

Rulemaking1CEm Resource

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Attachments: CACC letter to the NRC 11-19-2015 Final.pdf; NO_Safe_RAD Beyond Nuclear.pdf; The Health Consequences of TRITIUM.pdf

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TITLE: Linear No-Threshold Model and Standards for Protection Against Radiation

COMMENT#: 557

-----Original Message-----

From: kay cumbow [mailto:kcumbow@greatlakes.net]

Sent: Friday, November 20, 2015 1:18 AM

To: RulemakingComments Resource <RulemakingComments.Resource@nrc.gov>

Subject: [External_Sender] Comments for Docket ID NRC-2015-0057

Letter from Citizens for Alternatives to Chemical Contamination plus two attachments

To the Secretary,
U.S. Nuclear Regulatory Commission,
Washington, DC 20555-0001,
Rulemaking.Comments@nrc.gov.

November 20, 2015

ATTN: Rulemakings and Adjudications Staff,

Please include this addendum to the comment letter from Citizens for Alternatives to Chemical Contamination, 8735 Maple Grove Road, Lake, MI 48632-9511 on Docket ID NRC-2015-0057 :

In the comment letter from Citizens for Alternatives to Chemical Contamination to the NRC Rulemakings and Adjudications Staff on Docket ID NRC-2015-0057, on page 2, the name of the author of ***The Petkau Effect*** was misspelled. His name is spelled Ralph Graeub.

The paragraph should read:

The book ***The Petkau Effect***, by Ralph Graeub, documents the findings of Dr. Abram Petkau, former head of the Medical Biophysics Branch of the Canadian Atomic Energy research laboratory in Manitoba, that showed that cell membranes were destroyed when continuously exposed to small amounts of nuclear radiation. With no cell membrane, the cell is vulnerable to damage and destruction by free radicals. The longer the exposure to these small amounts of radiation, the lower the total dose necessary to damage the membrane.

Thank you,

Kay Cumbow, Education Committee
Citizens for Alternatives to Chemical Contamination

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The Health Consequences of TRITIUM.pdf	384418	

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Citizens for Alternatives to Chemical Contamination

Member of the Michigan Environmental Council,
Earth Share of Michigan, and
Michigan Network for Children's Environmental Health

8735 Maple Grove Road, Lake, Michigan 48632-9511
Voice and Fax: 989-544-3318

Chapter Organizations:
Huron Environmental Activist League

November 19, 2015

To the Secretary,
U.S. Nuclear Regulatory Commission,
Washington, DC 20555-0001,
Rulemaking.Comments@nrc.gov.
ATTN: Rulemakings and Adjudications Staff

To the Rulemakings and Adjudications Staff,

Citizens for Alternatives to Chemical Contamination (CACC) is a 501 C3 grassroots environmental education and advocacy organization founded in 1978, based in Lake Station, Michigan (mid-Michigan) and dedicated to the principles of social and environmental justice and protection of the Great Lakes Ecosystem, which includes human health concerns.

CACC strongly opposes the potential by the U.S. Nuclear Regulatory Commission to adapt a theory of hormesis with regards to either low or very low levels of ionizing radiation. This would change current long-term policy, based on solid science, that states that there is **no safe level** of ionizing radiation to human beings, and that **even very low amounts of radiation can and do damage to human cells**. To change this haphazardly in the face of the many studies and reports of knowledgeable scientists and experts flies in the face of decades of findings to the contrary.

The experts speak: Scientific experts agree that there are no safe levels of radiation.

In his book review of **Chernobyl: Consequences of the Catastrophe for People and the Environment**, (by Alexey V. Yablokov, Vassily B. Nesterenko, Alexey V. Nesterenko, and Consulting Editor Janette D. Sherman,) Lynn Ehrle states: "The first warning to the world was issued by H. J. Muller in his Nobel Prize lecture on December 12, 1946, when he stated, *'There is no threshold dose (no safe dose) of radiation. The great majority of mutations being undesirable, their further random production in ourselves should so far as possible be rigorously avoided. With the coming increasing use of atomic energy, even for peace-time purposes, the problem will become very important of insuring that the human germ plasm- the all-important material; of which we are the temporary custodians – is effectively protected from this additional potent source of permanent contamination.'*

“...The ‘official’ report from the World Health Organization and the International Atomic Energy Agency (*Chernobyl Forum 2006*), projects only **9,350 deaths in 95 years** attributable to the accident. **The Yablokov book documents 985,000 deaths by 2005** (~120,000 of 830,000 clean-up workers were dead by 2005) and includes miscarriages, stillbirths, and deformed children.”

In “Radiation: The Myth of the Millirem”, a Nuclear Information and Resource Service factsheet states that: “The late Dr. Donnell Boardman, a physician with many years of medical observation of nuclear workers, explained that no two radiation exposures are ever the same, even to the same individual. Ongoing research about the biochemical and physical impacts of ionizing radiation on living cells by British scientists Eric Wright and Carmel Mothersill, and others, confirms Dr. Boardman’s observation. **A single alpha particle, acting on a single cell, may damage that cell to the same degree as if a thousand x-rays had hit it. That is, one radiation particle can cause great damage to a single cell; that damage can even lead to a person’s death, while registering a dose to the total body of zero!**¹ [emphasis added]

Dr. Gordon Edwards in “An Open Letter to Physicists” stated that “Time-lag factors are something which physicists are just not used to taking into account, and -- quite frankly -- they have very little experience to draw on in their particular field of study. **It may take twenty years or more before the biological effects of exposure to radiation become known.** [emphasis added] Studies of the survivors of Hiroshima and Nagasaki showed that all kinds of cancer had a very much higher incidence among those who had been exposed to radiation, but that these cancers did not develop until 5, 10, 15, or 20 years after the event. “

“There is a ‘latency period’ during which no increase in the incidence of cancer is observed -- and then comes a whopping big increase. For leukemia, the latency period is about 5 years, whereas for other types of cancer it can be much longer -- for thyroid cancer (as hinted above) the latency period is about 13-15 years. Studies of uranium miners as well as silver and cobalt miners (all of whom were exposed to radon gas in the mines) confirm these latency periods.”²

The book *The Petkau Effect*, by Ralph Graeb, documents the findings of Dr. Abram Petkau, former head of the Medical Biophysics Branch of the Canadian Atomic Energy research laboratory in Manitoba, that showed that cell membranes were destroyed when continuously exposed to small amounts of nuclear radiation. With no cell membrane, the cell is vulnerable to damage and destruction by free radicals. The longer the exposure to these small amounts of radiation, the lower the total dose necessary to damage the membrane.

CACC has attached a fact sheet from *Beyond Nuclear* noting some of the findings of scientific experts in the fields of health physics, mathematics and low level ionizing radiation as part of our comments to the NRC.

Embryos, infants, children, women are all at greater risk.

Mary Olson, Staff for the SE Office of Nuclear Information and Resource Service, gave a presentation to the United Nations in 2015: www.nirs.org/radiation/radhealth/untalk2015.pdf Several excerpts from this presentation are posted below. Mary Olson has a B.A. from Reed College, with a double major in Biology and History of Science, and subsequent study in chemistry and biochemistry at Purdue University. Her findings come from “the Biological Effects of Ionizing Radiation, #7, also called BEIR VII,” which has “... data...primarily from 93,000 survivors of the Hiroshima and Nagasaki; [and which] is the largest data-set we have that includes all ages and both genders. BEIR VII was published in 2006, after the youngest remaining ABomb survivors turned 60, hence the tag ‘life-span study.’ It is the source of the data for the findings I am about to present.”

¹ “Radiation: The Myth of the Millirem” Nuclear Information and Resource Service, www.nirs.org/factsheets/mythmiliremfactsht.htm

² “An Open Letter to Physicists”, Gordon Edwards http://www.ccnr.org/open_letter.html

“The Biological Effects of Ionizing Radiation, VII; Phase 2 is available at no charge for a PDF file here:
<http://www.nap.edu/openbook.php?isbn=030909156X> “

“Important note: BEIR VII data reflects acute (quick) external radiation exposure (the moment of the bomb explosion); internalized radioactivity in air, food and water is not considered. It is important to say that the findings in this presentation on Gender may, or may not apply to internal exposures.”

“The survivors of Hiroshima and Nagasaki were grouped by the age they were at the time of the bombing. These groups were tracked over their lifetimes. Cancers and cancer deaths were counted. There are many problems with this data, but we can broadly say that those who were five years or younger in August, 1945 had the most cancer at some point in their lives. **Those exposed as girls were twice as likely to get cancer.** [Emphasis added] For every male in the 0-5 cohort that suffered cancer at some point in their lives, TWO females got cancer at some point in their lives. The BEIR VII report is where these numbers are found; the report itself does not discuss gender as a risk factor. I published my findings in 2011. Independent from my work, Dr. Arjun Makhijani published the same findings in 2005.”

Olson, 2011. NIRS Briefing Paper: “Atomic Radiation is more harmful to women.” posted:
<http://www.nirs.org/radiation/radhealth/radhealthhome.htm>

Makhijani, 2005 started the Healthy from the Start Campaign to address disproportionate impact of ionizing radiation on young females.

See: <http://ieer.org/projects/healthy-from-the-start/>

See: <http://ieer.org/resource/health-and-safety/open-letter-to-president-bush-onprotecting-the-most-vulnerable/>

“Children’s bodies are small; so the same amount of radiation delivers a larger dose. Since children are growing, the cells in their bodies are dividing more rapidly. DNA is more likely to be damaged when in cell division.”

Resources on Disproportionate Impact of Radiation on Children / In Utero:

Dr. Alice Stewart; broad description of her work:

<http://www.nytimes.com/2002/07/04/world/alice-stewart-95-linked-x-rays-todiseases.html> and Gayle Green, 2001. “Alice Stewart, the Woman Who Knew Too Much.”

Original Study: Stewart, et al, 1958. “Survey of Childhood Malignancies” British Medical Journal, June 28, pages 5086 – 1508.

Dr. Rosalie Bertell; “No Immediate Danger?” 1985. Women’s Press Toronto, Canada and also Summertown Books, USA.

See also www.ieer.org – “Healthy from the Start.” [End of excerpts from Mary Olson’s presentation to the U.N.]

Tritium - HEALTH CONSEQUENCES [excerpts from an attached paper by Nuclear Information and Resource Service.]

“Tritium (3H) is a radioactive isotope of hydrogen; it gives off radiation in the form of a beta particle. Tritium will bind anywhere hydrogen does, including in water, and in plant, animal and human tissue. It cannot be removed from the environment once it is released. Tritium can be inhaled, ingested, or absorbed through skin. Eating food containing 3H can be even more damaging than drinking 3H bound in water. Consequently, an estimated radiation dose based only on ingestion of tritiated water may underestimate the health effects if the person has also consumed food contaminated with tritium. (Komatsu)

Tritium is primarily a byproduct of the nuclear power industry, which releases large amounts (megacuries) of

tritium per year. (Dobson, 1979) Tritium has a half life of 12.3 years which means it will be dangerous for *at least* 120 years, since the hazardous life for a radionuclide is ten to twenty times longer than its half-life... Most studies indicate that tritium in living creatures can produce typical radiogenic effects including cancer, genetic effects, developmental abnormalities and reproductive effects. (Straume) Tritium can cause mutations, tumors and cell death. (Rytomaa) Tritiated water is associated with significantly decreased weight of brain and genital tract organs in mice (Torok) and can cause irreversible loss of female germ cells in both mice and monkeys even at low concentrations. (Dobson, 1979)

Studies indicate that lower doses of tritium can cause more cell death (Dobson, 1976), mutations (Ito) and chromosomedamage (Hori) per dose than higher tritium doses. [emphasis added] Tritium can impart damage which is two or more times greater per dose than either x-rays or gamma rays. (Straume) (Dobson, 1976)

There is no evidence of a threshold for damage from 3H exposure; even the smallest amount of tritium can have negative health impacts. [emphasis added] (Dobson, 1974) ***Organically bound tritium (tritium bound in animal or plant tissue) can stay in the body for 10 years or more. While tritiated water may be cleared from the human body in about 10 days (Garland), if a person lives in an area where tritium contamination continues, he or she can experience chronic exposure to tritium.*** [emphasis added] (Laskey) ***Tritium from tritiated water can become incorporated into DNA, the molecular basis of heredity for living organisms. DNA is especially sensitive to radiation.*** [emphasis added] (Hori) ***A cell's exposure to tritium bound in DNA can be even more toxic than its exposure to tritium in water.*** [emphasis added]

(Straume)(Carr)

Cindy Folkers, NIRS, April 2006 [This paper with sources is included as an attachment.]

Bioaccumulation and Biomagnification

Another grave concern with human exposure to low or even very low levels of radiation, is the well-documented fact that many radionuclides bioaccumulate in the food chain, and many of those bioconcentrate in the food chain, just like DDT, with subsequent serious consequences to those organisms high on the food chain, like birds and human beings, once they are exposed to organisms where radionuclides have bioconcentrated. Some radionuclides biomagnify thousands of times, some by tens of thousands of times, some of them have even greater numbers of bioconcentration. This means that very small amounts can quickly become enormous amounts, as the radionuclides biomagnify from plankton, to algae, to macroinvertebrates, to wildlife and fish, to birds and human beings. As an example: "In the Columbia River, an isotope of this element (phosphorus-32) passed from a concentration of 1 in the water to 35 in aquatic invertebrates, to 7,500 in ducks and 200,000 in their eggs. The yolk, very rich in phosphorus, contains 2 million times as much as river water."³ Also, see: ***Fall 1999. Report of Bioaccumulation of Elements to Accompany the Inventory of Radionuclides in the Great Lakes Basin.*** <http://www.ijc.org/rel/boards/nuclear/bio/index.html/>

In "An Open Letter to Physicists", Dr. Gordon Edwards wrote: "In Par Pond, where the Oak Ridge Laboratory dumped some of its low-level wastes, it was found that even when the concentration of cesium-137 was only 3 hundredths of a millionth of a millionth of a curie, the flesh of the bass caught in the pond contained 100 times this amount. Similarly, strontium-90 in the bones of bluegill was 1,000 times the level in the water, and radioactive zinc was 8,720 times the level in the water.

Caddis fly larvae in the Columbia River (where the Hanford nuclear plant discharges) achieved concentrations 150,000 times that in the water. Birds also concentrate radioactivity, and being higher up in the food chain, they end up with correspondingly higher concentrations. Thus swallows may carry 75,000 times the ambient

³ *Before Nature Dies*, by Jean Dorst, Houghton-Mifflin Company Boston, 1970 p. 215.

level, because they feed on insects which in turn have concentrated it from algae which in turn have concentrated it 2,000 times above the level in the water. [3]

Since many of the radionuclides released from nuclear plants have long half-lives, their presence in the environment will be essentially cumulative. It is therefore most important to ask what the long-term consequence of small doses of radiation may be.

Since many of the radionuclides released from nuclear plants have long half-lives, their presence in the environment will be essentially cumulative. It is therefore most important to ask what the long-term consequence of small doses of radiation may be.⁴

All humans rely on the food chain at some point for survival. There are many people in the Great Lakes (including Indigenous Peoples and U.S. Tribes,) who depend to a greater extent on fishing and hunting (and thus a healthy ecosystem) in the Great Lakes region for a significant amount of their diet.

Other factors

Michigan and other Great Lakes states have also experienced localized drawdown of aquifers. Any pollutant then becomes more concentrated and potent.

Synergistic reactions of radionuclides with other toxins and chemicals – In **Water Fit to Drink**⁵, Carl J.

Johnson, M.D. cites a study documenting the synergistic effect that chlorine has on plutonium, making plutonium far more soluble to animals when ingested. Chlorine is ubiquitous in drinking water throughout the U.S. and is also used in many industries and released into watersheds. There are thousands of chemicals today in our environment, most of which have not been studied for synergistic effects with radionuclides.

The Decay Chain – Some radionuclides may decay into other radioactive materials with properties that have more energy, that have the ability to do greater harm to the cell. A substance may be inhaled as a radioactive gas, and decay into a solid, making exit from the body more difficult. Once in the body, whether inhaled, or taken in through ingestion or even the skin, through breaks in the skin, if a radionuclide becomes organically bound, no matter how small a particle, it will continue to emit radiation to the nearby cells for as long as it remains organically bound.

Summary

CACC is opposed to changing the current policy of the NRC regarding low level or even very low levels of ionizing radiation and human health, which currently acknowledges that there is no safe level of radiation. There is much greater evidence of harm to living cells and an organism, including humans, than is presented here, from both low and very low levels of ionizing radiation.

We strongly urge the Nuclear Regulatory Commission to make their decision based on the many decades of solid science regarding low and very low levels of radioactive wastes and human health, and to uphold their supposed guiding principle, which proclaims very visibly on the NRC website that the NRC is “Protecting People and the Environment” and to adopt standards based on science and that include erring on the side of the precautionary principle.

⁴ "An Open Letter to Physicists", Gordon Edwards http://www.ccnr.org/open_letter.html

⁵ **Water Fit to Drink**, by Carol Keough, 1980, Rodale Press

Respectfully and with grave concern,

Kay Cumbow, Education Committee

Wesley Raymond, Administrator,
Citizens for Alternatives to Chemical Contamination
8735 Maple Grove Road
Lake, MI 48632



There is No Safe Dose of Ionizing Radiation

There are many reputable scientists who believe, based on their research, that there is no threshold for radiation damage to humans- no dose which is harmless. These are just a few of their words:

“There is no safe level of exposure and there is no dose of radiation so low that the risk of a malignancy is zero”--Dr. Karl Z. Morgan, dubbed the father of Health Physics.¹

“...there is no safe level of exposure to ionising radiation, and the search for quantifying such a safe level is in vain.”—Rosalie Bertell, PhD.²

In 1940, several members of the US Committee on X-Ray and Radium Protection “proposed that the [radiation exposure] standard be lowered by a factor of five in response to the accumulating evidence that ANY amount of radiation, no matter how small, can cause genetic damage, injuring future generations.” Gioacchino Failla argued against the lowering of the standards saying that “if genetic damage were to be a consideration for standard-setters, then logically no radiation exposure should be allowed.”³

“...the human epidemiological evidence establishes—by any reasonable standard of proof—that there is no safe dose or dose-rate...the safe-dose hypothesis is not merely implausible—it is disproven.” Dr. J.W. Gofman⁴

“One thing we should take from this (1991 study of Oak Ridge weapons workers by Steve Wing, et al.) is that there isn’t any safe level of radiation exposure...” Dr. Carl Shy⁵.

“The reanalysis (of Hanford worker data) provides no support for the idea that...there is reduced cancer effectiveness of radiation at low dose levels...” Drs. G.W. Kneale and A. Stewart⁶.

“There is evidence that single tracks of all types of ionizing radiation can induce a variety of damage including DNA double-strand breaks which are believed to be critical lesions in radiation exposure. There is also a body of experimental evidence that argues against an error-free DNA repair system operating at low doses of ionizing radiation that might result in a dose threshold for the induction of gene and chromosomal mutations.” MP Little and CR Muirhead.⁷

“An important feature of alpha irradiation is that, no matter how low the total dose to the whole body, a substantial dose of radiation (approx. .5 Gy) is delivered to an individual cell if it is traversed by a single alpha particle.” E Wright⁸.

The U.S. Committee on the Biological Effects of Ionizing Radiations concludes that, despite some evidence of a partial repair mechanism, recent low-dose radiation data "do not contradict the hypothesis, at least with respect to cancer induction and hereditary genetic effects, that the frequency of such effects increases with low-level radiation as a linear, non-threshold function of the dose." (National Research Council BEIR V 1990)

A panel from the U.S. National Academy of Sciences (NAS) charged to investigate the dangers of low-energy, low-dose ionizing radiation has concluded, “that it is unlikely that a threshold exists for the induction of cancers... (BIER VII, 2005)

Works Cited:

- 1... "Cancer and low level ionizing radiation" *The Bulletin of the Atomic Scientists*. September 1978.
- 2.... *No Immediate Danger? Prognosis for a Radioactive Earth*. Women's Educational Press, Toronto, Ontario. 1985: 45. isbn 0-88961-092-4
- 3 Caulfield, Catherine. *Multiple Exposures: Chronicles of the Radiation Age*. Harper and Row, New York. 1989: 48. isbn 0-06-015900-6.
- 4... *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*. Committee for Nuclear Responsibility, Inc. 1990:18-16, 18-18. Isbn 0-932682-89-8.
- 5 Garloch, Karen. "Repeated low radiation doses hike leukemia risk, UNC study finds." *The Charlotte Observer*. Wednesday, March 20, 1991.
- 6 ... "Reanalysis of Hanford Data: 1944-1986 Deaths." *American Journal of Industrial Medicine*. 23:371-389 (1993).
- 7... "Curvilinearity in the Dose-Response Curve for Cancer in Japanese Atomic Bomb Survivors." *Environmental Health Perspectives*. 105 (6): 1505. (1997)
- 8... "Chromosomal instability in the descendants of unirradiated surviving cells after alpha particle irradiation." *Proc. Natl. Acad. Sci. USA*. 95: 5730 (1998).

The following are additional studies are not quoted above:

Epidemiology:

Stewart, A.M., et al. "Radiation Exposures of Hanford Workers Dying from Cancer and Other Causes." *Health Physics*. Nov (1977).

Stewart, A.M, et al. "Delayed Effects of A-bomb radiation: a review of recent mortality rates and risk estimates for five-year survivors." *Journal Epidemiology and Community Health*. 36(2):80-6 (1982).

Morgenstern, H., et al. "Epidemiologic Study to Determine Possible Adverse Effects to Rocketdyne/Atomic International Workers from Exposure to Ionizing Radiation" Report by the UCLA School of Public Health. September, 1997.

Wing S., et al. "Mortality Among Workers at Oak Ridge National Laboratory." *JAMA*, 26 (11):1397 (1991)

Cell studies:

Lorimore S. A., et. al. "Chromosomal Instability in the descendants of unirradiated surviving cells after alpha particle irradiation." *Proc. Natl. Acad. Sci. USA*. 95: 5730-5733 (1998). (Eric Wright is co-author)

Kadhim M. A., et al. "Transmission of chromosomal instability after plutonium alpha particle irradiation." *Nature*. 355:738 (1992). (Eric Wright is co-author)

**Beyond Nuclear, 6930 Carroll Avenue Suite 400, Takoma Park, MD 20912; www.beyondnuclear.org;
301-270-2209 phone; info@beyondnuclear.org**

TRITIUM: HEALTH CONSEQUENCES

Nuclear utility Exelon and its subsidiaries have leaked and released millions of gallons of cooling water contaminated with radioactive tritium into the environment, threatening drinking water supplies. From what is currently known, leaks that occurred as early as 1996 were not discovered by the public until recently. While leaks were first revealed at Exelon reactors in Illinois, other leaks have been revealed at reactors in New York, Arizona, and New Jersey. Reports indicate that tritium is being detected in leachate from municipal landfills in Pennsylvania. At this point, we do not know how many other communities are being affected. For further information and to keep up with the growing list of sites, please visit the NIRS website www.nirs.org.

Tritium (^3H) is a radioactive isotope of hydrogen;

it gives off radiation in the form of a beta particle. Tritium will bind anywhere hydrogen does, including in water, and in plant, animal and human tissue. It cannot be removed from the environment once it is released. Tritium can be inhaled, ingested, or absorbed through skin. Eating food containing ^3H can be even more damaging than drinking ^3H bound in water. Consequently, an estimated radiation dose based only on ingestion of tritiated water may underestimate the health effects if the person has also consumed food contaminated with tritium. (Komatsu)

Tritium is primarily a byproduct of the nuclear power industry, which releases large amounts (megacuries) of tritium per year. (Dobson, 1979) Tritium has a half life of 12.3 years which means it will be dangerous for *at least* 120 years, since the hazardous life for a radionuclide is ten to twenty times longer than its half-life. Much of the initial research on health effects of tritium was conducted in the 1970s when an increase in nuclear power was seen as inevitable. Existing nuclear power reactors have

been releasing dangerous levels of tritium into our air and water for decades.

The public is only now becoming aware of the magnitude of tritium's hazards.

Most studies indicate that tritium in living creatures can produce typical radiogenic effects including cancer, genetic effects, developmental abnormalities and reproductive effects. (Straume) Tritium can cause mutations, tumors and cell death. (Rytomaa)

Tritiated water is associated with significantly decreased weight of brain and genital tract organs in mice (Torok) and can cause irreversible loss of female germ cells in both mice and monkeys even at low concentrations. (Dobson, 1979)

Studies indicate that lower doses of tritium can cause more cell death (Dobson, 1976), mutations (Ito) and chromosome damage (Hori) per dose than higher tritium doses. Tritium can impart damage which is two or more times greater per dose than either x-rays or gamma rays. (Straume) (Dobson, 1976)

There is no evidence of a threshold for damage from ^3H exposure; even the smallest amount of tritium can have negative health impacts. (Dobson, 1974) Organically bound tritium (tritium bound in animal or plant tissue) can stay in the body for 10 years or more. While tritiated water *may* be cleared from the human body in about 10 days (Garland), if a person lives in an area where tritium contamination continues, he or she can experience chronic exposure to tritium.

(Laskey) Tritium from tritiated water can become incorporated into DNA, the molecular basis of heredity for living organisms.

DNA is especially sensitive to radiation.

(Hori) A cell's exposure to tritium bound in DNA can be even more toxic than its exposure to tritium in water.

(Straume)(Carr)

Cindy Folkers, NIRS, April 2006

..

First, as an isotope of hydrogen (the cells most ubiquitous element), tritium can be incorporated into essentially all portions of the living machinery; and it is not innocuous -- deaths have occurred in industry from occupational overexposure.

R. Lowry Dobson, MD, PhD. (1979)

TRITIUM: HEALTH CONSEQUENCES

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- Torok P, et al. Effects of a Single Injection of Tritiated Water During Organogeny on the Prenatal and Postnatal Development of Mice. *International Atomic Energy Agency symposium, Vienna: Biological Implications of Radionuclides Released from Nuclear Industries v. 1: 241. 1979.*
- For abstracts and further information on tritium, please see <http://www.nirs.org/radiation/tritium/tritiumhome.htm>**

NUCLEAR INFORMATION AND RESOURCE SERVICE

6930 Carroll Avenue, Suite 340. Takoma Park, MD 20912

301-270-NIRS (6477); Fax: 301-270-4291