section is followed by one on **"Human Ability to Screen Out Uranium"** in which Bertell differentiates between natural uranium and particles of the DU aerosol. The natural uranium (about 1.9 micrograms a day) which comes into the body through our food and drink passes through the gastrointestinal tract and out through the feces. Only 19-38 nanograms of this natural uranium are absorbed through the intestinal walls. It then goes through the hepatic portal system, is screened by the liver and goes out through the urine via the kidneys or into the blood. Bertell says the natural uranium in the blood is stored in the bone and later excreted. This does not happen to the DU aerosol particles which are inhaled and lodge in the deep lung. These nanoparticles from the metal fume, are too small to be filtered through the kidney and excreted from the body. They penetrate the lung-blood barrier, the blood-brain barrier and the placenta. They are insoluble for days, months or years and only react chemically once soluble. However, whether soluble or insoluble, DU particles remain radioactive.

In **"Carcinogenic Properties of Uranium"**, Bertell says that cancers "that have been attributed to DU", are linked to lowered immunity in the individual. She says, "A depressed immune system often changes the status of a subclinical cancer, with which the individual is coping, into a clinically diagnosable cancer. There is no doubt about the ability of radiation to initiate cancer and also to promote cancers initiated by other carcinogens". (p. 514) She mentions that the Armed Forces Radiobiological Research Institute (AFRRI) has come to the conclusion that DU can cause cancer. She also cites two papers, one by AFRRI and the other by the Royal Society in the U.K. that DU is synergistic, that is, that the radioactive component

and the chemically toxic component together can cause more damage to the cell than either component could alone, causing up to eight times more damage.

Bertell adds, “There is also serious discussion among radiobiologists about the inadequacy of the ICRP model for dose and does-response, based on the physics model. There is growing agreement that this model is inappropriate for application to internal alpha emitters”. (DU is mainly an alpha emitter). (p. 514)

Bertell says burning uranium fuel particulates which occurred in Nagasaki, Hiroshima and Chernobyl has not been fully recognized by the International Atomic Energy Agency researchers as having played a part in cancers resulting from these disasters. She says, “Since no internal dose estimates were ever attempted at Hiroshima and Nagasaki, and the dose estimates around Chernobyl” (which weren’t based on uranium or plutonium), “the effect of uranium and plutonium fuel aerosol was neglected. By assuming that the DU in war would act like uranium dust in mines, the experts made the mistake of assuming that the signature of this exposure would be uranium storage in bone and damage to the kidney tubules. Because these effects were not dominant - though they did occur - DU was dismissed as a cause of Gulf War syndrome.” She elaborates and adds that the cancers “may be expected to appear over the next 20-50 years.”

In **“Teratogenic Toxicity”**, Bertell says, “Soluble uranium oxide and all nanoparticles can cross the placenta, and these are particularly toxic to the rapidly developing embryo or fetus. At low doses, they damage the fetal brain, causing behavioral problems, such as aggressiveness and hyperactivity, and mental retardation. Other teratogenic effects are congenital malformations and diseases. The underdeveloped immune and hormonal systems of the fetus are more easily compromised than in a fully mature adult”. (p.515)

Bertell mentions a large epidemiological study of the health of the children of Gulf War veterans by Kang of the Department of Veterans Affairs. Under 21,000 veterans participated in the study which dealt with the first born child conceived after the end of deployment after the Gulf War – the control group of veterans did not serve in the theater of the Gulf War. Bertell says, “Male Gulf War veterans were twice as likely, and female veterans almost three times as likely, to report children with birth defects than their counterparts who did not serve in the first Gulf War. Birth defects included webbed fingers and toes, heart murmurs, chromosomal abnormalities, and brain tumors.”

Male Gulf War veterans also reported more miscarriages, a difference that was statistically significant whereas women Gulf War veterans reported more miscarriages but as the numbers were small the differences were not statistically significant. The Kang study did not deal with causes of the results of the study.

Bertell also mentioned research done at the Baltimore, Maryland Veterans’ Hospital where DU was found in the semen of Gulf War veterans.

In her final section, **“Empirical Findings”**, Bertell discusses the research of Dr. Hari Sharma, formerly of the University of Waterloo who tested the urine of some U.S., U.K., and Canadian veterans as well as Iraqi civilians from Basra and Baghdad. Using 24-hour urine samples, his isotopic analysis revealed a range of DU in the samples of 81 to 1,340 nanograms. Testing was done 8-9 years after the Gulf War. Two of the 3 Iraqi residents of Basra had either 147 or 426 nanograms of DU in their urine – the third had none. Two of 5 residents of Baghdad had

DU in their urine – 20 percent DU in one Iraqi and 64 percent DU in the other. The urine of the other 3 residents of Baghdad contained no DU.

In the **"Summary" and "Conclusion"**, Bertell says that "Ceramic nanoparticles may well stay in the body for a lifetime." She says as well, "Damage to the individual will occur not only from the inhaled DU aerosol but also from all the other toxic debris generated by the DU metal fume. Metal debris in the body, like debris from deteriorating hip implants, dental amalgams, or breast implants has been shown to be detrimental. Hence the variety of symptoms reported by Gulf War veterans derives from their battlefield environment, not least of which was the DU-caused metal fume. Use of DU in battle is certainly a major contributor to this medical disaster that has affected at least one-third of U.S. Gulf War veterans."(pp. 516-517).

She concludes by saying, "The problems of Gulf War syndrome are too complex for a reductionist methodology (that of the ICRP) that extracts the toxic effect of a single component, even depleted uranium. Increased free radicals, heavy metal toxicity, the complexity and sensitivity of disrupted cellular reactions, damaged organelles, dysfunctional enzymes and hormones, and mycoplasmal invasion - all occurring simultaneously within vital organs – pose monumental problems for function and survival."(p. 517).

For treatment, Bertell mentions use of distilled water for drinking and cooking which she adds helped atomic veterans in the 1950's and 1960's. She recommends increasing protein and mineral intake, especially zinc, magnesium and calcium, to replace bodily losses.

Finally, she mentions the legality or illegality of DU weapons. She says, "Serious questions about the legality of DU, as used in war, also need answers". She talks about the fact-finding teams of experts that have all based their methodology on ICRP methodology. She cites the Sub-Committee on the Promotion and Protection of Human Rights' finding that "the use of DU is illegal under existing Humanitarian Law". She adds, "It is not disputable that DU powder produces an invisible metal fume. This alone is a violation of the Geneva Protocol on the Use of Gas (metal fumes constitute a gas) in War (Geneva, 1925), " (p. 518). The United States and the U.K. are both signatories of this Protocol.

Bertell ends with, " Clearly depleted uranium is at least partially responsible for a series of biochemical events that are significantly harmful to human beings. The damage is indiscriminate, carrying not for national affiliation, age, gender, or status as combatant or civilian……" (p. 518).