Medical decision making and care of casualties from delayed effects of a nuclear detonation

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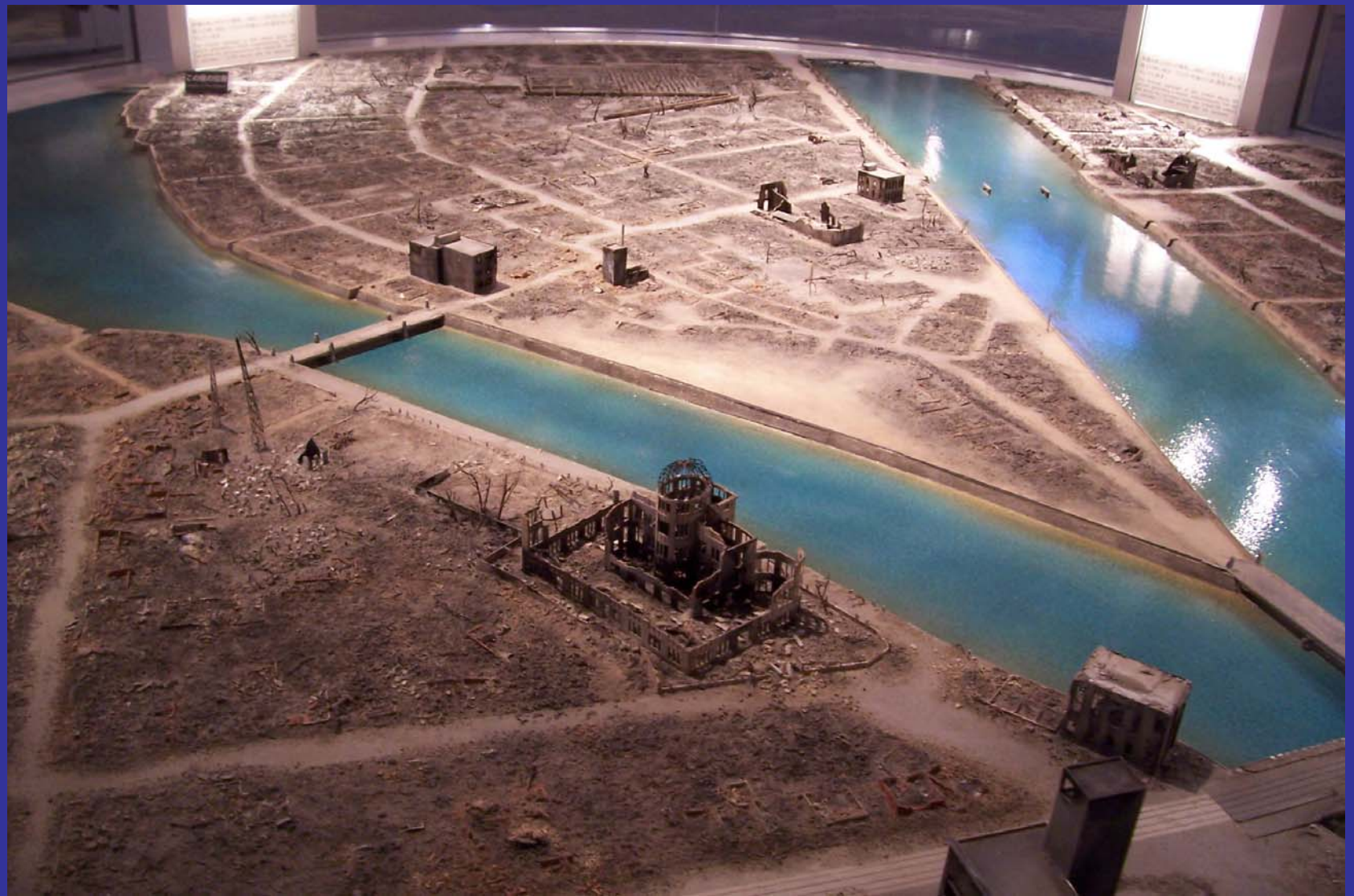
August 5 8:14 am

August 5 8:16 am

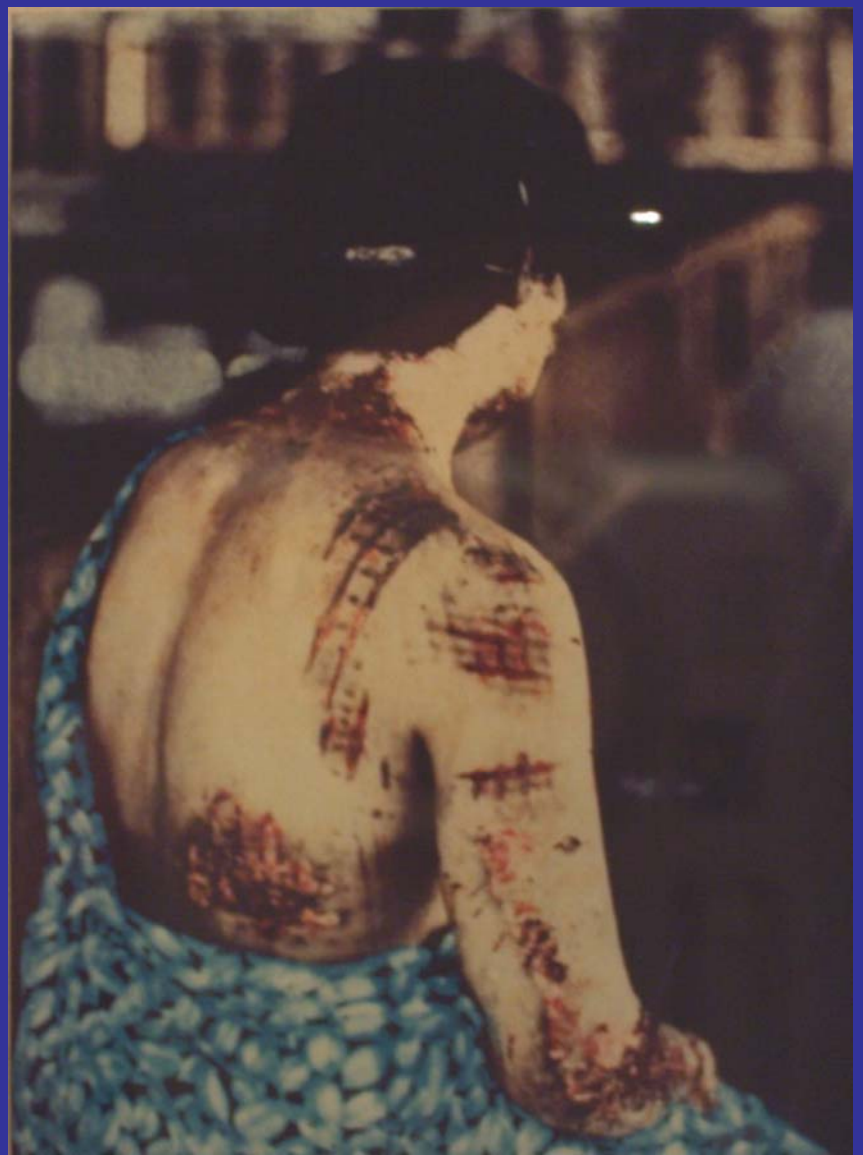


3 min

10 min post detonation

Early deaths

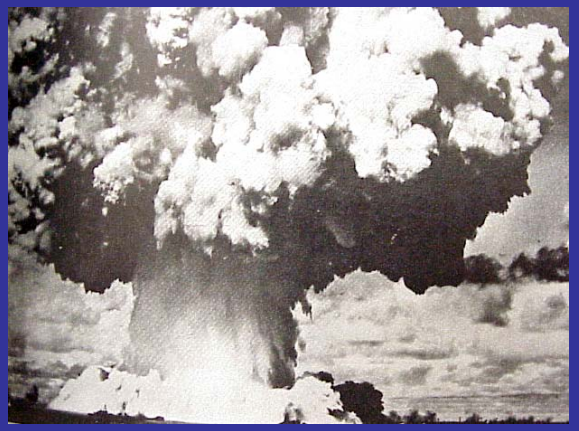
Early survivors - ? delayed deaths



Medical issues and delayed health effects

- General issues regarding fallout vs health effects
- Acute radiation syndrome
- Beta burns
- Internal contamination
- Carcinogenesis
- In-utero effects
- Genetic effects
- Psychological effects
- Dosimetry and records
- Follow-up of exposed persons

Nuclear weapons



- Thermal radiation
- Air blast
- Initial and residual radiation
- A ground burst will inject a lot of radioactivity into the atmosphere
- Unless protected, lethality and delayed radiation injury from fallout will extend further than blast or fireball

Potential health effect sources vary over time

- Early fallout gamma/beta external hazard
- Delayed fallout alpha, beta, gamma
  external and internal hazard
  iodine, strontium, cesium

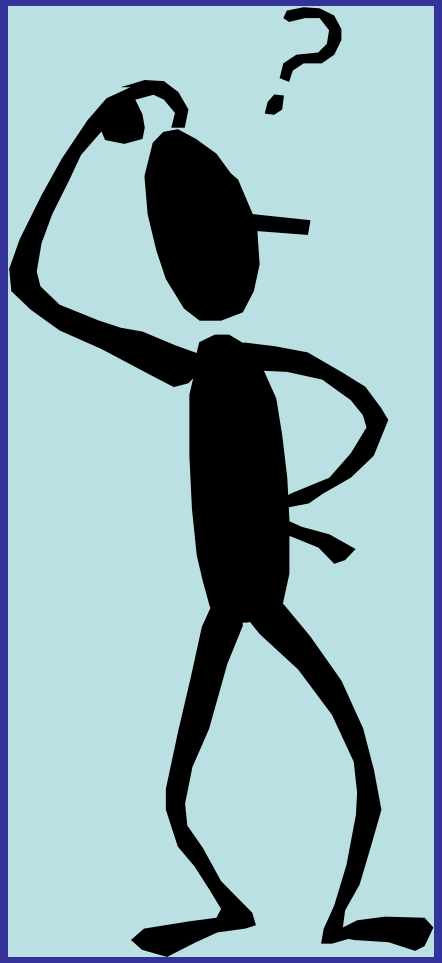
Very long term (yrs)

^{3}H, ^{14}C, ^{54}Mn, ^{55}Fe, ^{90}Sr, ^{95}Zr, ^{106}Ru, ^{125}Sb, ^{137}Cs, ^{144}Ce

The acute period is typically the focus

Gamma dose rate from fallout

- The dose rate decreases with a factor of 10 every 7 hours for early fallout
- At 2 days it will be roughly 100^{th}
- Makes it sound as if there is little or no problem after 2 days



When is it over ??

It isn’t really over at some specific time point !!!

The radiation exposure will continue although at much lower levels

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Operation UPSHOT-KNOTHOLE

NEVADA PROVING GROUNDS

March - June 1953

Project 4.7

BETA-GAMMA SKIN HAZARD IN TH
POSTSHOT CONTAMINATED AREA

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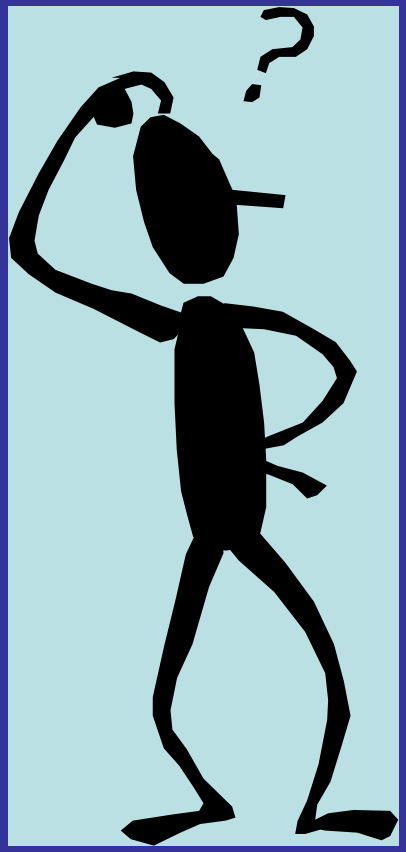
HEADQUARTERS FIELD COMMAND, ARMED FORCES SPECIAL WEAPONS
SANDIA BASE, ALBUQUERQUE, NEW MEXICO

CONF

Is it true that essentially all health risks will come from radiation received in the first week ?



No

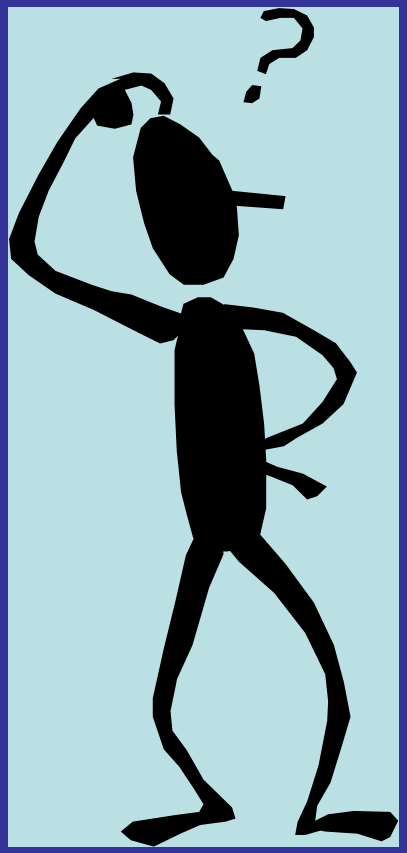
Bikini fallout data show health risks can be accumulated weeks and months later

Period	Inhabited	Uninhabited
0-96 hrs	220 rads	3300 rads
96 h-1 wk	35	530
1 wk- 1 mo	75	1080
1 mo-1 yr	75	1100
Total to 1 yr	405	6010

Same issue from Chernobyl fallout doses (mSv) in villages with ~ 15 Ci/km^2

Dose component	0-4 yrs	4-70 yrs	Total
External	16-32	47-95	63-130
Internal			
Cesium	0.8-2.3	13-26	15-27
Strontium	0.2-2.4	0.2-1.6	0.4-4
Total	17-35	60-120	78-160

Is it true that most health risks from fallout come from internal contamination ?

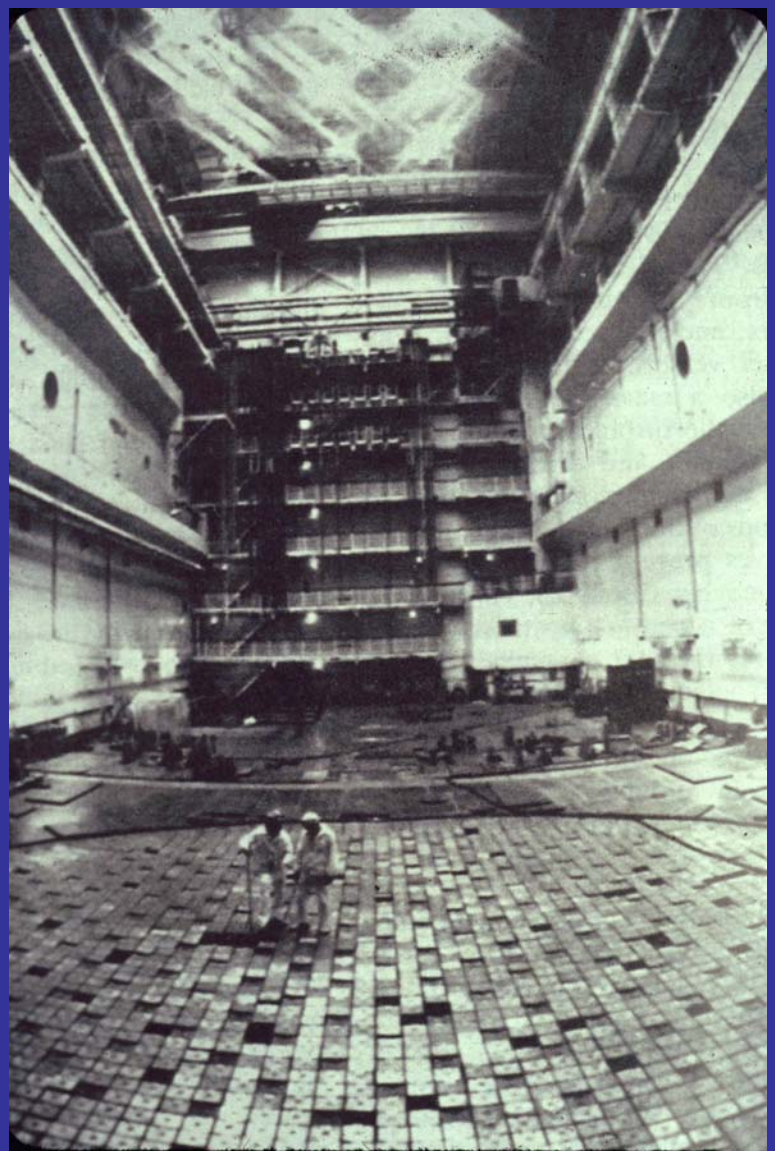


No

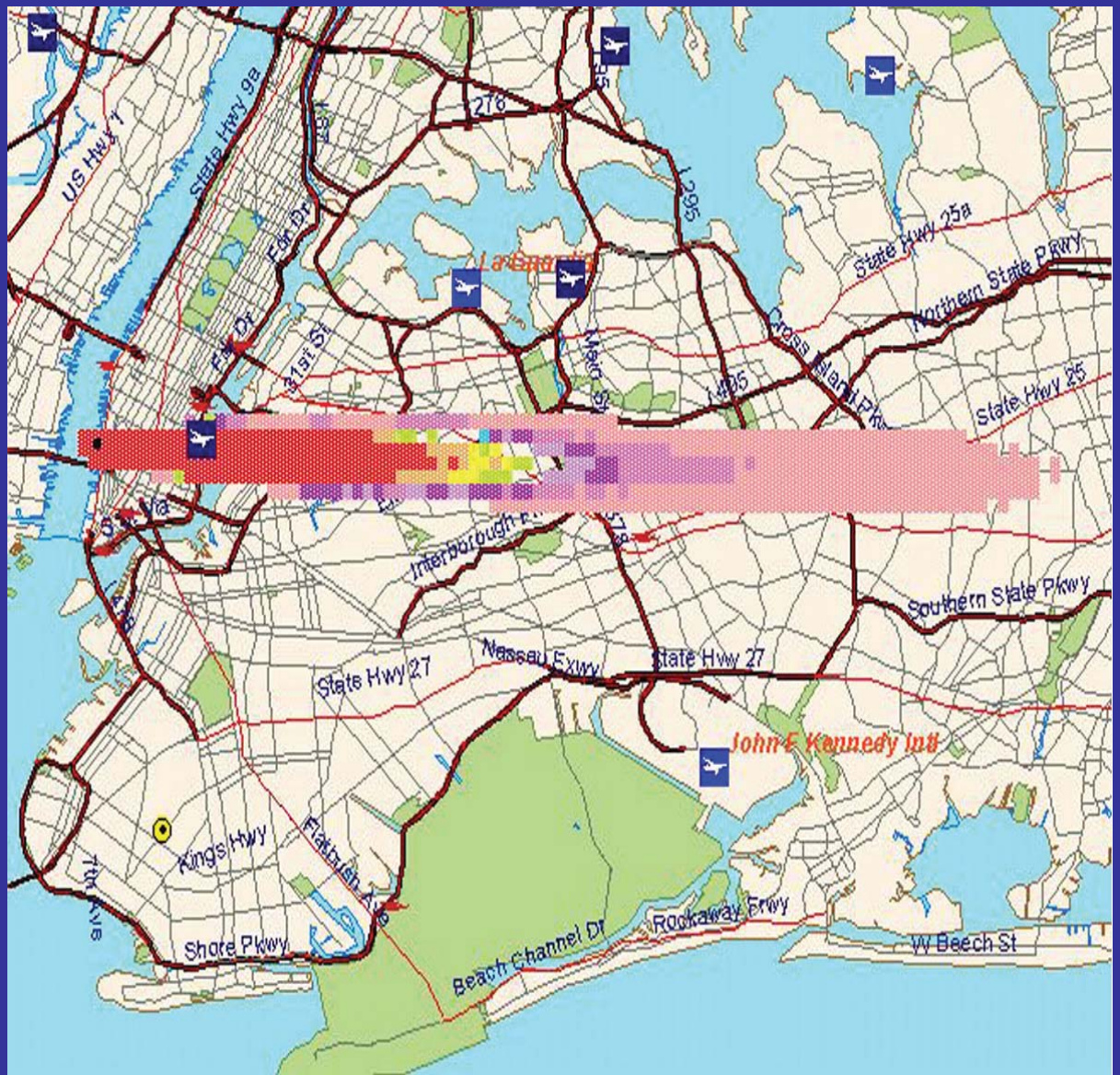
~80% of Chernobyl fallout doses (~% of total) in villages with ~ 15 Ci/km^2 ^{137}Cs come from external exposure

Dose component	0-4 yrs	4-70 yrs	Total
External	20	60	80
Internal			
Cesium	**1.4**	16	17
Strontium	1.4	1	2.4
Total	23	75	100

Some other lessons from Chernobyl

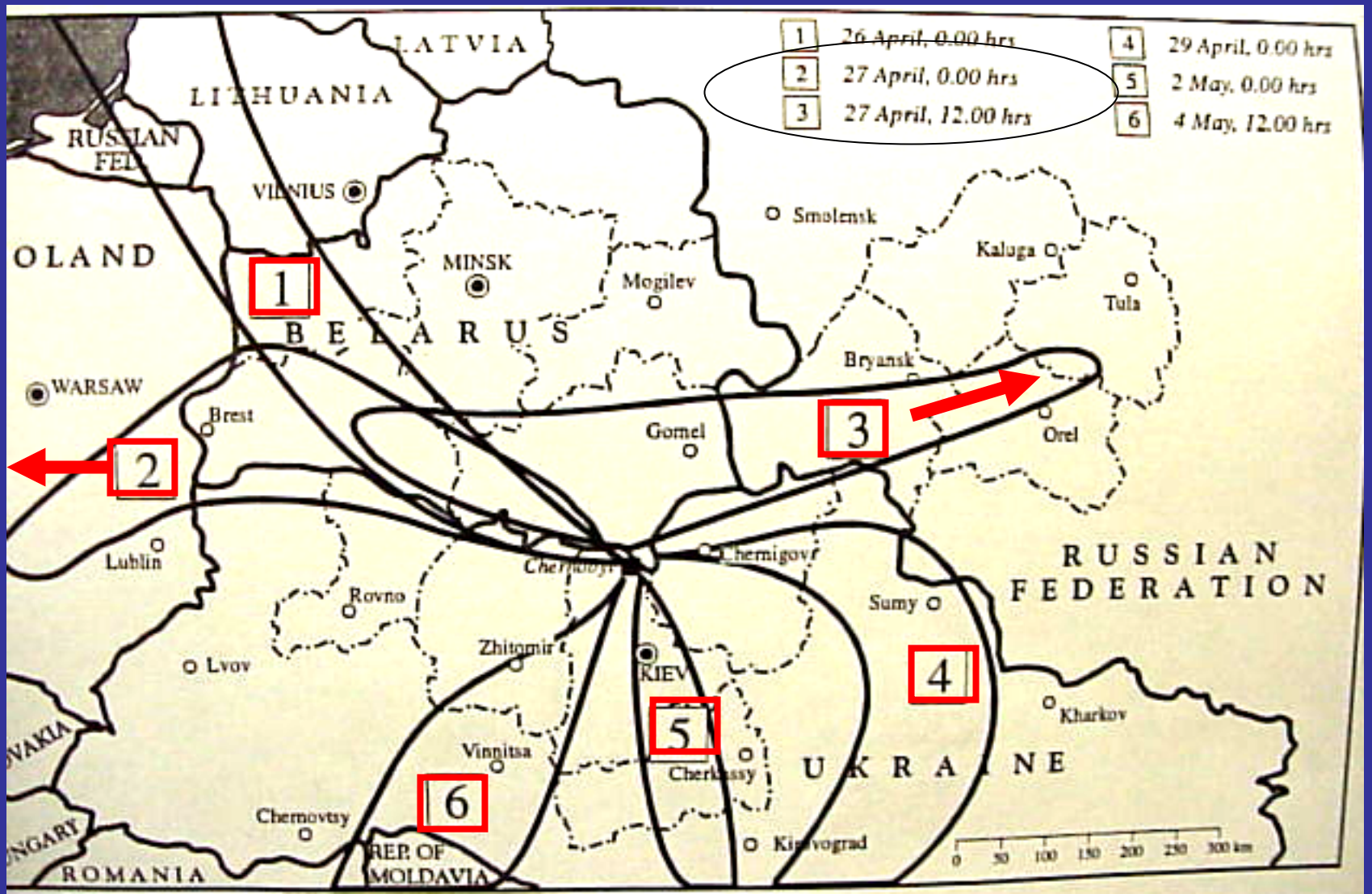


Stylized NYC fallout mortality 12.5 Kt



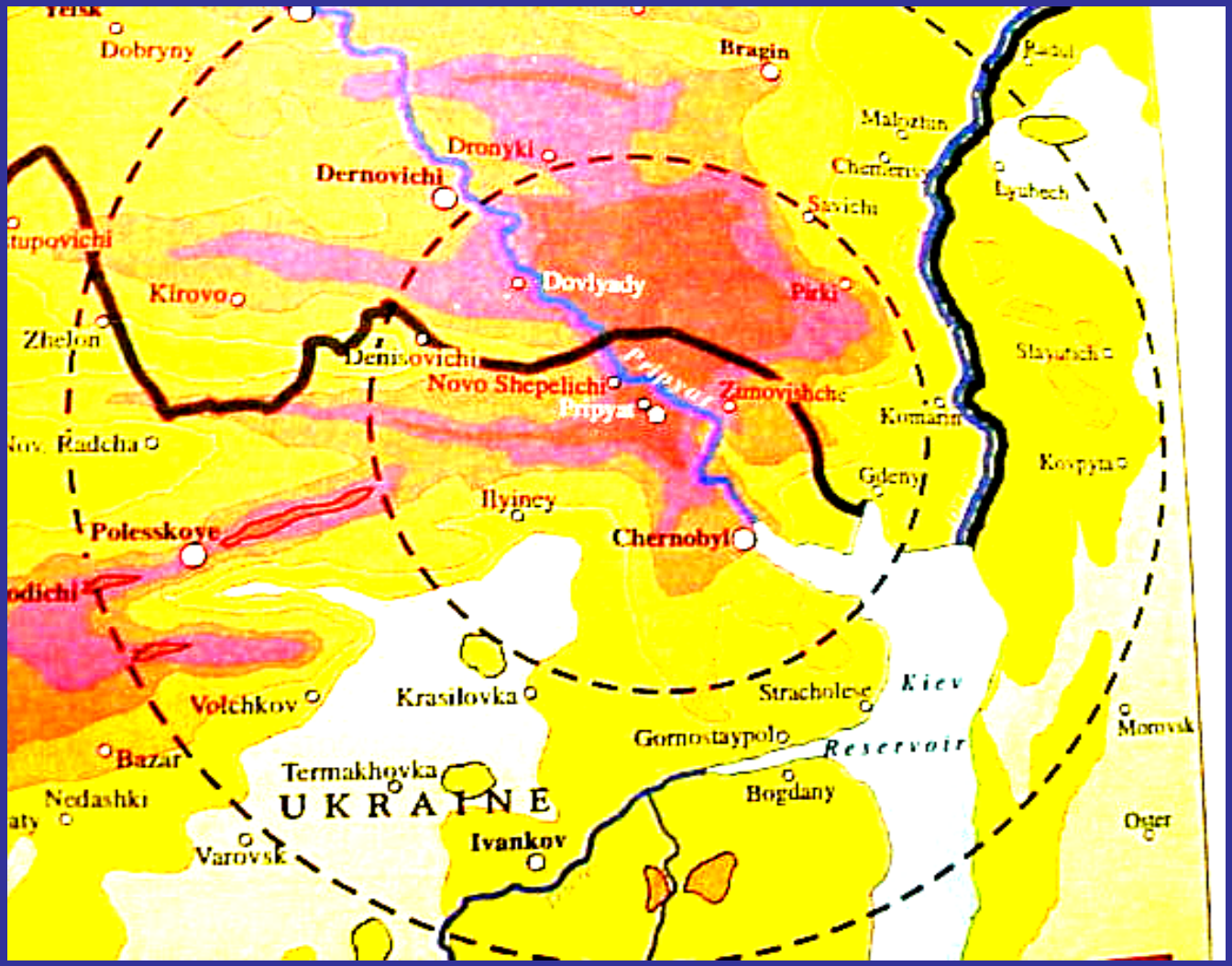
Helfand 2002 BMJ

Chernobyl 180 degree wind shift can occur in 12 hours: Delayed injuries can occur anywhere

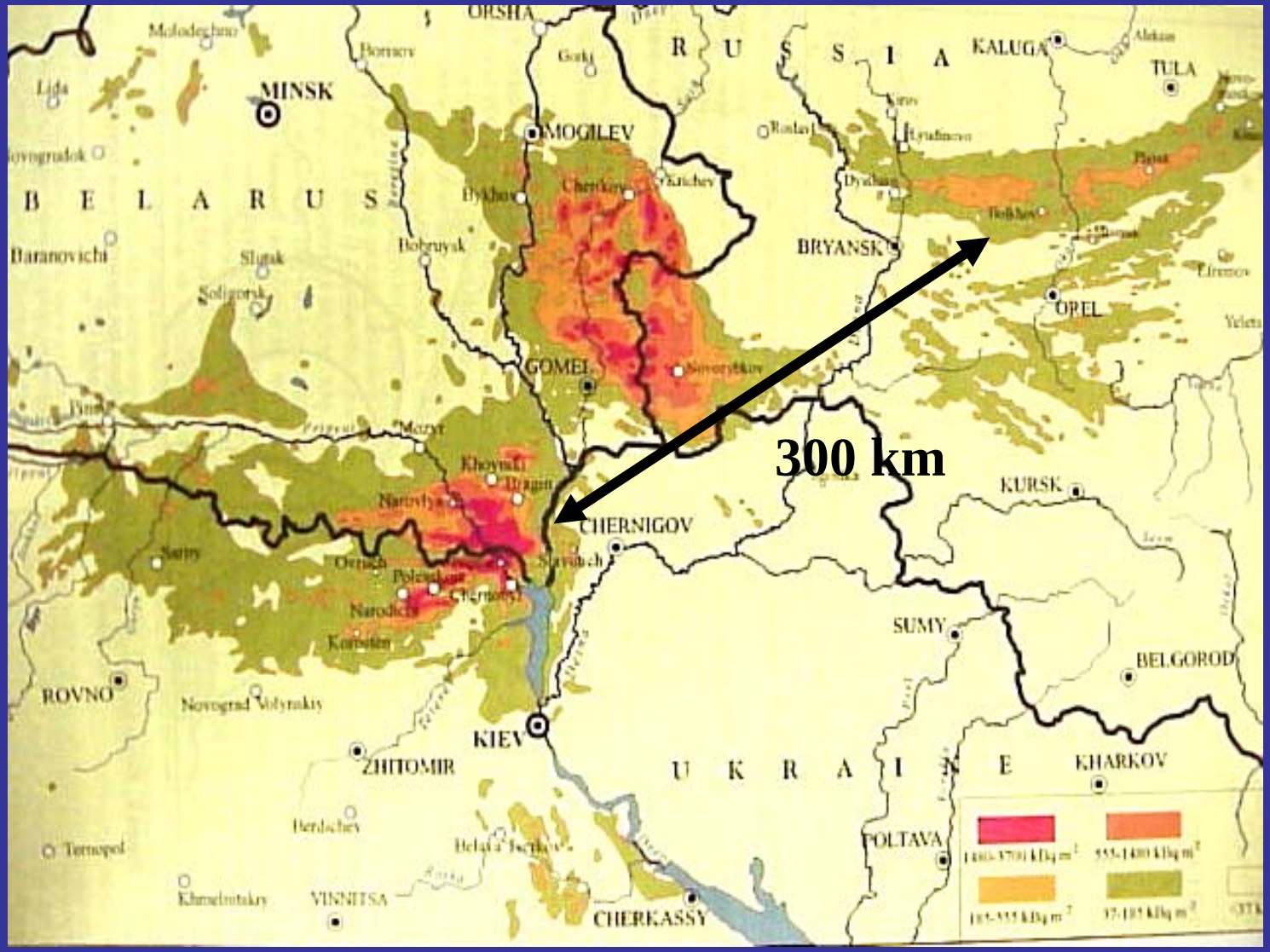



World Trade Center from satellite
Normal wind direction

Even nearby fallout is heterogeneous
Very different health effects can occur with minor differences in distance



Measurable fallout can extend for great distances



Millions of people will be exposed to some radiation and will want evaluation and be concerned about health effects

What do survival and medical decisions depend upon ?

- Deep tissue dose and damage
- Skin injury extent
- Combined injury from blast/thermal

What do we do about early survivors who got external whole body radiation exposure ?

Possibly hundreds of thousands of persons

How much dose did they get ?

How do we tell ?

Who needs treatment ?

Sorting methodology will need to be applied to fallout and prompt radiation areas to determine need for delayed care (Chernobyl lessons)

- Any test will need to process tens or hundreds of thousands of people and be rapid
- Nausea, vomiting, diarrhea
- Complete blood count with differential
- Chromosome aberrations especially PCC and automated (maybe ???)

Whole body radiation dose/effect

- 10mGy (1 rad) 1/1000 chance of cancer
- 100 mGy (10 rads) 1/100 chance of cancer

Some deaths in decades

- 1 Gy (100 rads) Prodromal symptoms
- 3.5 Gy (350 rads) LD50 (without treatment)
- 6.5 Gy (600 rads) LD50 (with treatment)

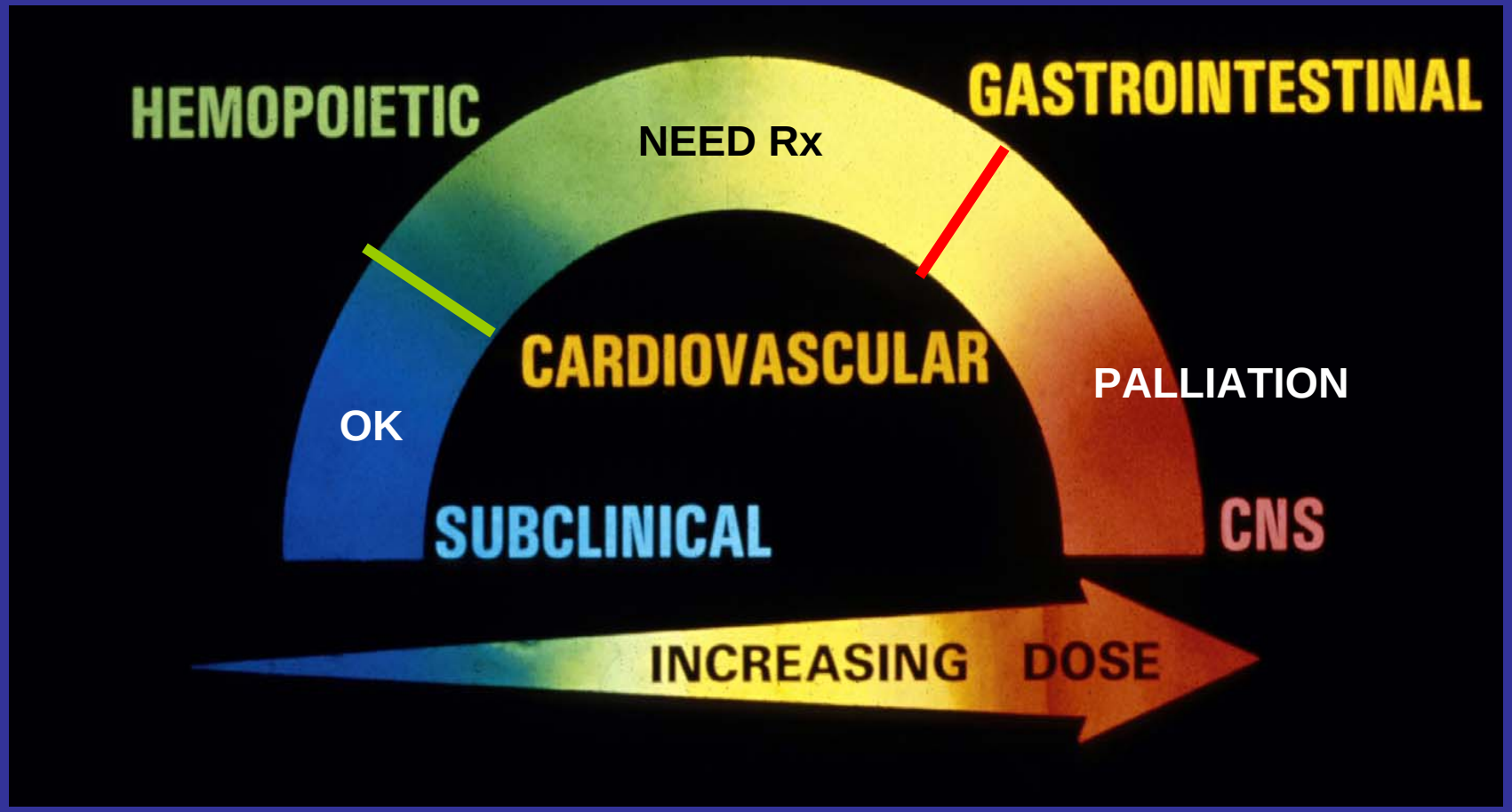
Many deaths in weeks - months

- >12 Gy (>1200 rads) Not survivable

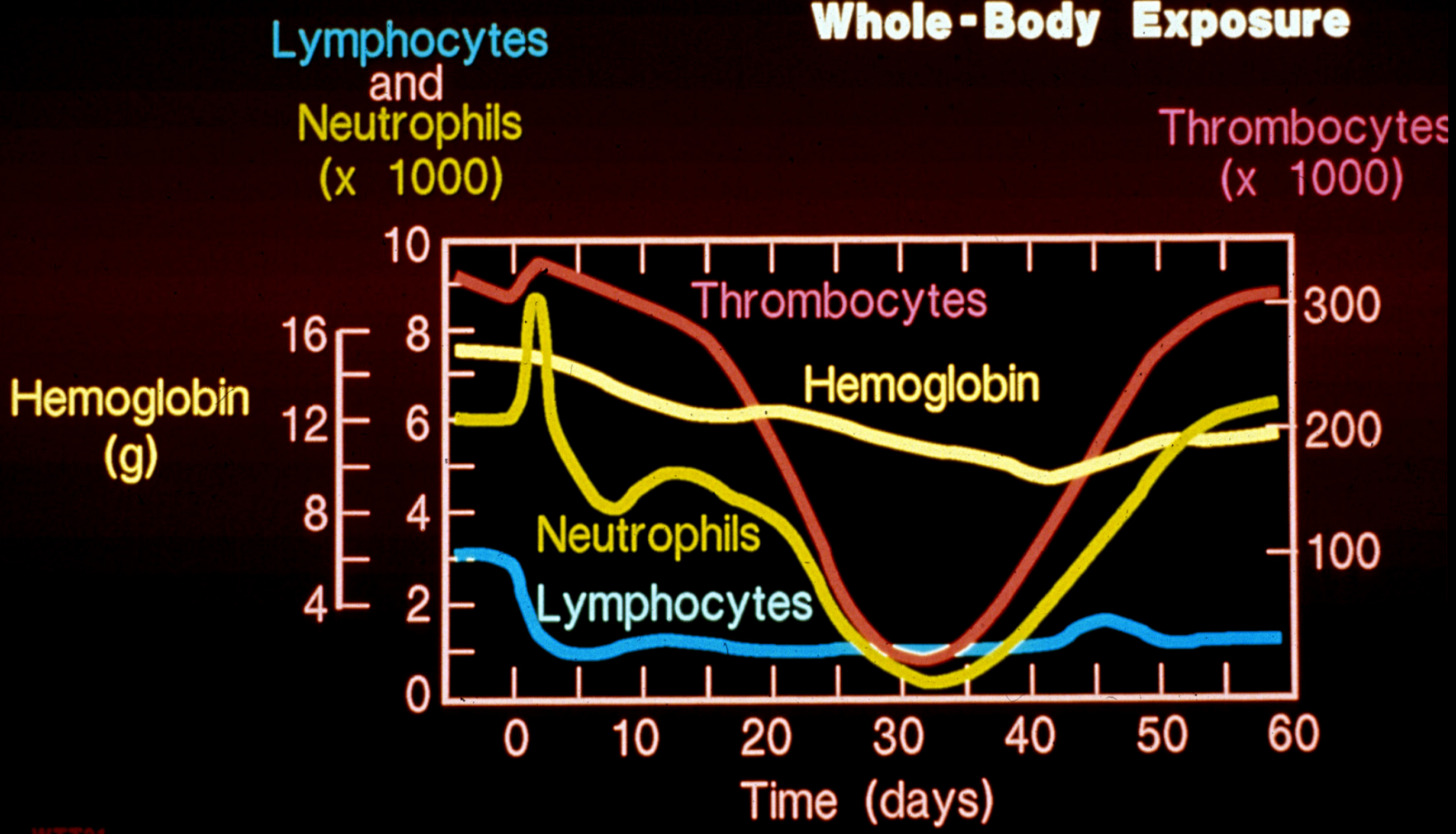
Deaths in weeks

Treat the patient not the estimated dose ?

Acute Radiation Syndrome from whole body penetrating radiation



Hematological Response to 300 rads

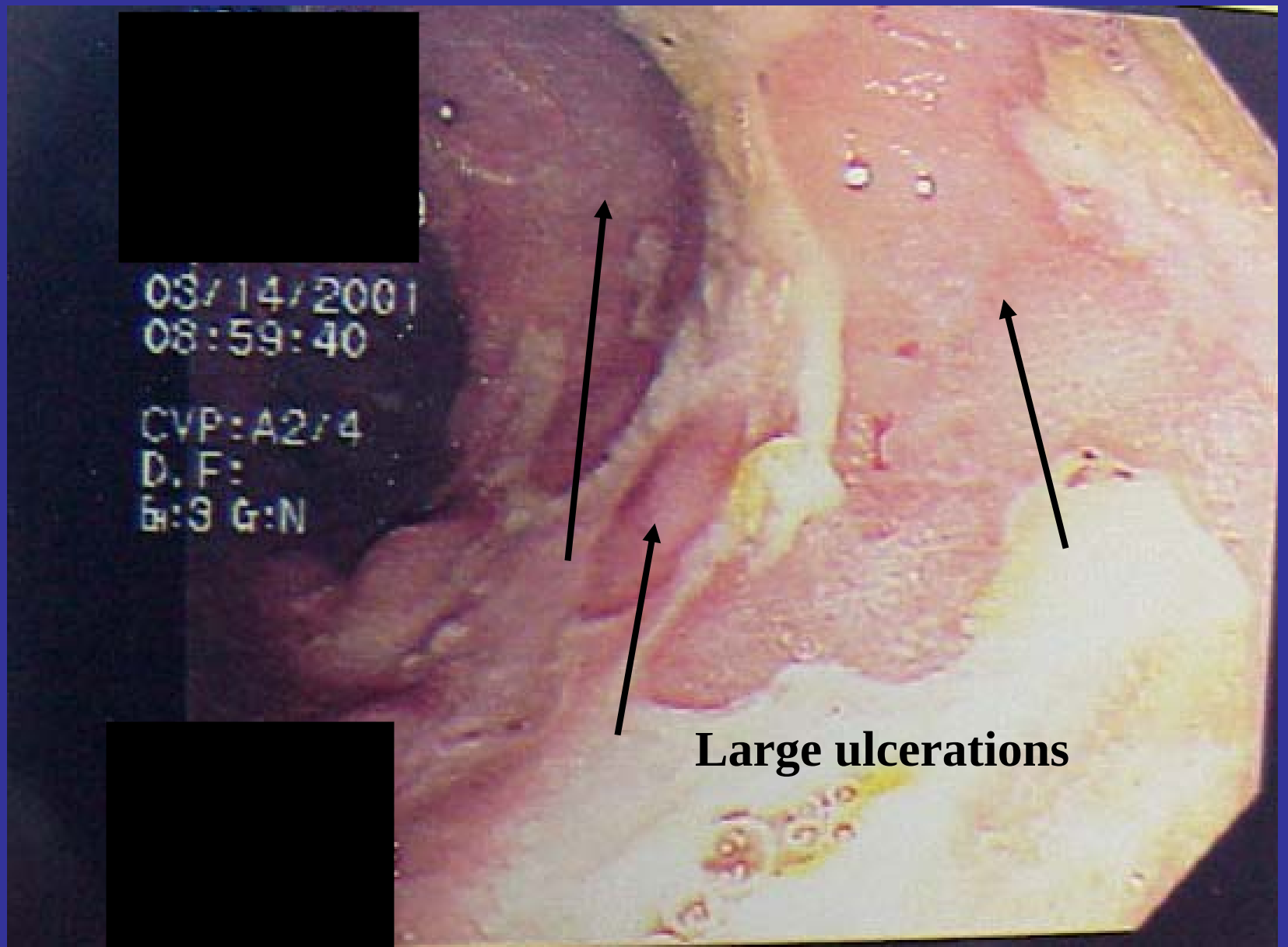


WTT21

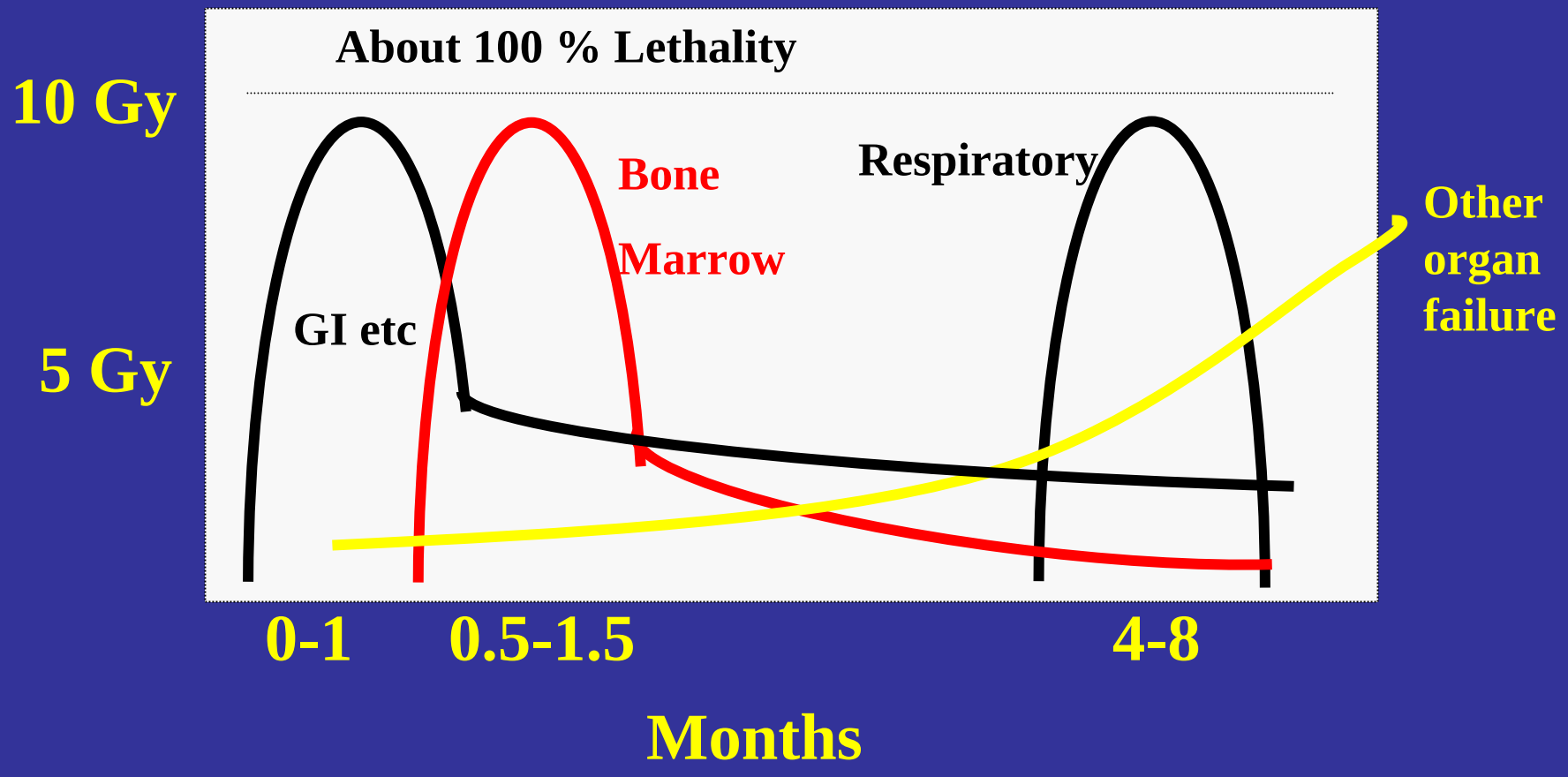
Have bone marrow transplants been useful to treat whole body exposure?

- 34 patients as of 2002
- 1 survived 8.7 Gy (recovered native marrow) = survival less than 4%
- Several died as a result of complications
- 4 Chernobyl patients (6-8 Gy) survived without transplant
- CSF etc will be in huge demand

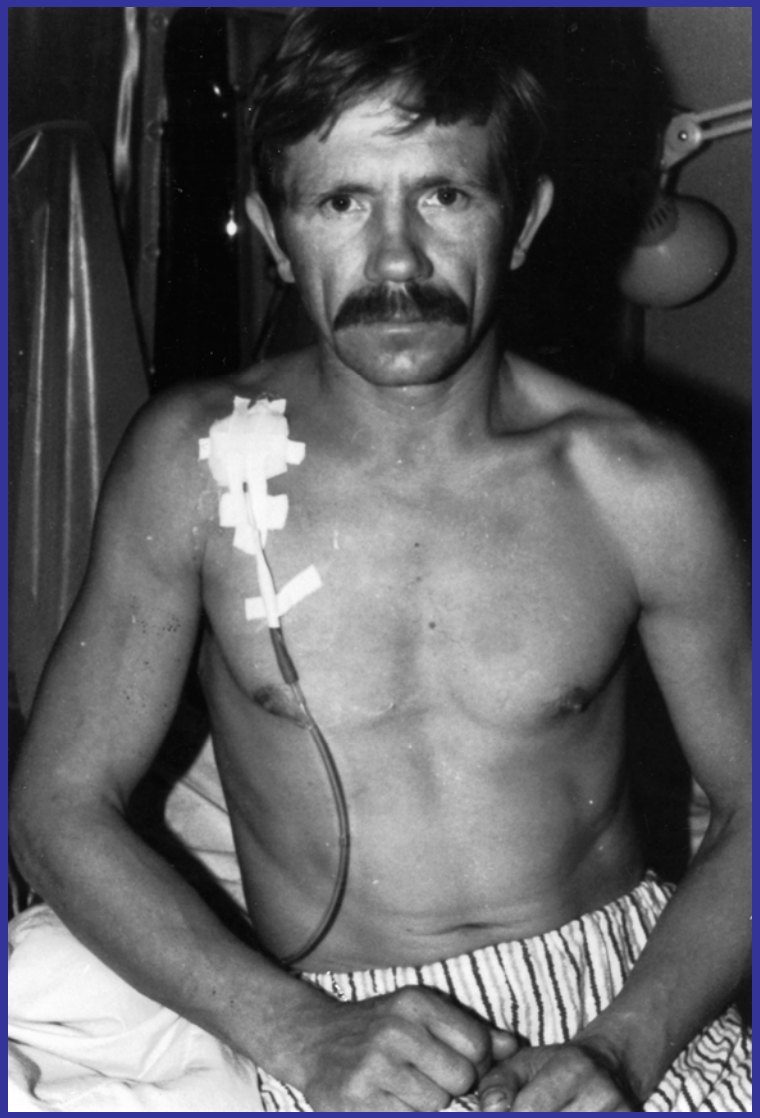
Gastrointestinal changes – days to many months



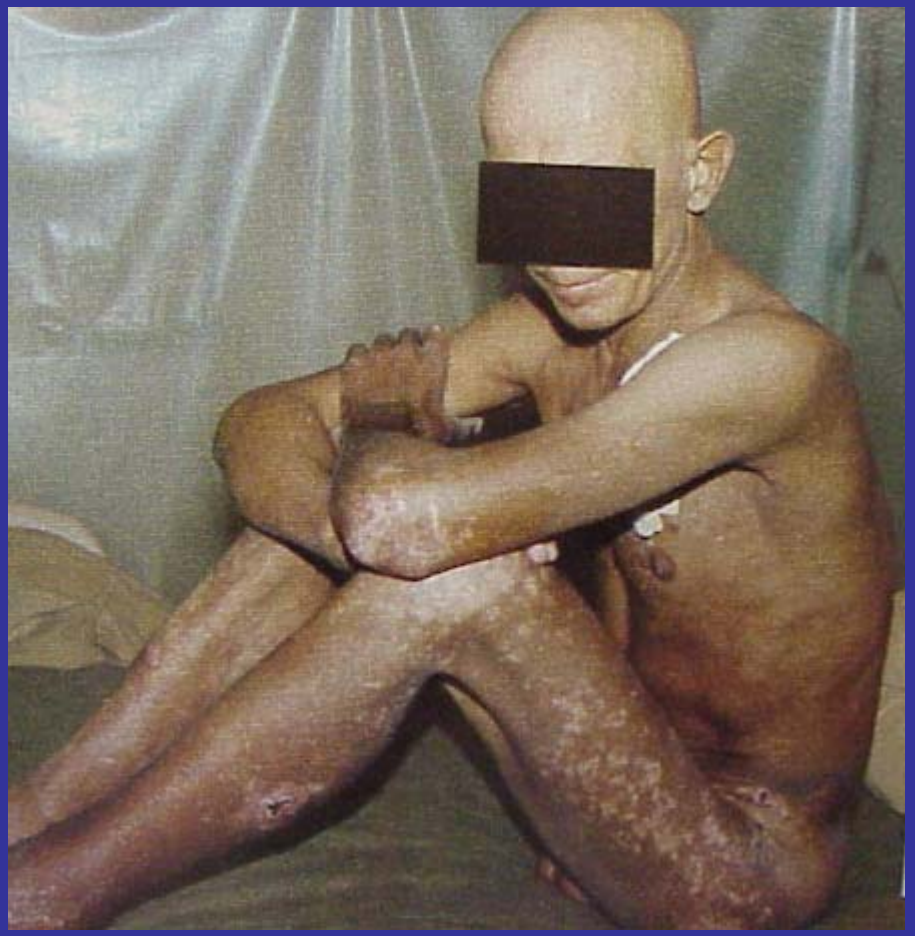
Acute causes of death at various times following whole body exposure



Belarus industrial irradiator accident



24 hours post exposure



90 days-
pulmonary
failure death

Deaths at 6-15 months
Multi-organ failure

Bottom line on external exposure and ARS (a factor of ~ 2-3)

- ARS treatment will be needed both for prompt radiation as well as fallout victims
- LD 50/30 ~ 3-3.5 Gy without medical treatment
- LD50/30 ~ 6-8 Gy with intensive medical treatment
- The issue of long term issue of multi-organ failure has not been overcome

How effective is medical treatment ?

Current medical treatment can only improve things by a factor of ~2-3

If …we have the best ICU care, beds.. transport and staff. …..Which we won't

Protective actions can reduce doses and consequences by factors of up to 1000 or more

Issue of combined agents

Chemical agents have immediate effects that must be dealt with first

There is not likely to be synergism between radiation and chemical or biological agents

Do plans deal with medical care for multi-agent attacks ?

Radiation injury to the skin

- Will occur as a result of both beta and gamma radiation
- Skin doses can be much higher than deep tissue dose
- Can seriously and adversely affect survival when occurring with ARS (depressed marrow etc)
- Skin injury was ***the*** major cause of mortality in Chernobyl ARS patients so will thermal burns, glass

Beta burns

- Fresh fission products from reactor core or from recently exploded weapon
- Beta/gamma ratio is often 3-20
- Skin injury if a large enough area will be a major cause of mortality

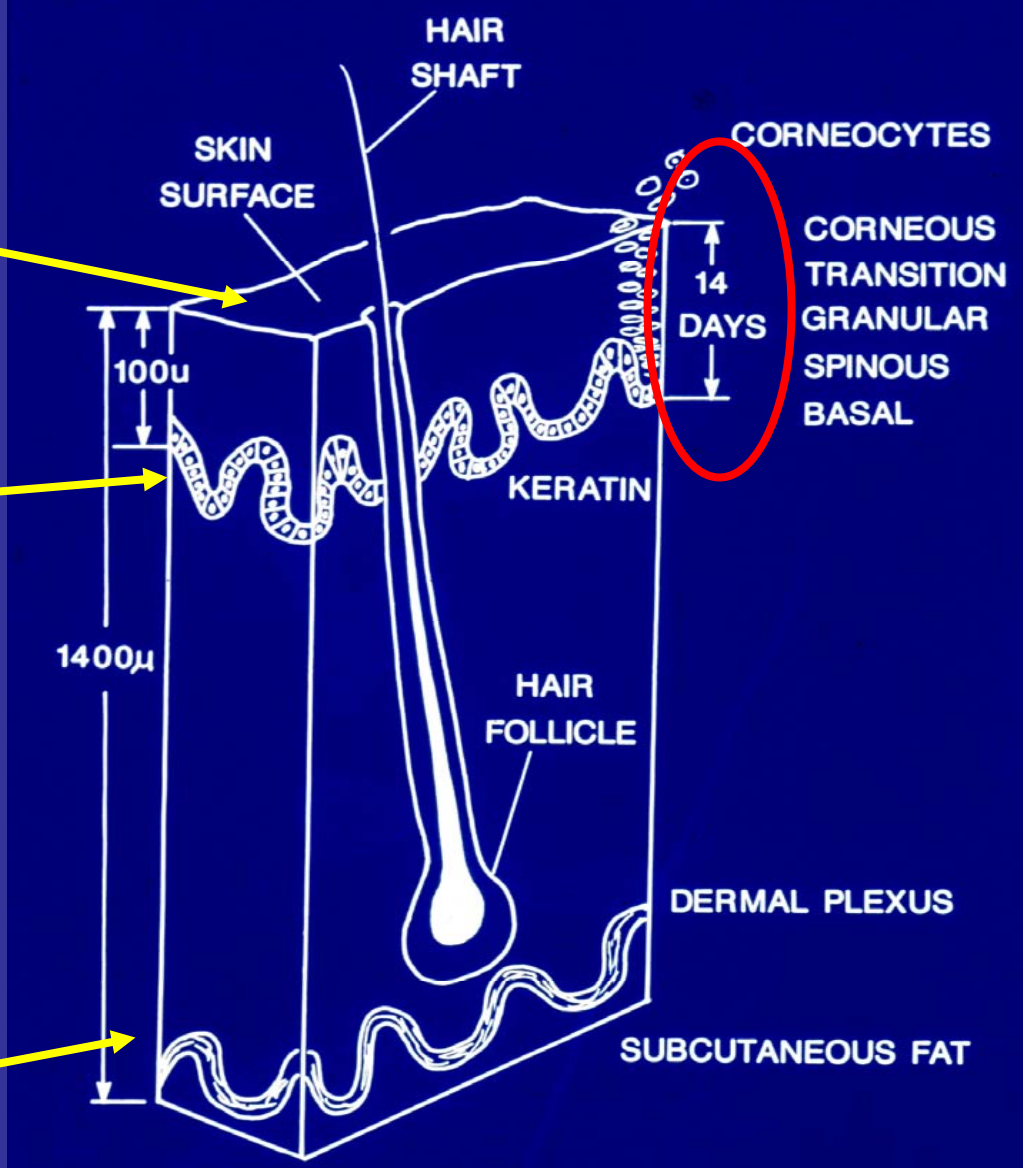
Skin injury with acute radiation exposure often take days to weeks to appear

2-6 Gy	Transient erythema 2-24 h
• 3-5 Gy	Dry desquamation 3-6 wks
• 3-4 Gy	Temporary epilation 3 wks
• 10-15 Gy	Erythema 18-20 days
• 15-20 Gy	Moist desquamation
• 25 Gy	Ulceration/ slow healing
• 30-50 Gy	Blistering, necrosis at 3 wks
• 100 Gy	Blistering, necrosis at 1-3 wks

Cells already dead

Radiation damaged cells

Long-term arteriolar occlusion



Late Skin and Soft Tissue Changes cause problems for months to years

- Epilation - permanent or temporary
- Pigmentation
- Atrophy
- Fibrosis with limitation of range of motion
- Necrosis

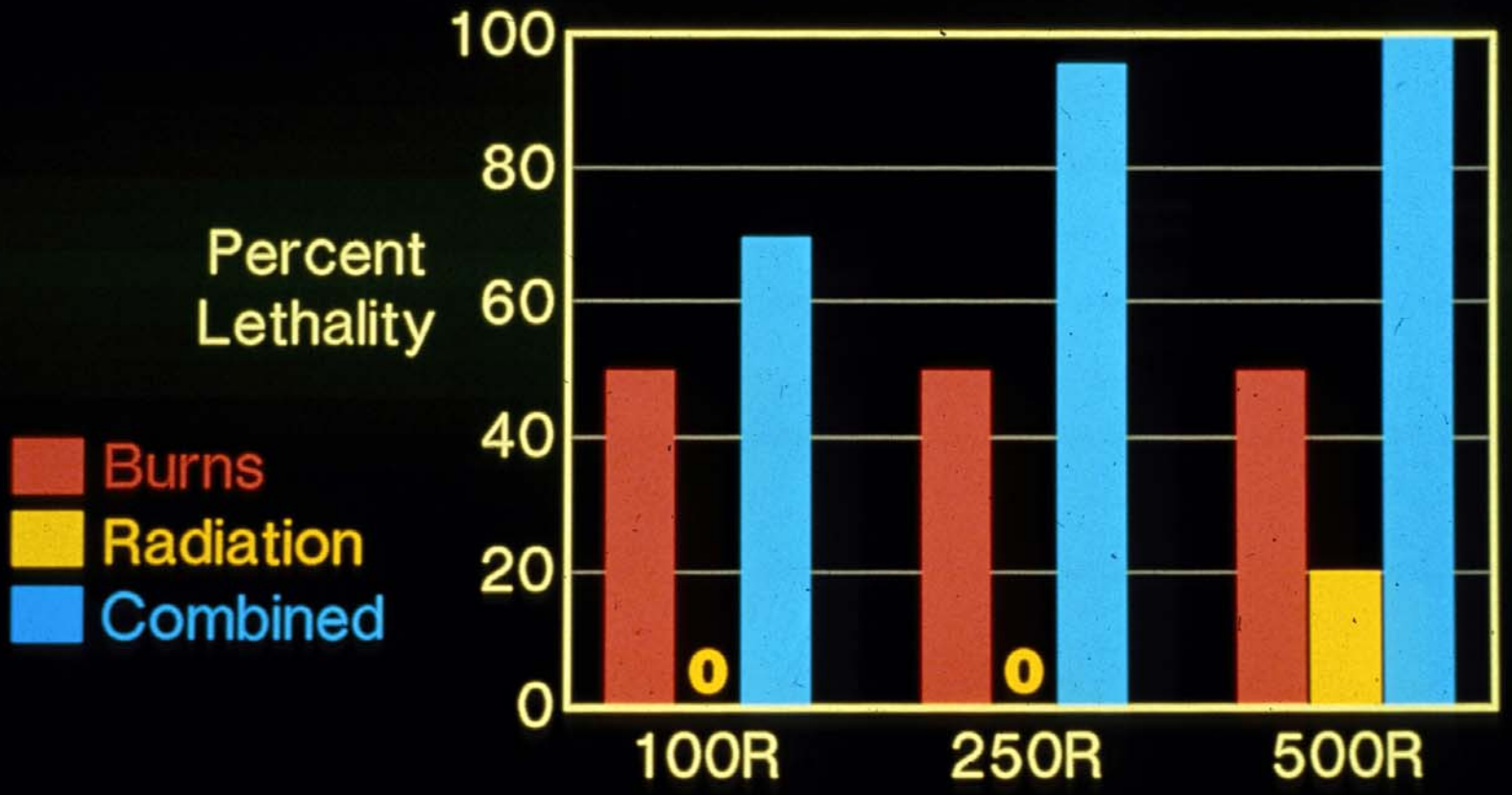
- Dose calculation notoriously inaccurate and treatment based on clinical appearance and temporal changes

BETA BURNS
ON 13 YEAR OLD
MARSHALLESE BOY
45 DAYS AFTER
EXPOSURE

13 YEAR OLD
MARSHALLESE BOY
6 MONTHS AFTER
EXPOSURE

Chernobyl fireman-acute fatal beta burns

Combined Effects of Simultaneous Whole-Body Irradiation and Burns on Rats

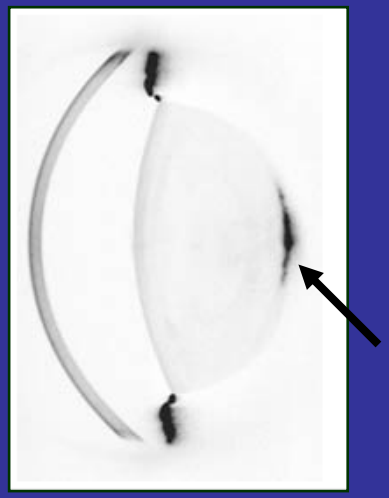


WTT31

Chernobyl reactor worker
- healed beta burns- 2 decades later

Gamma from prompt radiation as well as from fallout will also cause skin and underlying tissue injuries

Long term cataracts 2-5 years



Issue present but of relatively minor significance

Internal exposure – complex issue

38 elements and about 300 radionuclides

- Americium (bone)
- Californium (bone)
- Cerium (GI,lung)
- Curium (bone)
- Iodine (thyroid)
- Plutonium (bone)
- Polonium (lung)
- Strontium (bone)
- Tritium (whole body
- Uranium (bone)

Deaths very unlikely from internal exposure

Except for radioiodine in young persons relatively minor clinical significance.

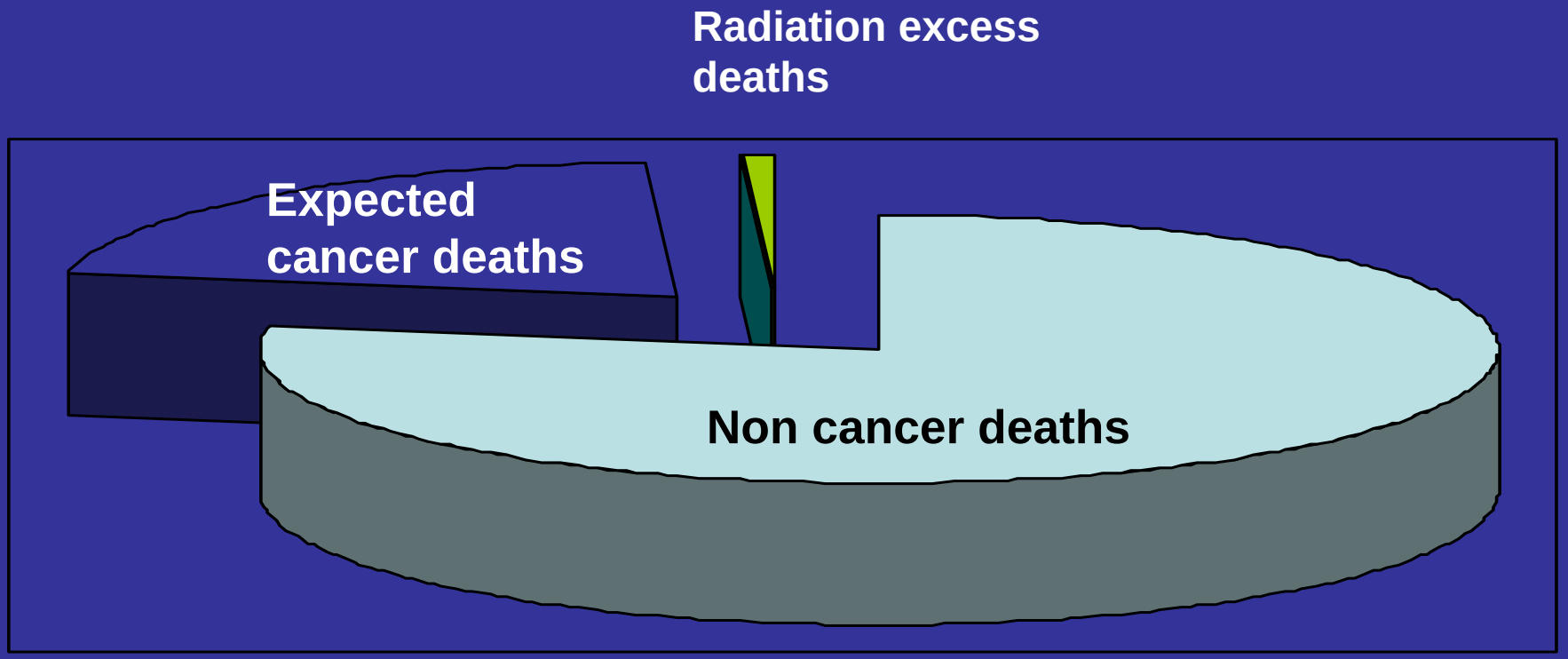
Radiation carcinogenesis :Long term problem
Small overall percentage impact

86, 572 A-bomb survivors with average dose of 23 rem (0.23 Sv)

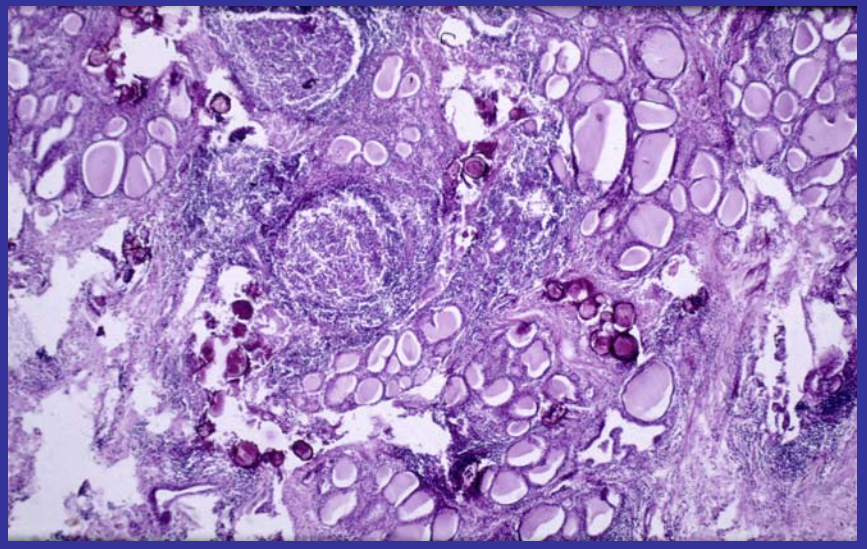
7,578 cancer deaths total 334 excess (4.6% increase)

•UNSEAR 2000

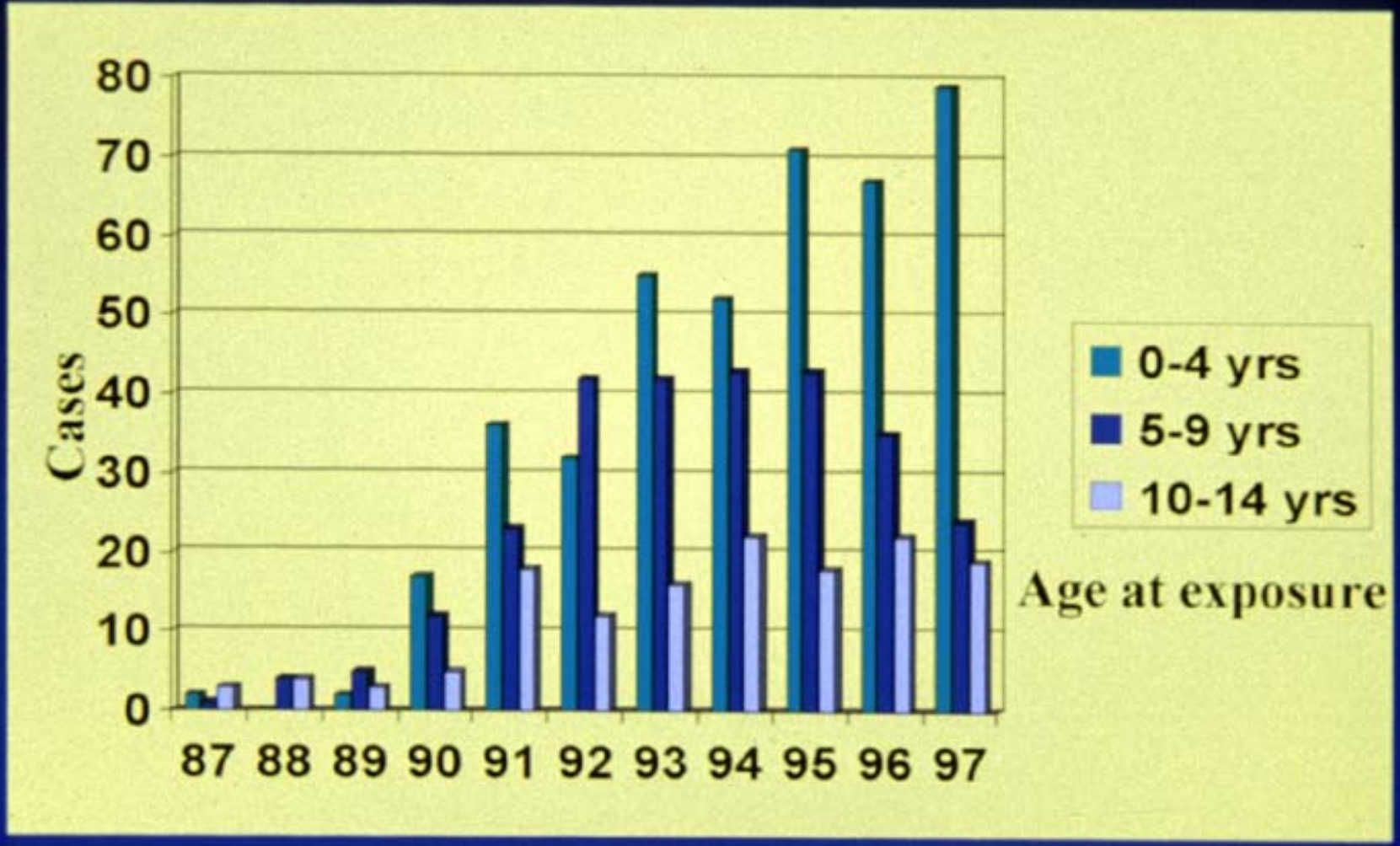
Causes of death in atomic bomb survivors



Radiation-induced thyroid cancer in a child from Chernobyl



Childhood Thyroid Cancer after Chernobyl



- High risk: non-CLL leukemia, breast, lung, stomach colon, thyroid (children)
- Moderate risk: esophagus, skin
- Little risk: lymphoma, pancreas
- No detectable risk: cervical, endometrial, prostate, CLL

Latent periods (years) for various tumors

Site	Mean	Minimum
Thyroid	20	~ 5
Breast	23	10
Skin	25	10
Bone	20	2-3
Leukemia	7	2

Fetal Radiation Risk

- There are radiation-related **risks** throughout pregnancy which are **related to the stage of pregnancy and absorbed dose**
- Radiation risks are most significant during organogenesis and in the early fetal period somewhat less in the 2nd trimester and least in the third trimester

Most risk

Less

Least

Radiation-Induced Malformations

- Malformations have **a threshold of 100-200 mGy (10-20 rads) or higher** and are typically associated with central nervous system problems

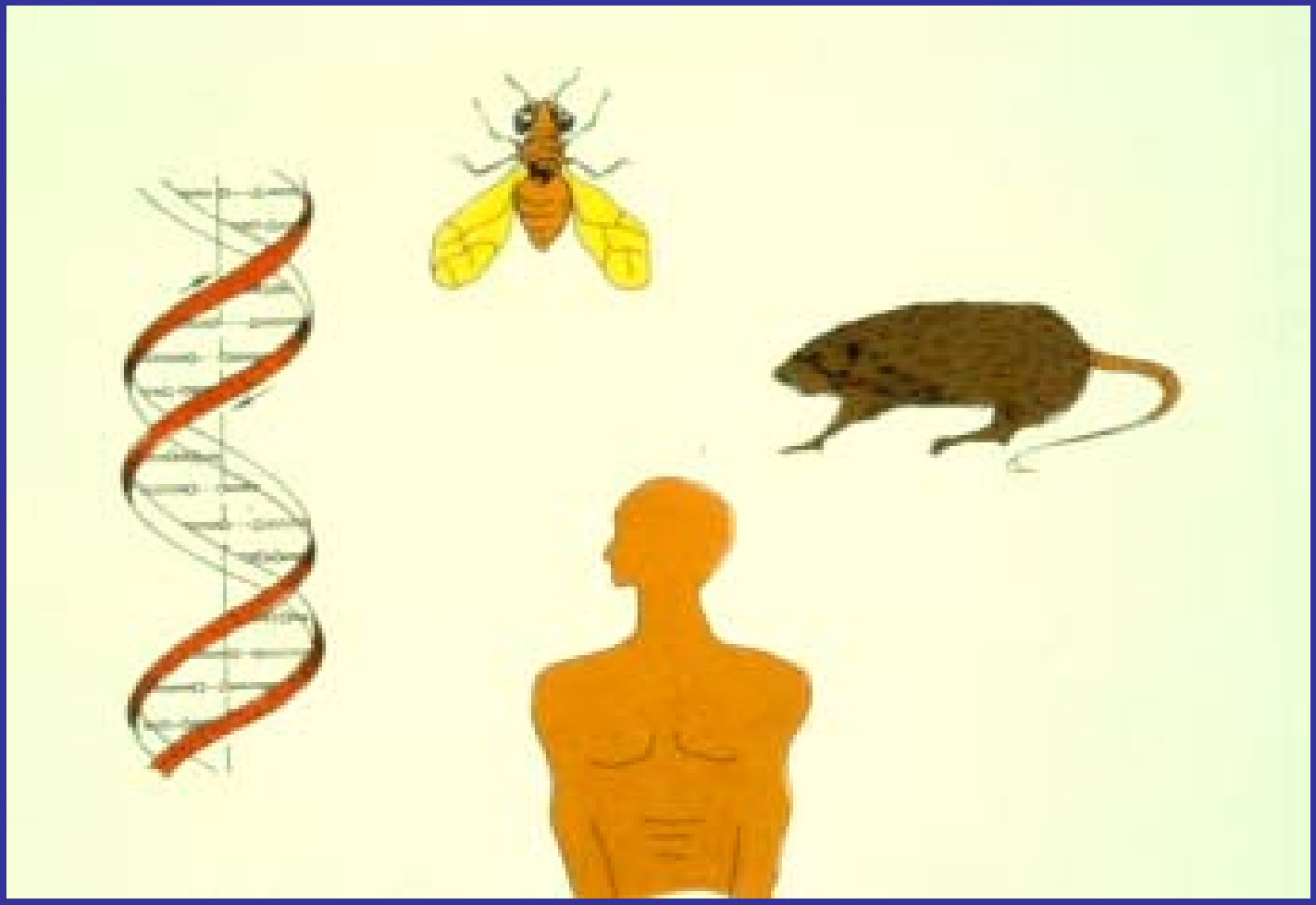
Percent severe mental retardation as a function of radiation dose and fetal age

EGA		Fetal	dose	in rads	
	< 1	1-9	10-49	50-99	100+
0-7	0.5	0	0	0	0
8-15	0.8	4.3	8.0	30.8	66.7
16-25	0.6	1.2	0	13.3	20.0
25+	1.3	0	0	0	0

Hiroshima and Nagasaki ICRP 49


55歳
百合子さんは毎日この場所にすわったまま一日を
過(す)ごします。
55 years old
Yuriko spends her days sitting right here.

Hereditary effects of radiation

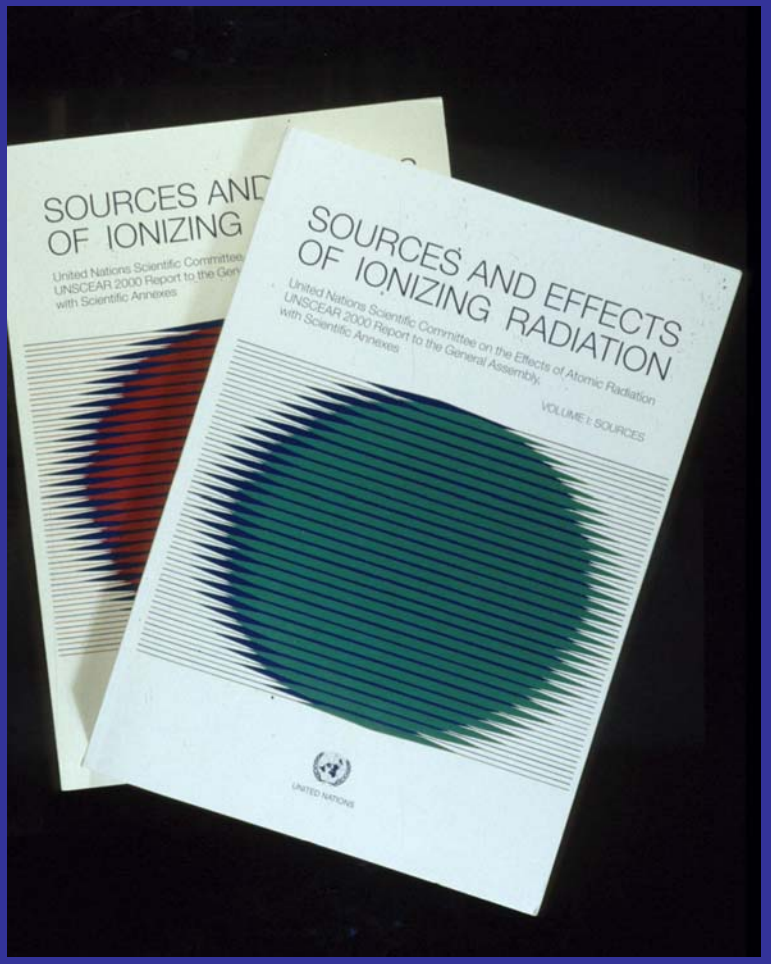


United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR)

Hereditary effects have not been seen in humans in spite of 3 generations of study in atomic bomb survivors

Hereditary effects are not apparent in children of radiation therapy patients

Risk not exactly known but estimated to be less than 1/10th of radiogenic cancer risk



Psychosocial issues

- Persist for decades
- Occur regardless of dose level
- Remain major issues in A-bomb and Chernobyl populations

Ethical Issues

Planners usually worry about the acute period (days-week) and leave long term effects to others. Who are the others ??

Many serious health effects will not be immediately evident and will last for decades

Examples: A-bomb, Downwinders, Chernobyl etc

Record keeping

- Always a big problem
- Registry of exposed persons ??
- Dose often expressed as effective dose rather than organ dose
- Doses usually not individual and subject to large uncertainties
- Privacy issues (HIPPA)
- Bias in reporting of health effects

An unsolved issue ?

Who is responsible for planning and providing intermediate or long term medical care and or follow-up ?

Assumedly a large portion will be absorbed in the current health care system and by having the government print additional money

Long term - Relocate or stay ?
Contaminated village 5 years later

Good luck