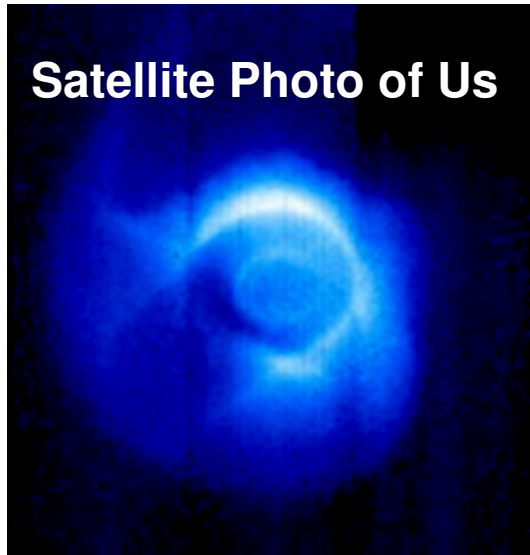


# ***Radiation & Health***

Dr. Alexander Cannara, TEAC5 May 2013, Lockheed ATC 2014/15  
[cannara@sbcglobal.net](mailto:cannara@sbcglobal.net) [www.thoriumenergyalliance.com](http://www.thoriumenergyalliance.com)

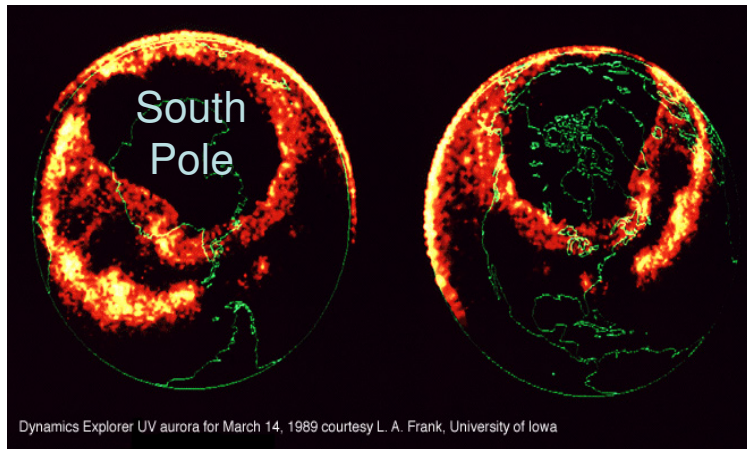
- Nature wisely evolved its organisms to have **immune systems** that combat invasion by micro-organisms, including parasites, viruses & bacteria.
- Nature, even earlier, evolved mechanisms in single cells that protect against chemical & radiological damage – **repair systems**, even genetic sharing in bacteria.
- Chemicals can break or distort molecules important to cells, while energetic radiation simply breaks molecular bonds, such as in proteins & DNA, by ionizing individual atoms.
- Decades ago, some **poor science** led to the conclusion that no level of ionizing radiation was small enough not to cause irreparable damage to living cells. That belief led to radiation-exposure standards with no relation to reality or evolutionary history.
- In recent years, that **error & outright lies about radiation dangers** have begun to be corrected. This talk attempts to explain why **Mother Nature isn't dumb about radiation**.

# Electromagnetic Radiation



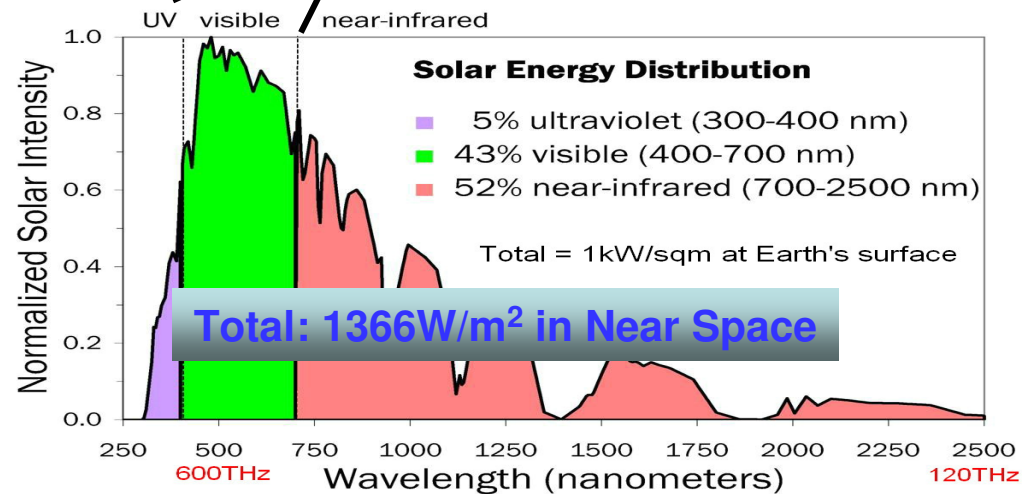
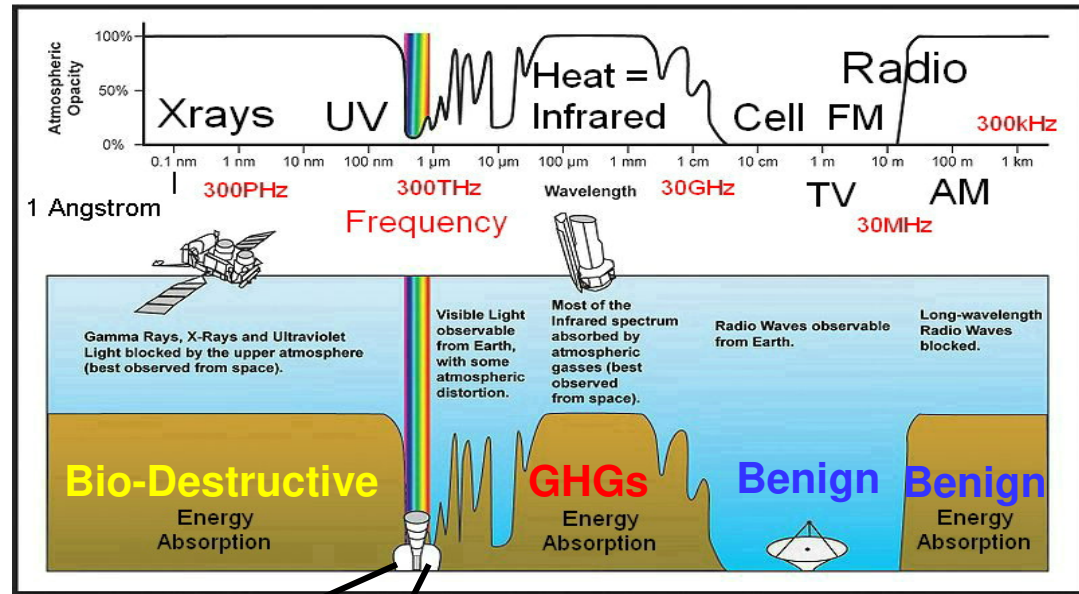
Satellite Photo of Us

Earth in UV from Solar Wind Protons; Polar Aurorae Below



Dynamics Explorer UV aurora for March 14, 1989 courtesy L. A. Frank, University of Iowa

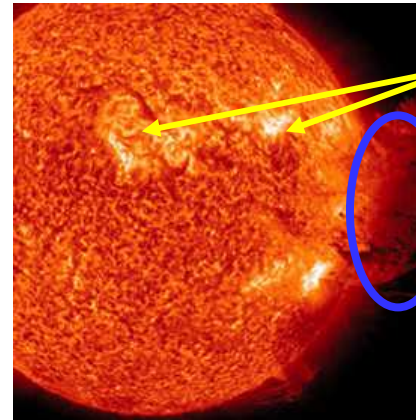
## All Radiant Energy (Electromagnetic Spectrum)





# Natural Radiation – Solar

**Solar radiation** is mostly **Protons**. They arrive at ~1 million mph, from coronal mass ejections (CMEs) related to sunspots & create auroras as they spiral down Earth's magnetic field in polar regions. The sun has an 11-year **Sunspot Cycle**, superimposed on a longer ~90-year activity cycle. We're currently entering a peak of the 11-year and a trough of the longer cycle: [www.spaceweather.com/](http://www.spaceweather.com/)



Sunspots (false color)

CME (50x bigger than earth)



Aurora

## "SEEING" THE SUN

Astronomers have seen the sun at every wavelength of light, and now they have seen it in neutrinos. The image is blurry—the Super-Kamiokande experiment that made it has a resolution of 26 degrees, whereas the sun is 0.5 degree wide (*black circle*)—but is still a technological milestone. Whereas light shows only the surface of the sun, neutrinos expose the core.

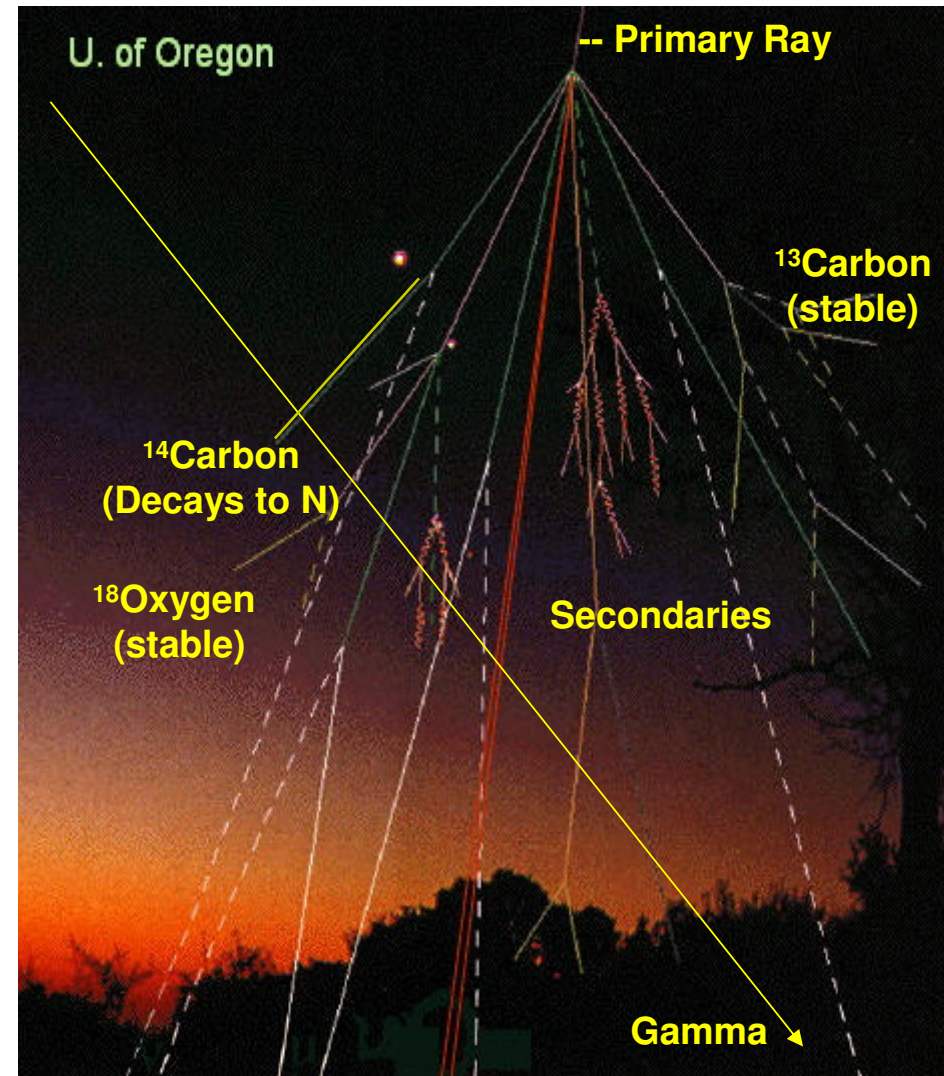
Courtesy NASA

| VISIBLE (FILTERED) | ULTRAVIOLET                      | RADIO WAVES     | NEUTRINOS                                 |
|--------------------|----------------------------------|-----------------|---|
| <p>Too Bright</p>  | <p>Dangerous</p> <p>XraysToo</p> | <p>Harmless</p> | <p>Harmless</p> <p>Billions/sq cm/sec</p> |



# Natural Radiation – Cosmic Rays

A **Primary Cosmic Ray** is a Gamma Ray or high-speed particle from the Sun or other distant stellar sources, including supernovae, black holes, magnetars, even from another galaxy. It can be an **atomic nucleus, an Electron or other subatomic particle**. About **85% are Protons, ~12% Alpha particles, & the remainder Electrons & nuclei of heavier atoms**. Most primary rays are charged & thus influenced by the Earth's & interplanetary magnetic fields. Most have energies >1 GeV -- speeds >87% the speed of light. Solar Protons arrive at ~1 million mph, from coronal mass ejections & create auroras as they spiral down Earth's magnetic field in polar regions. **Secondary Cosmic Rays** are particles streaming downward from Primary collisions with air molecules. This is the source of radioactive atmospheric isotopes (e.g.,  $^{14}\text{C}$  &  $^{18}\text{O}$ ) used for dating fossils, sediments, ice cores, temps, etc. The downward stream of these particles is quite constant. Strong **Gamma bursts** come straight from vastly-distant sources, such as colliding black holes & collapsing massive stars.

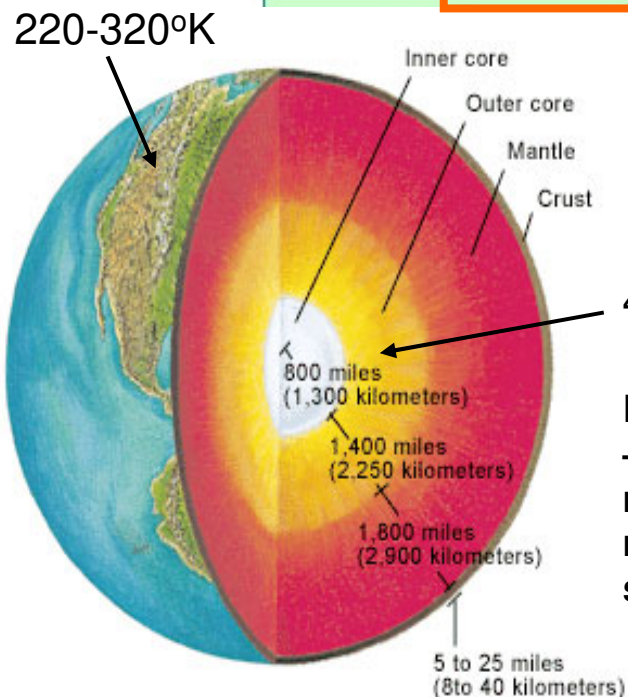




# Natural Radiation

*<sup>40</sup>K is also a key driver of Earth's magnetic field, as are Thorium & Uranium.*

| Radioactive Properties of Potassium-40 |                |                       |                          |            |                        |          |           |
|--|----------------|-----------------------|--------------------------|------------|------------------------|----------|-----------|
| Isotope                                | Half-Life (yr) | Natural Abundance (%) | Specific Activity (Ci/g) | Decay Mode | Radiation Energy (MeV) |          |           |
|  |                |                       |                          |            | Alpha (α)              | Beta (β) | Gamma (γ) |
| <b>K-40</b>                            | 1.3 billion    | 0.012                 | 0.0000071                | β, EC      | -                      | 0.52     | 0.16      |



Thorium's  $\frac{1}{2}$  life = 14 billion years  
<sup>238</sup>Uranium = 4.5 billion years  
<sup>235</sup>U = 700 million years  
<sup>234</sup>U = 250,000 years

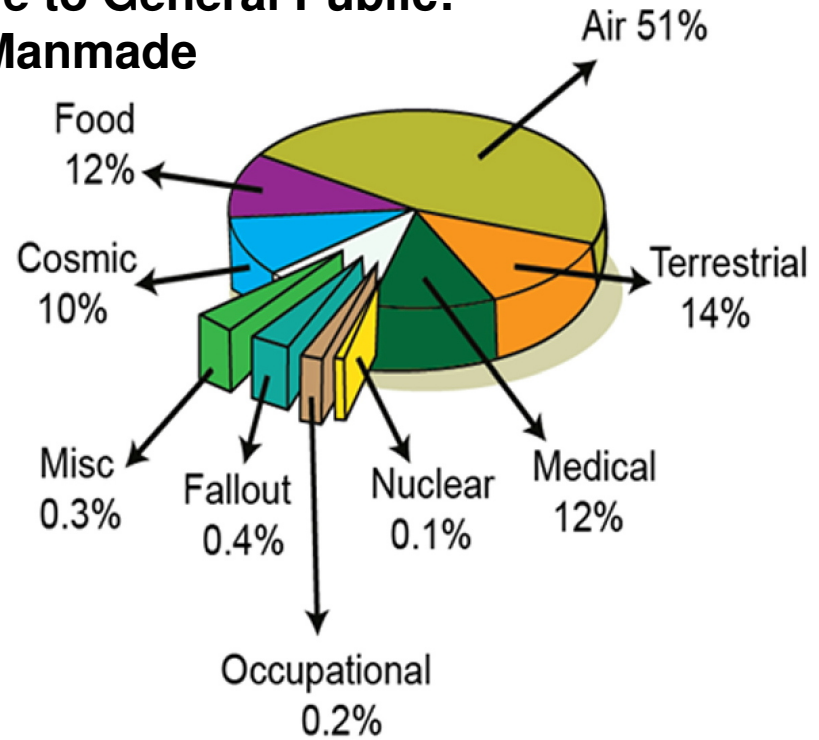
Emissions  
 Beta = electron  
 Gamma = photon

Earth's inner heat is 80% due to radioactive decay of Th, U & <sup>40</sup>K – geothermal energy is nuclear energy. Earth's protective magnetic field only exists because its mostly Iron/Nickel core is molten & electrically conductive – no field = no air, but plenty of solar & cosmic radiation. Mars -- no molten core & almost no air.

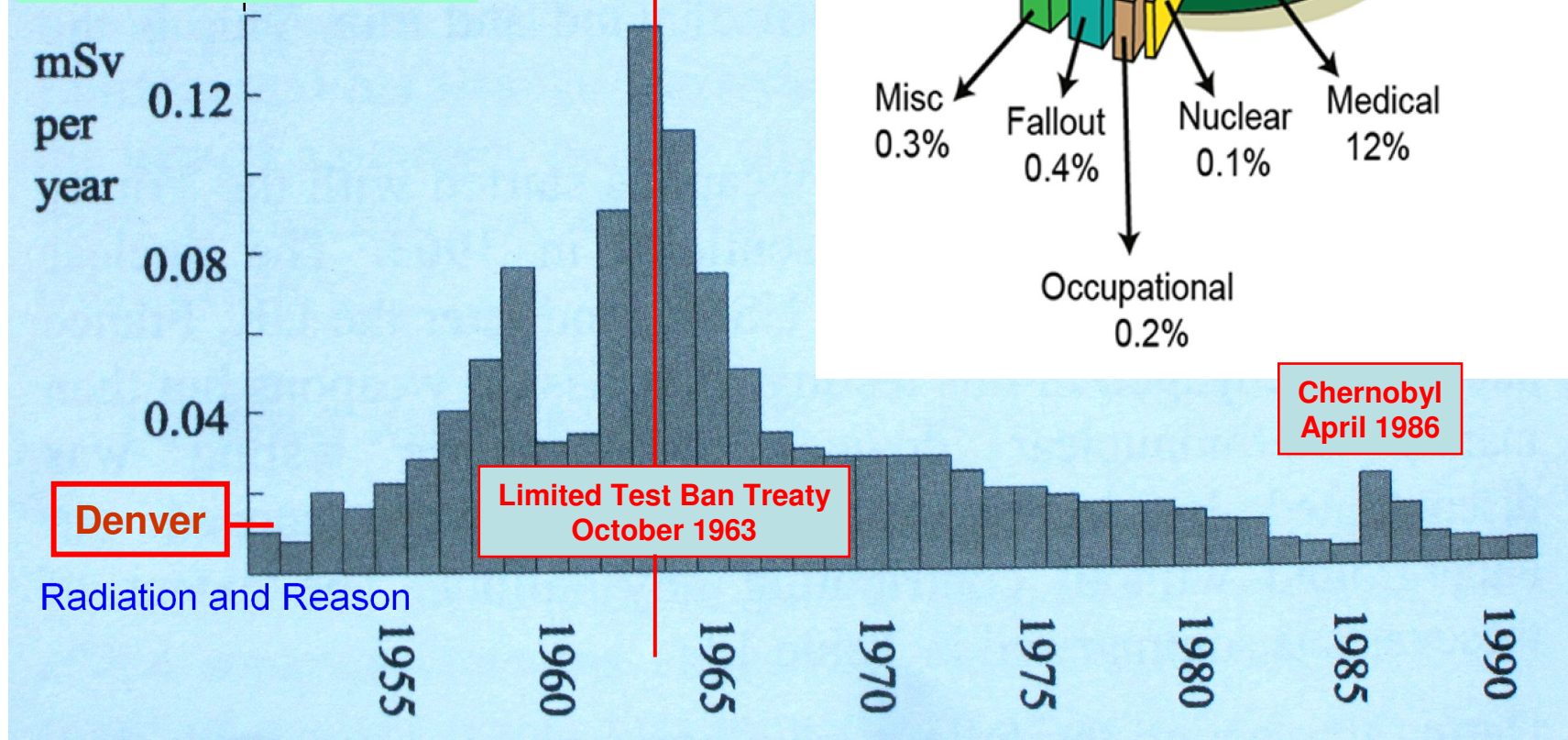
# Relative Radiation Dangers

0.2mSv  
0.5  
BED

**Radiation Exposure to General Public:  
87% Nature, 13% Manmade**



**Radiation Exposure to British Public:**



Radiation and Reason



# Radiation & Health

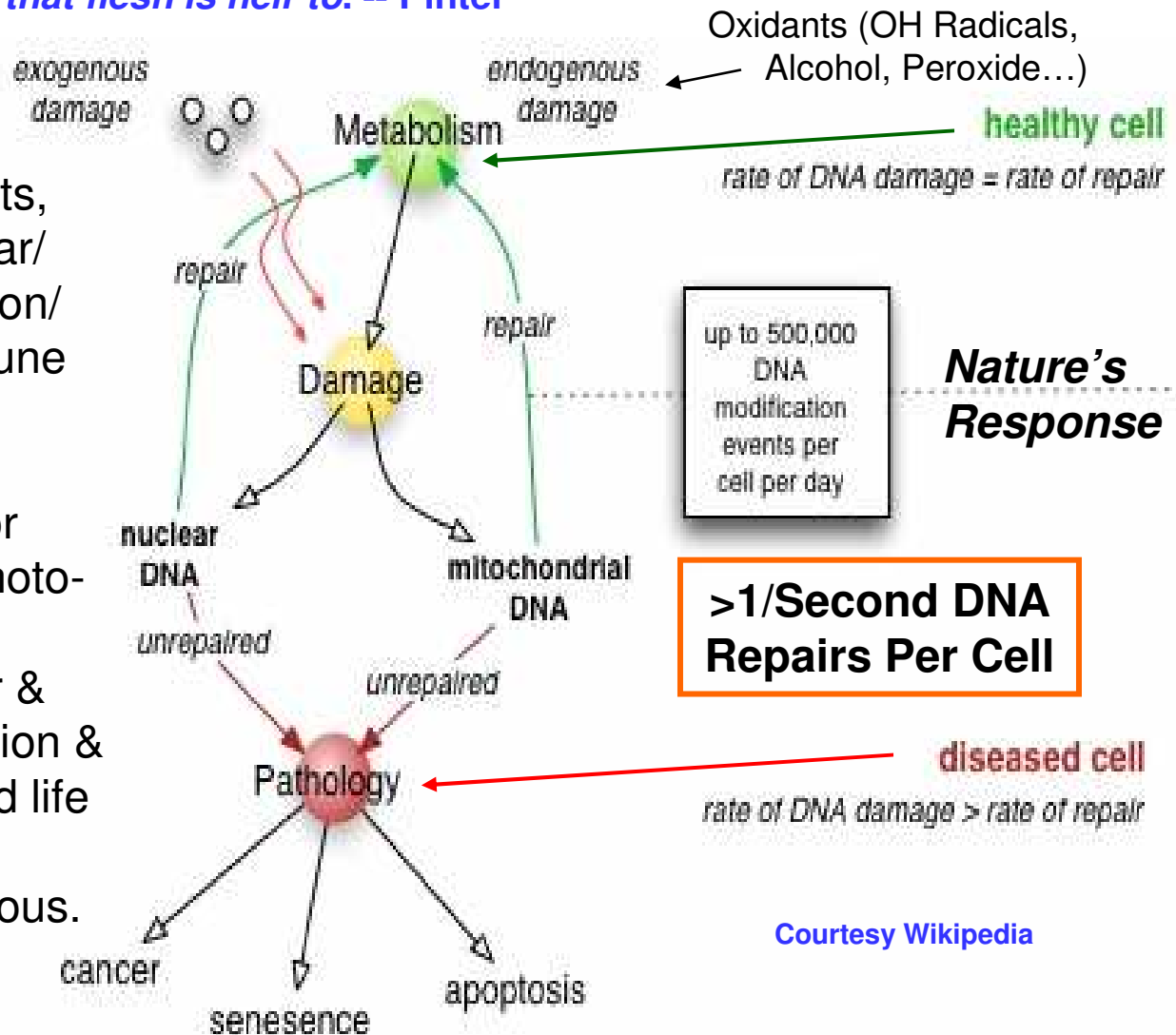
*The thousand natural shocks that flesh is heir to. -- Pinter*

## Threats to Living Cells...

Oxygen, chemical pollutants, particulates, microbes, solar/cosmic/nuclear-decay/fission/fusion radiation, auto-immune diseases, or parasites.

Nature has dealt with all for ~1.6 billion years, when photosynthesis finally produced enough Oxygen to alter air & water. Earlier, heat, radiation & Sulfur chemistry dominated life & its need for defenses. Oxidants are more dangerous.

Dr. Alexander Cannara  
[cannara@sbcglobal.net](mailto:cannara@sbcglobal.net)  
 650-400-3071



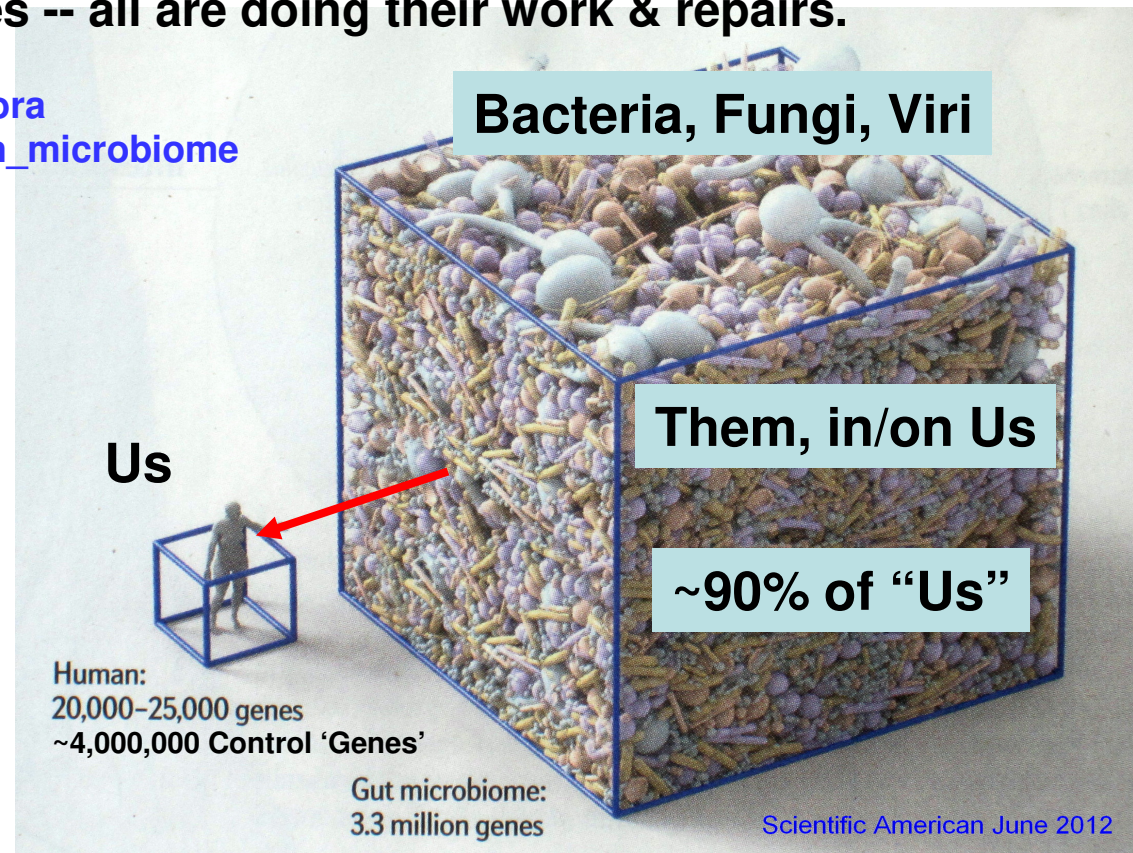
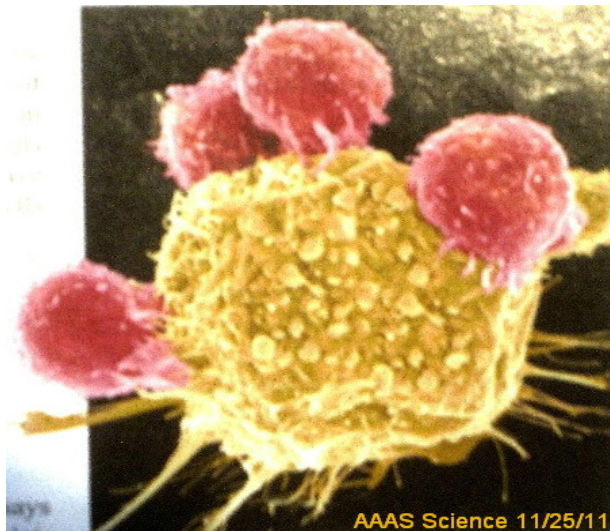
# Cells That Serve & Protect

~100 times the genes of a human are in internal/external microbes.  
*Virome* and *microbiome* coexist peacefully, and may even cooperate.  
More than 4,000 different viral strains in the human biome.

Humans' ~10 trillion cells are outnumbered by 100 trillion microbial cells throughout our bodies -- all are doing their work & repairs.

[http://en.wikipedia.org/wiki/Gut\\_flora](http://en.wikipedia.org/wiki/Gut_flora)  
[http://en.wikipedia.org/wiki/Human\\_microbiome](http://en.wikipedia.org/wiki/Human_microbiome)

T-cells attacking a cancer cell





# Radiation Lies I

**The lie about no safe radiation level, LNT – linear dose effect, no threshold:** <http://tinyurl.com/4xqwzjc> (IEEE Spectrum, October 2011)

“In 1946, **Herman Muller** was awarded the Nobel Prize in Medicine for work done on spontaneous gene mutation, including the effects of X-rays...right around the same time, the National Academy of Sciences formed a committee to offer expert advice to the government on the biological effects of atomic radiation. *In his Nobel acceptance speech\* and in the NAS committee meetings, Muller argued there are no safe levels of radiation exposure, a position the Academy came to adopt.* That...influenced official policies toward radiation for decades. [UNSCEAR has partly corrected, 2012]

The problem is, **Herman Muller knowingly lied.** Says Edward J. Calabrese, a professor of toxicology at U. Mass. School of Public Health. He bases that opinion on a wealth of materials...formerly classified files and...overlooked correspondence between Muller and one of his co-researchers.”

**Calabrese:** “...In Muller’s own groundbreaking work that led to his Nobel Prize, *his own dose responses really did not support a linear dose-response* relationship. But he was particularly interested in trying to better define the nature of the dose-response in the low-dose zone, and, in fact, he got several individuals to work on that project and inspired other people... But the data that emerged was not very clear. **Some data actually seemed to support a threshold, and some clearly did not, but *the problem with the work that Muller and the people of that era were doing was that the doses of radiation that they were using were extraordinarily high and have nothing to do at all with anything that we might view as remotely low dose today...*** they were probably exposing fruit-fly germ cells at a level that would be equivalent to... *about a thousand X-rays in 3.5 minutes...the lowest dose that they were testing.*”

\* [www.nobelprize.org/nobel\\_prizes/medicine/laureates/1946/muller-lecture.html](http://www.nobelprize.org/nobel_prizes/medicine/laureates/1946/muller-lecture.html)

# Radiation Exposure

**Evolution** has had to cope with chemical damage to RNA/DNA, etc. forever. Radioactivity is a minor actor in typical damages each living cell must repair each second of each day. So, it's not surprising that unnaturally-high doses, even of Gamma radiation, are seen to have little effect on living things, due to **DNA repairs** done billions of times per second/animal.

**Ingestion** of radioactive elements that stay within cells, however, **is the serious issue** to deal with –  $^{131}\text{I}$ ,  $^{137}\text{Cs}$ ,  $^{90}\text{Sr}$ , etc. can be taken into biological molecules, in place of normal isotopes, say Calcium. Once in place, their radiation, even Alpha & Beta, can repeatedly challenge key structures such as DNA molecules. This is why protective clothing & masks are used by nuclear workers. Alpha & most Beta emissions are stopped by paper & skin, perhaps burning if strong, but if inside our Bodies, they are trouble, breaking molecular bonds.

## A study of British radiologists showed more radiation improved mortality

| Group                | Av Dose per year     | SMR reduction |
|----------------------|----------------------|---------------|
| Shipyards workers    | 280 mrem             | 24%           |
| British radiologists | 500 mrem <b>5mSv</b> | 32%           |

**DNA Repair Stimulated?**

## Leukemia deaths of atomic bomb survivors were not affected by radiation exposure < 200 mSv

| mSv step to..   | Survivors | Survivor deaths | Control deaths |
|-----------------|-----------|-----------------|----------------|
| <5              | 37,407    | 92              | 84.9           |
| UN Limit -- 100 | 30,387    | 60              | 72.1           |
| Threshold? 200  | 5,841     | 14              | 14.5           |
| 500             | 6,304     | 27              | 15.6           |
| 1,000           | 3,963     | 20              | 9.5            |
| 2,000           | 1,972     | 39              | 4.9            |
| >2,000          | 737       | 25              | 1.6            |

Allison, "Radiation and Reason" 2009



# Our 100+ -Year CO<sub>2</sub> Emissions Debt

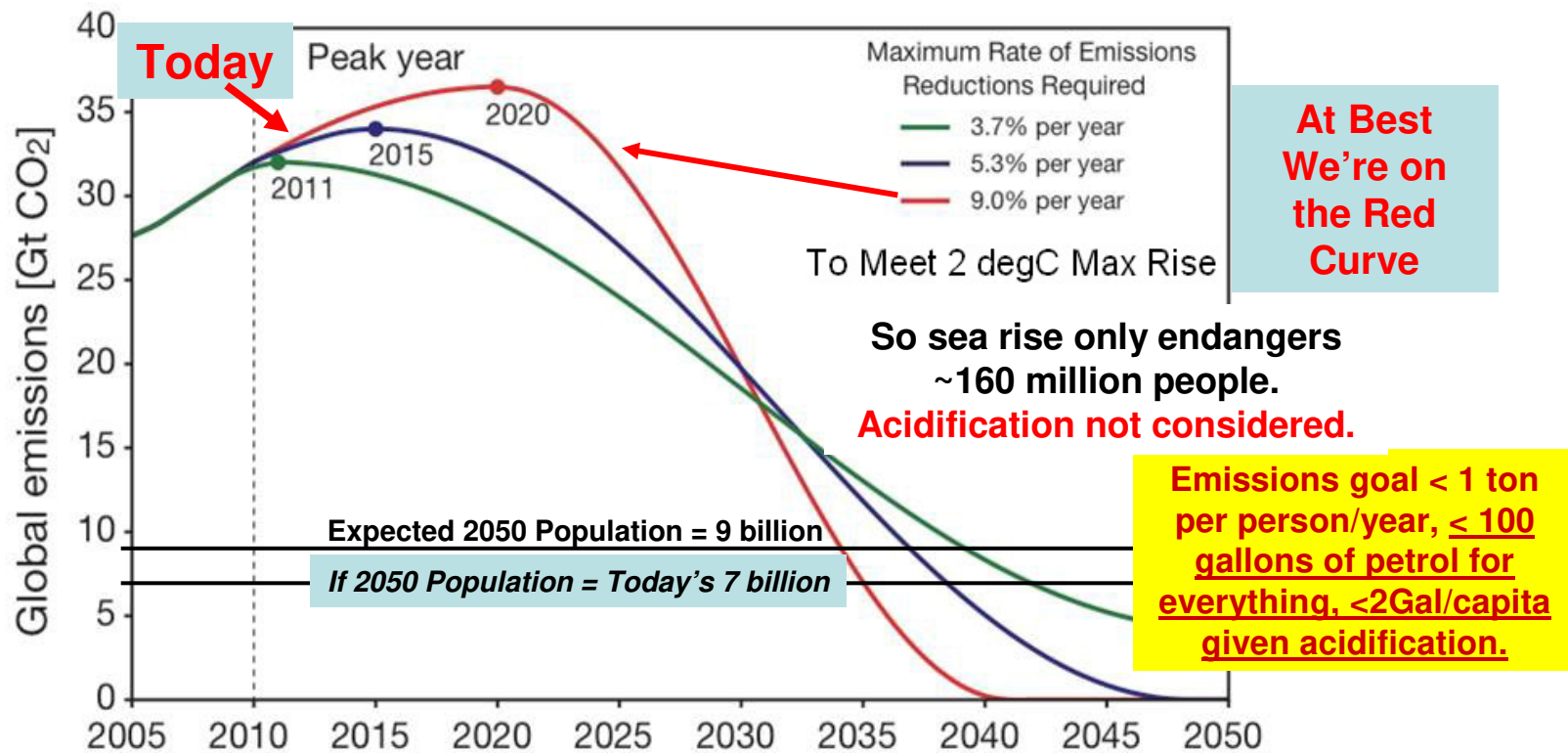
*The problem to work:* <1 ton of CO<sub>2</sub> per capita/year by 2050...

<http://download.copenhagendiagnosis.org/default.html> (10/2009 1st edition, p51)

<http://tinyurl.com/2a7lswe> (latest projections)

<http://tinyurl.com/3cw4rkc> <http://tinyurl.com/bueq2ev> (how bad it is)

<http://online.wr.usgs.gov/calendar/2012/mar12.html> (USGS 2012 update)



**World CO<sub>2</sub> emissions from just power grew 6% in 2010, to a record 30+ billion metric tons:**

[www.bbc.co.uk/news/science-environment-13595174](http://www.bbc.co.uk/news/science-environment-13595174) (1 Metric ton = 1.1 English ton)

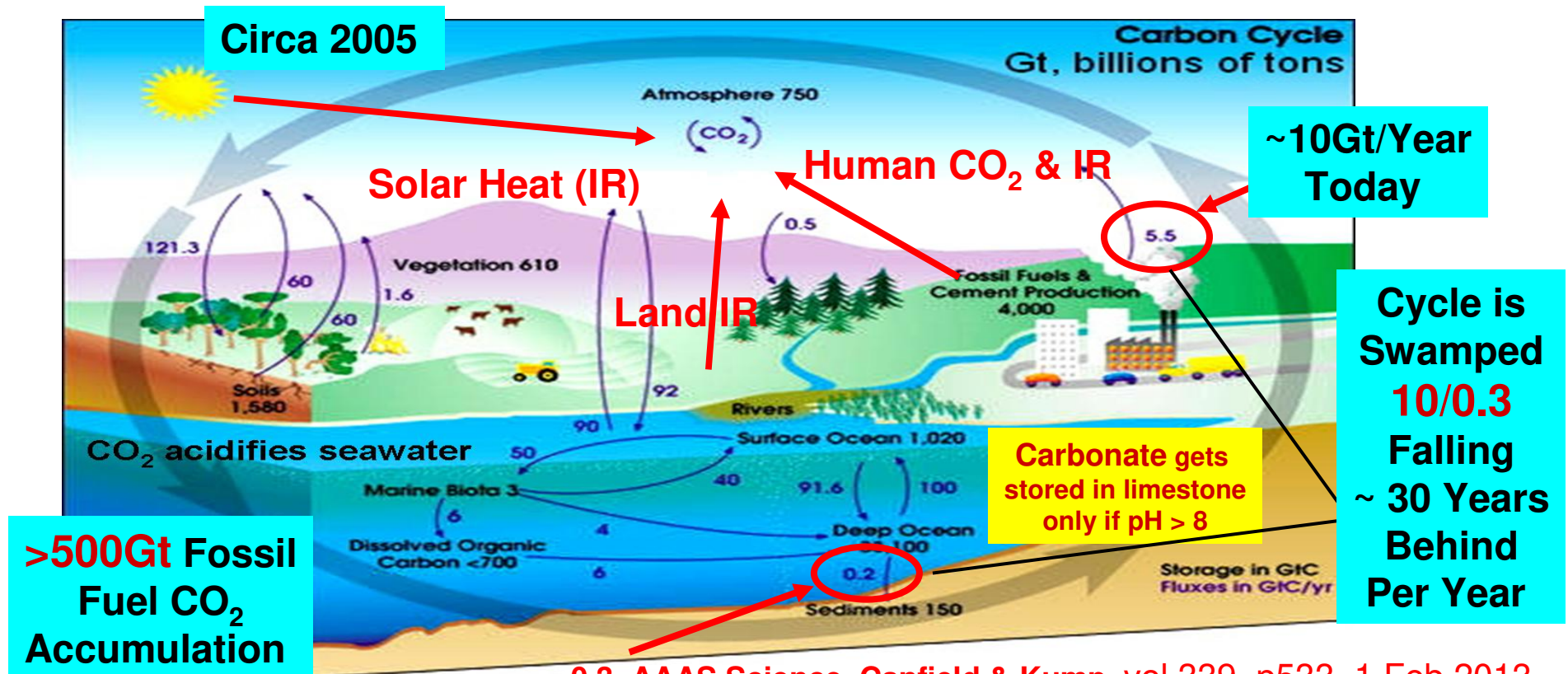
# The Carbon Cycle (**3 Numbers**)

Cyanobacteria, plankton & algae produced most of the Oxygen we have to breathe & use, starting ~2 billion years ago, with the earliest photosynthesizing ocean life. Land plants later evolved & helped. All fossil fuels we dig up were made this way. Carbon emissions today are **~10Gt** (>30Gt CO<sub>2</sub>)

[www3.geosc.psu.edu/~jfk4/PersonalPage/Pdf/annurev\\_03.pdf](http://www3.geosc.psu.edu/~jfk4/PersonalPage/Pdf/annurev_03.pdf)

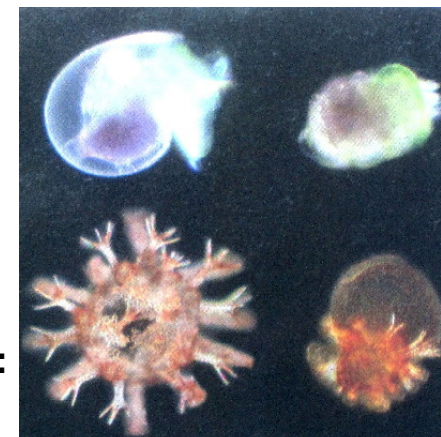
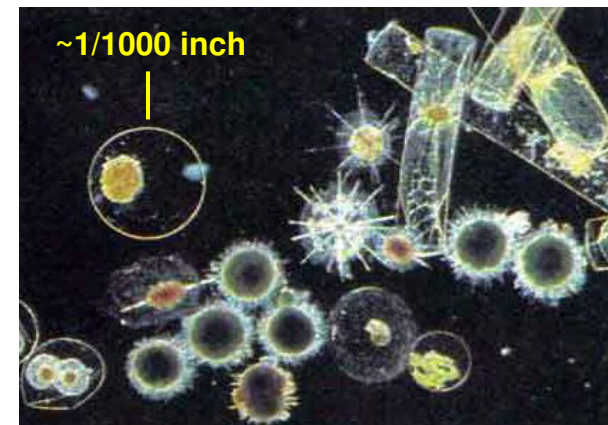
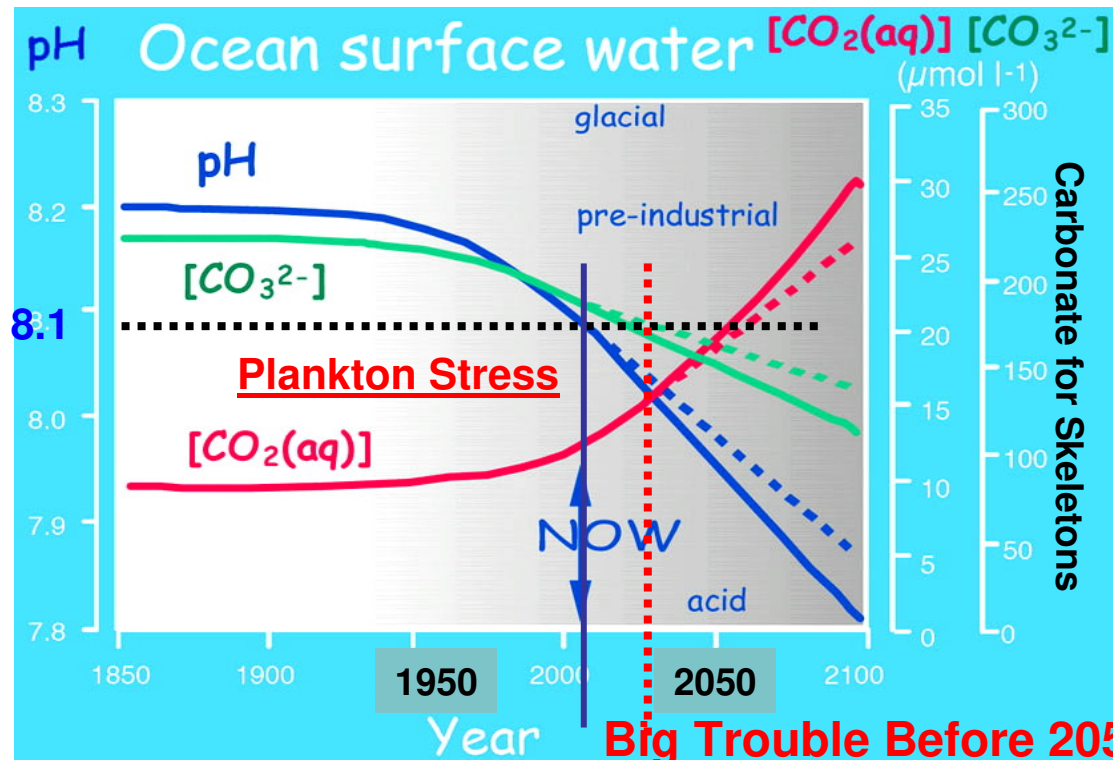
[www.atmo.arizona.edu/courses/fall07/atmo551a/pdf/CarbonCycle.pdf](http://www.atmo.arizona.edu/courses/fall07/atmo551a/pdf/CarbonCycle.pdf)

[www.annualreviews.org/doi/abs/10.1146/annurev.earth.031208.100206?journalCode=earth](http://www.annualreviews.org/doi/abs/10.1146/annurev.earth.031208.100206?journalCode=earth)



# Acidification

~30% of all ~1.8 trillion tons of CO<sub>2</sub> emissions are now in oceans creating less alkaline seawater, affecting entire sea food chains -- sea life provides ~15% of all human food protein – “*The Sixth Extinction*” by Kolbert 2014; “*A short history of ocean acidification science in the 20th century*” by Brewer 2013



Deformed Larvae

Normal Larvae:

Warmer, acidifying North Atlantic

[www.ocean-acidification.net/](http://www.ocean-acidification.net/)

<http://tinyurl.com/6mtd8db>

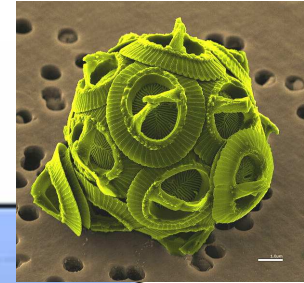
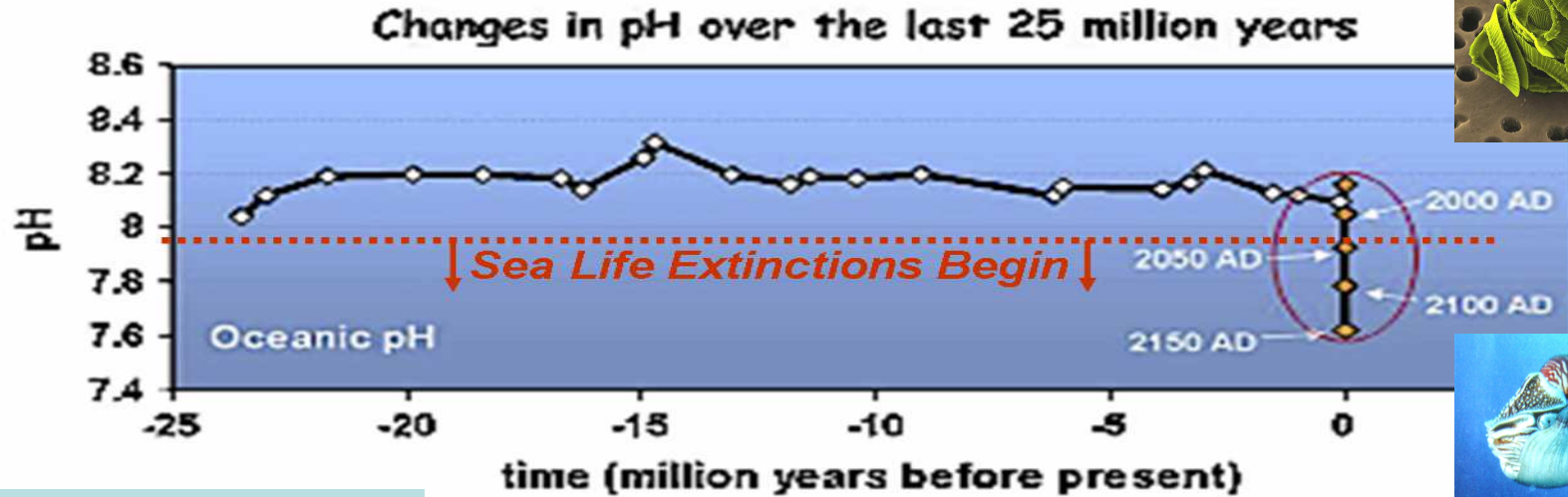
[www.noaa.gov/video/administrator/acidification/index.html](http://www.noaa.gov/video/administrator/acidification/index.html)

[www.bbc.co.uk/news/science-environment-18938002](http://www.bbc.co.uk/news/science-environment-18938002)



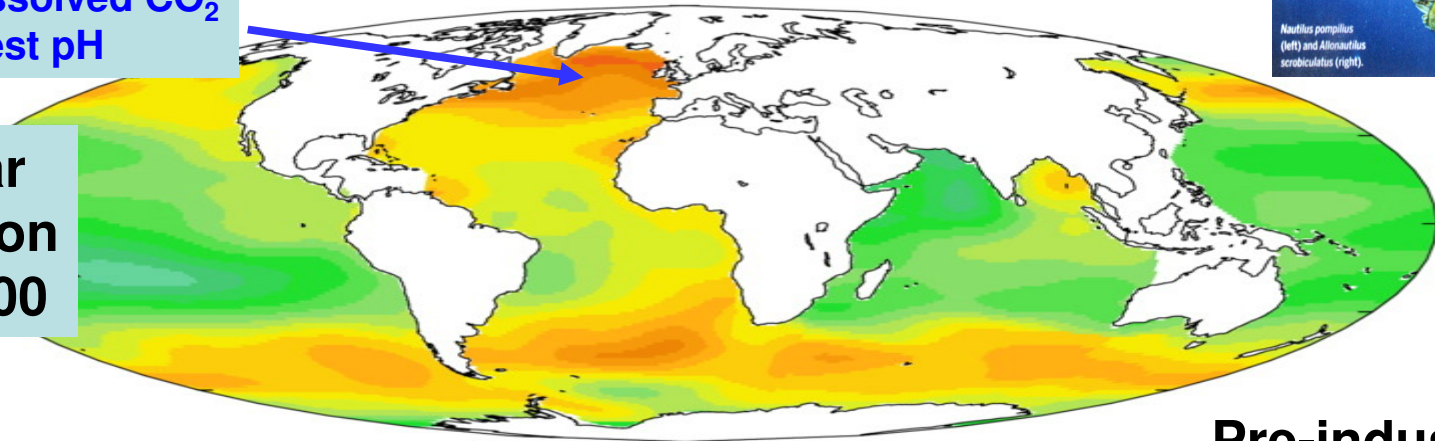
# Acidification

Oceans are Acidifying Fast .....



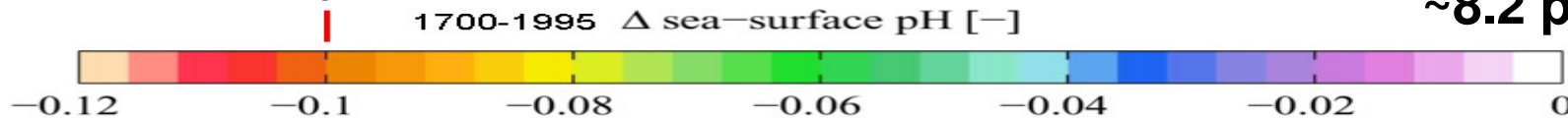
Highest Dissolved CO<sub>2</sub>  
Lowest pH

~300-Year  
Acidification  
From ~1700

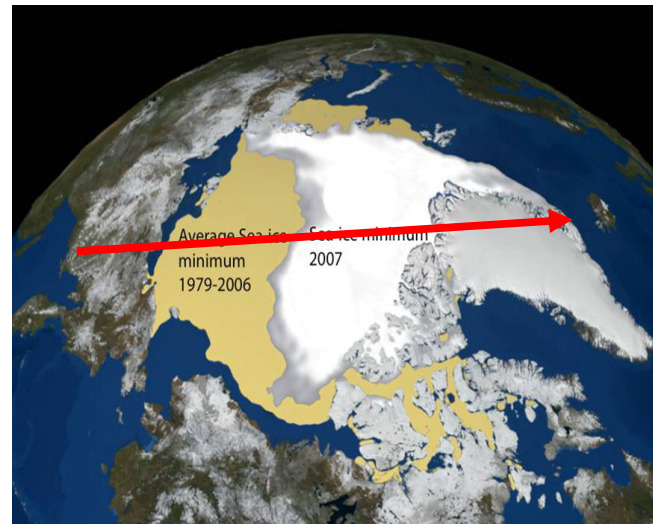
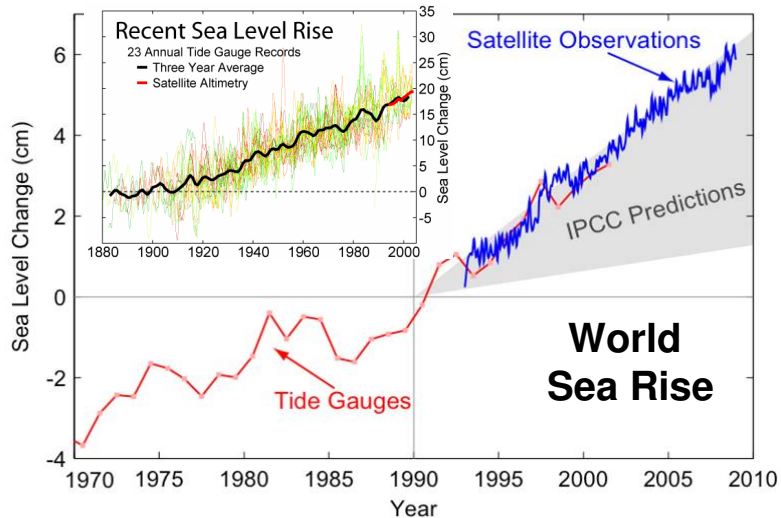
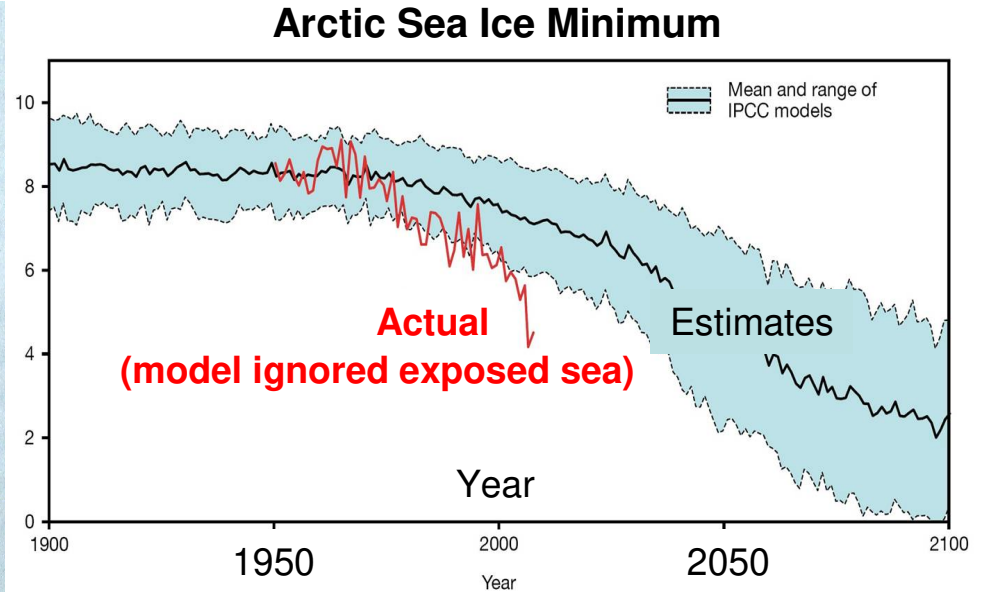
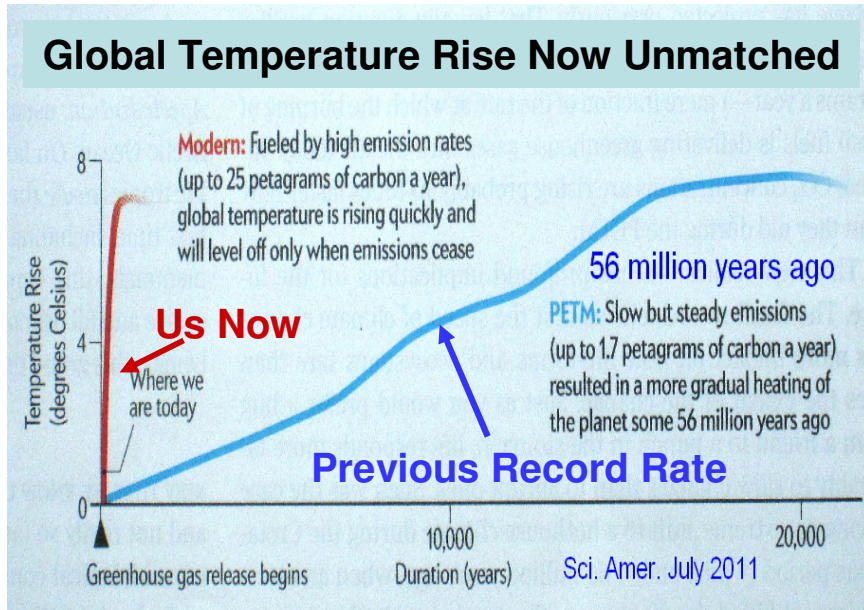


Today ~8.1

Pre-industrial  
~8.2 pH



# Emissions Effects



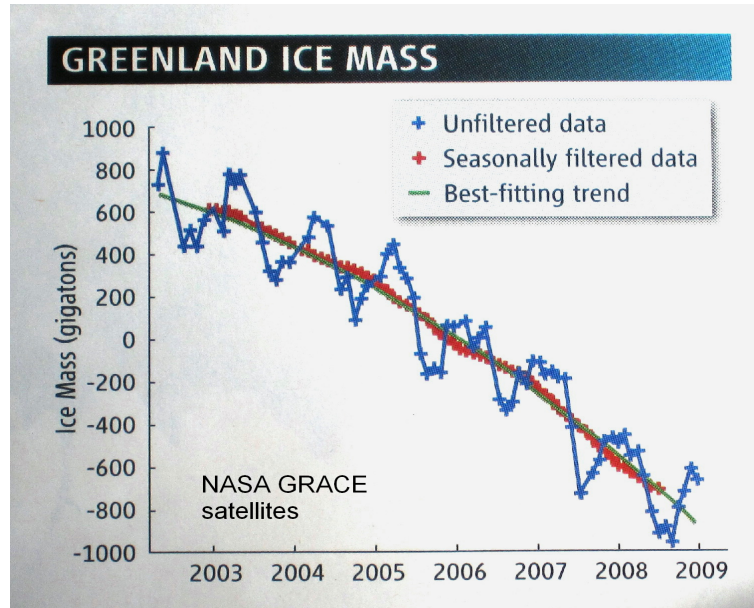
**China Ships to Iceland.  
Russia deploys shipborne reactors to power Siberian coastal industrial development.**

**2013 Sea Ice...**  
<http://tinyurl.com/kr8vrgn>



# Ice Loss

**Greenland:** 51 Cubic Miles lost in 2008, doubling every 7-8 years, 20 feet of sea rise possible -- **most of Greenland's surface melted in 4 days in July 2012:**



<http://tinyurl.com/cepqxag>

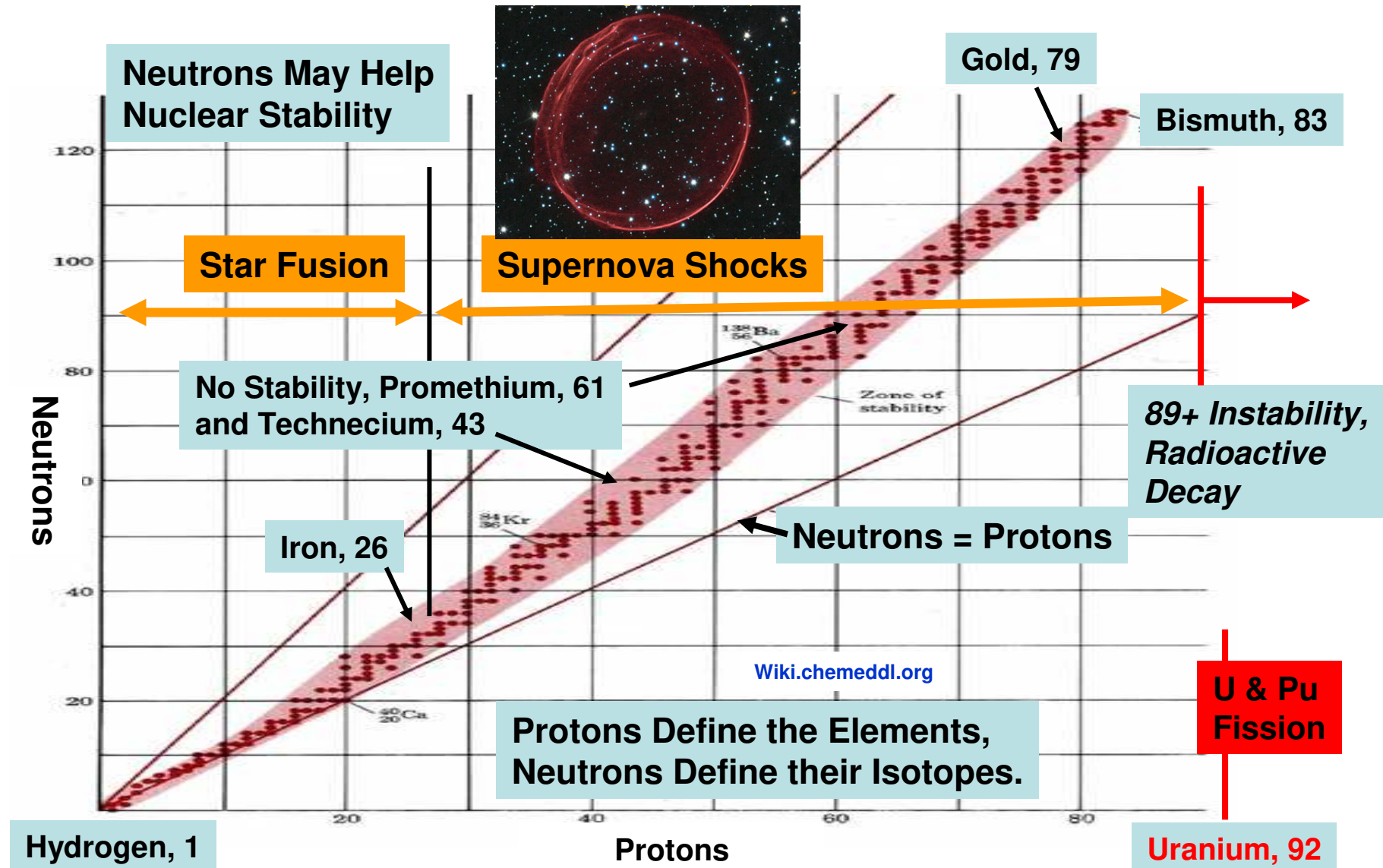


5 August 2010, ~100 square miles of ice broke away from Greenland.





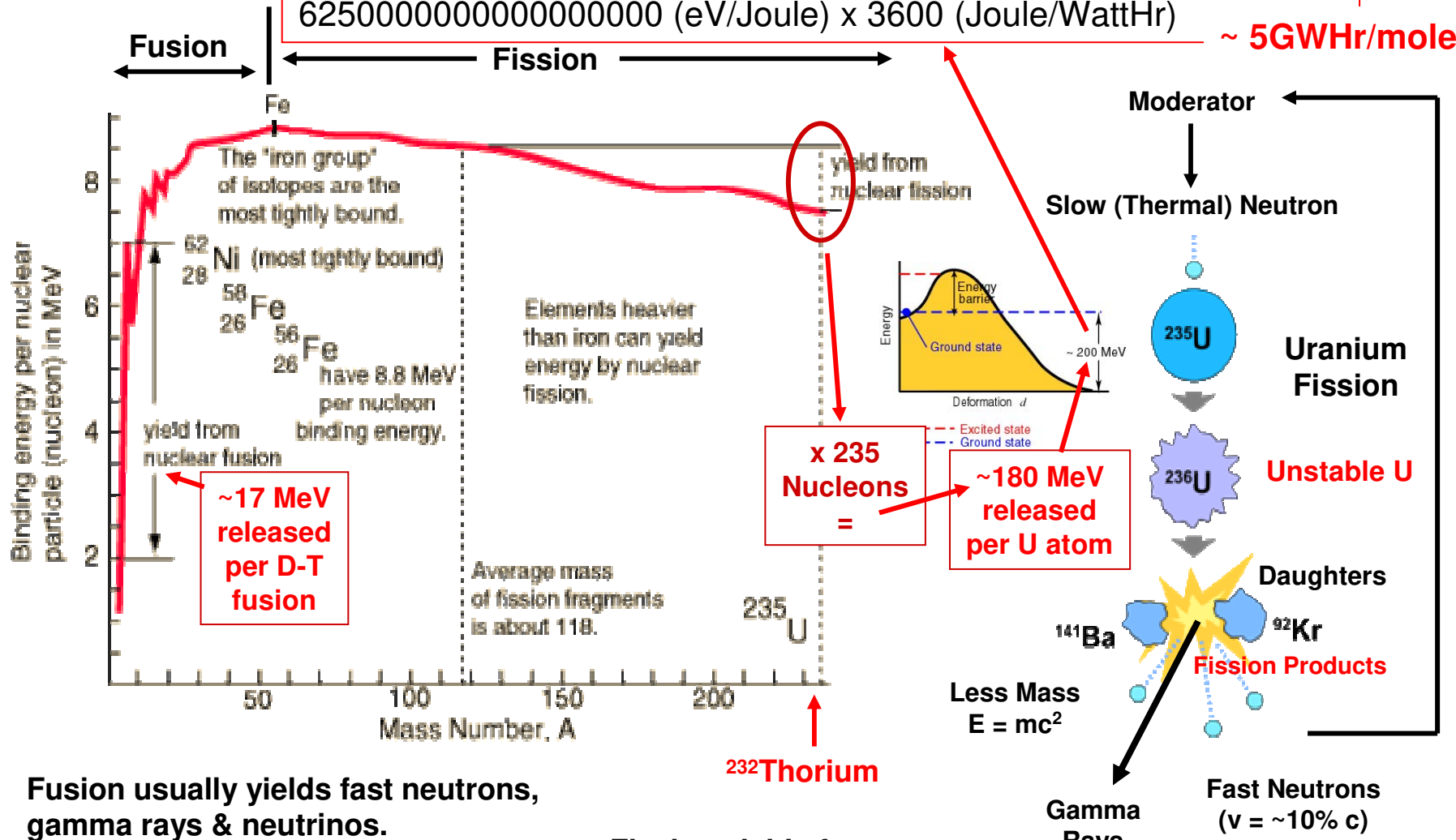
# Elements & Origins



# Nuclear Energy

$$E = mc^2$$

60200000000000000000000000 (atoms/mole) x 180000000 (eV/atom)  
62500000000000000000000 (eV/Joule) x 3600 (Joule/WattHr) ~ **5GWHr/mole**

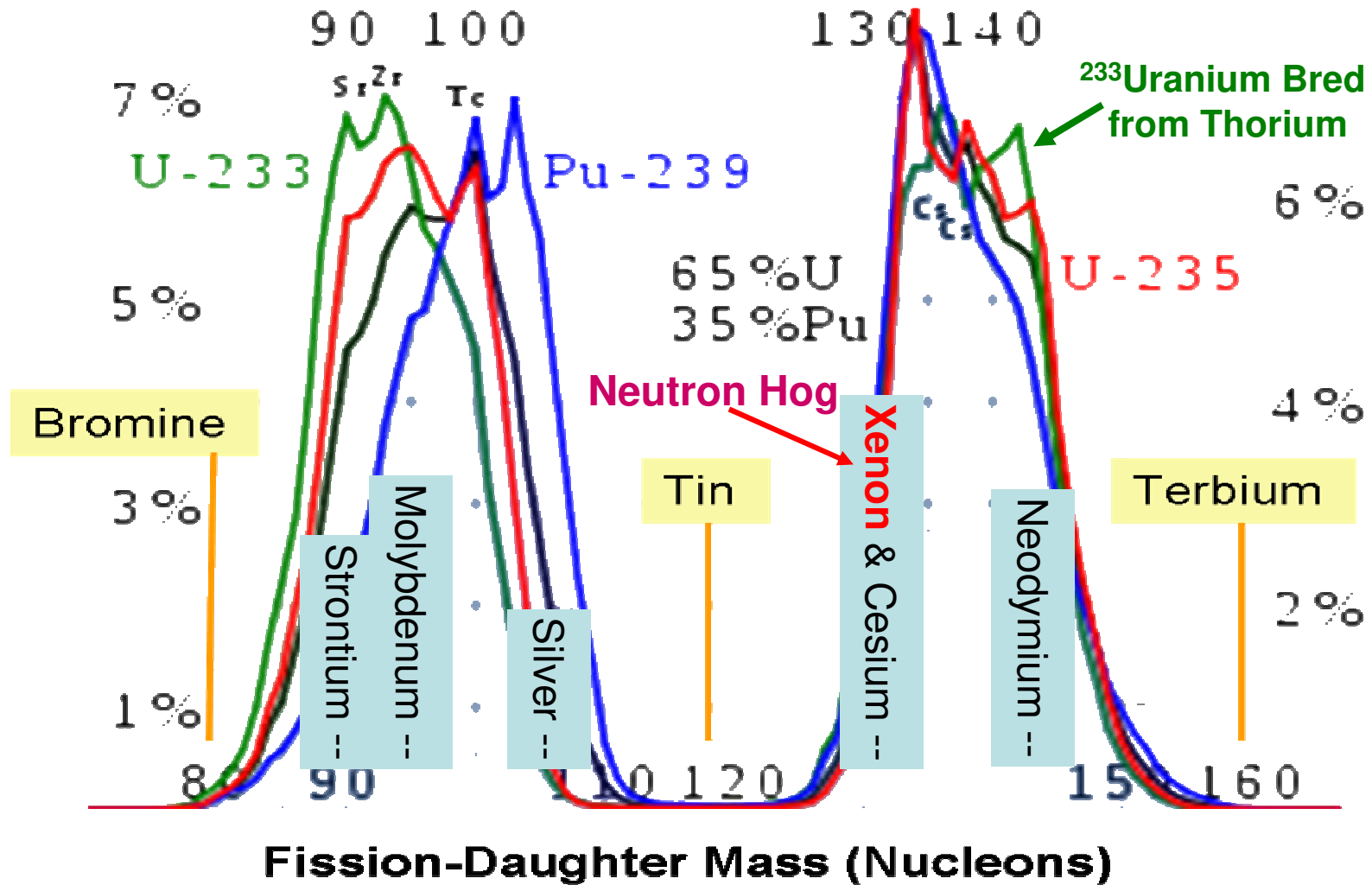


Fusion usually yields fast neutrons, gamma rays & neutrinos.

Fission yields fast neutrons, gamma rays & energetic isotopes (Fission Products).



# Fission Products



Asymmetrical yields of thermal-fission-product pairs versus fissile element

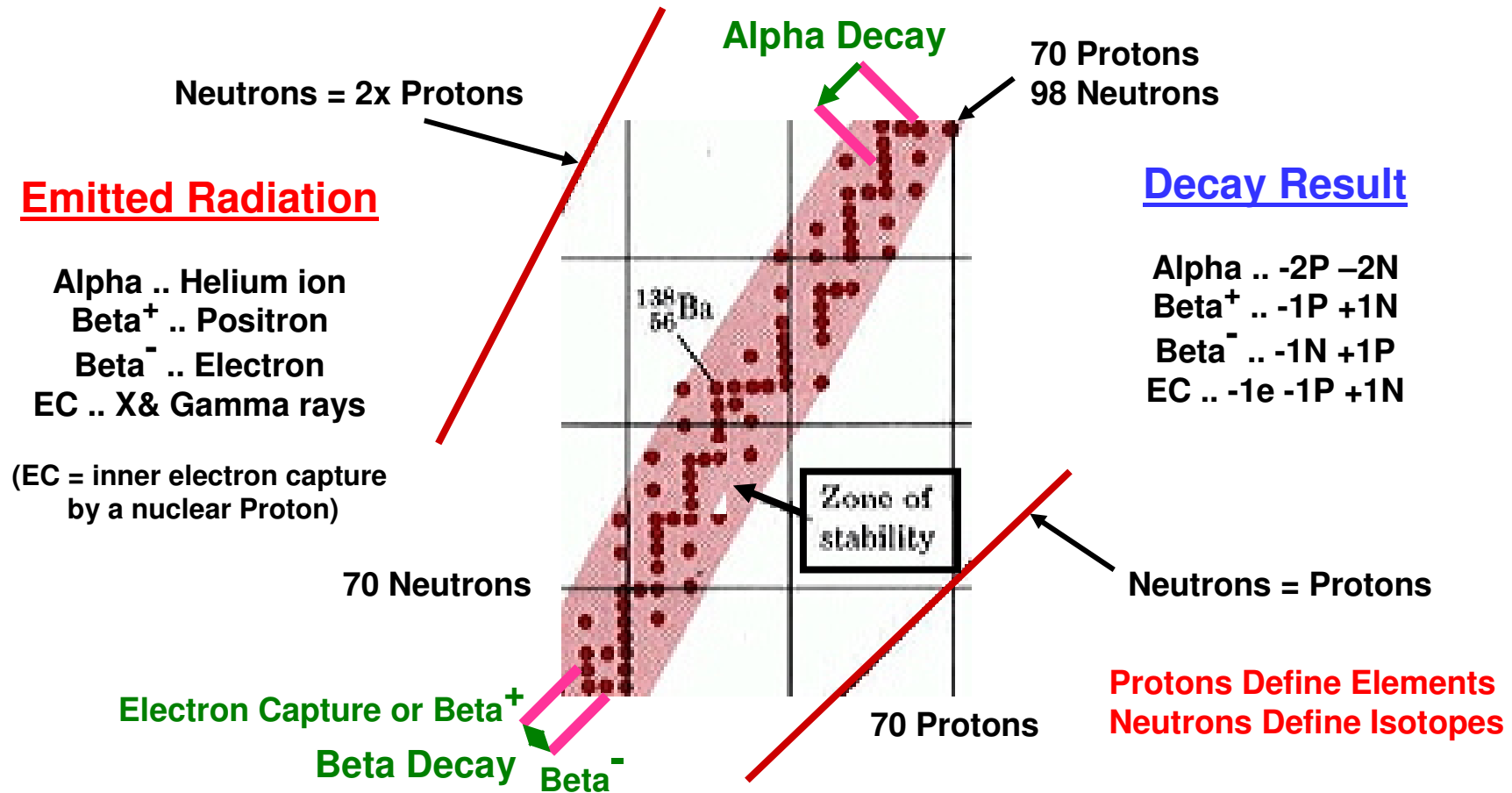
# Types of Radiation I

**Alpha** Particle ( ${}^4\text{He}$  ion): A fast-moving, Helium nucleus (2 Protons, 2 Neutrons) with +2 charge. Alpha Particle emission moves an element 2 positions down (Z-2) the Periodic Table, to become a lighter element. Radioactive decay produces Alpha emissions that can't penetrate skin but can damage a cell's molecules and cause radiation burns under high exposure. Cosmic Rays and solar fusion can create higher Alpha energies.

**Beta** Particle: A freely-moving, energetic Electron. Beta emission releases some nuclear energy and effectively converts a Neutron to a Proton, thus creating an isotope of the next element (Z+1) in the Periodic Table. The opposite move occurs by emission of a Positron. Beta emissions are also easily stopped but can burn if strong. An animation of Beta and Beta+ emissions is here: [www.colorado.edu/physics/2000/applets/iso.html](http://www.colorado.edu/physics/2000/applets/iso.html)

**Gamma** Ray: Photons of electromagnetic radiation whose energy exceeds those of Xrays (about 100keV) and UV (>1eV), with wavelengths less than an Angstrom (the scale of an atom). Gamma rays have exceedingly high frequencies and are highly-ionizing radiation, easily disrupting molecules. Ultraviolet light can deliver 3eV or more, breaking DNA bonds, while Gamma photons deliver thousands of times as much energy, freeing even innermost electrons from an atom. Gamma radiation above 10MeV occurs from environments near Black Holes, Magnetars, etc. Gamma rays are emitted by nuclear fission or fusion, by particles meeting Anti-Particles, or by interaction of energetic, charged particles with extreme magnetic fields.

# Alpha & Beta Decay Detail



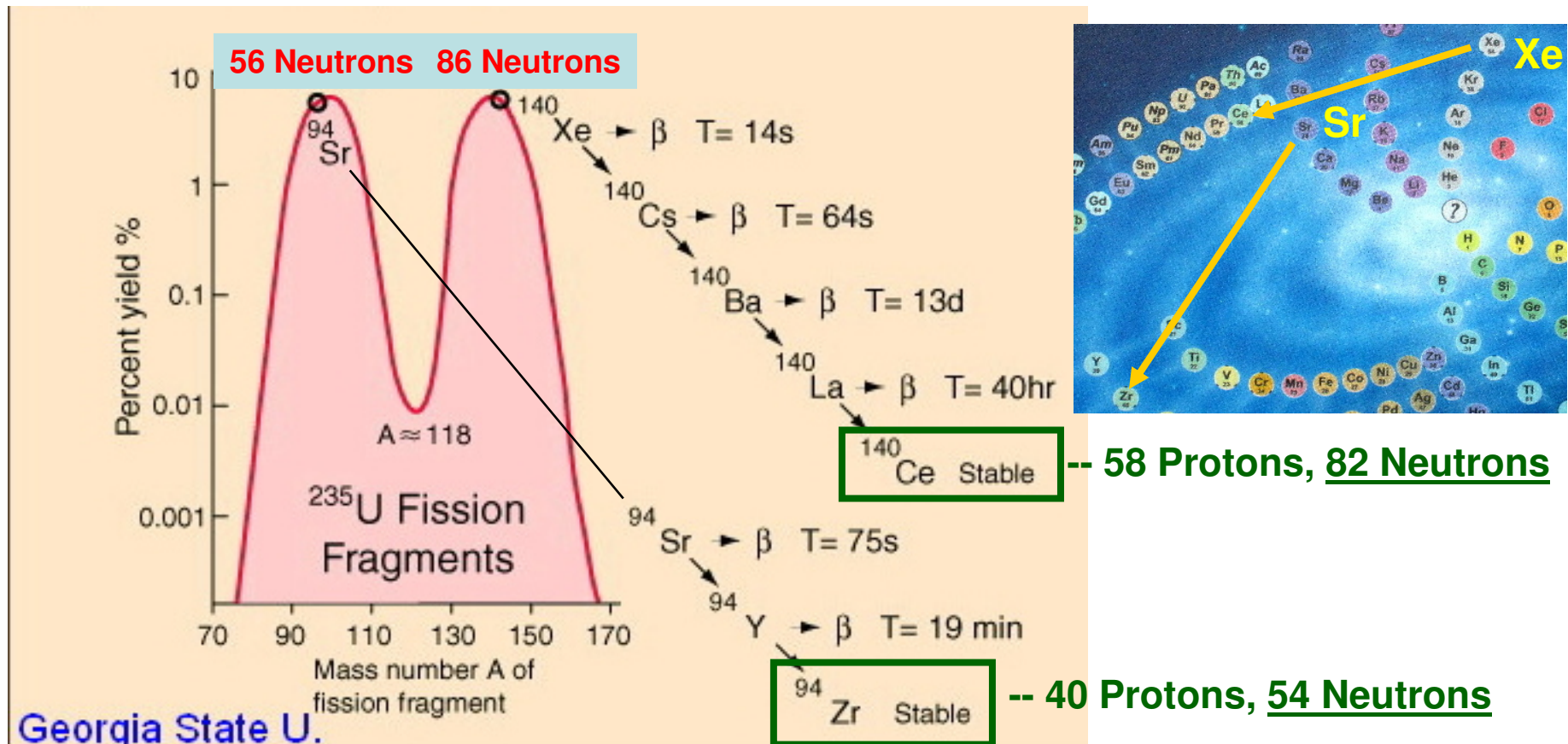
Note 1: Illustrated decays would only occur outside the Zone of Stability, or for isotopes not indicated by red dots, e.g., <sup>139</sup>Ba.

Note 2: Decays are accompanied by Gamma or X radiation at some energies reflecting needed nucleon reshufflings.



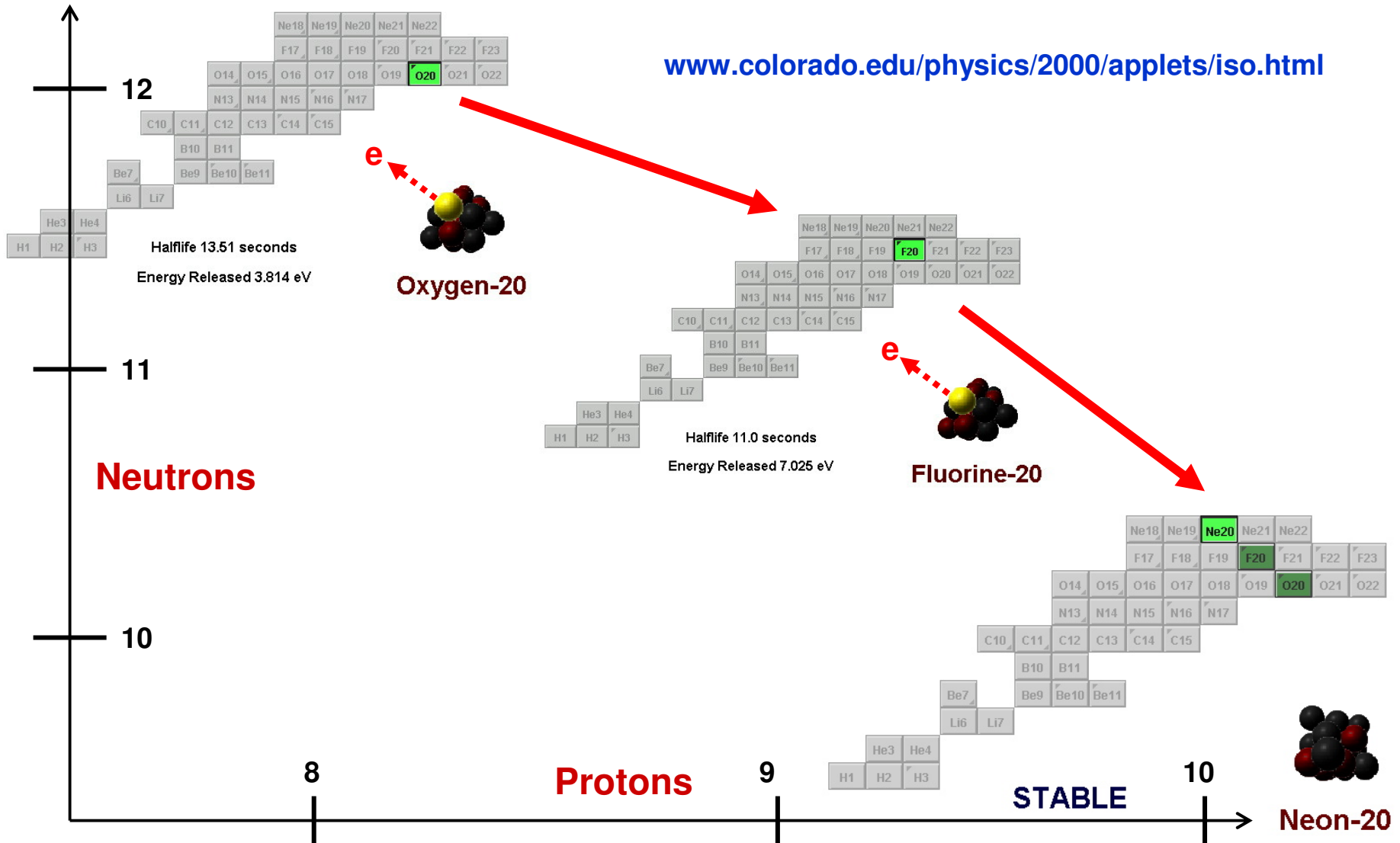
# Fission-Product Radiation

$^{235}\text{U}$  fission can result in the FP pair  $^{94}\text{Sr}$  and  $^{140}\text{Xe}$ , which are Highly radioactive, due to excess of several neutrons each. They decay within minutes or days to stable Zirconium and Cerium, by shedding Beta particles (electrons), thus moving up the Periodic Table to higher Proton/Neutron ratios..



# Beta (Neutron to Proton) Decay

[www.colorado.edu/physics/2000/applets/iso.html](http://www.colorado.edu/physics/2000/applets/iso.html)



# Types of Radiation II

**Neutron:** An uncharged nuclear particle about the same mass as a Proton, but unstable outside a nucleus – it Beta decays to a Proton, Electron and Anti-Neutrino within minutes. Its neutrality delayed its discovery until 1932, long after Alpha, Beta and Gamma discoveries. It carries away most of the energy from D-T fusion, but only a little of fission's energy release, which is mostly carried by the energetic, new fission product nuclei (FPs). Neutrons are generally more interactive with Carbon, which can be used as a Moderator to slow Neutron velocities. But this also leads to them being damaging to the hydrocarbon molecules of life – the intention of the “Neutron bomb”.

**Proton:** The charged nuclear particle that defines elements: 1 P = a Hydrogen nucleus.

**Radiation exposure** is measured by the Gray or **Sievert** -- both correspond to 1 Joule (1 Watt-second) of energy delivered to 1 kilogram of target material (also equivalent to an exposure of 100 Rem). The **Sievert measures biological effect**, so different types of radiation are rated in “dose equivalents”, using multipliers (e.g., **Photons/Electrons = 1, Protons = 2, Alpha particles or fission fragments = 20, thermal-fast Neutrons = 1-30...**). Living targets depend on DNA-repair mechanisms to correct for natural Gamma exposures, oxidants & chemical insults, etc.

**Dose equivalents** depend on the form of radiation and the target tissue:

<http://en.wikipedia.org/wiki/Sievert>

<https://radiationeffects.org/>



# Natural Radiation

*Foods concentrate various elements, including natural, unstable isotopes.*

**Banana-Equivalent Dose**

**Radiation:  
It's Organic!**

Eating a banana a week exposes a person to roughly the same amount of radiation as living near a nuclear power plant, less than 1 millirem of radiation each year. But don't go and give up bananas! Your body releases 40 millirem of radiation internally each year as it breaks down vitamins and minerals to keep your body healthy and functioning!

**~20 Bq,  
0.1 uSv**



[http://en.wikipedia.org/wiki/Banana\\_equivalent\\_dose](http://en.wikipedia.org/wiki/Banana_equivalent_dose)  
<http://www.bbc.co.uk/news/magazine-15288975>

<sup>40</sup>K is a very small fraction of stable Potassium & decays to stable <sup>40</sup>Calcium by emitting a beta particle with no attendant gamma radiation (89% of the time) or to stable <sup>40</sup>Argon gas by electron capture with emission of an energetic gamma ray photon (11% of the time).

With a biological half-life of 30 days, the <sup>40</sup>K content in the body is constant. **Each year <sup>40</sup>K decay delivers doses of about 0.18mSievert to soft tissues of the body & 0.14mSv to bone.** This suggests a 4/100,000 lifetime cancer risk, compared to 20,000/100,000 for all cancers.

| Isotope      | Lifetime Cancer Mortality Risk     |  |
|--------------|------------------------------------|--|
|              | Inhalation<br>(pCi <sup>-1</sup> ) | Ingestion<br>(pCi <sup>-1</sup> )                        |
| Potassium-40 | 2.1 × 10 <sup>-10</sup>            | ~0.04 Bq (pCi <sup>-1</sup> )<br>2.2 × 10 <sup>-11</sup> |

Argonne National Laboratory, Human Health Fact Sheet 2005

# Natural Radiation -- Fission

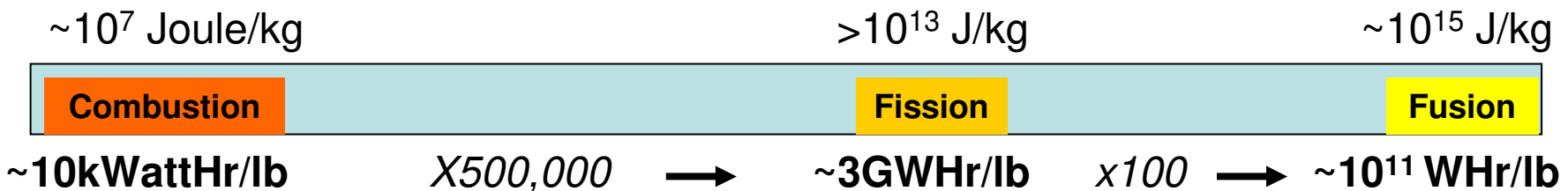
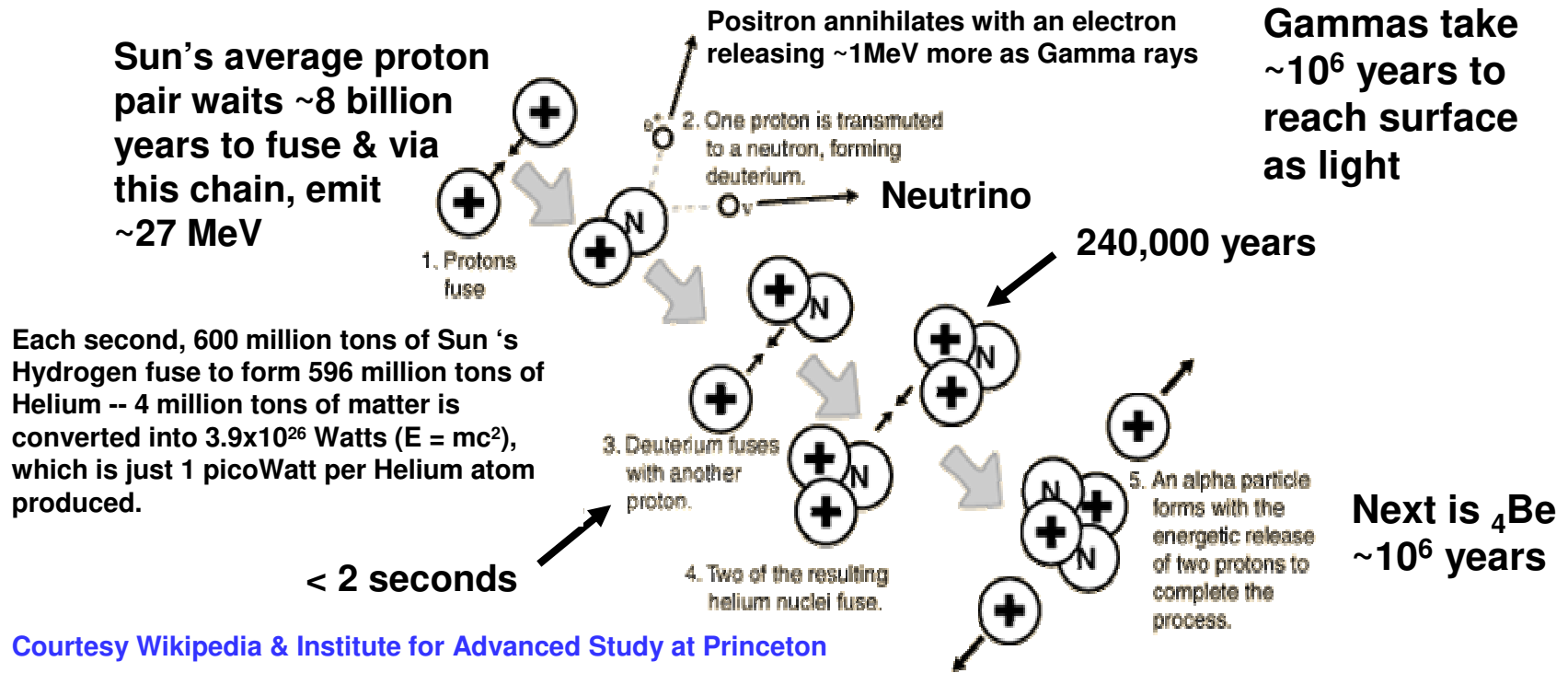
The mountains in Oklo, south-eastern Gabon are home to several natural  $^{235}\text{U}$  Uranium fission reactors. They operated about 2 billion years ago, when the 700-million-year half life of that isotope would have meant it was about 8 times as abundant in typical rock containing Uranium ore. The Earth's growing *atmospheric Oxygen content, water & bacteria concentrated  $\text{UO}_2$  enough that rainfall & groundwater acted as a neutron moderator to enhance fission* by slowing neutrons to 'thermal' speeds, making their capture by  $^{235}\text{U}$  nuclei more probable. When water stopped flowing, the reactors stopped fissioning. When it flowed again, they restarted. The site is now useful to judge stability of fission wastes. Niger & Gabon have very significant U deposits.



<http://www.ans.org/pi/np/oklo/>  
<http://www.ans.org/pi/np/oklo/>  
[http://en.wikipedia.org/wiki/Natural\\_nuclear\\_fission\\_reactor](http://en.wikipedia.org/wiki/Natural_nuclear_fission_reactor)  
[www.physics.isu.edu/radinf/Files/Okloreactor.pdf](http://www.physics.isu.edu/radinf/Files/Okloreactor.pdf)

# Natural Radiation – Solar Fusion

**Sun's energy density is low** – about 1/4 that of a resting human's body heat: 260uW/cm<sup>3</sup>) -- lower than a candle's -- why it's been around for over 4 billion years, turning Hydrogen into Helium, then Beryllium, plus neutrinos and gamma rays (light).





# Natural Radiation (From Unnatural Acts)

**Allowed combustion emissions/wastes – NORM exemptions...**

[https://en.wikipedia.org/wiki/Naturally\\_occurring\\_radioactive\\_material](https://en.wikipedia.org/wiki/Naturally_occurring_radioactive_material)



✦ TVA Kingston Coal Plant, Dec. 2008

# Radiation Lies II

**A lie: Welsh child leukemia was caused by the Sellafield nuclear plant...**  
[www.monbiot.com/2011/11/22/how-the-greens-were-misled/](http://www.monbiot.com/2011/11/22/how-the-greens-were-misled/) (The Guardian, 22 Nov. 2011)

“...the long-running *failure by people within the ‘green’ movement to challenge the claims made by a Dr. Christopher Busby* ...a visiting professor at the U. of Ulster... formerly the science and technology **spokesperson for the Green Party, which still consults him on...low-level radiation and depleted uranium.** Following...revelations published by the Guardian today, this may now change. *One of Busby’s...contentions, widely repeated by anti-nuclear campaigners, is that there is a leukaemia cluster among children living close to the coast of north Wales. This cluster, he maintains, is caused by radionuclides in the sea, from Sellafield and other sources.*

**His findings were self-published and released by the consultancy he runs, called Green Audit... they were not subjected to the scientific assessment required by peer-reviewed journals.**

Busby’s claims were later *assessed by professional scientists working for the Welsh Cancer Intelligence and Surveillance Unit at the NHS.* They published...peer-reviewed...Journal of Radiological Protection. Their paper reported a simple and devastating finding: **there is no such cluster. Busby’s claims...were the result of some astonishing statistical mistakes:**

- *He counted the overall leukaemia incidence for Wales twice;*
- *He mixed up the figures from urban areas with those from small rural areas, “trebling the local incidence in north Wales” and creating “spurious clusters in various locations”;*
- *He claimed there were ten cases of leukaemia in young children in Snowdonia. In reality there was just one case;*

# Radiation Lies II (continued)

[www.monbiot.com/2011/11/22/how-the-greens-were-misled/](http://www.monbiot.com/2011/11/22/how-the-greens-were-misled/) (The Guardian, 22 Nov. 2011)

[re Busby] **Worst of all...**

• *“We found clear evidence of data dredging which renders all subsequent statistical inference spurious...the dataset has been systematically trawled.”* Busby’s “findings” were repeated uncritically in the Welsh media, *spreading fear and distress among local people.*

As for *his “second event theory”, which maintains that radionuclides are far more dangerous than scientists say they are, the paper asserts that there is no evidence supporting this, and it has “no biological plausibility”.*

None...is as disturbing as the remarkable story published in the Guardian today. **Busby appears...on YouTube.** In it *he makes a number of wild allegations...[a] that the Japanese government is deliberately spreading radioactive material from Fukushima all over Japan.* The reason, he says, is that *when clusters of childhood cancer start appearing in Fukushima, the parents...will want to sue the...government.*

*“But the only way that they can say that they’ve got high levels of cancer is to have a control group in an area that’s not contaminated, for example the south of Japan. So I believe that the project to take this material and burn it all over Japan is to destroy all of Japan, to increase the cancer rate in the whole of Japan, so that there will be no control group to which you can compare these children in the Fukushima area.”* -- Busby



# Radiation Lies II (continued)

[www.monbiot.com/2011/11/22/how-the-greens-were-misled/](http://www.monbiot.com/2011/11/22/how-the-greens-were-misled/) (The Guardian, 22 Nov. 2011)

[re **Busby on YouTube**]: *He produces no evidence to support this claim.* Given that no radioactive waste has been removed from Fukushima prefecture, and there are no plans to do so, it is hard to see how he could.

*He then goes on to [b] promote expensive new pills and tests which, he says, will protect people in Japan* from these alleged horrors. Scientists contacted by the Guardian describe these treatments as useless and baseless.

*An organisation based in Japan, calling itself the Christopher Busby Foundation for the Children of Fukushima, and linked to Busby's own enterprise in Wales called Busby Laboratories, solicits donations for its work. But the bank account it asks people to send them to is not in Japan. It is called **Green Audit**, and the bank is in Busby's home town of Aberystwyth. **Green Audit is an environmental consultancy and research organisation founded by Busby.***

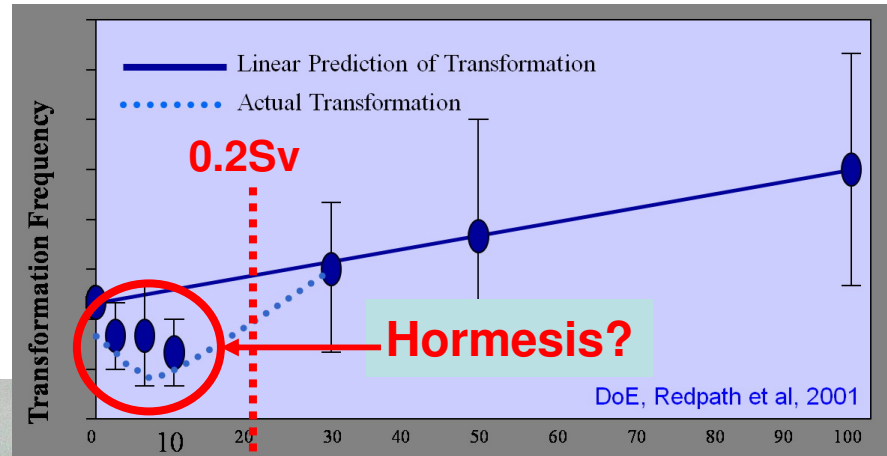
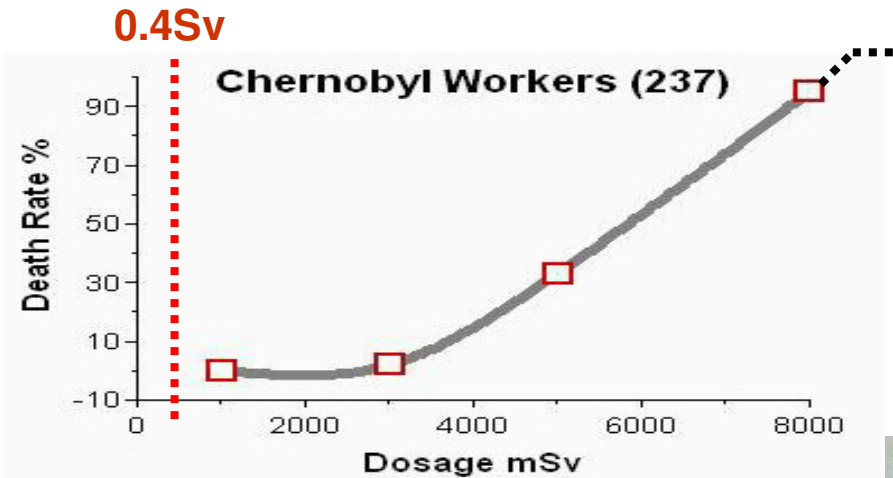
:

When I [Monbiot] *phoned Busby* to ask him some questions about these issues, his responses were less than enlightening. He began as follows: *“You can f\_\_k off frankly.”* When I asked him what his involvement was with the Christopher Busby Foundation for the Children of Fukushima, he told me: *“I think you can f\_\_k off. I'm not going to answer your questions.”*

Those who oppose nuclear power often maintain that they have a moral duty to do so. But it seems to me that moral duties cut both ways. – George Monbiot

**“A lie gets half way around the world before the truth gets its boots on”** -- Mark Twain.

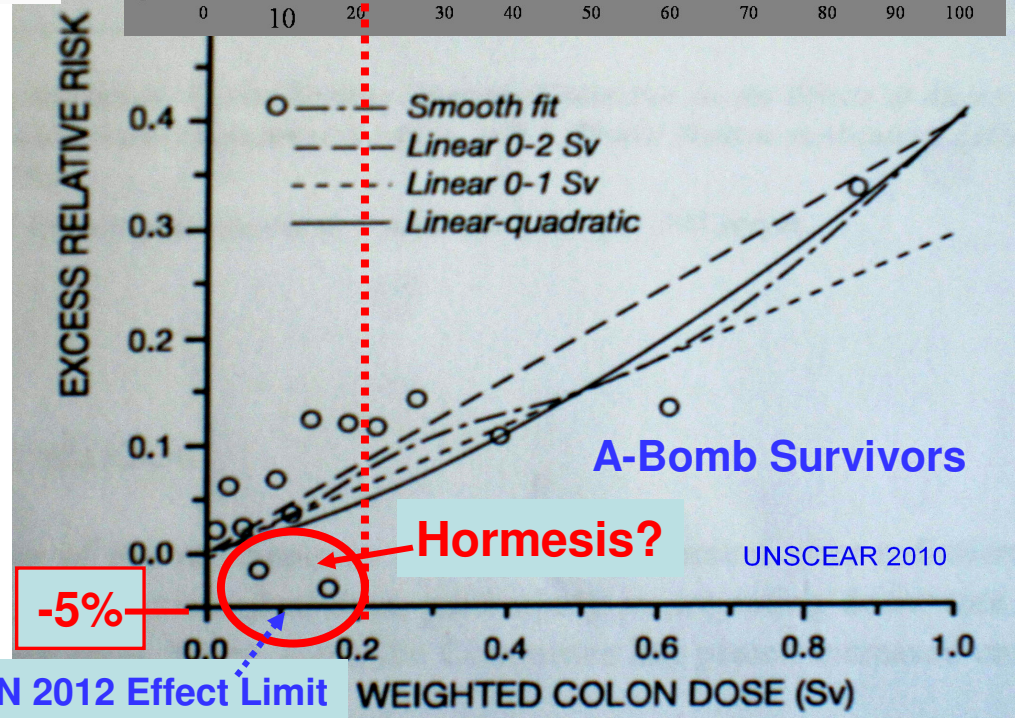
# Radiation Dose Thresholds



Solid cancer deaths of atomic bomb survivors were not affected by radiation exposure < 100-200 mSv

| mSv step to.. | Survivors | Survivor deaths | Control deaths |
|---------------|-----------|-----------------|----------------|
| <5            | 38,507    | 4,270           | 4,282          |
| 100           | 29,960    | 3,387           | 3,313          |
| 200           | 5,949     | 732             | 691            |
| 500           | 6,380     | 815             | 736            |
| 1,000         | 3,426     | 483             | 378            |
| 2,000         | 1,764     | 326             | 191            |
| >2,000        | 625       | 114             | 56             |

Threshold?



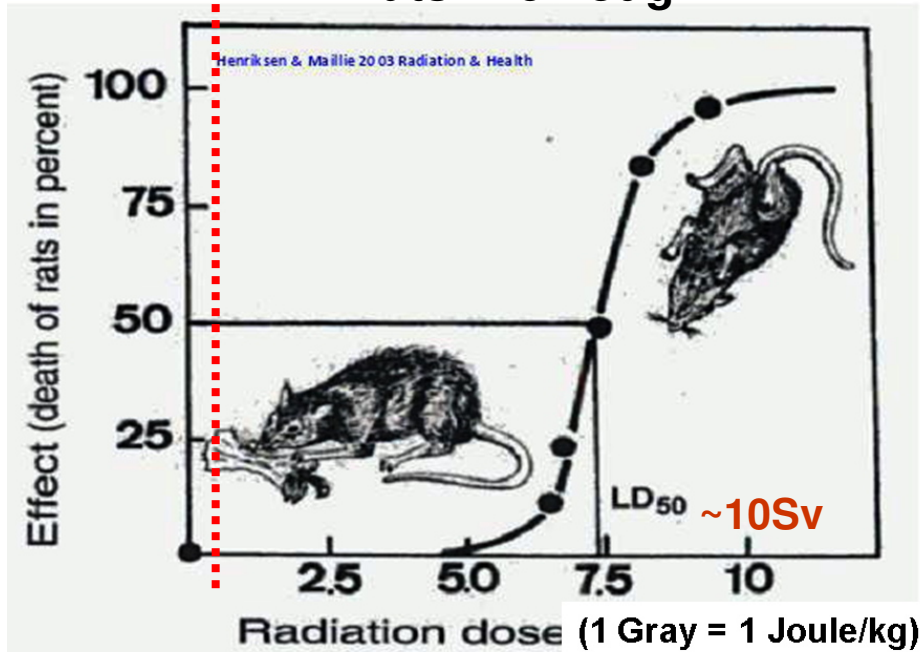
UN 2012 Effect Limit

Allison, "Radiation and Reason" 2009

# Relative Dose Thresholds

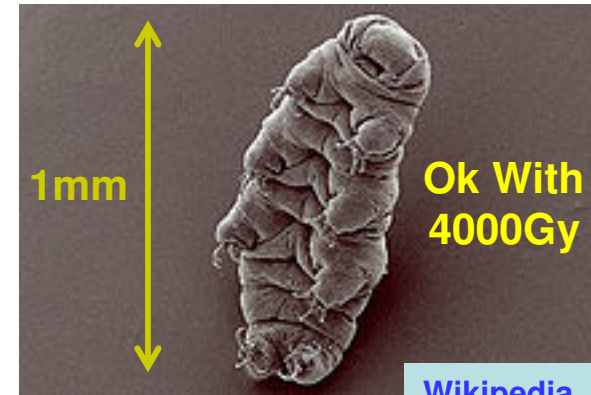
0.4Sv

Rats Are Tough



"Radiation and Health", Henriksen & Maillie, Taylor & Francis, New York, 2003

Tardigrades (Water Bears) Tougher



Wikipedia

But No Life Beats D. Radiodurans



Deinococcus Radiodurans can withstand an acute dose of 5,000 Gy of ionizing radiation with almost no loss of viability, and an acute dose of 15,000 Gy with 37% viability. 5,000 Gy is estimated to introduce **several hundred double-strand breaks into the organism's DNA.** 5 Gy can kill a human, 200-800 will kill E. coli, & >4,000 kills the radiation-resistant Tardigrade.



# Relative Industrial Dangers

## Public Health Impacts per TWh\*

|                                     | Coal | Lignite | Oil   | Gas  | Nuclear | PV   | Wind |
|-------------------------------------|------|---------|-------|------|---------|------|------|
| Years of life lost:                 |      |         |       |      |         |      |      |
| Nonradiological effects             | 138  | 167     | 359   | 42   | 9.1     | 58   | 2.7  |
| Radiological effects:               |      |         |       |      |         |      |      |
| Normal operation                    |      |         |       |      | 16      |      |      |
| Accidents                           |      |         |       |      | 0.015   |      |      |
| Respiratory hospital admissions     | 0.69 | 0.72    | 1.8   | 0.21 | 0.05    | 0.29 | 0.01 |
| Cerebrovascular hospital admissions | 1.7  | 1.8     | 4.4   | 0.51 | 0.11    | 0.70 | 0.03 |
| Congestive heart failure            | 0.80 | 0.84    | 2.1   | 0.24 | 0.05    | 0.33 | 0.02 |
| Restricted activity days            | 4751 | 4976    | 12248 | 1446 | 314     | 1977 | 90   |
| Days with bronchodilator usage      | 1303 | 1365    | 3361  | 397  | 86      | 543  | 25   |
| Cough days in asthmatics            | 1492 | 1562    | 3846  | 454  | 98      | 621  | 28   |
| Respiratory symptoms in asthmatics  | 693  | 726     | 1786  | 211  | 45      | 288  | 13   |
| Chronic bronchitis in children      | 115  | 135     | 333   | 39   | 11      | 54   | 2.4  |
| Chronic cough in children           | 148  | 174     | 428   | 51   | 14      | 69   | 3.2  |
| Nonfatal cancer                     |      |         |       |      | 2.4     |      |      |

1998 Swiss report on power sources...

<http://tinyurl.com/42wvr9l>

2010 UN SCEAR Report...

<http://tinyurl.com/7amwjgg>

(beginning to recognize threshold)

Review...

<http://tinyurl.com/3nwjboz>

2012 UN begins to admit LNT false & that 100mSv => undetectably few cancers

<http://tinyurl.com/babxels>

Wind-Death Samples...

[caithnesswindfarms.co.uk/accidents.pdf](http://caithnesswindfarms.co.uk/accidents.pdf)

<http://tinyurl.com/kqce99w>

National Cancer Institute...

<http://tinyurl.com/d2bbom>

International Dose-Response Society...

<http://dose-response.org/>

\*Kerwitt et al., "Risk Analysis" Vol. 18, No. 4 (1998).

# Relative Industrial Dangers

## Severe accidents with at least 5 fatalities (1970-2005)

| Energy chain | OECD      |            | EU 27     |            | non-OECD        |                    |
|--------------|-----------|------------|-----------|------------|-----------------|--------------------|
|              | Accidents | Fatalities | Accidents | Fatalities | Accidents       | Fatalities         |
| Coal         | 81        | 2123       | 41        | 942        | 144<br>1363 (a) | 5360<br>24'456 (a) |
| Oil          | 174       | 3388       | 64        | 1236       | 308             | 17'990             |
| Natural Gas  | 103       | 1204       | 33        | 337        | 61              | 1366               |
| LPG          | 59        | 1875       | 20        | 559        | 61              | 2636               |
| Hydro        | 1         | 14         | 1         | 116 (b)    | 12              | 30'007 (c)         |
| Nuclear      | —         | —          | —         | —          | 1               | 31 (d)             |

- (a) First line: coal non-OECD without China; second line: coal China  
 (b) Belci dam Romania (1991)  
 (c) Banqiao and Shimantan dam failures alone caused 26'000 fatalities  
 (d) Latent fatalities treated separately

Burgherr & Hirschberg, 2008

# Relative Industrial Dangers

Years of life lost worldwide per TWhr (courtesy of Burton Richter) --

**Nuclear: 25**  
**Gas: 42**  
**Coal: 140**

Energy & Environmental Science, 2012, DOI: 10.1039/C2EE22658H and  
 W. Krewitt et al. Risk Analysis, Vol. 18, No. 4, 1998.

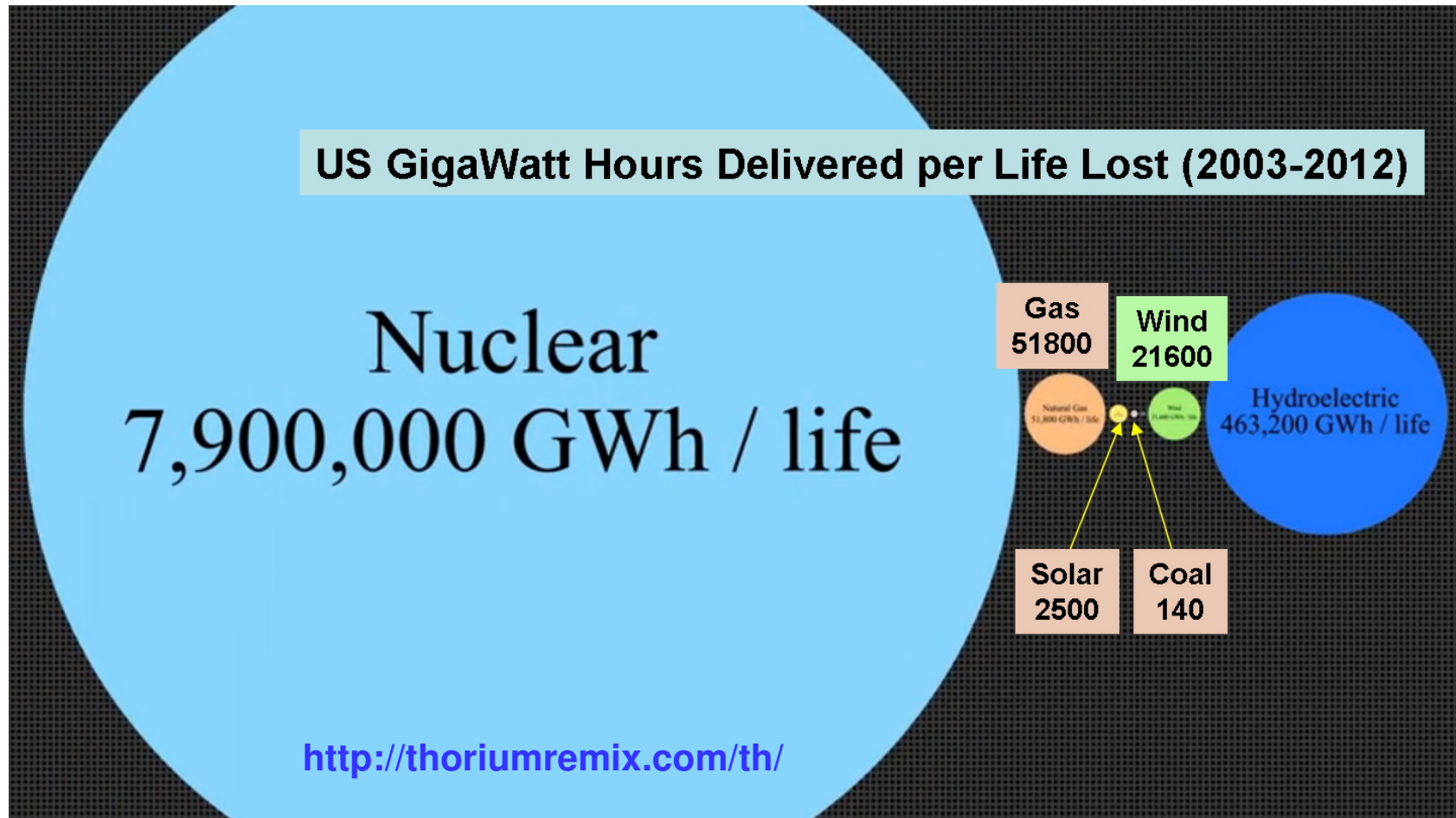
**Years of life lost had Japanese electricity been generated by nuclear versus combustion --**

| <i>Source...</i>        | <i>Fukushima Total</i> | <i>Japanese Total Nuclear</i> |
|-------------------------|------------------------|-------------------------------|
|                         | <b>898 Twh</b>         | <b>6097 Twh</b>               |
| <b>Coal</b>             | <b>124,000</b>         | <b>840,000</b>                |
| <b>Gas</b>              | <b>38,000</b>          | <b>260,000</b>                |
| <b>Nuclear (normal)</b> | 22,000                 | 153,000                       |
| <b>Fukushima (est.)</b> | 4,800                  | 4,800                         |
| <b>Total Nuclear</b>    | <b>26,800</b>          | <b>157,800</b>                |



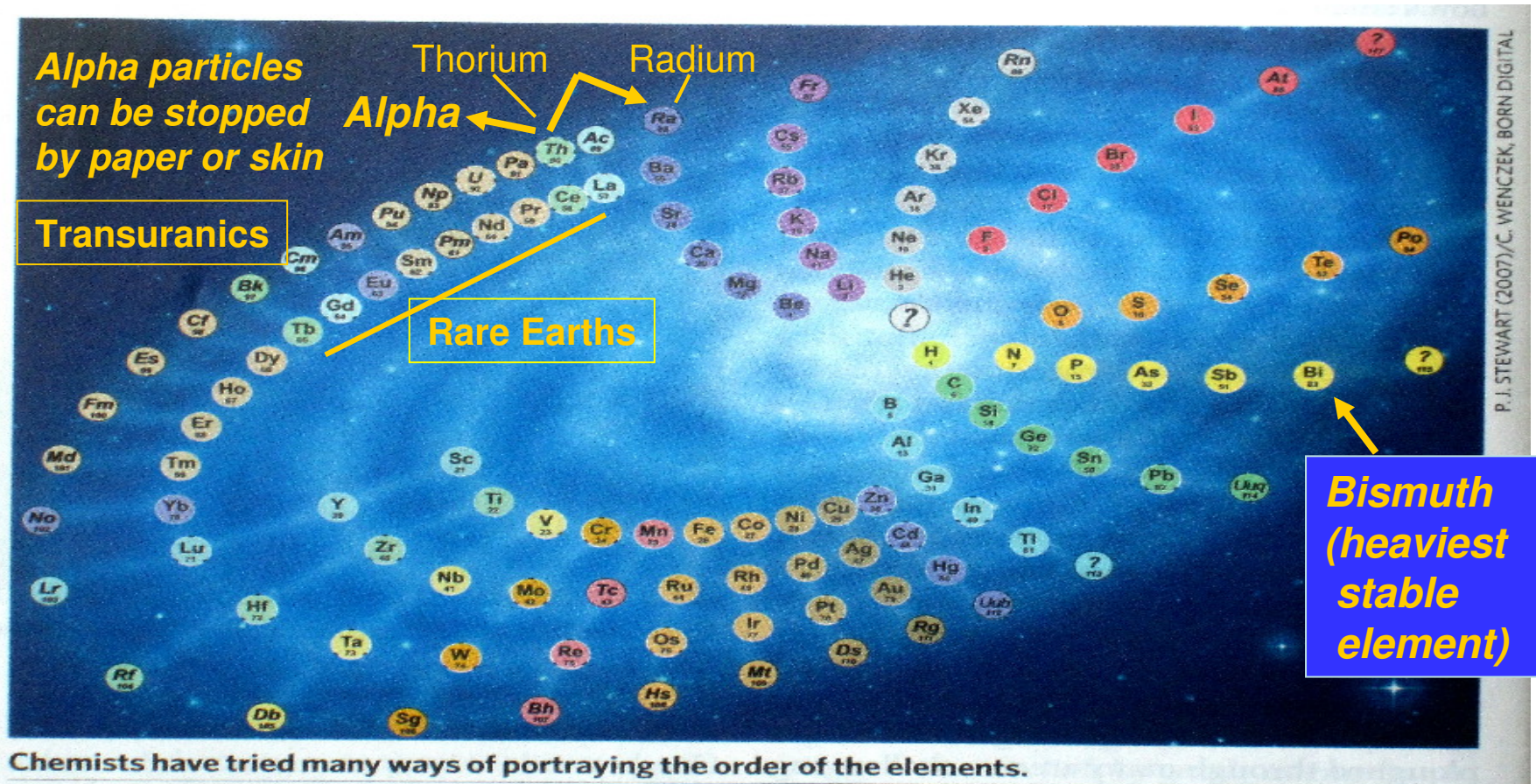
# Relative Industrial Dangers

Present Civilian & Naval Nuclear Power is the Safest Form of Power Generation Ever Deployed by Humanity: <http://tinyurl.com/42wvr9l> (1998)  
[www.scientificamerican.com/article.cfm?id=the-human-cost-of-energy](http://www.scientificamerican.com/article.cfm?id=the-human-cost-of-energy) (2013)



# Periodic Table & Decay Emissions

**Alpha** -- Particle ( ${}^4\text{He}$  ion): A fast-moving, Helium nucleus (2 Protons, 2 Neutrons) with +2 charge. Alpha Particle emission moves an element 2 positions down (Z-2) the Periodic Table, to become a lighter element. Radioactive decay produces Alpha emissions that can't penetrate skin but can damage a cell. Cosmic Rays create higher Alpha energies.



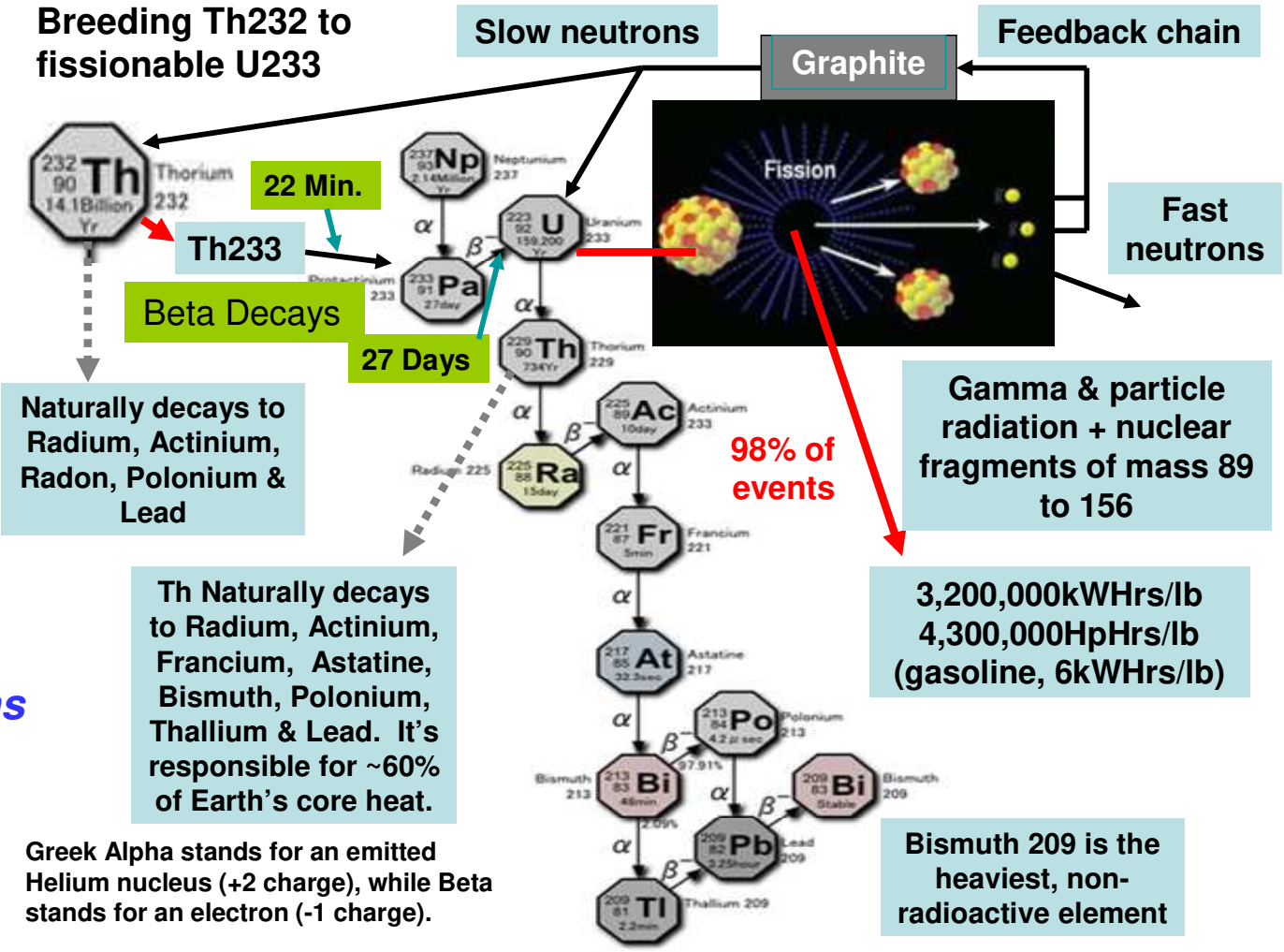




# Thorium-Bred $^{233}\text{U}$ -Based Fission

**Abundant,  
Cheap, low  
radioactivity**

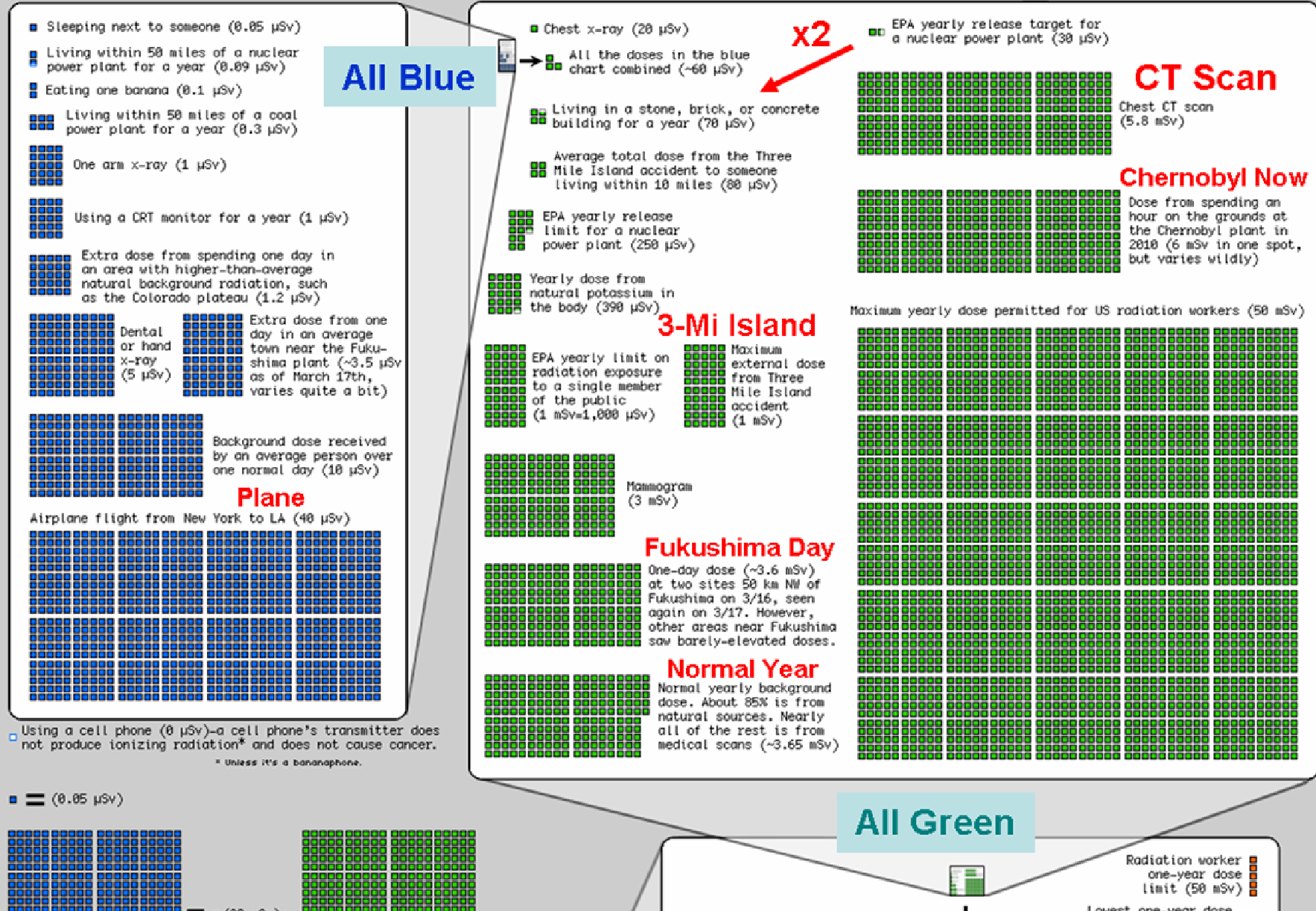
*Alternatively,  
spallation-  
injected neutrons  
can breed  $\text{Th}_{232}$   
directly to  $\text{U}_{233}$*



# Radiation Dose Chart

<http://imgs.xkcd.com/blag/radiation.png>

This is a chart of the ionizing radiation dose a person can absorb from various sources. The unit for absorbed dose is "sievert" (Sv), and measures the effect a dose of radiation will have on the cells of the body. One sievert (all at once) will make you sick, and too many more will kill you, but we safely absorb small amounts of natural radiation daily. Note: The same number of sieverts absorbed in a shorter time will generally cause more damage, but your cumulative long-term dose plays a big role in things like cancer risk.



# Dose Chart Continued

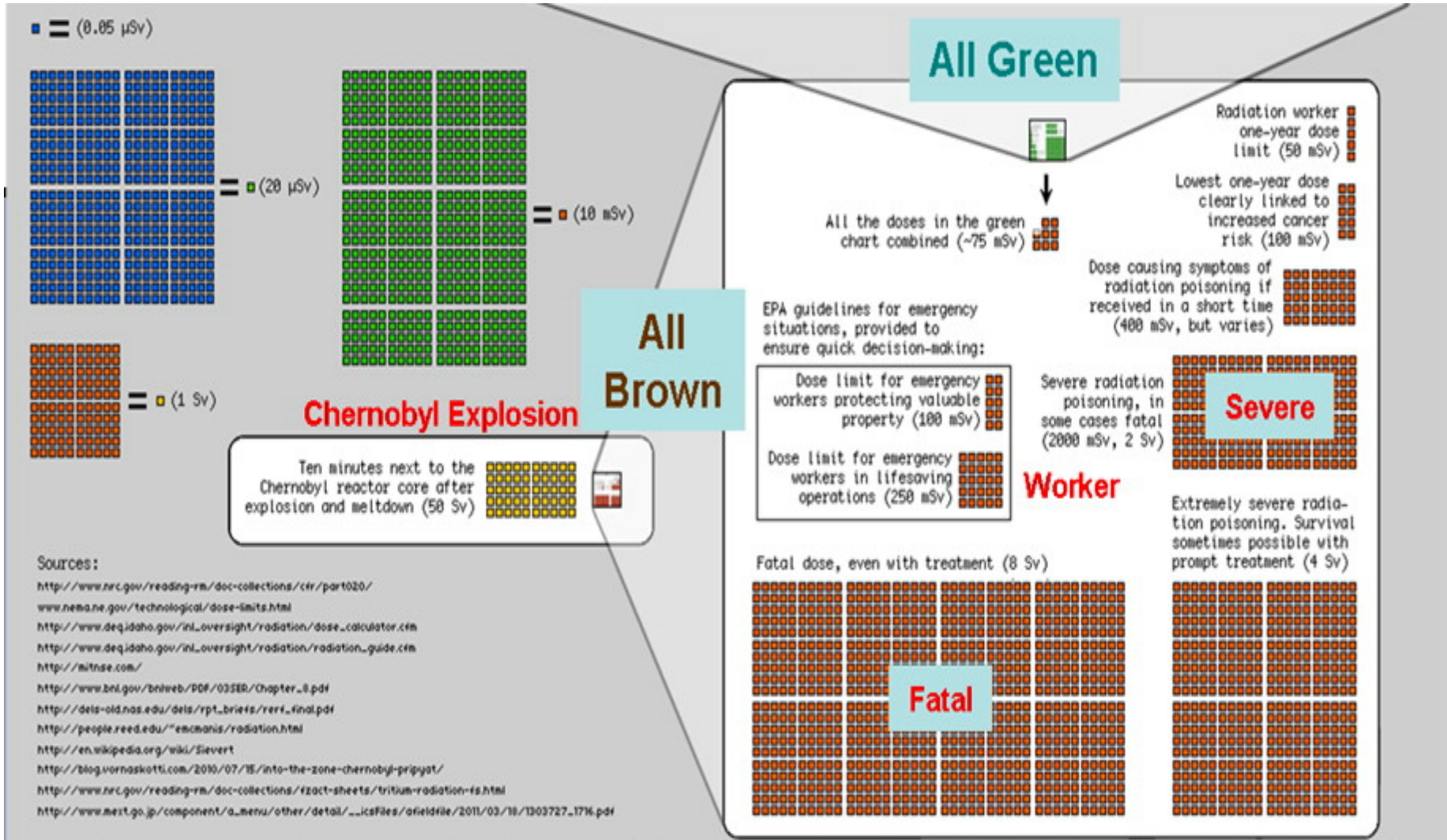
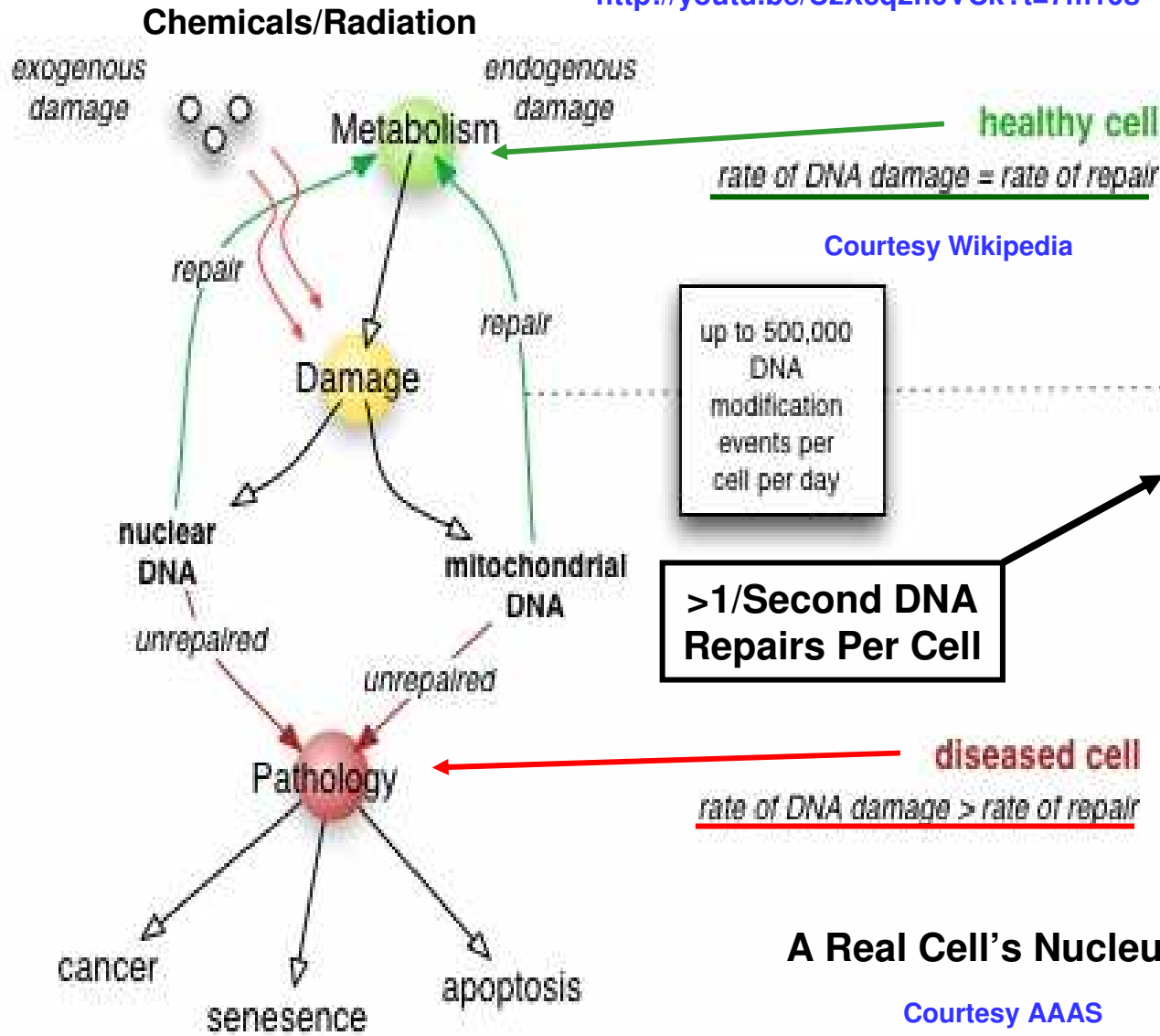


Chart by Randall Munroe, with help from Ellen, Senior Reactor Operator at the Reed Research Reactor, who suggested the idea and provided a lot of the sources. I'm sure I've added in lots of mistakes; it's for general education only. If you're basing radiation safety procedures on an internet PNG image and things go wrong, you have no one to blame but yourself.



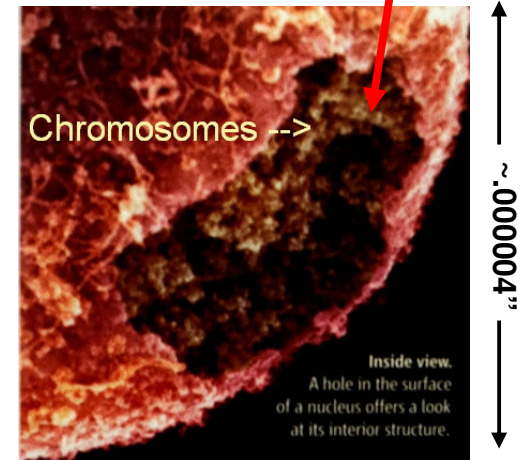
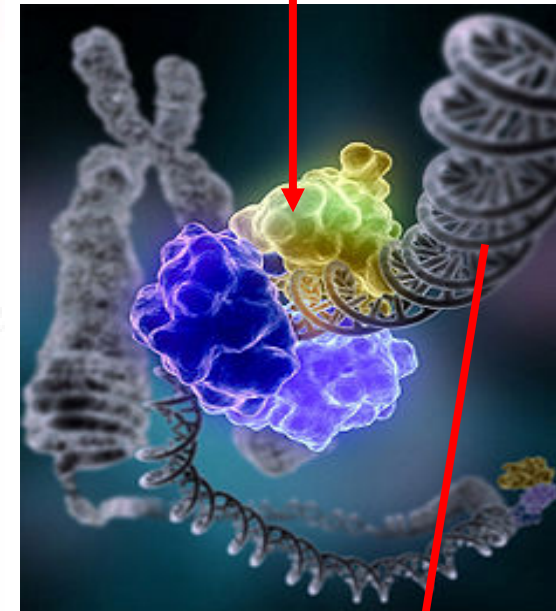
# Cellular DNA Repair

<http://youtu.be/UzXcq2h0VCK?t=7m10s>



Courtesy Wikipedia

## DNA Ligase Repairing a Chromosome Break



**diseased cell**  
rate of DNA damage > rate of repair

## A Real Cell's Nucleus:

Courtesy AAAS

# Cellular Protection/Repair

**Lysosomes** are cellular organelles that contain acid hydrolase enzymes to **break down waste materials and cellular debris**. They can be described as the stomach of the cell...**Lysosomes digest excess or worn-out organelles, food particles, and engulf viruses or bacteria**. The membrane around a lysosome allows the digestive enzymes to work at the 4.5 pH they require. Lysosomes fuse with vacuoles and dispense their enzymes into the vacuoles, digesting their contents. They are created...from the Golgi apparatus...The size of a lysosome varies from 0.1–1.2  $\mu\text{m}$ ...The lysosomal membrane protects the... rest of the cell, from the degradative enzymes within the lysosome...

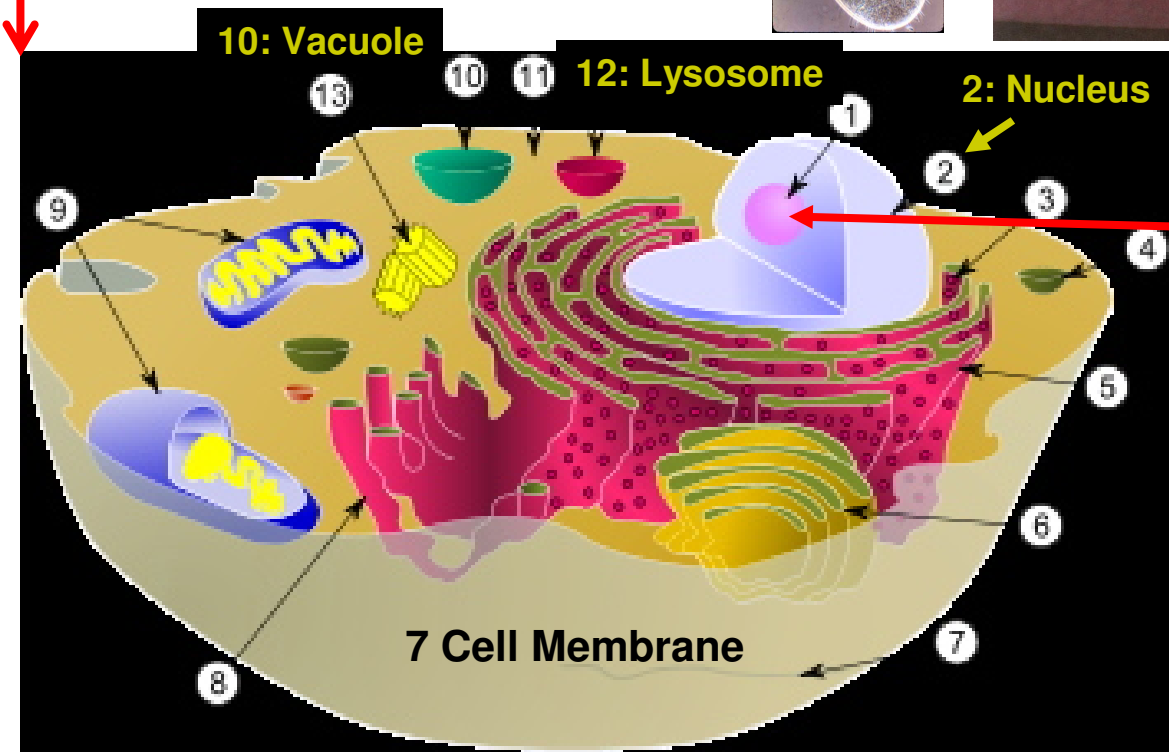
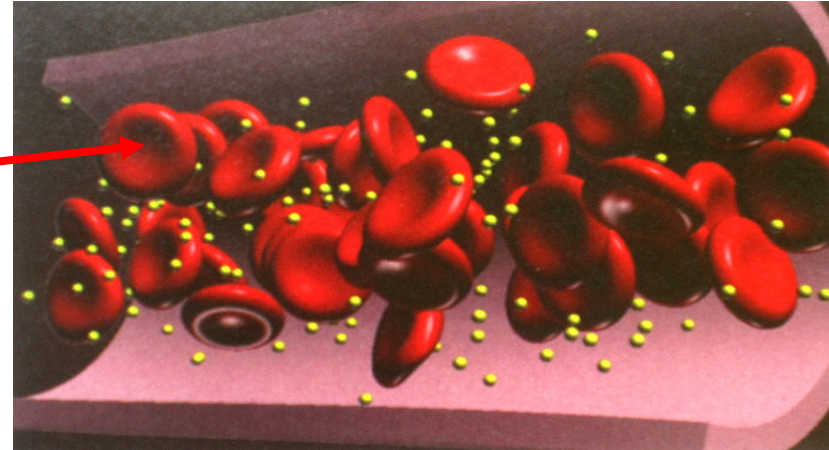
They are used for the **digestion of macromolecules** from phagocytosis (ingestion of other **dying cells or larger extracellular material**, like foreign **invading microbes**), endocytosis (where receptor proteins are recycled from the cell surface), and autophagy (where in old or unneeded organelles or proteins, or microbes that have invaded the cytoplasm are delivered to the lysosome). **Autophagy may also lead to autophagic cell death** [apoptosis], a form of programmed self-destruction...which means that the **cell is digesting itself**.

Other functions include...helping **repair damage to the plasma membrane** by serving as a membrane patch, sealing the wound. In the past, lysosomes were thought to **kill cells that are no longer wanted**...in the tails of tadpoles or in the web from the fingers of a...fetus.

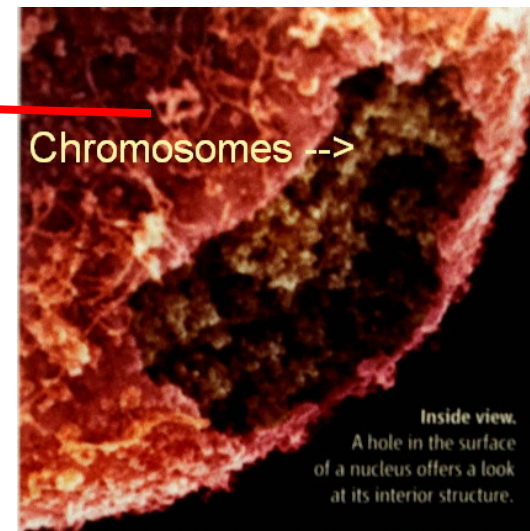
-- Wikipedia

# Cellular Scale & Structure

- Large Atom Nucleus -- .000000001 micron
- Large Atom -- .00005 micron
- Virus -- .02 -.45 micron
- Red Cell – 10 microns
- Avg. Cell – 50 microns
- Hair/Paper – 100 microns
- Skin Mites – 100-400 microns



1: Cell Nucleolus

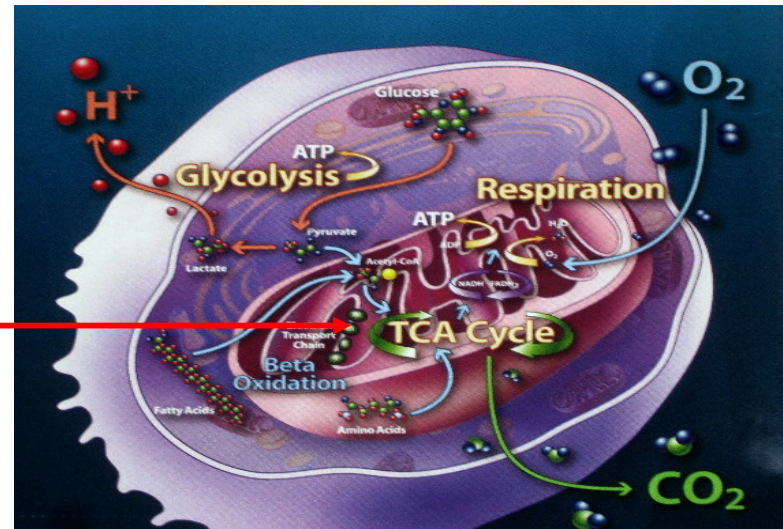
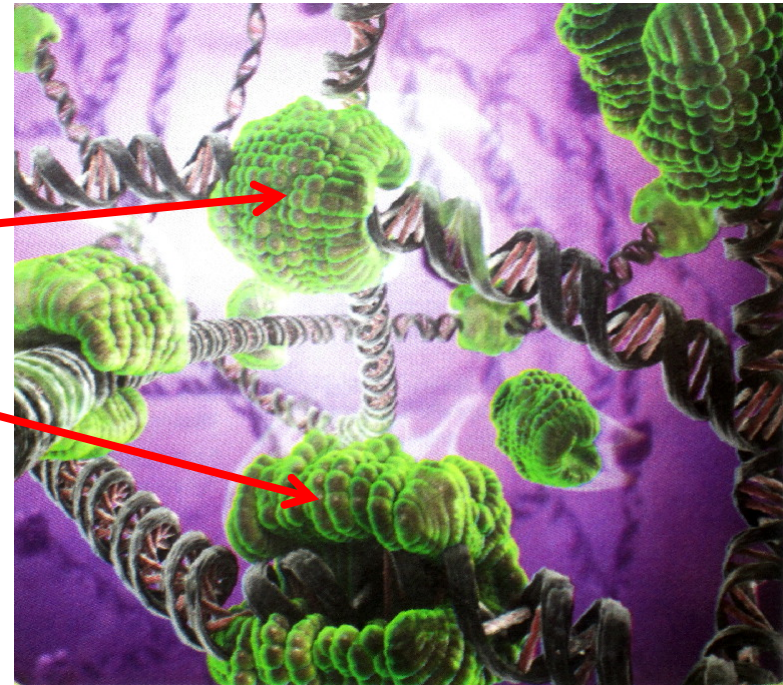
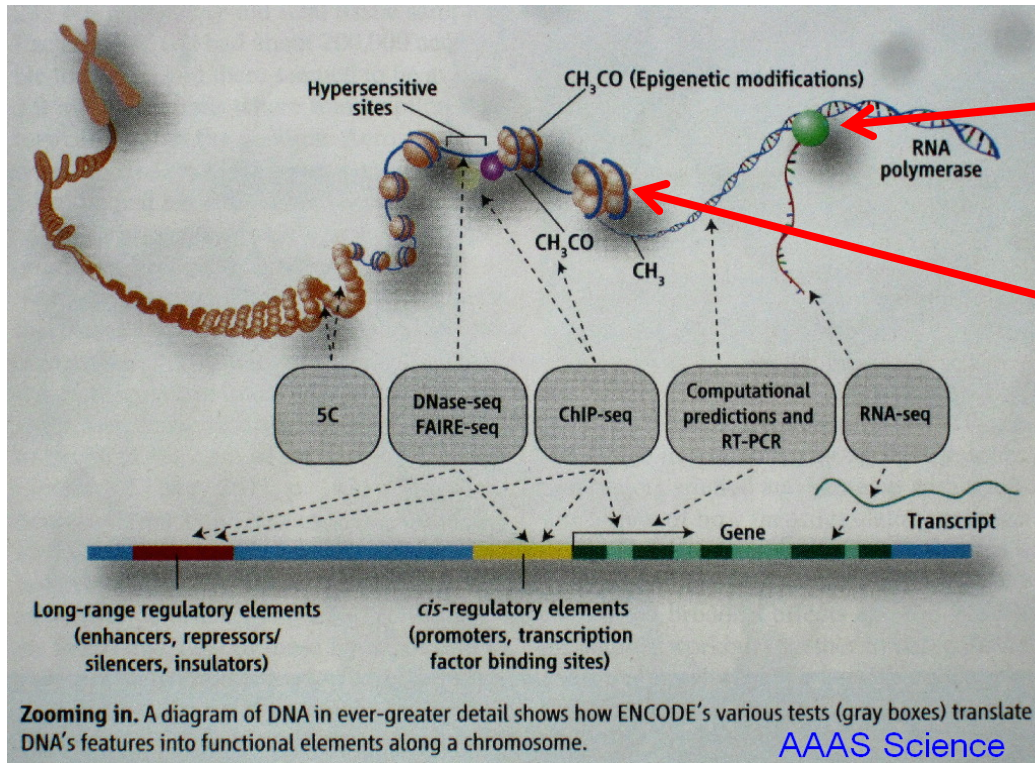


~20,000 Genes for Proteins  
 ~4,000,000 for Control

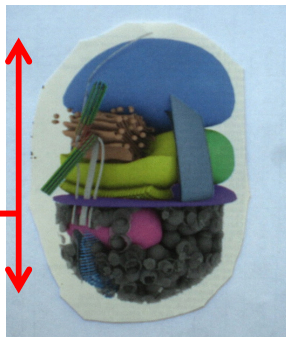


# Cellular Structure & Function

## DNA Control (former 'junk' DNA) & Reading



Oceanic  
Picobiliphyte  
~3 micron

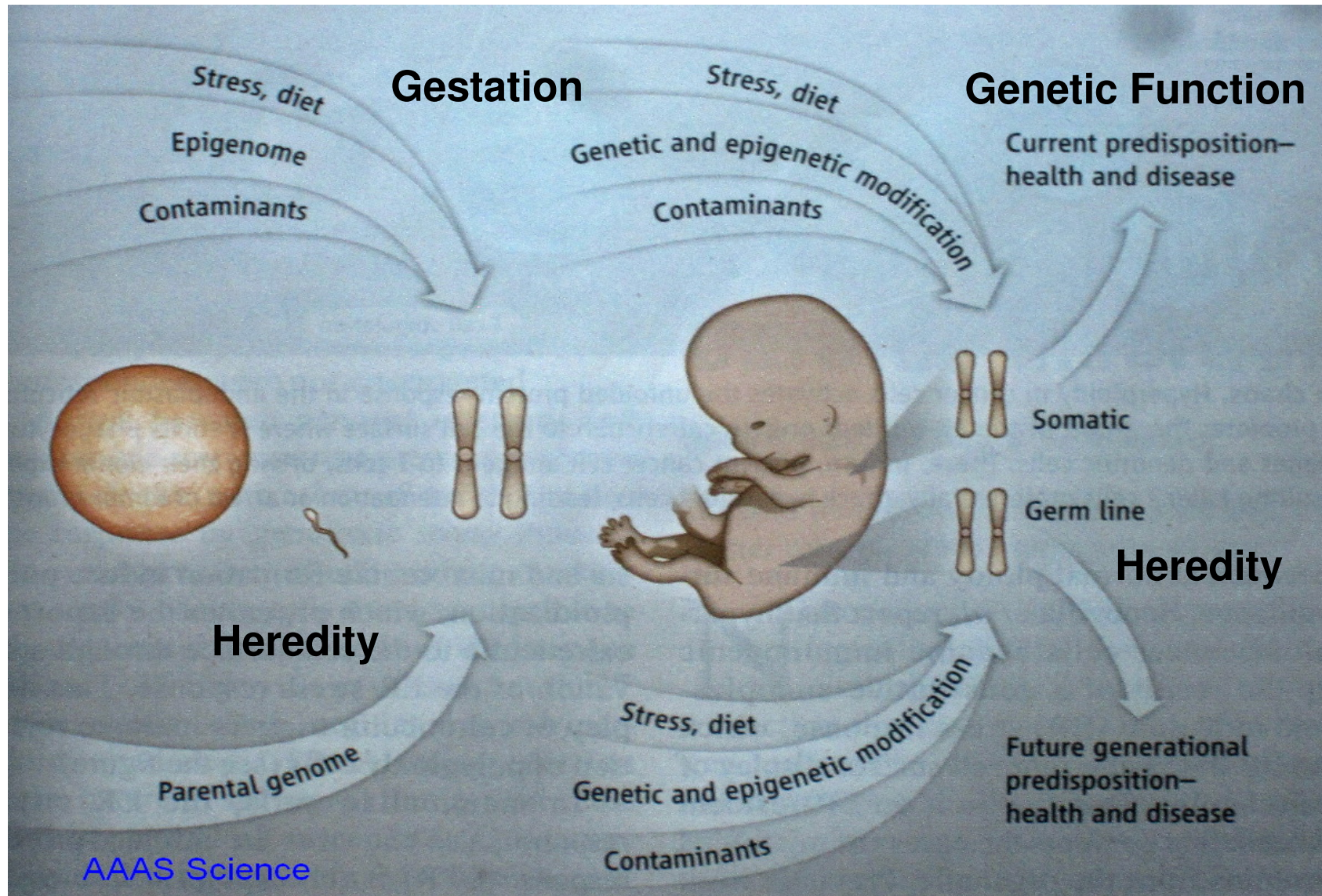


Mitochondrion

Cell Respiration:

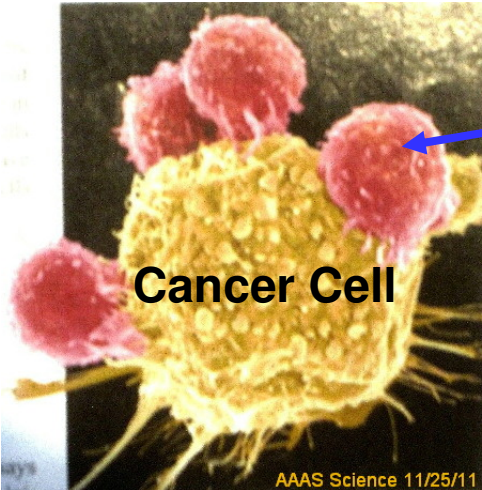
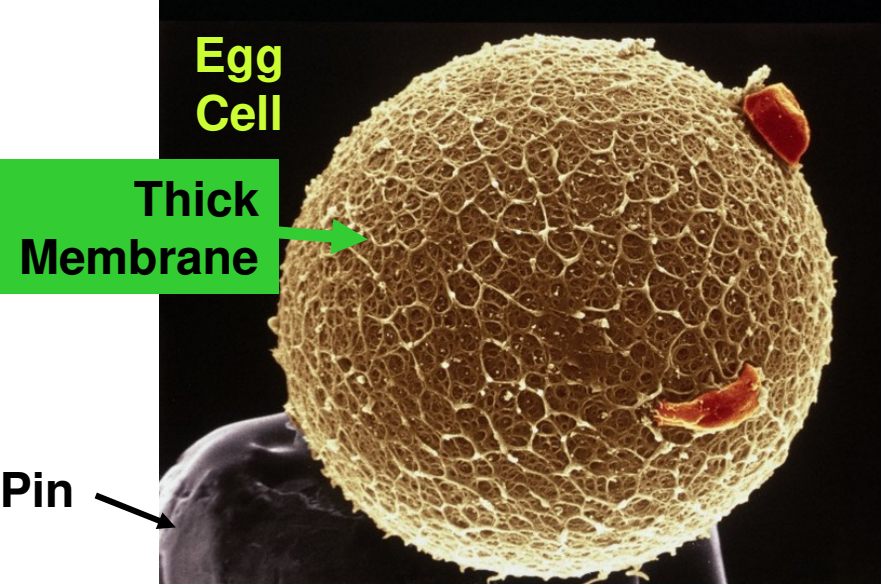


# Cellular Threats



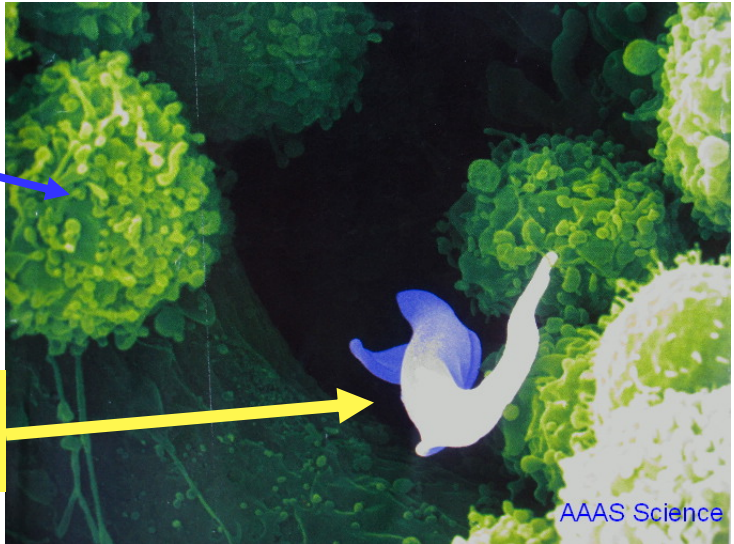


# Cellular Protection



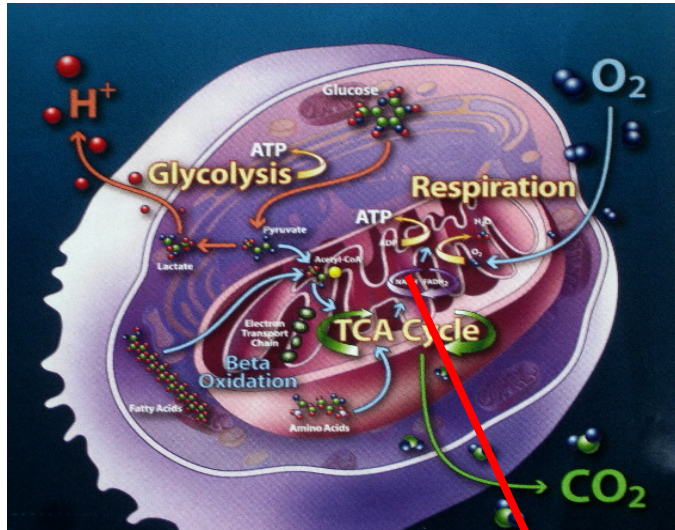
**Immune System  
T Cells**

**Parasite  
(Sleeping Sickness)**

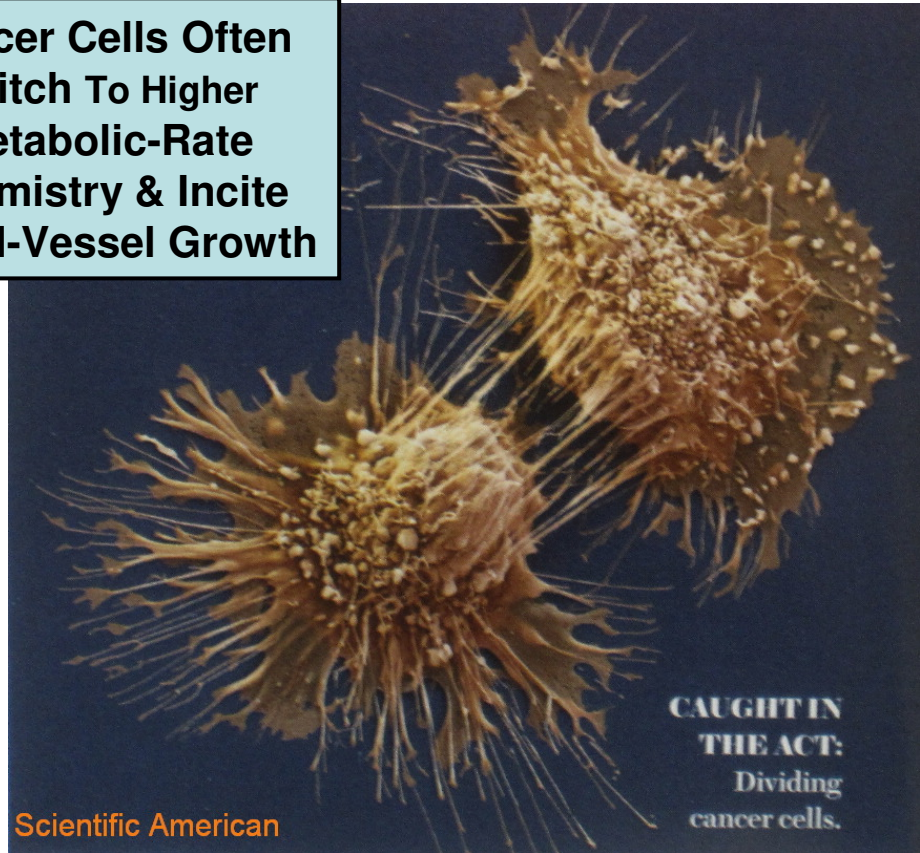




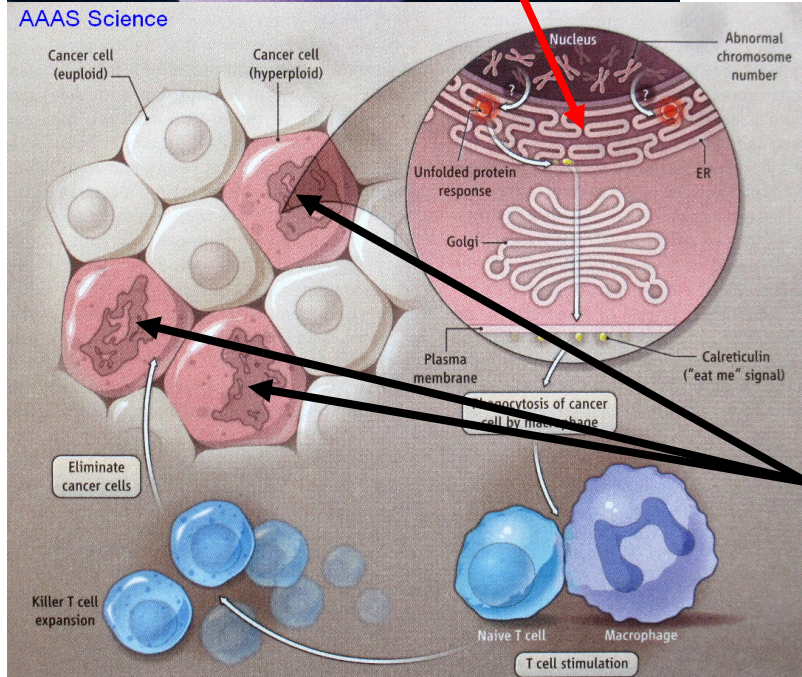
# Cancer



**Cancer Cells Often Switch To Higher Metabolic-Rate Chemistry & Incite Blood-Vessel Growth**



**Cancer Cell Dividing/Replicating**



**Cancer Cells With Too Many Chromosomes Get Attacked By T Cells**

**Cancer initiation requires several specific genetic changes in sequence – heredity helps.**

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