Science and Depleted uranium (DU) weapons

"Clearly, this kind of ammunition leaves behind a long-lasting contamination on the battlefields, which **is not compatible with civil radiation protection norms**." [bold format added by the authors of the sudy]

Schmid, E. and Wirz, Ch.: *Depleted uranium*, AC-Spiez Laboratory / Defence Procurement Agency, Switzerland, (May 2000), page 7; http://www.labor-spiez.ch/d/h_info/du/index.htm

"You could receive a dose (or intake) of DU that potentially exceeds US safety standards if you are in, on or near an armored combat vehicle at the time it is struck by DU munitions, or a DU-armored vehicle where the encased DU armor is struck and ruptured by hostile fire (DU or non-DU)."

U.S. Army Chemical School, Directorate of Training Development: *Tier I: Depleted Uranium General Awareness*, Training Support Package, respond to depleted uranium on the battlefield, (1 July 1999), p. 9, ; zie ook de videotape TVT 3-117, http://www.amc.army.mil/amc/sf/du.html

"C'est néanmoins un principe accepté au niveau international que l'on doit éviter toute exposition inutile au rayonnement aussi infime que soit le risque escompté d'effets néfastes sur la santé."

OTAN: *AASTP-1 – Manuel sur les principes de securité OTAN applicables au stockage des munitions et des explosifs militaires – chapitre 8 – munitions à l'uranium appauvri*, *§ 2.8.1.4. Caractéristiques de rayonnement*, (1992); www.avigolfe.com

"The health effects of depleted uranium (DU) are mainly caused by its chemical toxicity. Although the kidneys are the main target organs for uranium toxicity, uranium can also reach the brain. In this paper, the central effects of acute exposure to DU were studied in relation to health parameters and the sleep-wake cycle of adult rats. [...] It has been demonstrated that Uranium can cross the blood -brain barrier to accumulate in the brain (Gilman et al., 1998; Pellmar et al., 1999a; Lemercier et al., 2003). [...] Recently, neurocognitive deficits were observed in veterans exposed to DU fragments during the Gulf War (McDiarmid et al., 2000)."

Lestaevel, P., et al.: *The brain is a target organ after acute exposure to depleted uranium*, in *Toxicology*, vol. 212, (6 May 2005), pp. 219-220; www.elsevier.com/locate/toxicol

"Under most circumstances, use of DU will make a negligible contribution to the overall natural background levels of uranium in the environment. However, levels of DU may be significantly raised over background levels in close proximity to DU contaminating events. Over the days and years following such an event the contamination will become dispersed into the wider natural environment. The greatest potential for DU exposure will follow conflict where DU munitions are used and people living or working in these areas inhale dusts and consume contaminated food and drinking water. Measurements of DU in conflict areas indicate only localised (within a few tens of metres from impact sites) contamination at the ground surface. However, levels of contamination in food and drinking water could rise after some years and should be monitored where it is considered that there is a reasonable possibility of significant quantities of DU entering the ground water or the food chain.[...] Young children could receive greater exposure to DU when playing in or near DU impact sites. Typical hand-to-mouth activity could lead to high DU ingestion from contaminated soil. Necessary preventative measures should be undertaken. [...] Since DU is a radioactive metal, restrictions are needed on the disposal of DU. There is the possibility that DU scrap metal could be added to other scrap metals for use in refabricated products. DU is a pyrophoric metal that can produce oxides that can be inhaled when heated (welded). Disposal of DU should normally come under appropriate national or international (IAEA) recommendations for use of radioactive materials. [...] **Genotoxicity**: Some *in vitro* studies suggest genotoxic effects occur via the binding of uranium compounds to DNA. This and other mechanisms causing possible genotoxicity should be further investigated."

World Health Organization: *Depleted uranium: Sources, exposure and health effects*, Department of Protection of the Human Environment, Geneva, (2001), chapter 15, pp. 147-149; http://www.who.int/ionizing_radiation/pub_meet/en/Depluranium4.pdf

"It is probable that many [DU] penetrators and jackets are hidden at some metres depth in the ground. These penetrators and jackets as well as those on the ground surface, constitute a risk of future DU contamination of ground water and drinking water. Heavy firing of DU in one area could increase the potential source of uranium contamination of ground water by a factor of 10 to 100. While the radiation doses will be very low, the resulting uranium concentration might exceed WHO health standards for drinking water."

United Nations Environment Programme (UNEP): *Depleted uranium in Kosovo – post-conflict environmental assessment*, (2001), p. 35; http://postconflict.unep.ch/publications/uranium.pdf

"Most particles that deposit in the upper airways are trapped in mucus that moves to the throat and are swallowed within a few hours. Most particles that deposit in the deep lungs are quickly captured by mobile cells called macrophages, rather similar to white blood cells. They may move the particles to the bronchial tree, to be carried away and swallowed, but this is a slow process, and some particles may remain in the lungs for years. A very small fractions of particles deposited in the lungs will be transferred to lymph nodes, where they would probably remain if they did not dissolve. However, whether in lungs or lymph nodes, uranium oxide particles will gradually dissolve, and the dissolved uranium will be absorbed into the blood. [...] Uranium does stay much longer in the bone, so there will still be a few % left after 5 years, and about 1 % after 25 years."

Health Protection Agency: *What happens to depleted uranium inside the body*, (16 July 1996), United Kingdom National Radiological Protection Board (NRPB); www.hpa.org.uk/radiation/faq/du/du7.htm

"In the current study we demonstrate that DU can generate oxidative DNA damage and can also catalyze reactions that induce hydroxyl radicals in the absence of significant alpha particle decay. [...] DU was 6-fold more efficient than iron at catalyzing the oxidation of ascorbate at pH 7.These data [...] also suggest that DU can induce **carcinogenic** lesions, e.g. oxidative DNA lesions, through interaction with a cellular oxygen species. [...] Our laboratory has used both an in *vitro* human cell-model and rodent studies to examine the potential late health effects of these heavy metals. Data from our laboratory have demonstrated that DU is neoplastically transforming and genotoxic *in vitro*. The *in vivo* effects of internalized DU include enhancement of urine **mutagenicity**, oncogene activation, and uranium redistribution to multiple organs. [...] While these findings might suggest that the chemical component of DU could be primarily responsible for the transforming effects, recent cellular transformation and cytogenetic findings from our laboratory have shown that alpha particles are involved in the neoplastic transformation process. Furthermore, the involvement of '**bystander effects**' cannot be ruled out. Bystander effects, whereby cells that are not directly exposed to radiation exhibit adverse biological effects, have been observed in a number of experimental systems. Using uranium isotopes with differing specific activity, our laboratory has provided the first evidence that alpha particle radiation is involved in DU-induced effects. [...] While our recent *in* vitro data have demonstrated that alpha particles are involved in DU-induced cellular effects, we also propose that a portion of the transforming mechanisms of DU might be related to its chemical properties. Specifically, DU could participate in cellular biochemistry that generates reactive oxygen species similar to the heavy metal nickel. Alpha particles are high-LET radiations and can cause DNA damage initiated from either diect ionization by the alpha particles or the indirect action of water radiolysis products. "

Miller, Alexandra C. et al.: *Depleted uranium-catalyzed oxidative DNA damage: absence of significant alpha particle decay*, in *Journal of Inorganic Biochemistry*, (2002), vol. 91, pp. 246-247; http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12121782&dopt=Abstract

"**Chromosome aberrations** and '**sister chromatid exchanges**' were determined in standard peripheral lymphocyte metaphase preparations of 13 British Gulf War veterans, two veterans of the recent war in the Balkans and one veteran of both wars. [...] The Bremen Laboratory control served

as a reference in this study. Compared with this control there was a statistically significant increase in the frequency of dicentric chromosomes and centric ring chromosomes in the veterans' group, indicating a previous exposure to ionising radiation. [...] Numerically, this indicates a 5.2 fold elevation among the volunteers compared with the controls. The difference is statistically significant. Among the volunteers, no sample was without chromosomal aberrations. [...] Incorporated DU causes exposure to ionising radiation, predominantly alpha radiation of about 4 MeV [Million electron Volts]"

Shröder, H., et al.: *Chromosome aberration analysis in peripheral lymphocytes of Gulf war and Balkans war veterans*, in *Radiation Protection Dosimetry*, Vol. 103, No. 3, (21 November 2002), pp. 211, 214; http://www.cerrie.org/committee_papers/INFO_9-H.pdf

"DU is radioactive and poisonous. Exposure to sufficiently high levels might be expected to increase the incidence of some cancers, notably lung cancer, and possibly leukaemia, and may damage the kidneys."

Goodhead, prof. Dudley T., et al.: *The health hazards of depleted uranium munitions, part 1*, chapter 5.1: *Conclusions*, The Royal Society**,** (May 2001), p. 21; http://www.royalsoc.ac.uk/displaypagedoc.asp?id=11496

"Genotoxic effects of DU exposure were assessed at both the chromosome and gene level. [...] The association between chromosomal aberrations and urine uranium observed here does not appear to be the result of smoking, exposure to mutagens, or age in this cohort, since none of these were found to be significantly associated with either average chromosomal aberrations or urinary uranium levels. Moreover, x-ray history was not significantly associated with the chromosomal aberrations observed."

McDiarmid, Melissa A., et al.: *Health effects of depleted uranium on exposed gulf war veterans: a ten year follow-up*, in *Journal of Toxicology and Environmental Health, Part A*, (2004), vol. 67, pp. 288-289; www.pdhealth.mil/downloads/Env_Health%20Effects_DU.pdf

"There is considerable evidence that cells that themselves are not exposed to ionizing radiation but are the progeny of cells irradiated many cell divisions previously may express a high frequency of gene mutations, chromosomal aberrations and cell death. These effects are collectively known as radiation-induced **genomic instability**. A second untargeted effect results in non-irradiated cells exhibiting responses typically associated with direct radiation exposure but occurs as a consequence of contact with irradiated cells or by receiving soluble signals from irradiated cells. These effects are collectively known as radiation-induced bystander effects. Reported effects include increases or decreases in reactive oxygen species, cell death or cell proliferation, and induction of mutations and chromosome aberrations."

Lorimore, S.A., Wright, E.G.: *Radiation-induced genomic instability and bystander effects: related inflammatory-type responses to radiation-induced stress and injury? A review*, in *International Journal of Radiation Biology*, January 2003, vol. 79, no. 1, pp. 15-25 (11).

"It is known that radiation can induce a transmissible persistent destabilization of the genome. We have established an *in vitro* cellular model using human osteoblast cells to investigate whether genomic instability plays a role in depleted uranium (DU)-induced effects. Transmissible genomic instability, manifested in the progeny of cells exposed to ionizing radiation, has been characterized by de novo chromosomal aberrations, gene mutations, and an enhanced death rate. Cell lehtality and micronuclei formation were measured at various times after exposure to DU, nickel, or gamma radiation. [...] Delayed reproductive death was observed for many generations (36 days, 30 population doublings) following exposure to DU, nickel, or gamma radiation. While DU stimulated delayed production of micronuclei up to 36 days after exposure, levels in cells exposed to gamma-radiation or nickel returned to normal after 12 days. [...] These studies demonstrate that DU exposure *in vitro* results in genomic instability manifested as delayed reproductive death and micronuclei formation."

Miller, A.C., et al.: *Genomic instability in human osteoblast cells after exposure to depleted uranium: delayed lethality and micronuclei formation*, in *Journal of Environmental Radioactivity,* Vol. 64 (2-3), 2003, pp. 247-259; http://www.ncbi.nlm.nih.gov/entrez/query.fdgi?holding=npg&cmd=Retrieve&db=PubMed&list_uids=12500809&dopt=Abstract

"Although there are no conclusive epidemiological data correlating DU exposure to specific health effects, studies using cultured cells and laboratory rodents continue to suggest the possibility of leukemogenic, genetic, reproductive and neurological effects from chronic exposure."

McClain, David E., Miller, A.C. et al.: *Depleted uranium – properties, uses and health consequences*, (2007), CRC Press, Taylor and Francis Group, pp. 1-2.

"The true extent of contamination with cancer-causing uranium in soldiers who served in Bosnia and Kosovo may never be known, because the test government officials are planning to use to screen veterans will not pick up metal lodged deep in the body. ... The most dangerous contamination might not show up in urine. [...] White blood cells scavenge the particles in the lungs, and deposit them in the tracheobronchial lymph nodes. They are highly insoluble, and might not show up at all in urine, while still emitting intense local alpha and beta radiation. That could damage blood stem cells, causing leukaemia. If the urine tests show normal levels [of uranium], that does not mean there is no danger. What's needed is chemical analysis of lymph nodes from the servicemen who died, but there have been no reports of such autopsies."

MacKenzie, Deborah: *Off target - tests on soldiers may not spot the real damage done by uranium weapons*, in *New Scientist* 2273, 13 January 2001, page 5; http://www.newscientist.com/article/mg16922730.400.html

"Although Desert Storm ended in 1991, military operations in the region have continued through the early years of the 21st century. American and allied forces have also served in other war zones around the world in the intervening years, and are now engaged in active hostilities in both Iraq and Afghanistan. Many of the risk factors potentially associated with Gulf War veterans illnesses' continue to be a concern for those serving in these areas. They include the potential for exposure to chemical weapons, **depleted uranium**, multiple vaccines, infectious diseases and drugs taken to protect against local infections, the use of multiple types and combinations of pesticides, and the use of PB as a protective measure against the nerve agent soman."

Steele, Lea, et al.: *Scientific progress in understanding gulf war veterans' illnesses*, Research Advisory Committee on Gulf War Veterans' Illnesses, september 2004, p. 96; www.nunnturnerinitiative.org/e_research/official_docs/congress/Congress150904.pdf

At impact not only the DU oxide particles from the projectiles represent a hazard. Also the burning metals of the hit tank can become toxic nanoparticles.

"When DU projectiles hit a tank, the temperature in the core of the explosion exceeds 3,000 °C, which is more than enough to have all solid matter [of the tank] sublime and, in some cases, form new metal alloys. That gas expands over a large volume of atmosphere, then, rapidly, the matter becomes solid again taking the shape of very small spheres, stays suspended in the air and is carried away over distances depending on atmospheric conditions like wind, rain, snow, and pressure. After some time, all the air-borne particles fall slowly down and settle on grass, vegetables, fruit or expenses of water, where they become inevitably a guest of food and drink for animals and men alike. [...] We have amply demonstrated with our researches that once debris that size [nanometer] enter the body, be it via the digestive or the respiratory system, they can easily negotiate the luminal tissues and either be captured by the tissues itself which acts the way a filter does, or be transported by the blood or the lymph untill they end their travel in some organ (for instance the kidneys and the liver). Lymph nodes, for example, are the organs where lymphomas start and develop and where, in all pathological cases checked, we found the presence of inorganic particles. [...] It is important to underline that none of the particles we found is biodegradable. [...] If no uranium was ever detected, that does not necessarily mean there is none somewhere in the tissues of patients."

Montanari, dr. Stefano: *Nanoparticles from high DU temperature, cause of cancers and birth defects*, 13 February 2004;

http://www.indymedia.org.uk/en/2004/02/285283.html

“Following the detection of Uranium-236 [an isotope not present in pure DU] in DU ammunition used during the Balkans conflict in the 1990s, concern has been expressed about the possibility that other nuclides from the nuclear fuel cycle and, in particular, transuranium nuclides, might be present in this type of ammunition. In this paper we report the results of uranium and plutonium analysis, carried out on a DU penetrator [the core of a DU projectile] recovered from a target site in Southern Serbia. Our data show the depleted nature of the uranium and confirm the presence of trace amounts of plutonium in the penetrator. The activity concentration [of this penetrator] is the highest reported to date for any penetrator recovered from the Balkans. [...] From a radiological perspective this concentration would only give rise to a very small increase in dose to exposed persons compared to that from the DU itself.”

McLaughlin, J.P., et al: *Actinide analysis of a depleted uranium penetrator from a 1999 target site in Southern Serbia* in *Journal of environmental radioactivity*, (2003), vol. 64, n° 2-3, pp. 155-165; http://cat.inist.fr/?aModele=afficheN&cpsidt=14037082.

“For DU armor containing 0.2 % Uranium-235 and 0.003 % Uranium-236 the excess inhalation dose from transuranics and fission products of max. 0,042 % mSv/g represents a 0.035 % increase over the dose from the DU alone.”

Diehl, Peter: *Hazards from depleted uranium produced from reprocessed uranium caused cause of* WISE uranium project - factsheet; p. 7; http://www.wise-uranium.org/pdf/durepe.pdf

Notes from the compiler.
Of course there exist many more inventigations dealing with the harmful effects of DU.
The word 'depleted' means here that DU contains less fission product than the so-called 'natural uranium' concentrate.