



UCI's TRIGA Reactor or “How Did it Happen”?

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A Brief History

- UCI is the only *Chemistry Dept.* that has a currently operating, licensed nuclear reactor.
- The TRIGA Mk III has been operated from 1965.
- Radiochemistry, tracer chemistry, was crucial in studying atmospheric chemistry: 1995 Nobel Prize to F.S. Rowland, 'Ozone Hole' and current Pres. of the National Academy R. Cicerone, Global Warming.
- In 2007, I became Vice-Chair for Facilities, and was forced to learn about the reactor, safety, emergency procedures, *etc.*
- About 5 yrs prior I had become interested in the chemistry of aging.



A Brief History

- Dept. seminars also made Climate Change a focus: how to cut CO₂ emissions?
- Solar power was the “answer”, but
 - First Solar was guaranteed **35¢** kW•hr (!) in Germany.
 - I was quoted **\$16 k** for 3 kW solar PV in my backyard.
 - The low mp alkyl ionic salts (for solar thermal storage) break down over time: problem not yet solved.
 - Solar’s intermittent, and for the rich, only, at this time.
- Wind turbines look promising, but
 - In an earthquake they fail catastrophically.
 - They kill many bats and birds.
 - Power is intermittent. Storage is a problem.
 - The wind doesn’t blow much at night.



Energy Farming

- This is one approach, in Spain:





The World 4°C Warmer



As deserts encroach on fertile land, as it has near Dunhuang, China, people will be forced to move towards the poles (Image: George Steinmetz/Corbis)

- Food-growing zones & high-rise cities
- Uninhabitable due to floods, drought or extreme weather
- Uninhabitable desert
- Land lost to rising sea levels
- Solar energy
- Geothermal energy
- Wind energy

"I would like to be optimistic that we'll survive, but I've got no good reason to be," says Crutzen. "In order to be safe, we would have to reduce our carbon emissions by 70 per cent by 2015. We are currently putting in 3 per cent more each year."

*New Scientist*₅



A Brief History

- I remained deeply suspicious of nuclear power, mostly because I knew *nothing about it*.
- When I had to oversee the reactor, I had to learn more about the technology; the more I learned, the more comfortable I became.
- But, we had only one (76 yr old) senior operator, Dr. Miller, and would be helpless if anything happened.
- I worried about the health effects of radiation, but decided to get trained.
- The more I read about radiation, the more I realized that, as Paracelcus wrote *the dose makes the poison*.



Live To 100?

How's this for an elixir of youth: an X-ray, a mild case of sunburn, a couple of beers and a sauna. If you think all that would leave you feeling anything but youthful, think again. Many researchers believe that small doses of "stressors" such as poisons, radiation and heat can actually be good for you - so good that they can even reverse the ageing process. This counter-intuitive effect, called "hormesis", was once considered flaky, but in recent years it has been shown to extend longevity in yeast, fruit flies, protozoans, worms and rodents. If the findings extend to people, it could stretch the average healthy human lifespan to 90, says biologist Joan Smith-Sonneborn of the University of Wyoming in Laramie.

How so? Stressors seem to kick-start natural repair mechanisms, including heat-shock proteins and DNA-repair enzymes, to fix the damage they have caused. If this damage is not too severe, the repair systems may overcompensate, building up enough oomph to repair unrelated damage as well. And if you accept the idea that damage equals ageing, this is nothing less than rejuvenation.

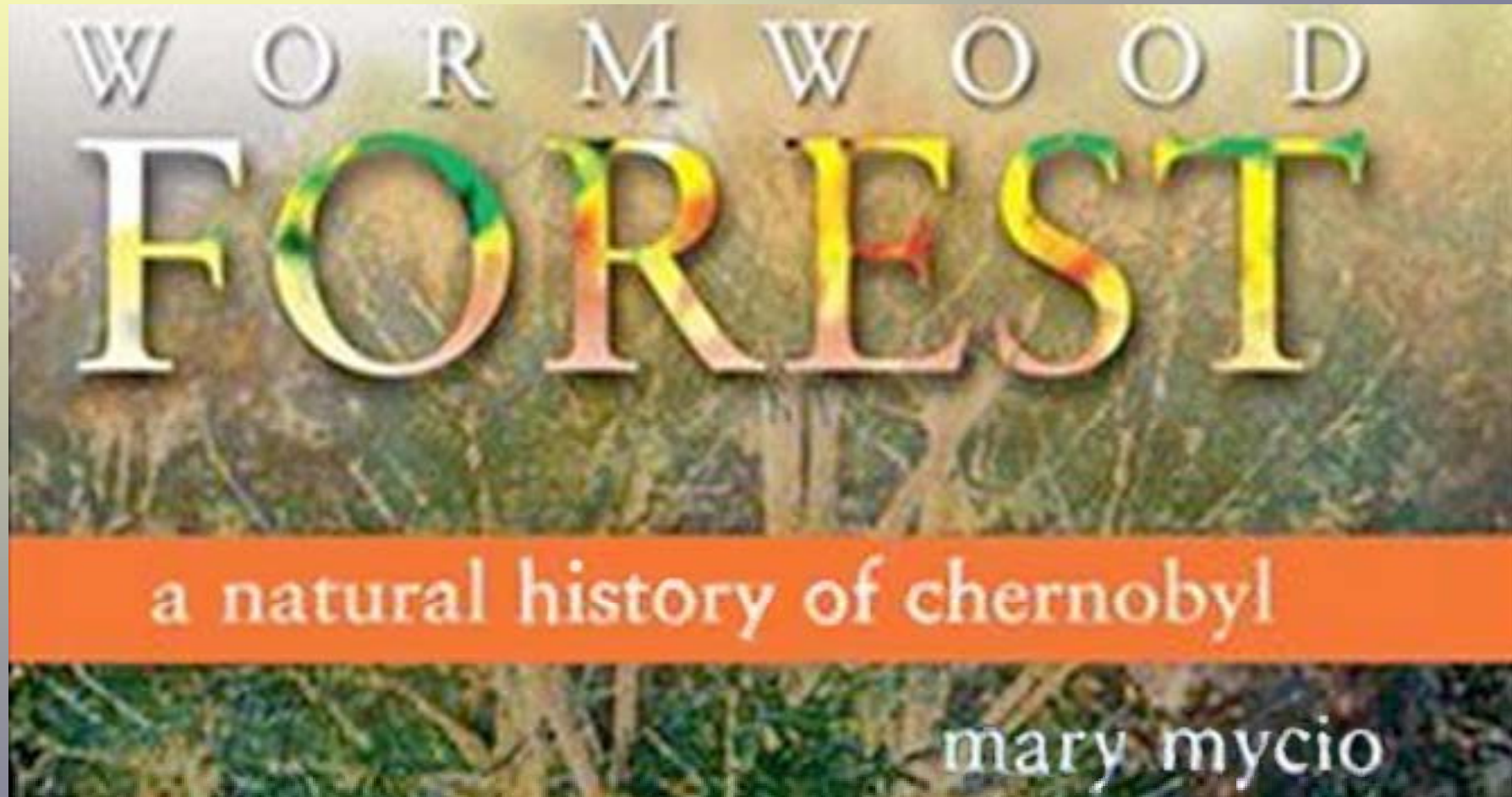
There is already some indirect evidence that hormesis has positive effects on human longevity. Between 1980 and 1988, researchers at Johns Hopkins University in Baltimore, Maryland, tracked 28,000 nuclear shipyard workers to study the effects of low doses of radiation. To their surprise, they found that the mortality rate of these workers was 24 per cent lower than in a control group of 32,500 shipyard workers of similar ages who were not exposed to radiation.

New Scientist



A Brief History

- Mary Mycio's book made an impression on me.





A Brief History

- 2009: UCI hired Prof. Micke Nilsson, a Swedish-trained expert on nuclear fuel cycles, and reprocessing.
- I decided to become a licensed reactor operator, and am currently being trained (Prof. Nilsson is not yet a US citizen).
- We also have some experiments underway to examine high-energy (660 keV) gamma-rays at low total dose, to define the J-shaped curve for radiation.
- It seems that the quality and energy of the radiation at low dose is important to understand.



TRIGA Features

- 250 kW research reactor.
- 20% enriched uranium + ZrH_2 solid fuel, 57 rods.
- Control rods fixed with push-pull air pressure system, can be suddenly pulsed out of the core.
- Power goes from 0.25 MW to >900 MW for 10 to 12 ms, and then drops back below (Xe-135 poisoning).
- Reactor is unconditionally stable, and can be pulsed many times with a suitable delay in between. Never a problem
- Nevertheless, unpopular with some Orange County residents: very vocally opposed to it.



Summary

- Chemists who specialize in the bottom of the Periodic Table are in short supply.
- Chemists with training in radiochemistry are in short supply.
- Very few chemists are trained to understand molten salt reactions and/or phase diagrams.
- Chemists use thorium for *absolutely nothing*: it is therefore ideal to use as a fuel. *We need* petroleum for all of our chemical streams!
- Worries about exposure are overblown, and the LNT claims have not been verified at low dose.
- Extrapolation is an error-prone endeavor...



Summary

“While a calculator on the ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1000 tubes and weigh only one and a half tons.”

Popular Mechanics, March 1949