

**INTERNAL EMITTERS:  
ARE WE IN THE KNOW?**

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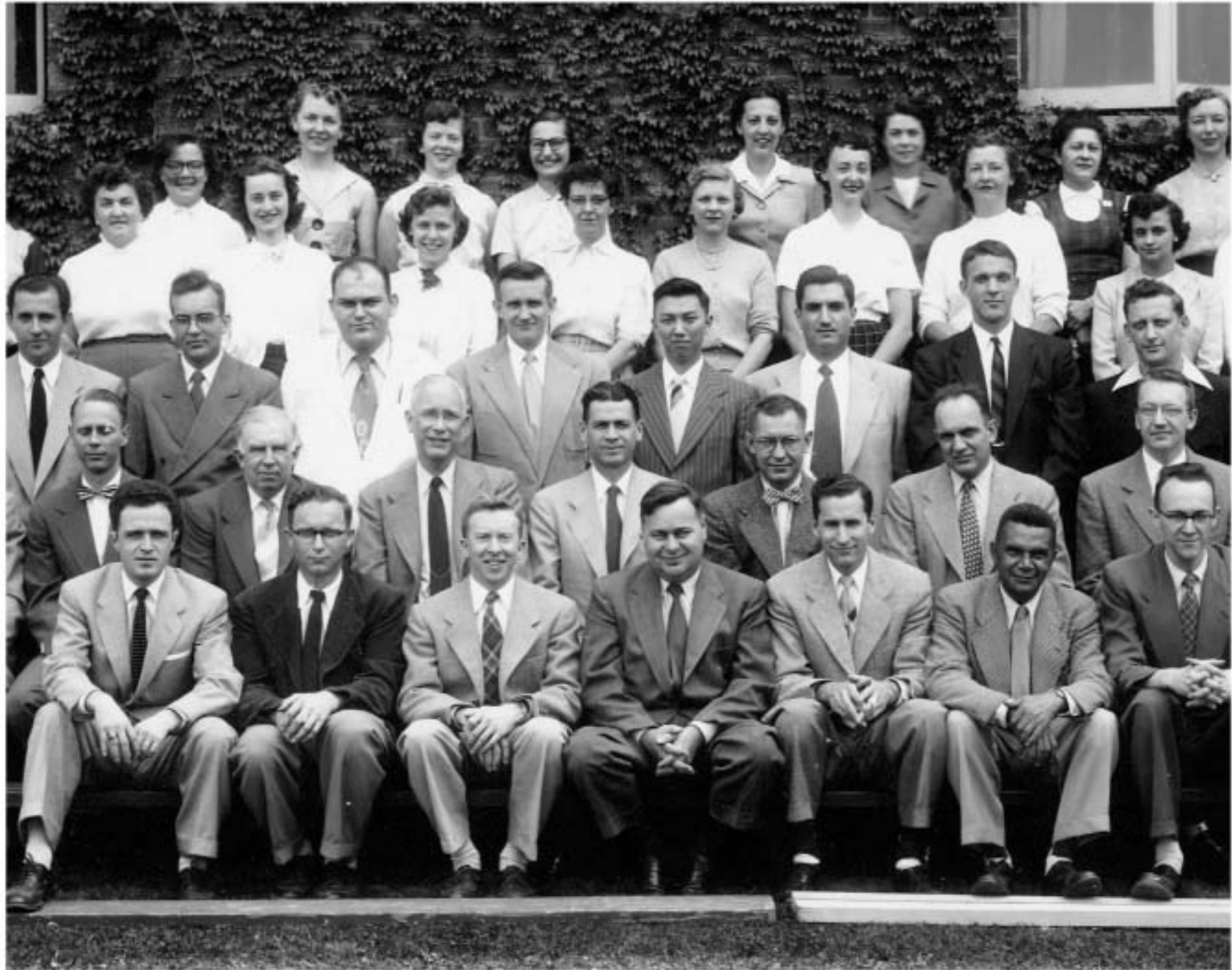
**12<sup>th</sup> Annual J. Newell Stannard  
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**Sierra Nevada-Northern California  
Chapters of Health Physics Society**



# **INTERNAL EMITTERS: ARE WE IN THE KNOW?**

- **SOME HISTORY**
- **CURRENT STATE OF KNOWLEDGE**
- **NEEDS**
- **FUTURE PROSPECTS**



# **WHY INTERNAL EMITTERS?**

**GREATEST SOURCES OF RADIATION EXPOSURE**

**BACKGROUND RADIONUCLIDES**

**NUCLEAR WASTE (TRANSPORT & STORAGE)**

**POWER REACTORS**

**5000 CONTAMINATED COLD WAR SITES**

**MEDICAL RADIOISOTOPES**

**CONSUMER PRODUCTS**

**RESEARCH & INDUSTRY**

**DISASSEMBLY OF WEAPONS**

**SPACE VEHICLES**

**ORPHAN SOURCES**

**TERRORIST ACTIVITIES**

**“RADIATION” AS IN THE  
PUBLIC’S FEAR OF RADIATION  
IS SYNONYMOUS WITH  
INTERNAL EMITTERS**

# **INTERNAL EMITTERS**

- **ENERGY DISTRIBUTION IS DEPENDENT UPON BIOKINETIC AND RADIOLOGICAL PROPERTIES OF THE RADIONUCLIDE**
- **ENERGY IS DISTRIBUTED OVER TIME AND GENERALLY IS NON-UNIFORM IN BODY OR TISSUE**

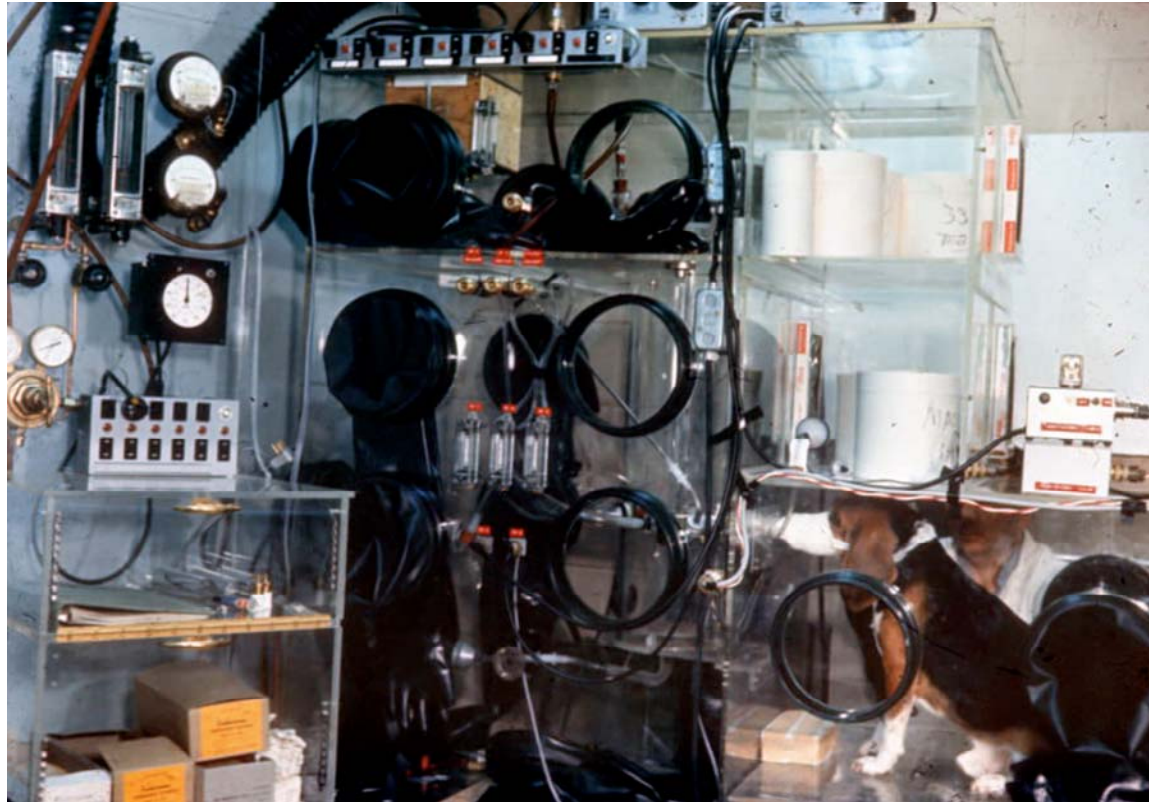
# **HANFORD INTERNAL EMITTER CONCERNS IN 1954**

- **RADIONUCLIDE EMISSIONS**
  - **IODINE-131**
  - **RUTHENIUM-106 “HOT PARTICLES”**
  
- **WORKER EXPOSURES**
  - **PLUTONIUM-239 DIOXIDE**

# TRANSMUTATION EFFECT

- **HYPOTHESIS:**  
CELLULAR DNA DAMAGE OCCURS WHEN INCORPORATED RADIONUCLIDES SUCH AS  $^{35}\text{S}$  DECAYS AND BECOMES ANOTHER ELEMENT,  $^{35}\text{Cl}$ .
- **RESULTS: INCONCLUSIVE**

# BEAGLE $^{239}\text{Pu}$ EXPOSURE



# **CURRENT ISSUES HEALTH CLAIMS**

- **NUCLEAR WORKERS (51,000)**  
**“ENERGY EMPLOYEES OCCUPATIONAL ILLNESS  
COMPENSATION PROGRAM”:**  
**DOSE RECONSTRUCTION & “AT LEAST AS LIKELY  
AS NOT” GUIDELINES (COMPENSATION)**
- **DOWN WINDERS (LITIGATION)**
- **WEAPON TESTS FALL-OUT (COMPENSATION)**
- **RADON (MITIGATION)**
- **HOT PARTICLES (LITIGATION)**
- **DEPLETED URANIUM (LITIGATION)**

# THE STATES OF KNOWLEDGE

- **KNOWN KNOWNS**  
**THINGS WE KNOW WE KNOW**
- **KNOWN UNKOWNS**  
**THINGS WE KNOW WE DO NOT KNOW**
- **UNKNOWN UNKNOWNS**  
**THINGS WE DON'T KNOW WE DON'T  
KNOW**

# **THE QUESTION!**

**HAS THE LARGE MASS  
OF INFORMATION  
GENERATED ON  
HEALTH EFFECTS OF  
INTERNAL EMITTERS  
PUT US IN THE KNOW?**

# THINGS WE KNOW WE KNOW FROM HUMANS

- **CANCERS- HIGH DOSES**

<b><math>^{226-228}\text{Ra}</math>: RADIUM DIAL PAINTERS-</b>	<b>BONE</b>
<b><math>^{224}\text{Ra}</math>: ANKYLOSING SPONDILYTICS-</b>	<b>BONE</b>
<b><math>^{232}\text{Th}</math>: THOROTRAST PATIENTS-</b>	<b>LIVER</b>
<b>RADON: HARD ROCK MINERS-</b>	<b>LUNG</b>
<b><math>^{131}\text{I}</math>: MARSHALLESE AND CHERNOBYL-</b>	<b>THYROID</b>
<b><math>^{239}\text{Pu}</math>: SOVIET WEAPONS WORKERS-</b>	<b>LUNG</b>

- **BIOKINETICS & DOSIMETRY: NUCLEAR  
MEDICINE & ACCIDENTS**

# THINGS WE KNOW WE KNOW FROM RESEARCH\*

- **ANIMALS: BIOKINETICS, DOSIMETRY & HEALTH EFFECTS**
  - FISSION PRODUCTS
  - TRANSURANICS
  - URANIUM
  - RADON
  - POLONIUM
  - HOT PARTICLES
- **CELL STUDIES: RADON, Pu,  $^{210}\text{Po}$ ,  $^3\text{H}$ ,  $^{35}\text{S}$**

\*PNNL, LANL, ANL, UC-DAVIS, ITRI, LBL, U of R, U of UTAH

# KNOWN KNOWNS

## SUMMARY

- **BIOKINETICS & DOSIMETRY: LARGE DATA BASE FROM HUMANS & ANIMALS**
- **HEALTH EFFECTS: RISK ESTIMATES AT HIGH DOSES FROM HUMANS AND ANIMALS**
- **CELL & MOLECULAR: MINIMAL DATA BASE**
- **RADIATION: EFFECTIVE CELL KILLER, POOR MUTAGEN**

# **THINGS WE KNOW WE DON'T KNOW**

- **RADIATION CANCERS VS. OTHER CANCERS**
- **VALIDITY OF HEALTH EFFECTS CLAIMS BY EXPOSED WORKERS & PUBLIC**
- **NATURAL RADIONUCLIDE EFFECTS**
- **RADON & SMOKING SYNERGISM**

# **THINGS WE KNOW WE DON'T KNOW**

- **MECHANISM OF RADIATION INJURY**
- **INDIVIDUAL SENSITIVITIES**
- **SPECIES SENSITIVITIES**
- **EXTRAPOLATION FROM ANIMALS**
- **MEASUREMENT OF BODY BURDENS**
- **THERAPY FOR INTERNAL EMITTERS**

# **THINGS WE KNOW WE DON'T KNOW BUT PRETEND WE DO KNOW**

- **DOSE RESPONSES AT LOW DOSES**  
LINEAR NO THRESHOLD THEORY
- **HUMAN CANCER RISKS FROM  
INTERNAL EMITTERS**  
A-BOMB SURVIVOR DATA  
RISKS FROM HIGH DOSE HUMAN CASES
- **CRITICAL TARGETS & DOSES**  
BIOKINETIC & DOSE MODELS
- **DOSES TO WORKERS & PUBLIC**  
DOSE RECONSTRUCTION MODELS

# **THINGS WE KNOW WE DON'T KNOW BUT PRETEND WE DO KNOW**

- **QUANTIFICATION OF TOTAL HEALTH  
DETRIMENT FROM INTAKES OF INTERNAL  
EMITTERS**
  - **COMMITTED EFFECTIVE DOSE**
    - **RADIATION WEIGHTING FACTORS**
    - **TISSUE WEIGHTING FACTORS (DERIVED FROM A-  
BOMB SURVIVORS + DDREF)**
  - **MODELS OF RESP. TRACT, G.I. TRACT, BONE**
  - **DOSE COEFFICIENTS**
- **DOSES FROM RADIOPHARMACEUTICALS**
  - **MIRD & ICRP MODELS & DOSE COEFFICIENTS**

# **THINGS WE DON'T KNOW BUT THINK WE DO KNOW**

**VERY LIKELY WE ARE WRONG ABOUT  
SOME THINGS WE ARE CERTAIN  
ABOUT**

- SENSITIVE CELLS & TISSUES?**
- DOSE EFFECT RELATIONSHIP AT HIGH DOSES?**
- INTERACTION OF RADIATION WITH DNA?**

# **THINGS WE KNOW BUT LIE ABOUT**

**WHO WOULD DO THIS?**

**SOME EXPERT WITNESSES?**

**SOME ANTI NUCLEAR VOICES?**

# **THINGS WE DON'T KNOW THAT WE DON'T KNOW**

- **WILL ONLY KNOW IN RETROSPECT**
- **CONSIDER PAST SURPRISES**
  - **MENTAL RETARDATION IN JAPANESE**
  - **NO GENETIC EFFECTS IN JAPANESE**
  - **LACK OF LEUKEMIA IN CHERNOBYL PEOPLE**
  - **$^{238}\text{Pu}$  OXIDE MORE SOLUBLE THAN  $^{239}\text{Pu}$  OXIDE IN LUNGS**

# ARE WE IN THE KNOW?

**UNCERTAINTIES IN OUR KNOWLEDGE ARE REFLECTED IN:**

- **CONSERVATISM IN DOSE & RISK MODELS**
- **CONSERVATISM IN RISK PROJECTIONS**
- **CONSERVATIVE STANDARDS**
- **CAVEATS**
- **SCIENTIFIC DEBATES**
- **PUBLICATIONS (INTERNAL EMITTERS- 70% IN “HEALTH PHYSICS”)**
- **UNRESOLVED HEALTH ISSUES**

# **PUBLIC ISSUES IMPACTED BY UNCERTAINTIES IN KNOWLEDGE OF INTERNAL EMITTER RISKS**

- **NUCLEAR WASTE--TRANSPORT & STORAGE**
- **STAGNATION OF NUCLEAR POWER**
- **CLEAN-UP OF WEAPONS SITES**
- **ORPHAN SOURCES**
- **DIRTY BOMB!**

# **WHAT IS OUR HOPE FOR BEING “IN THE KNOW”?**

- **INTERNAL EMITTER RESEARCH  
PHASED OUT**
- **NEW MOLECULAR BIOLOGY BEGINS  
OBJECTIVE:  
RESOLVE LOW DOSE AND LOW DOSE-  
RATE ISSUES**

# **NEEDS FOR INTERNAL EMITTERS**

- **IMPROVEMENT OF BIOKINETIC AND DOSE MODELS:**
  - **ONGOING EFFORT (ICRP, NCRP, LABS, & UNIVERSITIES)**
- **BASIS FOR EXTRAPOLATION FROM ANIMALS TO HUMANS:**
  - **BEING ADDRESSED BY NCRP**
- **INTERNAL DECONTAMINATION THERAPY**
  - **NO ACTION**

# **NEEDS FOR INTERNAL EMITTERS**

- QUANTIFY RISKS AT LOW INTAKES**
- IDENTIFY SENSITIVE INDIVIDUALS**
- DISTINGUISH BETWEEN CANCERS  
CAUSED BY RADIATION FROM THOSE  
DUE TO OTHER CAUSES**

**(POTENTIAL OUTCOMES OF DOE LOW DOSE  
RESEARCH PROGRAM)**

# **DOE LOW DOSE PROGRAM\***

**(0 TO 10 RADS)**

- **GOAL: SCIENTIFIC BASIS FOR RADIATION PROTECTION STANDARDS**
- **FUNDING: \$20M PER YEAR, 10 YEARS**
- **70 PROJECTS**
- **MAJOR THRUST: CHALLENGE THE LINEAR NO THRESHOLD HYPOTHESIS**
- **DATA SUGGEST MECHANISM OF ACTION DOSE DEPENDENT**

(\* Program Mgr. Dr. A. L. Brooks  
<http://lowdose.tricity.wsu.edu>)

# LINEAR NO-THRESHOLD THEORY

- **PRIMARY LESION: DNA DOUBLE STRAND BREAK**
- **BREAKS ARE IN PROPORTION TO DOSE**
- **RADIATION RISKS ARE ADDITIVE**
- **RISK PER UNIT DOSE IS CONSTANT**
- **NO THRESHOLD DOSE**
- **DOSE DOMINATES BIOLOGICAL VARIABLES**

# ADAPTIVE RESPONSES

- **PRE-EXPOSURE TO LOW DOSES (1-10 RAD) REDUCES CHROMOSOMAL DAMAGE BY SUBSEQUENT (WITHIN 5 HRS.) EXPOSURES (~50 RAD)**
- **OBSERVATIONS: REDUCE**
  - **CHROMOSOME ABERRATIONS IN MICE & HUMANS**
  - **CANCER, GENETIC & TERATOGENESIS IN MICE**
- **NON-LINEAR: SUGGESTS RISK IS LESS THAN LNT PREDICTS**

# **GENETIC SUSCEPTIBILITY**

- **SOME INDIVIDUALS MAY BE MORE SENSITIVE TO RADIATION DAMAGE BECAUSE OF GENETIC DIFFERENCES**
- **APPLICATION OF NEW GENE SEQUENCING TECHNOLOGY**
- **POSSIBLE IDENTIFICATION OF INDIVIDUALS WITH GREATER SENSIVITY TO RADIATION-INDUCED CHANGES IN THEIR GENOME & THUS, TO CANCER**

# **NORMAL VS. RADIATION INDUCED MOLECULAR DAMAGE AND REPAIR**

- **IF DNA DAMAGE AND REPAIR FOR RADIATION ARE SAME AS FOR NORMAL DAMAGE AND REPAIR**
  - **POSSIBLE EVIDENCE FOR THRESHOLD EFFECT**
- **IF DNA DAMAGE AND REPAIR FOR RADIATION ARE UNIQUE**
  - **POSSIBLE EVIDENCE FOR LINEAR RESPONSE**

# **GENETIC INSTABILITY**

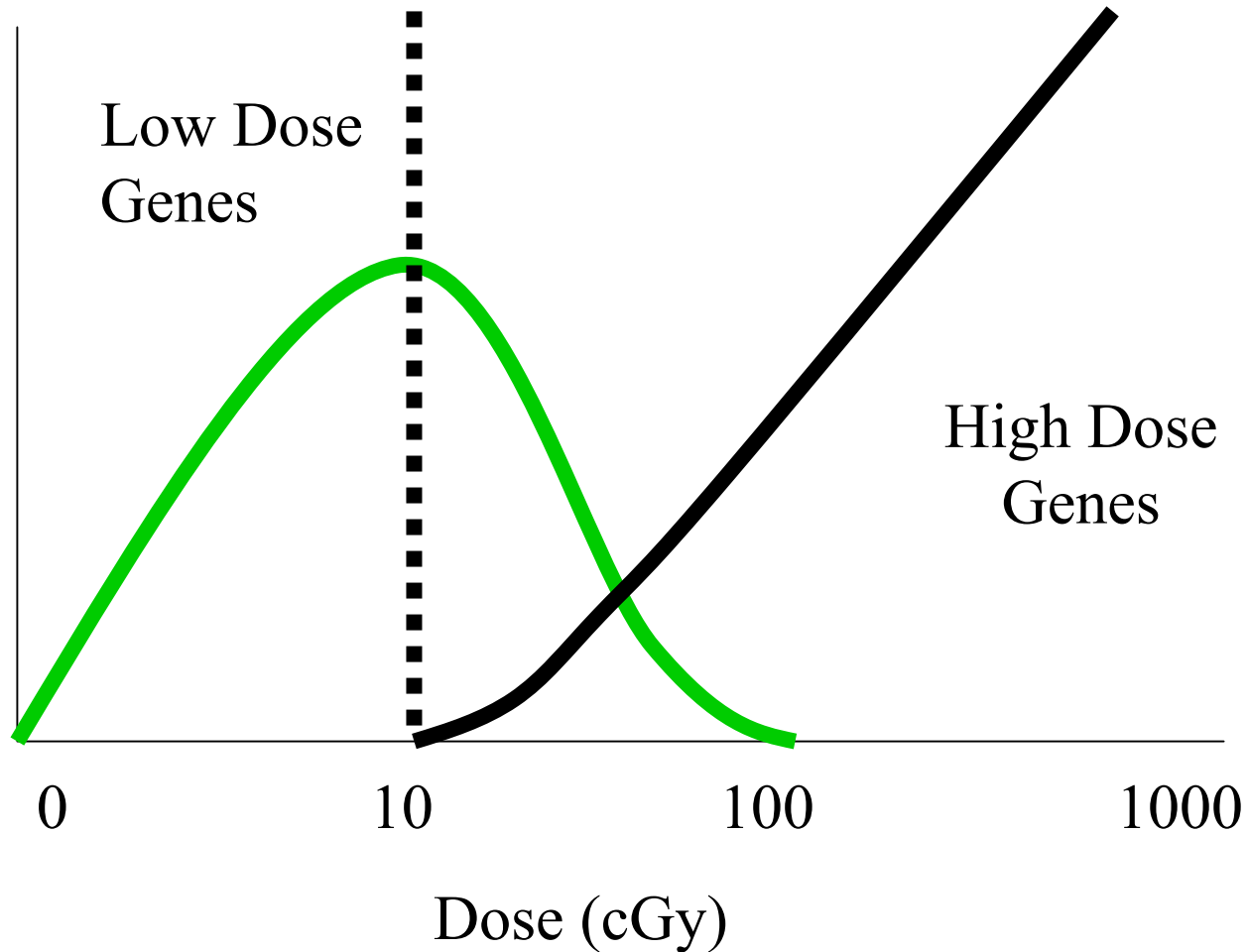
- **EXPRESSION OF CERTAIN CHROMOSOME ABERRATIONS AND MUTATIONS CAN OCCUR IN PROGENY OF IRRADIATED CELLS LONG AFTER EXPOSURE TO ALPHA RADIATION**
- **NON-LINEAR PROCESS**

# BYSTANDER EFFECT

**UNEXPOSED CELLS MAY BE DAMAGED  
WHEN ADJACENT CELLS ARE  
EXPOSED TO HIGH LET RADIATIONS**

- DO IRRADIATED CELLS SEND SIGNALS TO CAUSE INDIRECT DNA DAMAGE?**
- GREATER THAN LINEAR EFFECT, BUT POSSIBLE MITIGATION BY ADAPTIVE RESPONSE**
- APPLY TO RADON RISKS?**

# GENE EXPRESSION



# **APPLICATION TO INTERNAL EMITTERS**

- **PROSPECTS**
  - **LESS UNCERTAINTY IN DOSE & RISK ESTIMATES**
  - **IDENTIFICATION OF HIGH RISK INDIVIDUALS**
  - **IDENTIFICATION OF RADIATION INDUCED CANCERS**
  - **PREDICTION OF HEALTH CONSEQUENCES**

# **APPLICATION TO INTERNAL EMITTERS**

- **BENEFITS**
  - **ADDRESS HEALTH EFFECTS ISSUES**
  - **DECREASE PUBLIC FEAR OF  
RADIOACTIVE MATERIALS**
  - **GREATER SCIENTIFIC BASIS FOR  
STANDARDS & PROTECTION ?  
INCREASED CONFIDENCE**

# **SUMMARY & CONCLUSIONS**

- **INTERNAL EMITTERS ARE GREATEST SOURCES OF RADIATION EXPOSURE**
- **KNOWLEDGE IS INADEQUATE TO RESOLVE CURRENT & FUTURE HEALTH ISSUES**
- **LOW DOSE PROGRAM HAS POTENTIAL TO RESOLVE THESE ISSUES AND IMPACT RADIATION PROTECTION PRACTICES**
- **KEEP INFORMED**