The LNT Hypothesis vs. Radiation Hormesis: Different Implications for Managing the Fukushima and other Radiological Emergencies

Bobby R. Scott, Rio Grande Chapter HPS Spring Meeting, Albuquerque, NM, April 11, 2011

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Today’s Presentation

• The linear-no-threshold (LNT) hypothesis, and how it is used to unnecessarily frighten you, related to the current radiological emergency in Japan

• The natural radiation environment and the trillions of harmless natural radiation hits to your body already (according to your age)

• The hormetic model for cancer suppression and induction

• A few examples of the abundant evidence that low-dose radiation can protect you from harm: radiation hormesis

• Different implications of the LNT hypothesis and
Linear-no-threshold (LNT) Hypothesis

- Any amount of radiation can harm you no matter how small the radiation dose. *So-called experts have stated this on TV.*

- A single radiation hit of a given size to each member of a very large population (e.g., world population) will cause at least one cancer case.

- Two hits will double the number of cancers.

- One thousands hits will increase the number of cancers to one-thousand times the number for a single hit.
LNT Extrapolation from A-Bomb Survivors

Low-Dose and Low-Dose-Rate Extrapolation

Radiation Dose (mSv)

Cancer Risk

Hypothetical data

LNT

DDREF
Natural radiation is everywhere.

- Cosmic and Solar Rays
- Plants
- Radioactive Soil and Rocks
- Indoor Radon
Cumulative Natural Radiation Hits to Your Body

2-year old: more than 60 trillion
4-year old: more than 120 trillion
6-year old: more than 180 trillion
8-year old: more than 250 trillion
10-year old: more than 300 trillion
20-year old: more than 630 trillion

These radiation hits do not cause any measurable harm!

During the next second you will have received more than 1 million additional harmless natural radiation hits to your body.
None of You Have Hundreds or Thousands of Tumors from Your More Than One Trillion Hits

- If the LNT hypothesis were valid, then all of us should have many tumors from our > 1 trillion natural radiation hits we have received.

- Since none of us has hundreds or thousands of tumors, the evidence does not support the claim by so-called experts on TV that a single radiation hit to your body could cause cancer.

- The additional radiation hits you receive from diagnostic radiation exposure (e.g., CT scan, chest X ray) may be protecting you from cancer and other diseases (radiation hormesis) as discussed in the following slides.
Hormetic Dose-Response (J-Shaped) Curve

Cancer Relative Risk

Radiation Hits (trillions or more)

- Decrease in cancers
- Increase in cancers
- Relative risk = 1

Hormetic Zone: protective genes turned on epigenetically

Protective genes turned off

8271-8
Characteristics of our Hormetic Relative Risk Model for Radiation Associated Cancer

- Radiation hits slightly in excess of the natural rate help to stimulate the body’s natural defenses which are epigenetically regulated.

- The stimulated natural defenses prevent cancer and some other diseases (e.g., diabetes, other respiratory diseases) from occurring via ridding the body of abnormal cells and providing other types of protection.

- For the hormetic dose zone, the proportion of cancers avoided is given by the protection factor (PROFAC).

- PROFAC = 0.6 means that 60% of cancers that would normally occur are prevented.
There is abundant evidence that low doses and dose rates of sparsely ionizing radiation (e.g., X and $\gamma$ rays) protect from cancer (i.e., $PROFAC > 0$) and cancer-related biological changes (e.g., mutation, neoplastic transformation).

See my video: Radiation Hormesis and Life—Mild Radiation Stress Makes you Stronger

http://dspace.lrri.org:8080/xmlui/handle/123456789/891
Mega Sample Sizes are Not Needed to Demonstrate a Low-dose Hormetic Effect
Unlike for the LNT Hypothesis

Numbers of controls when an equal number of exposed individuals is used; 2-tail test, \( \alpha = 0.05 \), power = 0.90

Less than a total of 100 persons needed when \( PROFAC > 0.3 \)
Low Dose Rate Radiation *PROFACs* against Oral Cancer (Sanders 2010)

<table>
<thead>
<tr>
<th>Population</th>
<th>PROFAC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-131 hyperthyroid patients</td>
<td>0.63 (0, 0.91)</td>
</tr>
<tr>
<td>U.S. radiologic technologists</td>
<td>0.33 (0.05, 0.55)</td>
</tr>
<tr>
<td>French nuclear workers</td>
<td>0.81 (0.56, 0.94)</td>
</tr>
<tr>
<td>USDOE nuclear workers (12 sites)</td>
<td>0.39 (0, 0.76)</td>
</tr>
<tr>
<td>Idaho National Lab workers</td>
<td>0.46</td>
</tr>
</tbody>
</table>

*PROFACs of similar magnitude and as high as 1 have been found for protecting against lung cancer.*
Adjusted OR (95% C.I.):
Controlled for Smoking, Residency, Education, Income, and Job Category (R. Thompson, 2010 presentation)

Reference = 4.4 Bq/m$^3$

$PROFAC > 0.6$

4 pC/L $\approx$ 150 Bq/m$^3$
The LNT and Hormetic Models have Different Implications for Managing the Japanese Radiological Emergency

- Different choices of the evacuation zone radius around the Fukushima plant.
- Different choices of when to use bottle water.
- Different policies about when to ban use of radionuclide contaminated foods and milk.
- Different focus of news media reporting of the emergency (e.g., local health risks vs. global).
- Different ways of controlling radiation-phobia-related casualties (e.g., abortions, potassium-iodide-usage-related harm, stress-related psychological effects).
Acknowledgements

This research was supported by the Office of Science (BER), U.S. Department of Energy, Grant No. DE-FG02-09ER64783
Backup Slides
Low-Dose Sparsely Ionizing Radiation Activated Natural Protection (ANP)

- Protects against chromosomal damage (Ed Azzam’s group)!
- Protects against mutation induction (Pam Sykes’ group), even when the low dose follows a large dose (Tanya Day’s work)!
- Protects against neoplastic transformation (Les Redpath’s group)!
- Protects against high dose chemical- and radiation-induced cancer (Kazou Sakai’s group)!
- Enhances immune system defense (Shu-Zheng Liu’s group; Marek Janiak’s group)!
Low-LET Radiation ANP (Continued)

- Suppresses cancer induction by alpha radiation (Chuck Sanders group)!
- Suppresses metastasis of existing cancer (Kiyohiko Sakamoto’s group; Ewa Nowosielska’s and colleagues work)!
- Extends tumor latent period (Ron Mitchel’s group)!
- Protects against diseases other than cancer (Kazuo Sakai’s group)!
- Cooperates with exercise in enhancing our natural defenses against diseases (Doug Boreham’s group)!
Gamma-ray ANP against Alpha Radiation Induced Lung Cancer

Scott BR et al.

3,793 Wistar rats involved

$\alpha + \gamma, \text{PROFAC}=1$
Low-Dose X-Ray Stimulated Cellular Immunity in Mice (S-Z Liu, 2007)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dose (mGy)</th>
<th>Change (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NK activity</td>
<td>75</td>
<td>+19</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Mac. activity</td>
<td>75</td>
<td>+52</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Cytotoxic T Lymphocytes</td>
<td>75</td>
<td>+40</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Antibody depen. cell mediated cytotoxicity</td>
<td>75</td>
<td>+30</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>T cell proliferation</td>
<td>77</td>
<td>+101</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>
Low-Dose-Rate Gamma Ray ANP against MC-induced Skin Tumors in Mice

K. Sakai, 2006 International Dose-Response Conference presentation

MC: methylcholanthrene

Cumulative Tumor Incidence (%) vs. Days after MC Injection

- Non-Irradiated
- 0.35 mGy/hr
- 0.70 mGy/hr
- 1.2 mGy/hr
Prolongation of Life Span of db/db Mice by Low Dose Rate Irradiation

Diabetic mice, Sakai K, IDRS 2006

Gamma rays

Survival (%) vs Age (Weeks)
# Cancer PROFACs for Radon-spa Areas in Japan (Misasa)

<table>
<thead>
<tr>
<th>Cancer Site or Type</th>
<th>PROFAC</th>
<th>PROFAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Leukemia</td>
<td>0.47 ± 0.016</td>
<td>0.56 ± 0.016</td>
</tr>
<tr>
<td>Stomach</td>
<td>0.55 ± 0.016</td>
<td>0.60 ± 0.016</td>
</tr>
<tr>
<td>Breast</td>
<td>0.74 ± 0.014</td>
<td>(results not reported)</td>
</tr>
<tr>
<td>Lung</td>
<td>0.81 ± 0.012</td>
<td>0.53 ± 0.016</td>
</tr>
<tr>
<td>Colon/rectum</td>
<td>0.86 ± 0.011</td>
<td>0.70 ± 0.015</td>
</tr>
</tbody>
</table>

Something the Public Deserves to be Told:

- The public deserves to be told the hypothetical nature of LNT-based risk for doses < 100 mSv.
- There is no evidence of significant harm from radiation doses < 100 mSv (Tubiana M et al. Radiology 251:13-22, 2009).
- There is evidence for beneficial effects (hormesis) of irradiation for the indicated dose range which includes doses from CT and other diagnostic procedures.