National Cancer Institute

Uncertainties in Internal Radiation Dose Assessment

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

National Institutes of Health

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Background

- NCRP has undertaken the preparation of three related Reports on uncertainties in the measurement and dosimetry of external and internal sources of radiation, and the application of this information in performing radiation dose reconstructions. The “external” Report is published (NCRP #158; 2008). The “internal” Report, the second in the series, will be completed in 2009. The third Report in the series is on the topic “Principles and Practices of Radiation Dose Reconstruction”; it is under review by NCRP members.

Objective of the “internal” report

- The objective of this Report is to review the current state of knowledge of uncertainties in internal dose assessments, including uncertainties in the measurements that are used to perform these assessments.

Field of application

- Research (epidemiology): YES
- Compensation (legal): YES
- Regulation (dose limits): NO

Dose endpoint

- Effective dose (w_R; w_T): NO
- Equivalent dose (w_R): NO
- Absorbed dose (physical quantity): YES

Exposure situations

- Environmental
- Occupational
- Medical

Retrospective or prospective assessments for specific or unspecified individuals.

	Specific Individual	Unspecified Individual
Retrospective Assessment	Intake has already occurred Known, real individual Either personal, physical or physiological information available (e.g., bioassay data)	Intake has already occurred Any individual from a reference category No personal information available
Prospective Assessment	Intake is expected to occur Known, real individual Either personal, physical or physiological information available (e.g., bioassay data)	Intake may occur in the future Any individual from a reference category No personal information available

Examples of exposure situations

	Specific Individual	Unspecified Individual
Retrospective Assessment	Worker with positive urine bioassay data Real individual, member of the public, part of an epidemiologic study	Child in a city exposed to last year's releases from a nuclear facility Hypothetical adult member of the population exposed to past releases
Prospective Assessment	Treatment planning for a real patient Planned exposure for a given worker	Hypothetical farmer near a future nuclear facility Hypothetical male worker at a future nuclear installation

Models

- Uptake
- Systemic
- Dosimetric

Respiratory tract model

5 main regions

Extrathoracic airways

ET_1

ET_2

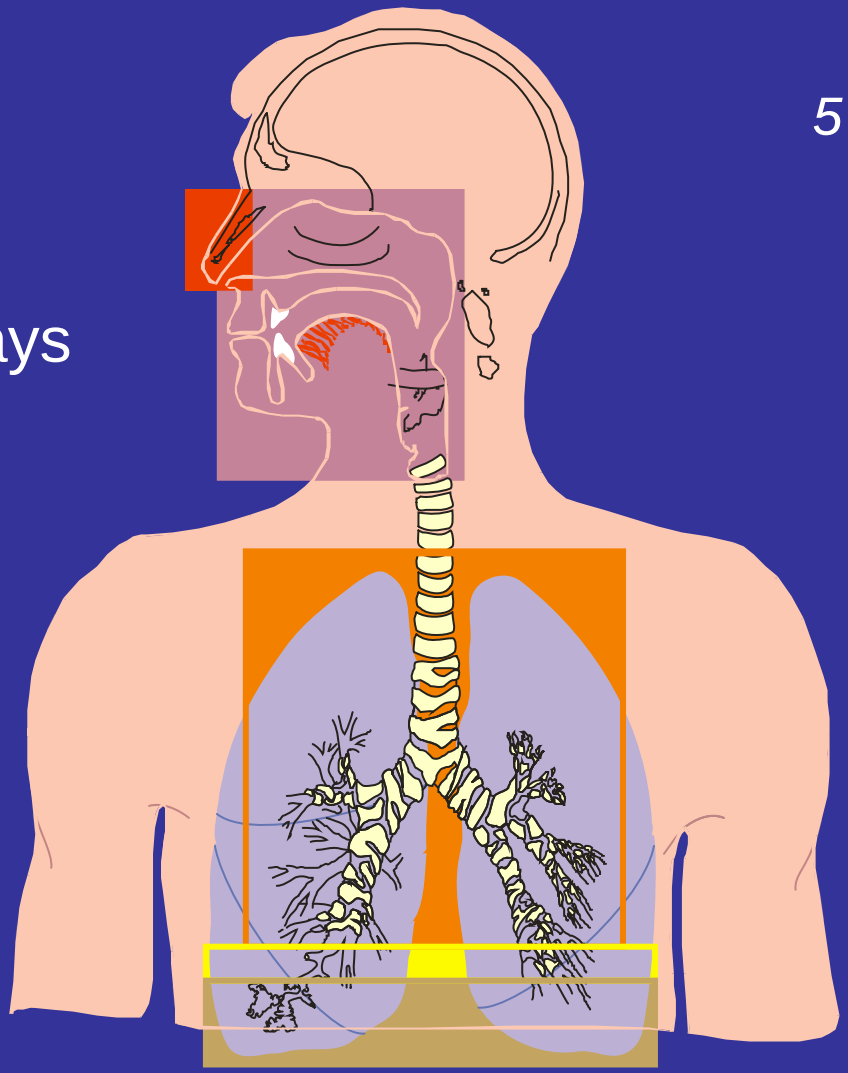
Bronchial

BB

bb

Alveolar interstitial

AI



Respiratory tract model

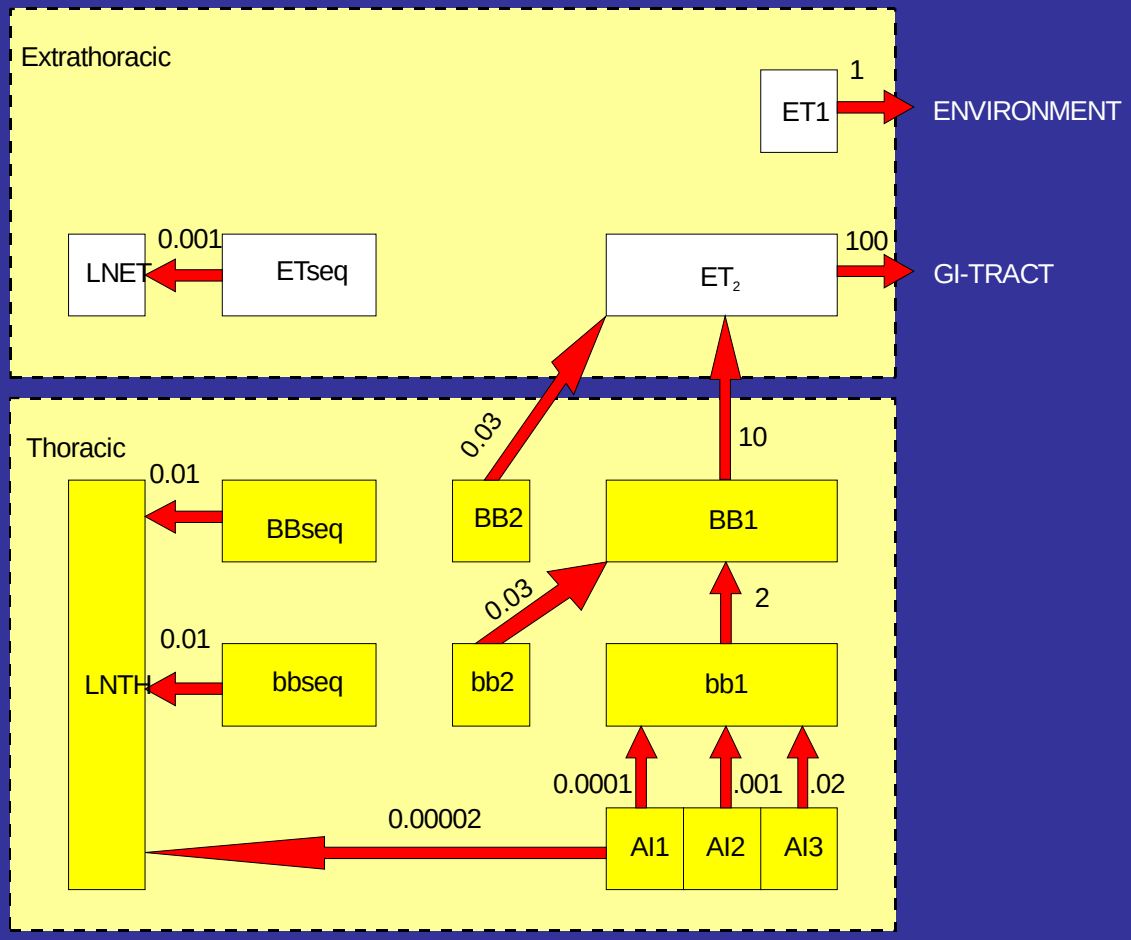
ET_1

ET_2

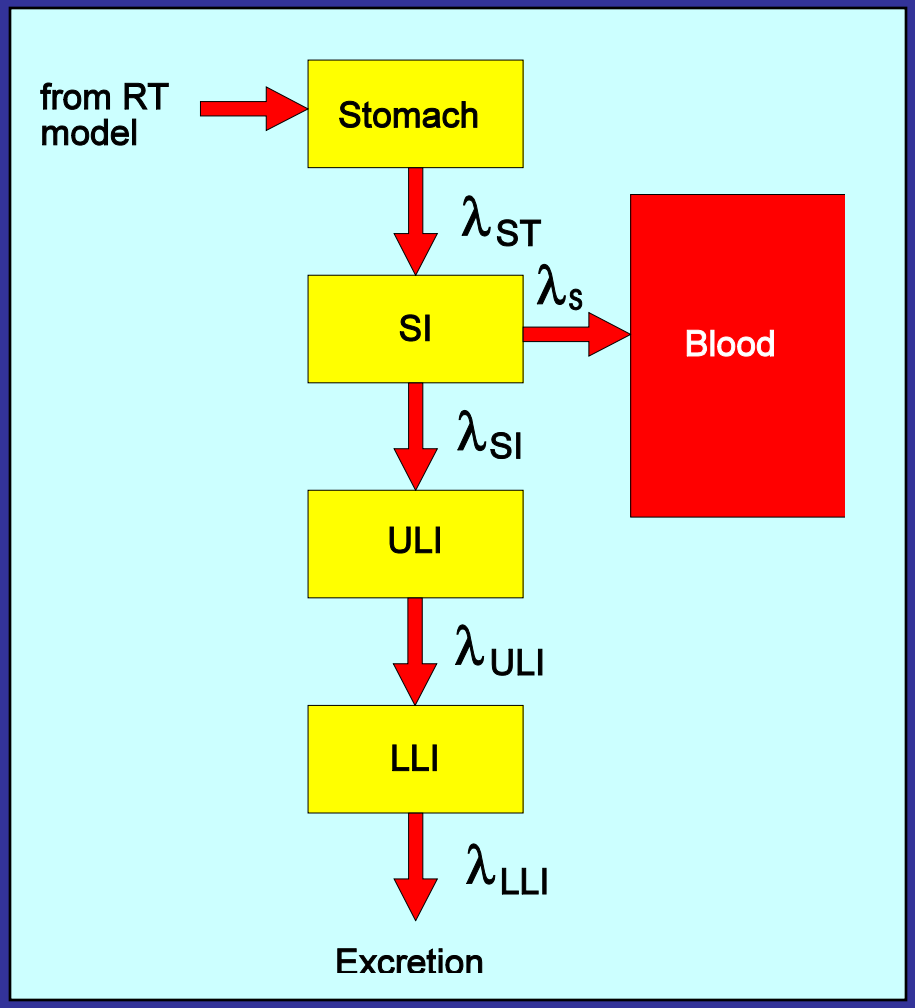
BB

bb

AI



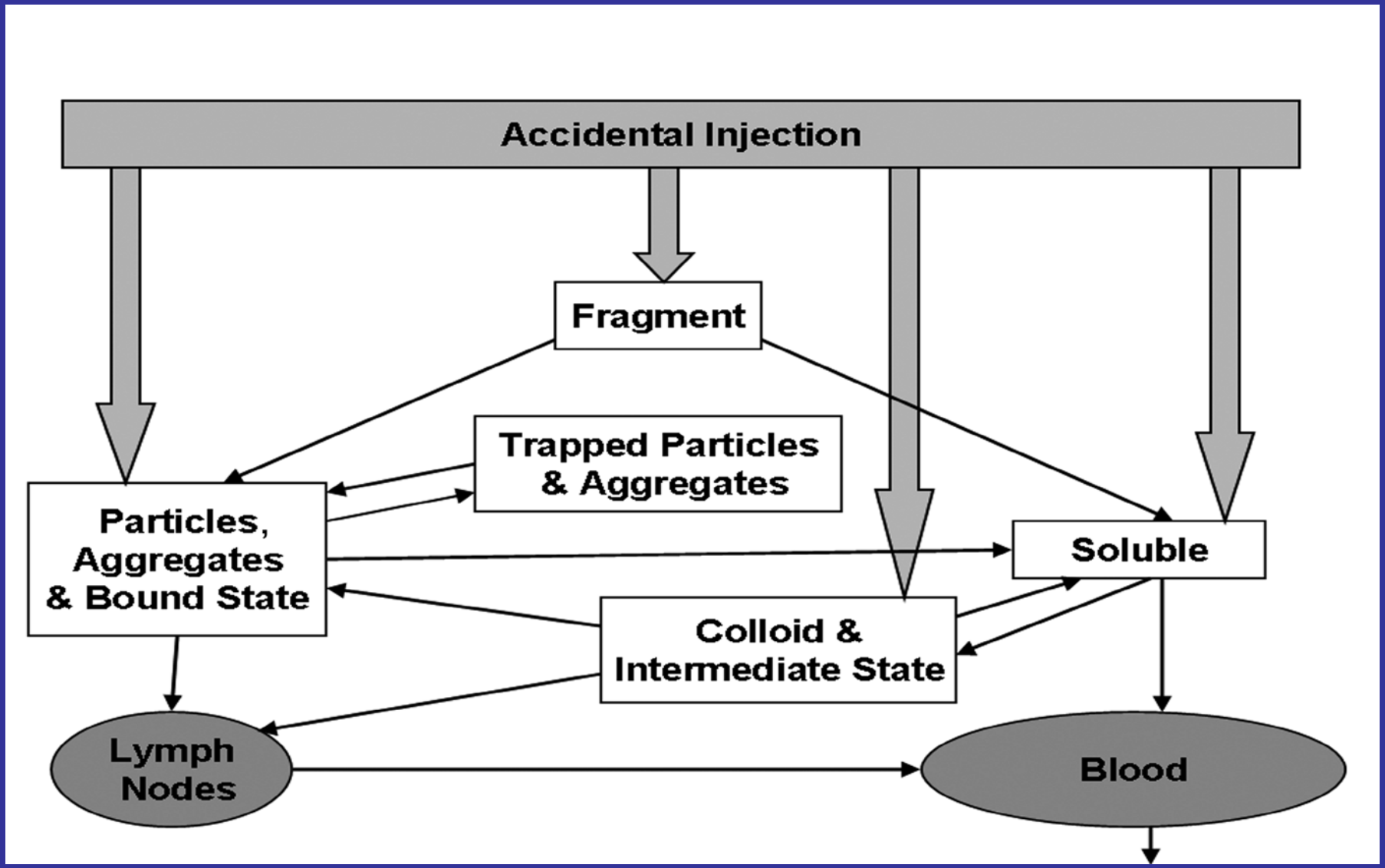
GI tract model



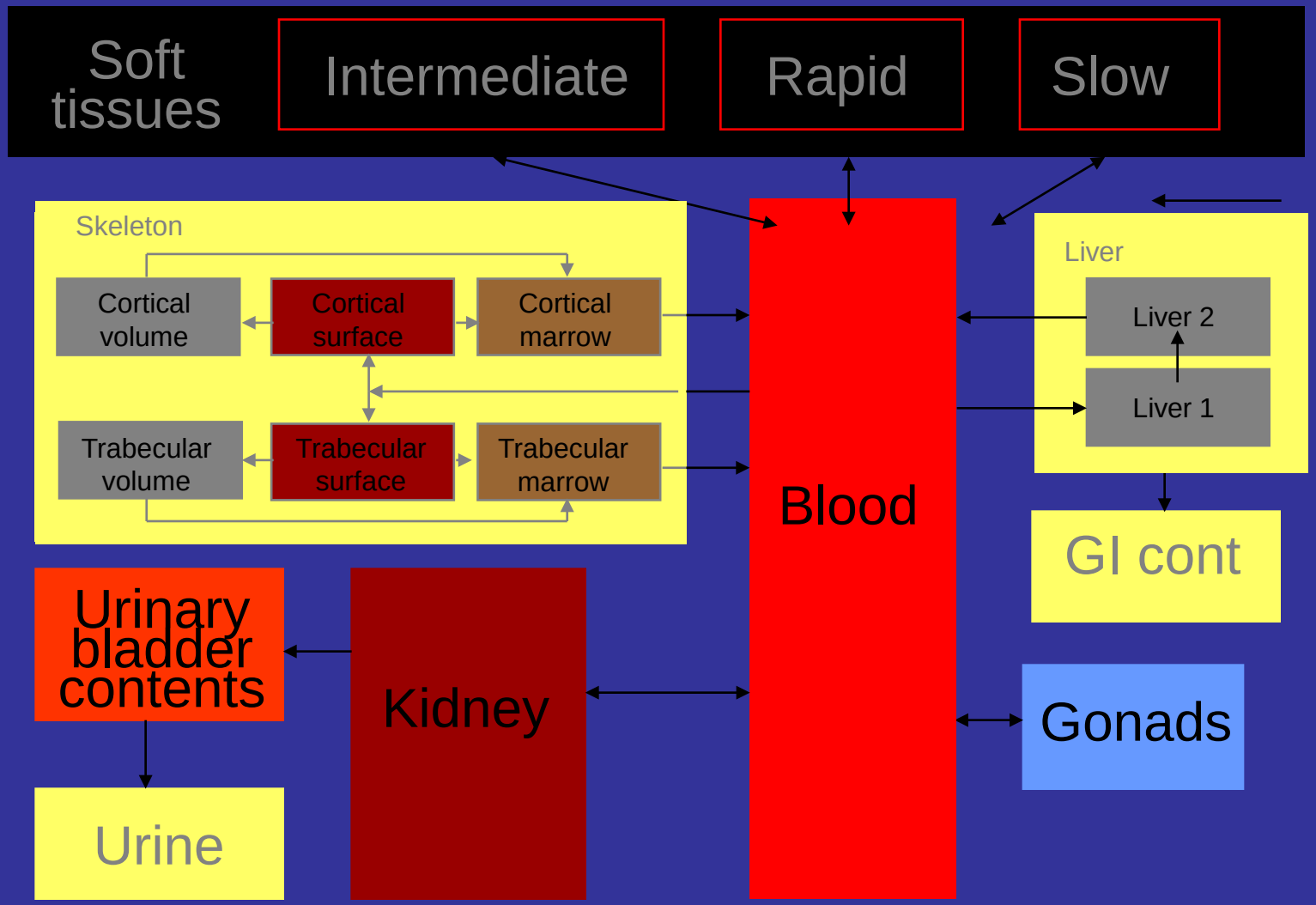
Rate constant	Rate (d^{-1})
λ_{ST}	24
λ_{SI}	6
λ_{ULI}	1.8
λ_{LLI}	1

$$f_1 \cdot \frac{\lambda_s}{\lambda_s \cdot \lambda_{SI}}$$

Wound model


Accidental Injection
Fragment
Trapped Particles & Aggregates
Particles, Aggregates & Bound State
Soluble
Colloid & Intermediate State
Lymph Nodes
Blood

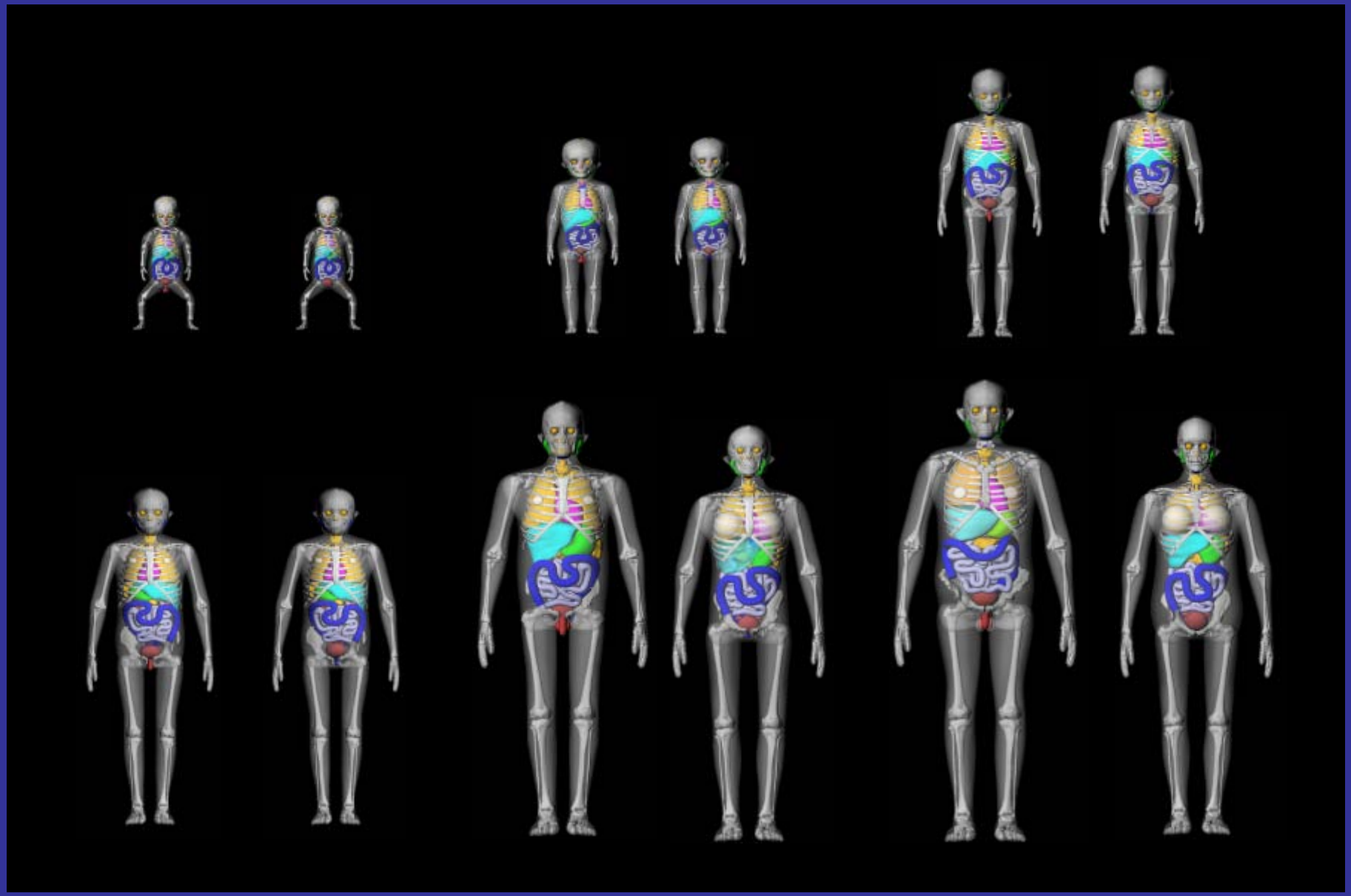
Systemic model (Pu)



Dosimetric models

- Calculate the doses to target organs per decay of a radionuclide in source organs.
- Tools:
  - Radionuclide decay data (new ICRP values)
  - Anthropomorphic phantoms (Wes Bolch)
  - Radiation transport software (MCNP)

UF Family of Hybrid Phantoms



Statistical methods

- Classical
- Bayesian
- Mixture of classical and Bayesian

Intake	Form	Tissue	Best Estimate (Gy Bq^{-1})	Lower Bound (Gy Bq^{-1})	Upper Bound (Gy Bq^{-1})	Ratio of Upper to Lower Bound
Chronic inhalation of ^{14}C	CO_2	Red marrow	$8.1\ 10^{-11}$	$4\ 10^{-12}$	$2\ 10^{-10}$	50
Acute inhalation of ^{90}Sr	Exposure to unknown form	Lung Bone Red marrow	$7.7\ 10^{-10}$ $4.7\ 10^{-7}$ $2.0\ 10^{-7}$	$5\ 10^{-10}$ $3.8\ 10^{-8}$ $2\ 10^{-9}$	$3\ 10^{-6}$ $5.8\ 10^{-6}$ $3\ 10^{-7}$	6,000 150 150
Acute ingestion of ^{131}I	Incorporated in food	Thyroid	$4.2\ 10^{-7}$	$1.8\ 10^{-7}$	$1.0\ 10^{-6}$	5.4
Acute ingestion of ^{137}Cs	Incorporated in food	Colon Red marrow	$1.3\ 10^{-8}$ $1.4\ 10^{-8}$	$6\ 10^{-9}$ $8\ 10^{-9}$	$3\ 10^{-8}$ $1.6\ 10^{-8}$	5 2
Acute inhalation of ^{137}Cs	Exposure to unknown form	Lung Colon Red marrow	$3.0\ 10^{-9}$ $6.0\ 10^{-9}$ $5.0\ 10^{-9}$	$1\ 10^{-9}$ $1\ 10^{-9}$ $1\ 10^{-9}$	$6\ 10^{-7}$ $1\ 10^{-8}$ $1\ 10^{-8}$	600 10 10

Dealing with uncertainties: Monte-Carlo method

parameter 1

parameter 2

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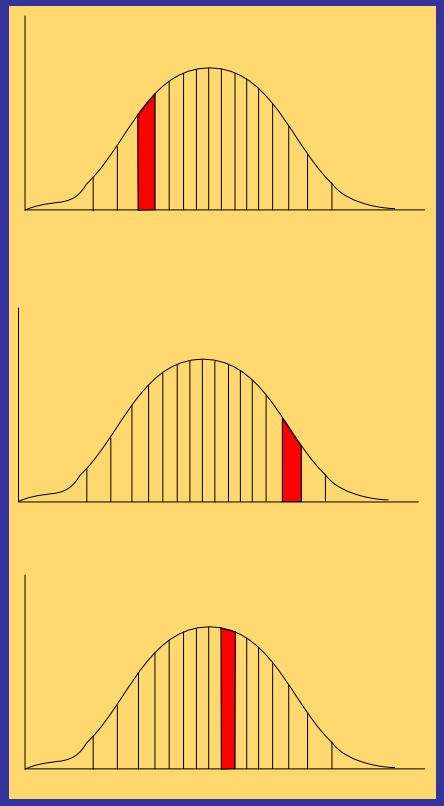
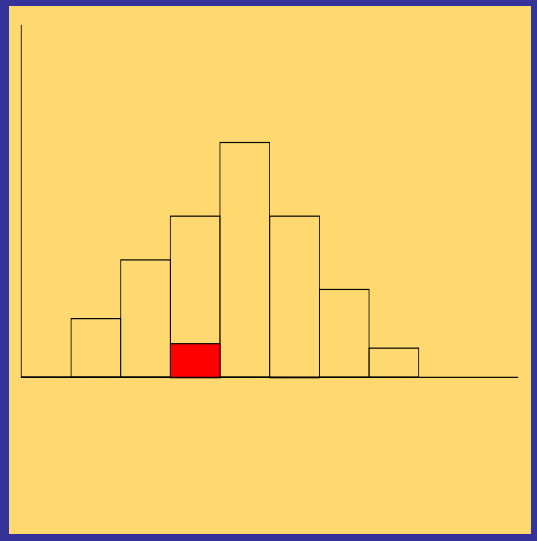
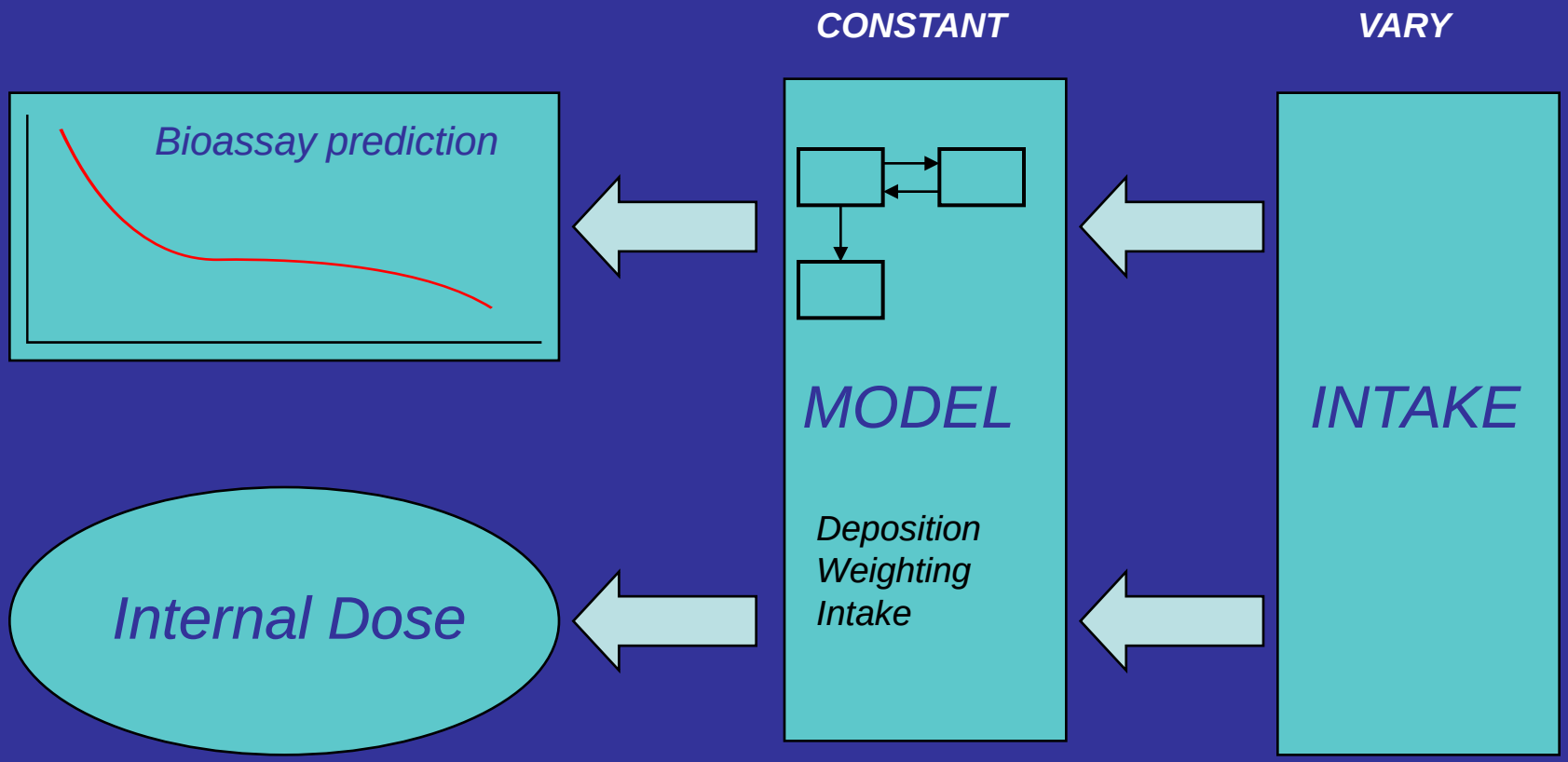
parameter n



MODEL

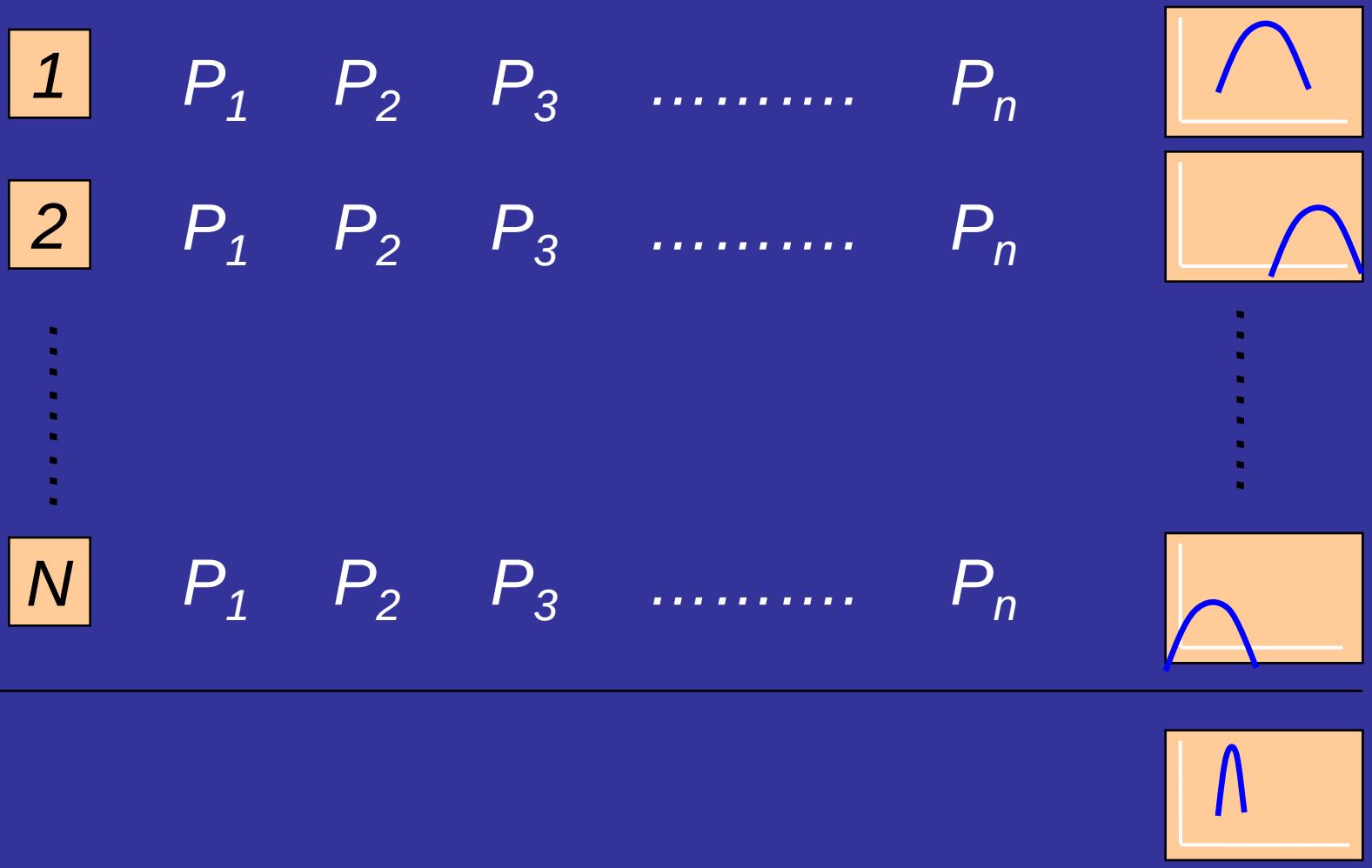


Dealing with uncertainties: regulatory world



A new method for dealing with uncertainties

The WeLMoS method



List of examples

- Atomic veteran (occ.)
- Chernobyl (env.)
- Thyroid cancer (med.)
- Lymphoma (med.)
- Lymphoma (med.)
- Tritium (occ.)
- Nuclear reactor (occ.)
- DoE worker (occ.)
- Sr-90 (env.)
- DU shrapnel wound
- Pu-238 (occ.)
- Goiania (env.)
- Pu wound (NCRP)
- Inhaled DU (Bayesian/WelMos)
- Inhaled Am-241
- Information transfer
- Mayak (Bayesian)

Timelines

- First draft:
  - June 2008
  - Reviewed by 5 experts
- Second draft:
  - February 2009
  - Reviewed by all NCRP members
- Final draft:
  - July 2009?

THE END

Thank you for your attention.