

# ***The Spy that Went Out Hot:***

## *Victor Litvinenko's Demise and Other Everyday Uses of Radiation*



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# Everyday Events.....

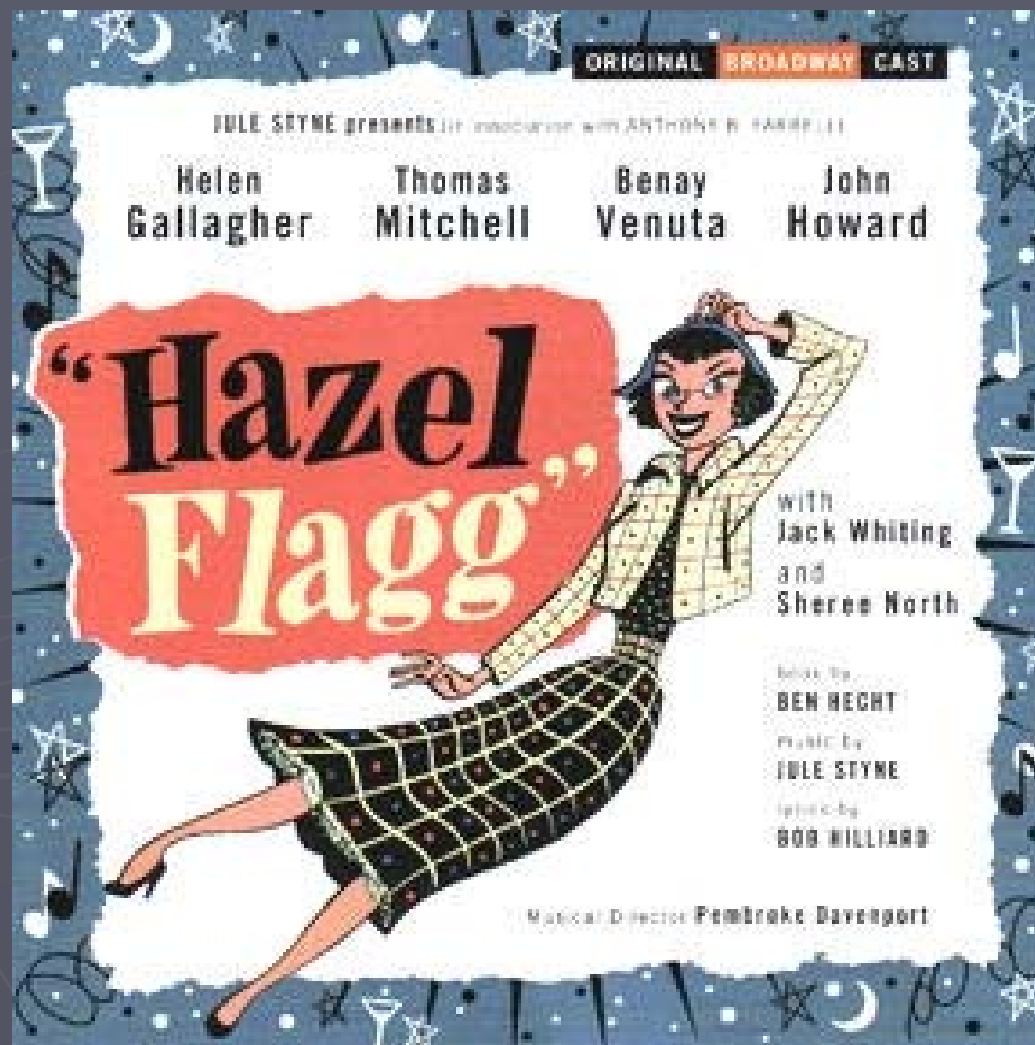
# Everyday Uses of Radiation.....

- ▶ Broadway Stage Productions
- ▶ Spy Stuff

# The Stage:

- Broadway Stage Flops!
- Set in 1933, *Hazel Flagg* is a satire on the manipulation of people, especially the general public.
- Hazel is wrongly diagnosed as having terminal radium poisoning and wants to spend her last few days having fun in NYC.

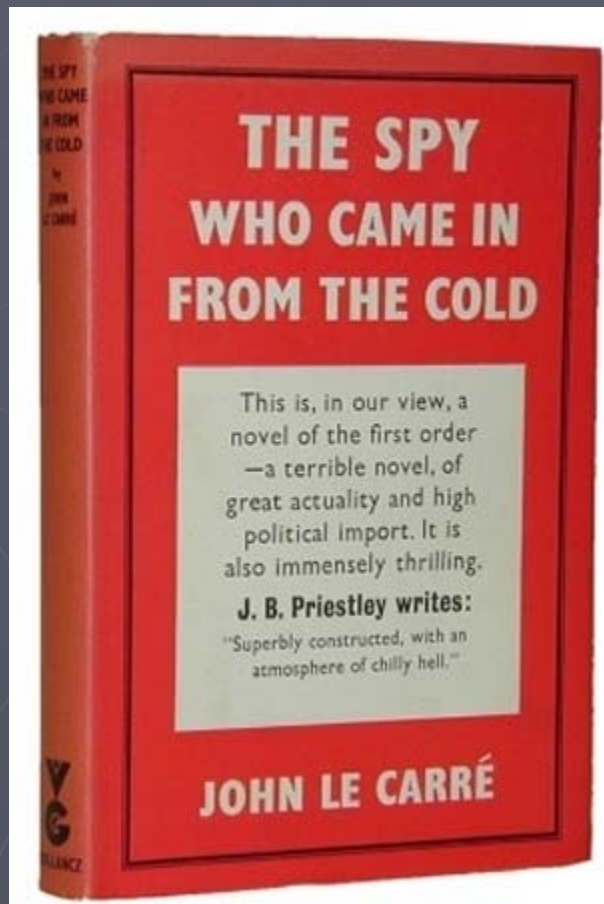
# 1953 Production of Hazel Flagg



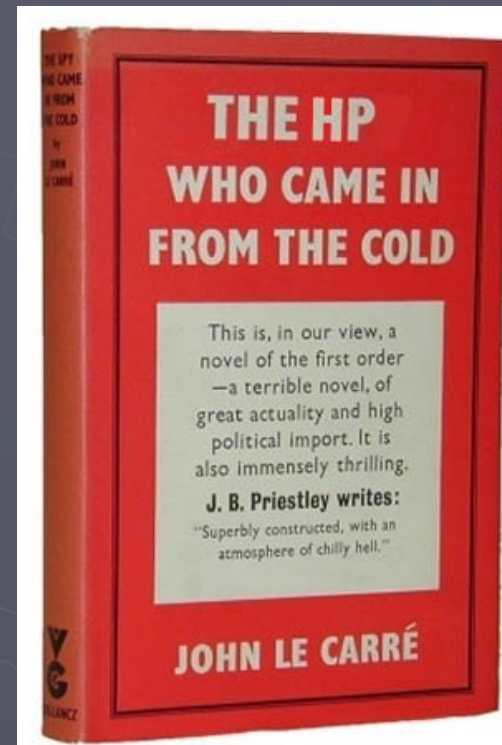
# The Spy Stuff:

- ▶ Spy Novels and the Spy museum
- ▶ Vienna, Yugoslavia and East Berlin in 1970
- ▶ Wien and the IAEA
- ▶ Kazakhstan
- ▶ Kiev and Chernobyl
- ▶ NCIS program on Tuesday
- ▶ My AE credit card number ends in 007

# The Spy Novel



# The Latest Spy Novel Sequel



# Victor Litvinenko and $^{210}\text{Po}$



Mr. Victor Litvinenko became an agent of the KGB in 1986.

Contrary to many news reports, Litvinenko was never a 'spy' and did not deal with secrets. He was trained by the military in counter-Intelligence.

He became a dissident in 1999-2000, fleeing to Turkey and then the UK.

Litvinenko said that "all the bloodiest terrorists of the world" were connected to FSB-KGB

**The FSB-KGB didn't like him anymore!**



# Disclaimer

- ▶ Not making fun of Mr. Litvinenko's untimely death
- ▶ Normally – one should not use Internet and news sources that have not been properly peer-reviewed
- ▶ This event is too recent to have a source of peer reviewed information
- ▶ SO, beware of inconsistencies and inaccuracies and manipulation like in **Hazel Flagg**

**"It was as if his internal  
organs received a severe  
sunburn and peeled"**

**Peter Zimmerman  
Physicist at King's College  
London.**

# How'd they do it?

- ▶ Litvinenko was poisoned by around 200 times the lethal dose
  - About 10 micrograms
- ▶ Dmitry Kovtun was one of the three Russian men who traveled from Russia to meet Litvinenko
- ▶ Shortly after returning to Moscow in early November, Kovtun was admitted to hospital with symptoms of radiation poisoning.

# How'd they do it?

- ▶ Traces of radiation were subsequently found where Kovtun had been
  - His wife's sofa in Hamburg
  - The car that took him to the airport
  - Documents that he handled in Hamburg were contaminated
  - Was the source "on him" or "in him" ?
  - (he was trained as a KGB officer)

# How'd they do it?

- ▶ The material is most likely to have been administered in powder form into the tea that Litvinenko drank at the bar of the Millennium Hotel on 1 Nov.
- ▶ Accordingly, the bar's dishwasher showed contamination and very low levels have been detected in the staff (about 7?) who worked there that evening.

- ▶ Over 600 people who were in places of potential contamination for Po-210 contamination were tested, and detectable excesses were found in 103 of them!
- ▶ levels were described as being extremely low and of negligible health consequences
- ▶ Pretty messy!

## Other Deaths from $^{210}\text{Po}$

- ▶ The first polonium death occurred in 1927
  - Nobus Yamada died after working in Marie Curie's lab in France
  - The Curies' daughter Irene died of leukemia in 1956, 10 years after a sealed capsule of polonium-210 was accidentally broken in her laboratory at the Radium Institute in Paris.

## Litvinenko was not the only spy ever murdered in London

- ▶ On September 7, 1978, Georgi Markov had walked across the Waterloo Bridge which crosses the River Thames in London, and was waiting at a bus stop when he was jabbed in the leg by umbrella held by a stranger.
- ▶ He died soon after of Ricin poisoning



# Lessons from Previous Experience with Incompatible Detection

- ▶ 17 January 1966, USAF B-52 bomber crashed into a refueling KC-135 and three of the four hydrogen bombs being carried fell into tomato fields in Palomares, Spain
- ▶ Early responders surveyed the area and did not detect elevated radiation levels.

But subsequent responders with appropriate (alpha detecting) equipment found the area significantly contaminated (over 500 acres of land affected)



# Risk Communications & Personnel Screening

- ▶ The subsequent tracking of Mr. Litvinenko's whereabouts resulted in the need for surge radiation monitoring capacity.
- ▶ Interesting that no health care workers were noted in reports as contaminated – standard precautions work!
- ▶ Swift and effective public communications were key to address concerns of possibly contaminated individuals.
- ▶ Meeting the voracious appetite for “content” for the media crucial to maintaining “rumor control” especially in situations involving uncertain exposures.

# Lessons from Previous Experience with Population Screening

- ▶ 24 January 1978, Soviet nuclear powered satellite Cosmos 954 crashed in Canada, spreading radioactivity from Great Slave Lake south to Alberta and Saskatchewan.
- ▶ Response activities included efforts to recover radioactive debris and the monitoring of populations for possible contamination.



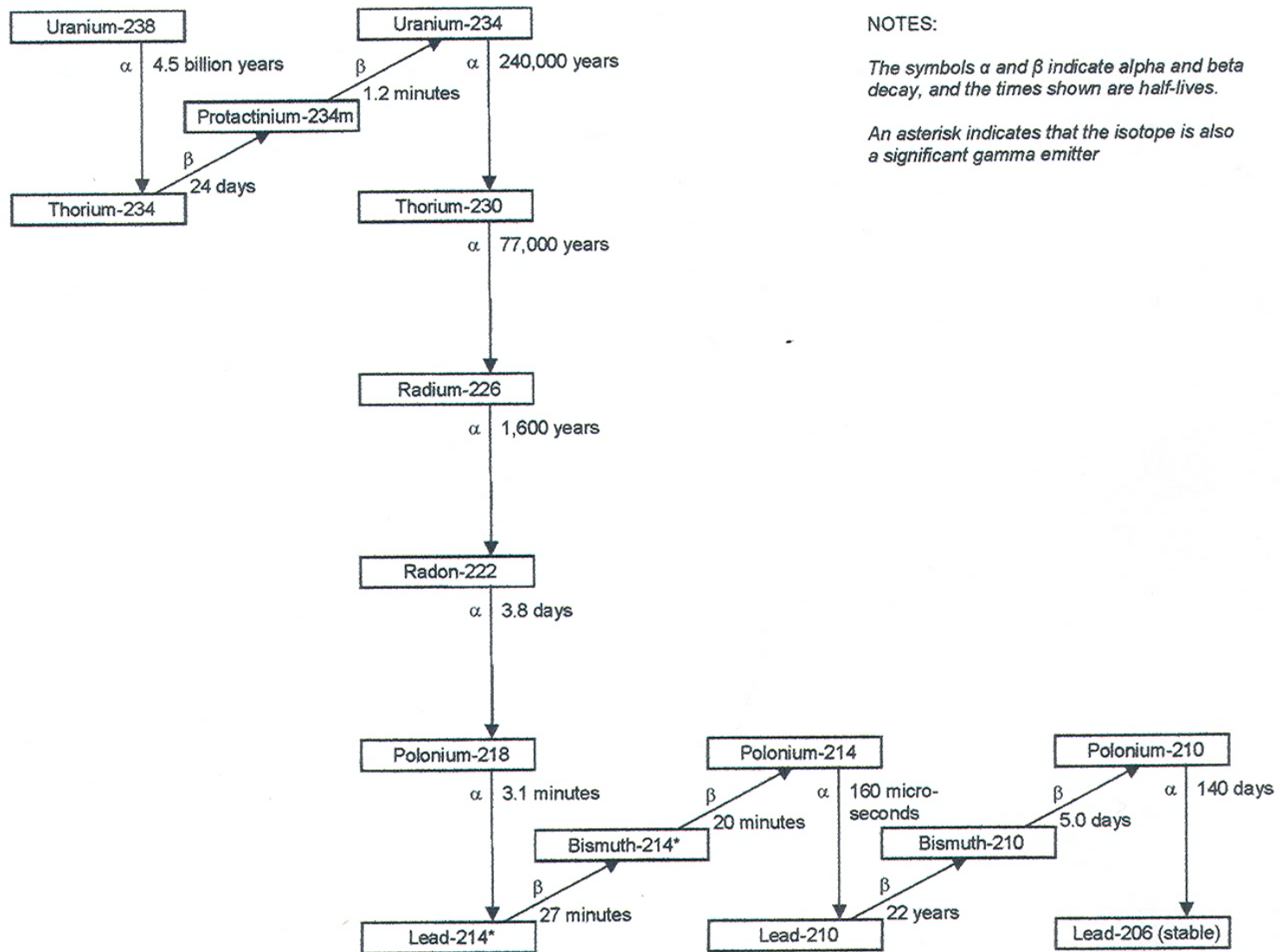
# Goiânia, Brazil

- Exposure of large number of public:
- 112 000 people monitored
- 249 people contaminated
- 49 people 0.1 - 6.2 Gy
- 4 people died
  - 6 y old girl
  - 18 y old man
  - 22 y old man
  - 38 y old mother



# What is $^{210}\text{Po}$ ?

- ▶ Polonium-210 is a naturally occurring radionuclide – from the  $^{238}\text{U}$  decay chain.  
(but also can be produced in a nuclear reactor)
- ▶ Uranium ores contain only about 100 micrograms of the element per ton – about 0.2% the amount of natural Radium
- ▶ It is the most readily available of 25 isotopes



**NOTES:**

The symbols  $\alpha$  and  $\beta$  indicate alpha and beta decay, and the times shown are half-lives.

An asterisk indicates that the isotope is also a significant gamma emitter

# More about $^{210}\text{Po}$

- ▶ low-melting, fairly volatile “semi”-metal
- ▶ alpha emitter:
  - $T_{1/2} = 138.39$  days;
  - $E_{\alpha} = 5.407$  MeV
- ▶ A milligram emits as many alpha particles as 5 g of radium.

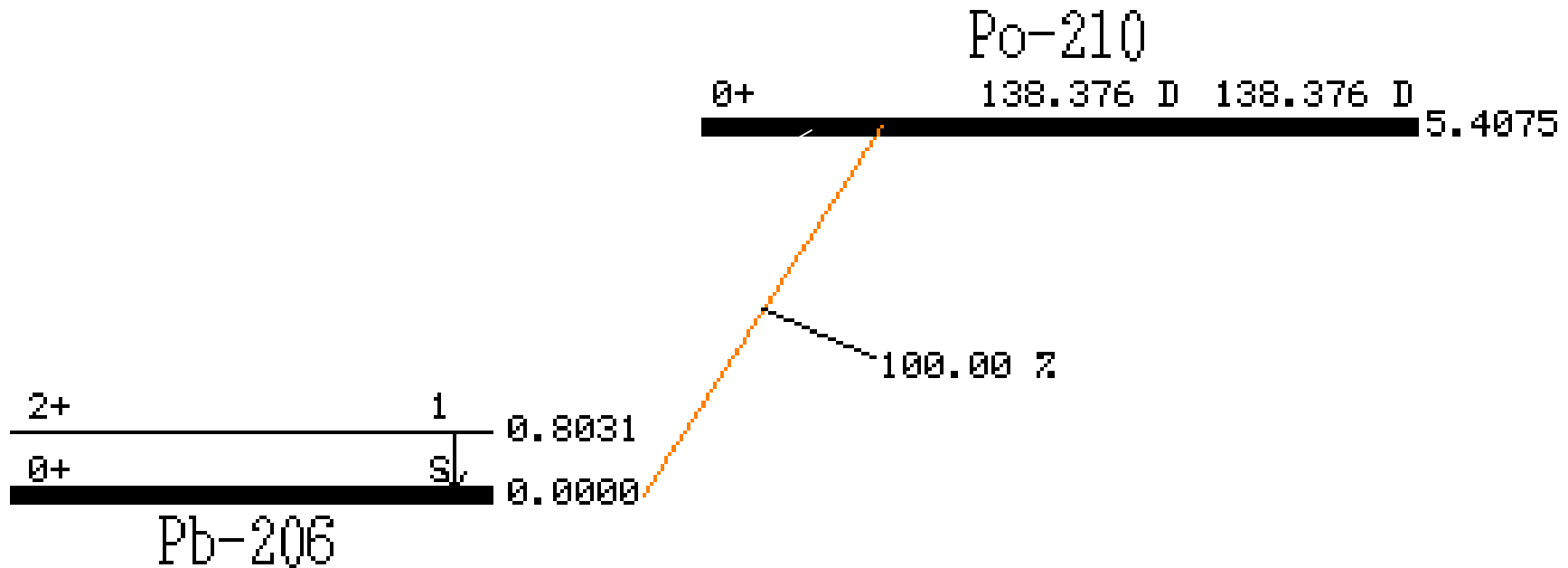
Remember:  $N\lambda = \text{activity} = N * 0.693 / T_{1/2}$

# Interesting property of $^{210}\text{Po}$

- ▶ It can become airborne with ease.
  - if a sample is heated in air to 328 K (55°C, 131°F), 50% of it is vaporized in 45 hours
  - suggestion is that small clusters of polonium atoms are ejected during alpha decay.
- ▶ It dissolves readily in dilute acids



# Decay scheme



About one in a 100,000 decays results in the emission of a gamma ray

<http://atom.kaeri.re.kr/cgi-bin/decay?Po-210%20A>

# More about $^{210}\text{Po}$

- ▶ To produce  $^{210}\text{Po}$  artificially
  - Bombard natural bismuth ( $^{209}\text{Bi}$ ) with neutrons
  - $^{210}\text{Bi}$  decays by  $\beta^-$  to  $^{210}\text{Po}$
  - Milligram amounts of  $^{210}\text{Po}$  can be prepared using neutrons in nuclear reactors.
  - Separation requires a complete radiochemical laboratory and special skills

# Uses of $^{210}\text{Po}$

- ▶ Its first use was in automobile spark plugs.  
1929 patent issued to J.H. Dillon of the Firestone Tire & Rubber Co
- ▶ Atom-Bomb trigger – PoBe neutron source  
 $^7\text{Be}(\alpha, n)^6\text{Be}$   
Mix  $^{210}\text{Po}$  with Be; makes nice neutron source
- ▶ Heat source – 140W per gram
  - SNAP (SYSTEMS FOR NUCLEAR AUXILIARY POWER) Power sources  
one gram of Po will self-heat to a temperature of around  $500^\circ\text{C}$

# More uses for $^{210}\text{Po}$

- ▶ Static Eliminator – phonograph records
- ▶ Static Eliminator - neutralize the static electricity in generated by moving sheets of paper, or fabric, and in photo labs
- ▶ Static Eliminator – painting processes

# Health Effects of $^{210}\text{Po}$

- ▶ External source – none
  - Alpha particles are stopped by a sheet of paper
- ▶ Ingestion – soluble, transported by blood
  - Alpha particles come in close contact with cells and are highly toxic killing tools
- ▶ Inhalation – attached, or soluble
  - Alpha particles come in close contact with cells and are highly toxic killing tools

# Health Effects of $^{210}\text{Po}$

- ▶ polonium-210 is at least a million times more toxic than hydrogen cyanide
- ▶ a fatal 4-Sv dose can be caused
  - by ingesting 8.8 MBq (238 microcurie), about 50 nanograms (ng),
  - or inhaling 1.8 MBq (48 microcurie), about 10 ng

# Handling $^{210}\text{Po}$

- ▶ Safe to transport in a plastic bag
- ▶ But highly disbursable
  - it naturally disintegrates producing "small chunks, of a few hundred atoms in size, that are blasted out of the surface and then drift around the room."  
[Zimmerman, King's College London ]
  - "If you had polonium in an open jar and you left it overnight, the next thing you knew, it would be all over the lab. It would jump on a dust particle and end up on lab benches and floors and things." [David A. Dooley, president and chief executive of MJW Corp ]

# Sources of $^{210}\text{Po}$

- ▶ From natural sources
  - Requires extensive laboratory equipment and skills
- ▶ From Neutron activation of  $^{209}\text{Bi}$ 
  - Requires extensive laboratory equipment and skills [about 3.5 grams produced annually in Russia]



# Expensive

- ▶ **The source used to poison Alexander Litvinenko was assumed to have been purchased on the black market for as much as \$10-30,000,000**
- ▶ **An expensive Poison**
- ▶ **Cheaper to use a bullet**

# Natural Occurring $^{210}\text{Po}$

- ▶ It is found naturally in the environment, and the general population is internally contaminated with small but measurable amounts of it on a regular basis through food, water, and air.
- ▶ Because tobacco leaves are known to concentrate Po-210, users of tobacco products are likely to have higher levels of this radioactive element in their bodies.
- ▶ The use of phosphate fertilizer increases soil concentrations of  $^{210}\text{Po}$

# Low Dose $^{210}\text{Po}$ Exposure

## ► Food

Between 50% and 90% of ingested polonium promptly appears in the gastrointestinal (GI) tract; from there it leaves the body in the feces.

The retained fraction enters the bloodstream where it concentrates in the soft tissues.

Approximately 45% of ingested Po-210 is deposited in the spleen, kidneys, and liver;

10% is deposited in the bone marrow and the remainder is distributed throughout the body. Within the bloodstream, polonium combines with the globin portion of hemoglobin.

# Low Dose $^{210}\text{Po}$ Exposure

- ▶ natural levels of Po-210 in urine are typically in the range 5-15 mBq per day

What does all this mean for us?



# NCRP Report No. 138 *Management of Terrorist Events Involving Radioactive Materials*, October 2001.

- ▶ Prevention, education
- ▶ Monitoring at any explosion (**also include unexplained clinical symptoms?**)
- ▶ Clear emergency command and control system
- ▶ Clear communication channels
- ▶ Address psychosocial effects
- ▶ Prepare for medical response
- ▶ Exposure control and guidance
- ▶ Late phase consideration

# A Reassuring Thought

- ▶ Best to think of this threat like an earthquake:
  - Can't be predicted
  - Best to make preparations
  - Carry on with normal life functions
- ▶ *“Chance favors the prepared mind”*

# Another Reassuring Thought ... The Newest Spy Gear!





*The End of this .....*

*.....Hot Spy Show!*

