

ICRP Perspective on Internal Dosimetry

OIR and Radiopharmaceuticals

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Disclaimer

The information and views set out in this presentation are those of the author and do not necessarily reflect the official opinion of ICRP and ICRP Committee 2.

Especially, I will present some draft information which may still be subject of change.

The Role of ICRP

is to develop, maintain, and elaborate the international system of radiological protection used world-wide as the common basis for radiological protection standards, legislation, guidelines, programmes, and practice.

This includes the task to provide (internal) dose coefficients and bioassay data for reference workers, reference members of the public and reference patients in diagnostic nuclear medicine.

For this the development of state of the art biokinetic and dosimetric models is needed.

History of ICRP Publications on Internal Dosimetry

Workers

Members of the public

Patients

ICRP 2 (1959)

ICRP 30 (1979 ff)

ICRP 68 (1994)

OIR (2015 ff)

ICRP 72 (1995)

EIR

ICRP 53 (1988)

ICRP 80 (1998)

ICRP 106 (2008)

ICRP 128 (2015)

ICRP 128 rev

Need to develop the OIR Series

Last revision of dose coefficients for workers (Publication 68) more than 20 years ago

Since that time

- Publication 100: New model for the Human Alimentary Tract (HATM)
- Publication 103: New standards for radiation protection (new effective dose concept etc.)
- Publication 107: New nuclear decay data
- Publication 110: New voxel phantoms for the derivation of dosimetric parameters based on new reference person data (Publication 89)

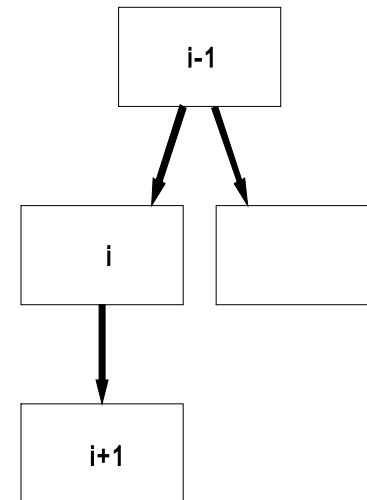
and new biokinetic information

Biokinetic Models

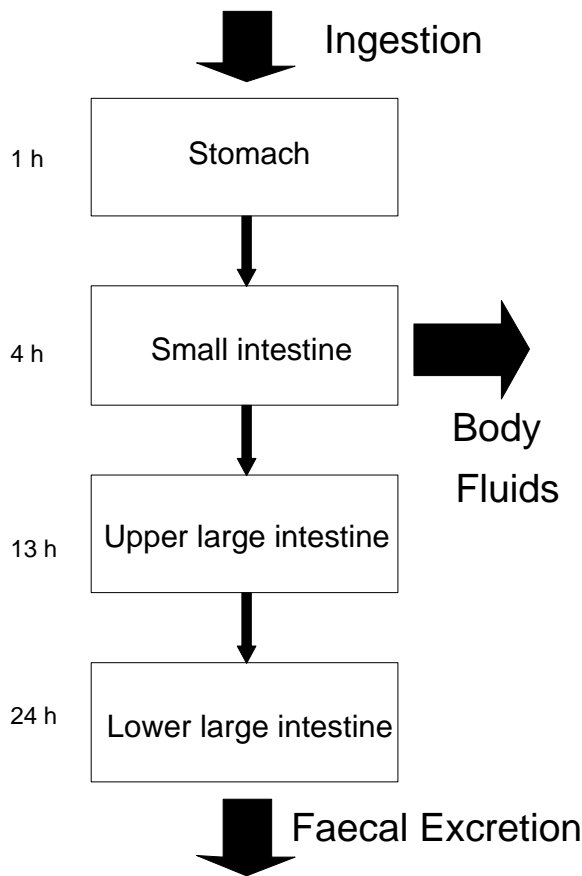
Biokinetic models describe deposition, distribution and retention of radionuclides within the body. Their aim is the calculation of the number of nuclear transformations in source regions (S) where radionuclides accumulate.

There are biokinetic models for the alimentary tract, the respiratory tract, and for the systemic circulation including excretion.

ICRP develops compartment models.

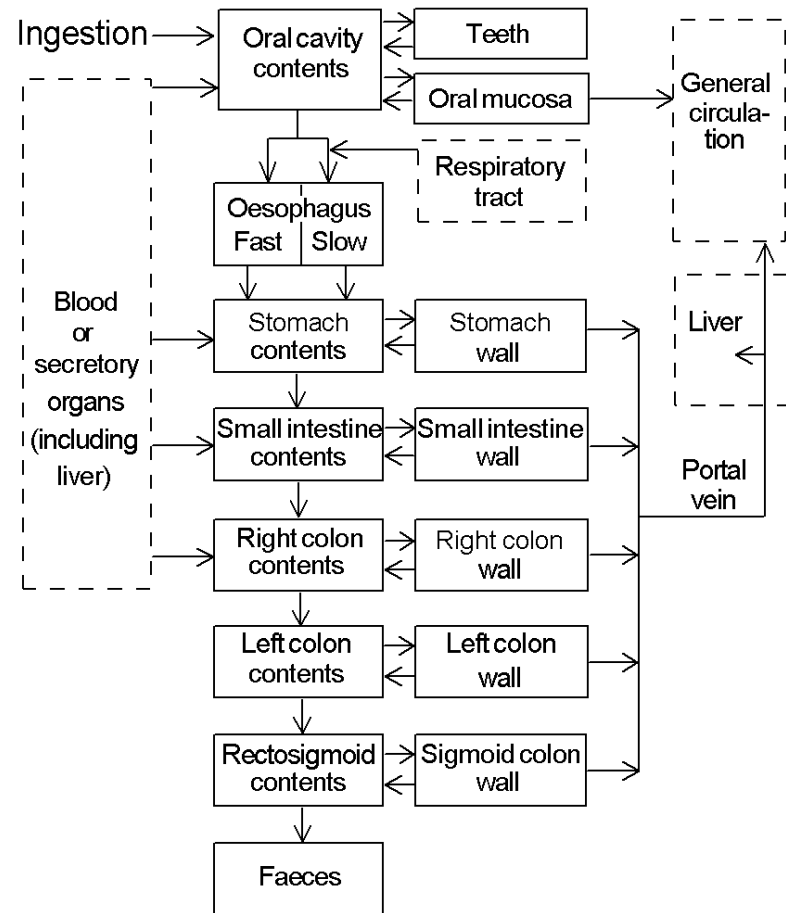
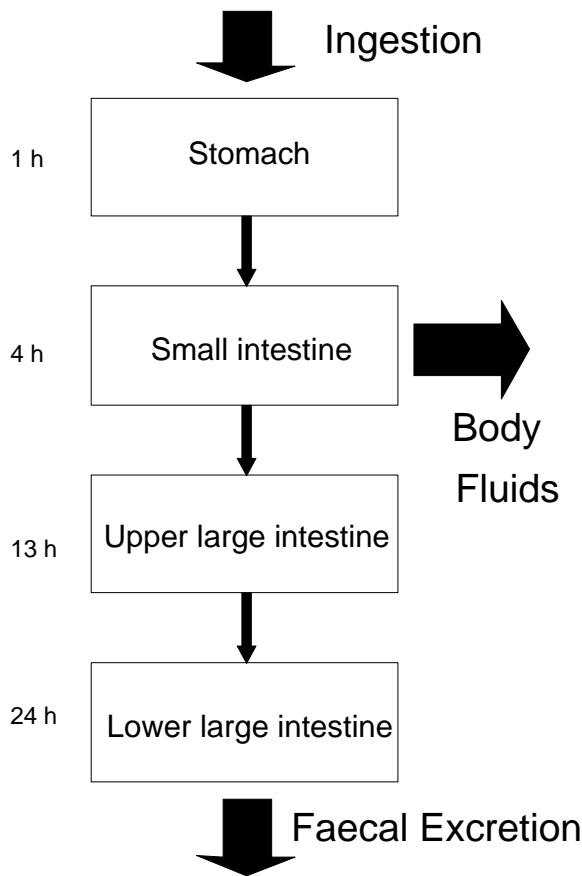


Biokinetic Model for the Gastro-intestinal Tract (ICRP 30)



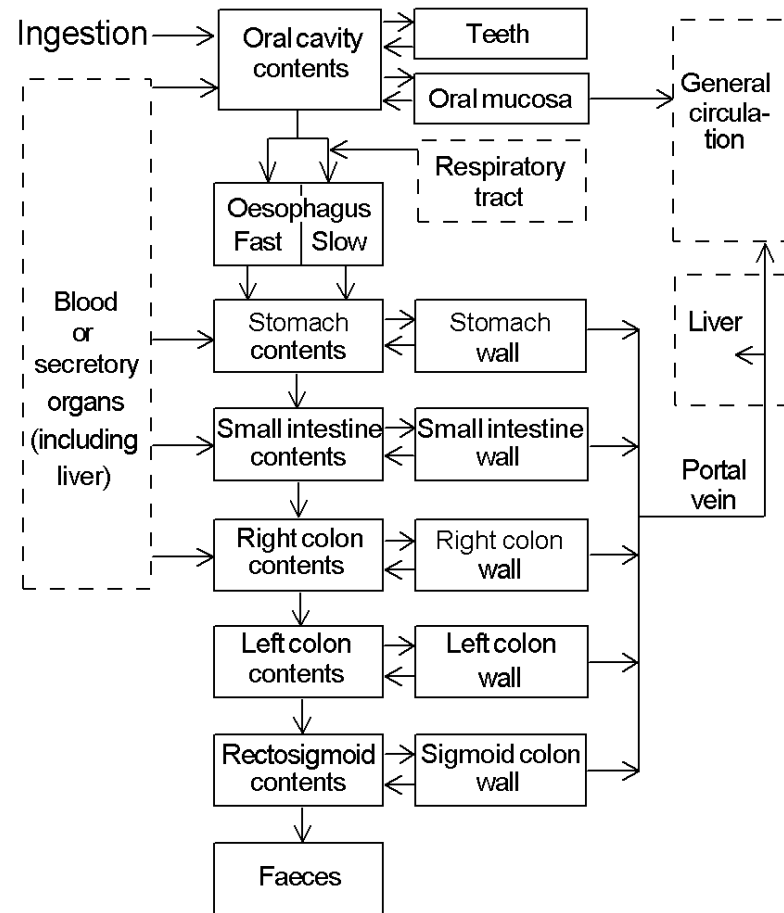
- Four compartments
- Transfer rates through the tract independent of age, sex, and ingested material
- Absorption to blood (only) from the small intestine; its fraction (f_1) is dependent on the solubility of the element and its compound

Biokinetic Models for the Alimentary Tract (ICRP 30/100)



Biokinetic Models for the Alimentary Tract (ICRP 100)

- More compartments
- Transfer rates through the tract dependent on age, sex, and material
- Absorption to blood possible from the whole tract with potential retention in the walls; its total fraction (f_A) is dependent on the solubility of the element and its compound



Mechanisms to be Considered by (ICRP) Respiratory Tract Models

Deposition in various (extrathoracic and thoracic) regions of the respiratory tract

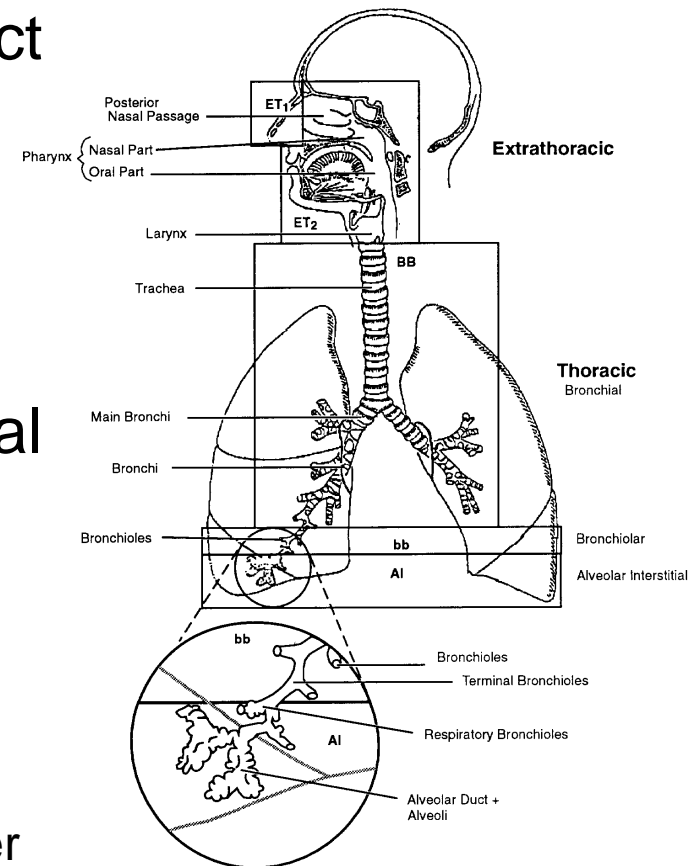
dependent on the physical properties of the aerosol, mainly its size

Mechanic transfer to the extrathoracic region (with subsequent transfer into the alimentary tract) and to the regional lymph nodes

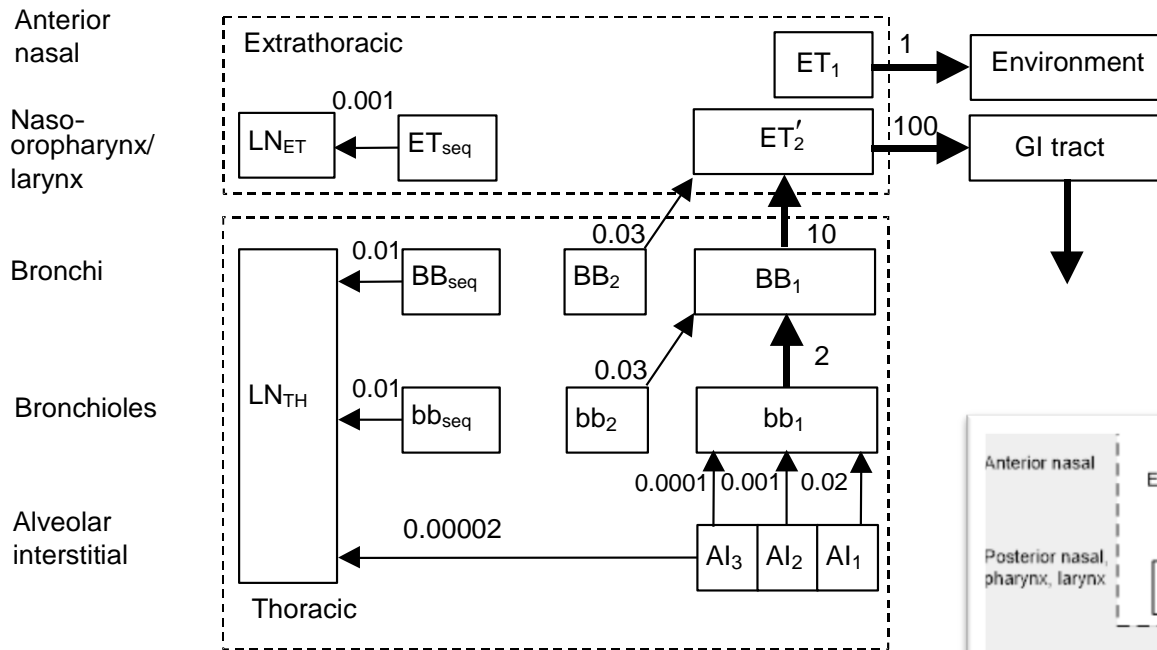
considered to be independent of the material

Absorption to blood

dependent on the chemical properties of the material; there are default absorption parameter sets in ICRP models

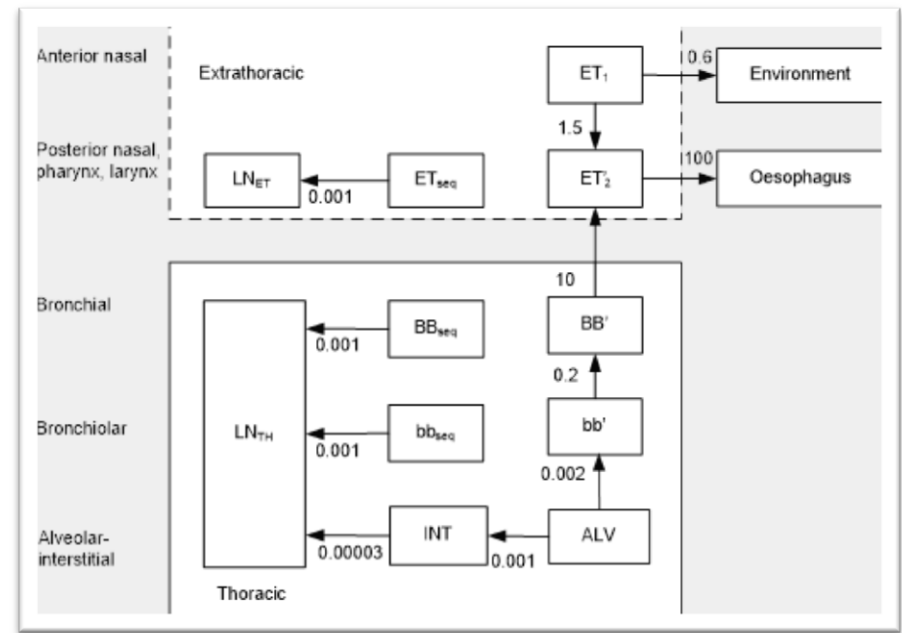


Respiratory Tract Models of ICRP 66 and OIR



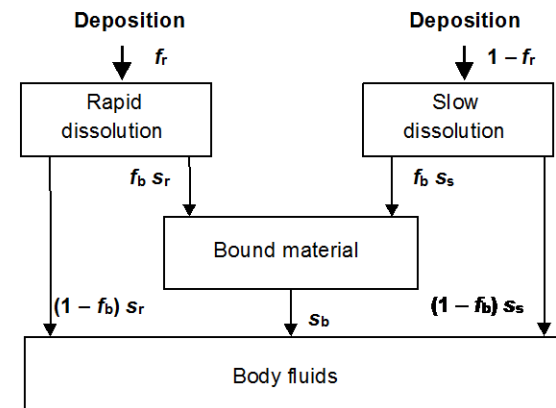
ICRP 66

OIR

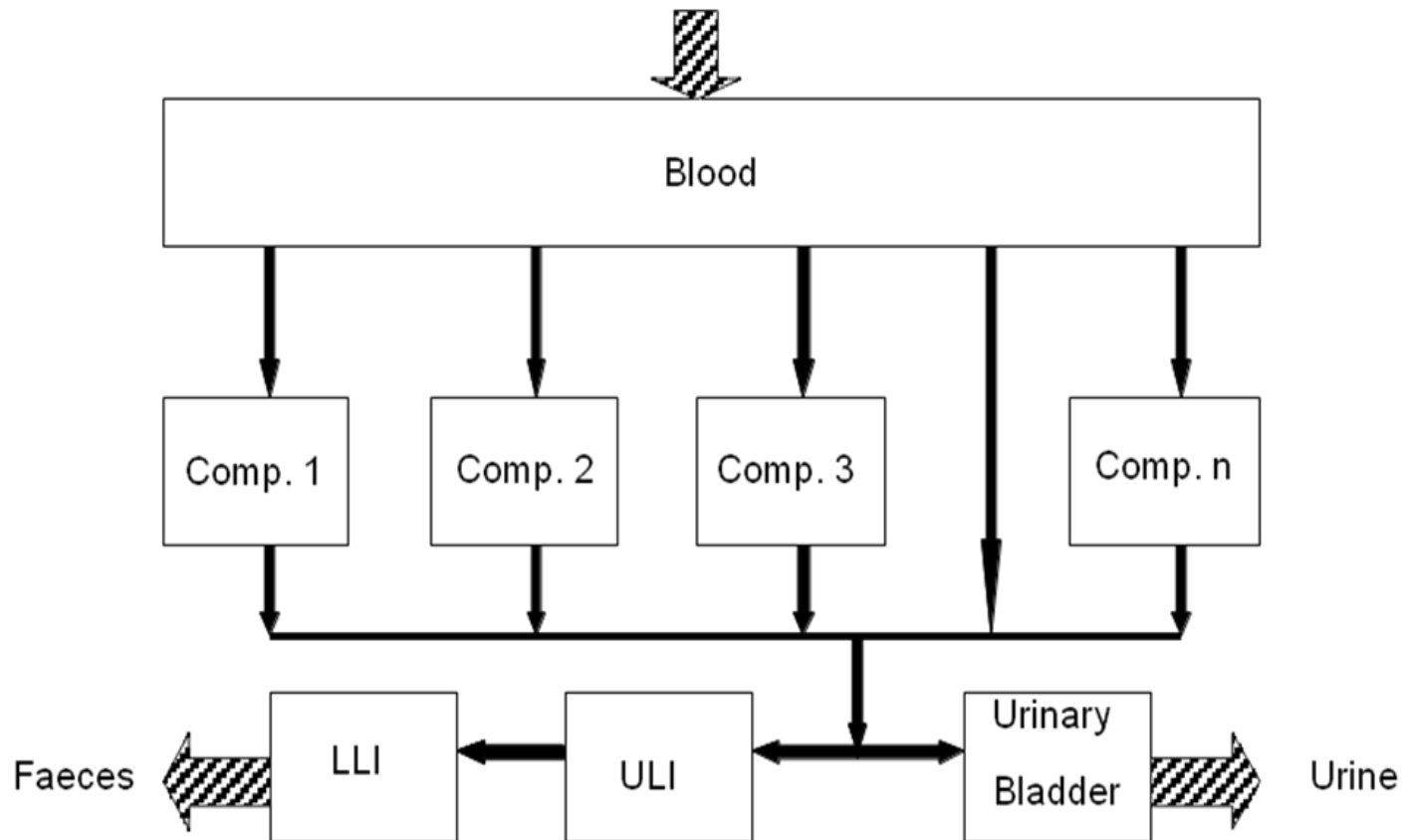


Changes of the HRTM in the OIR Series

- Material in the anterior nasal region is partly transferred to the posterior nasal region, pharynx and larynx.
- For absorption, all default absorption Types F, M, and S are considered.
- Additionally, further compound-specific absorption parameters are defined, if information is available.
- Also the bound state is considered in the absorption process, if information is available.



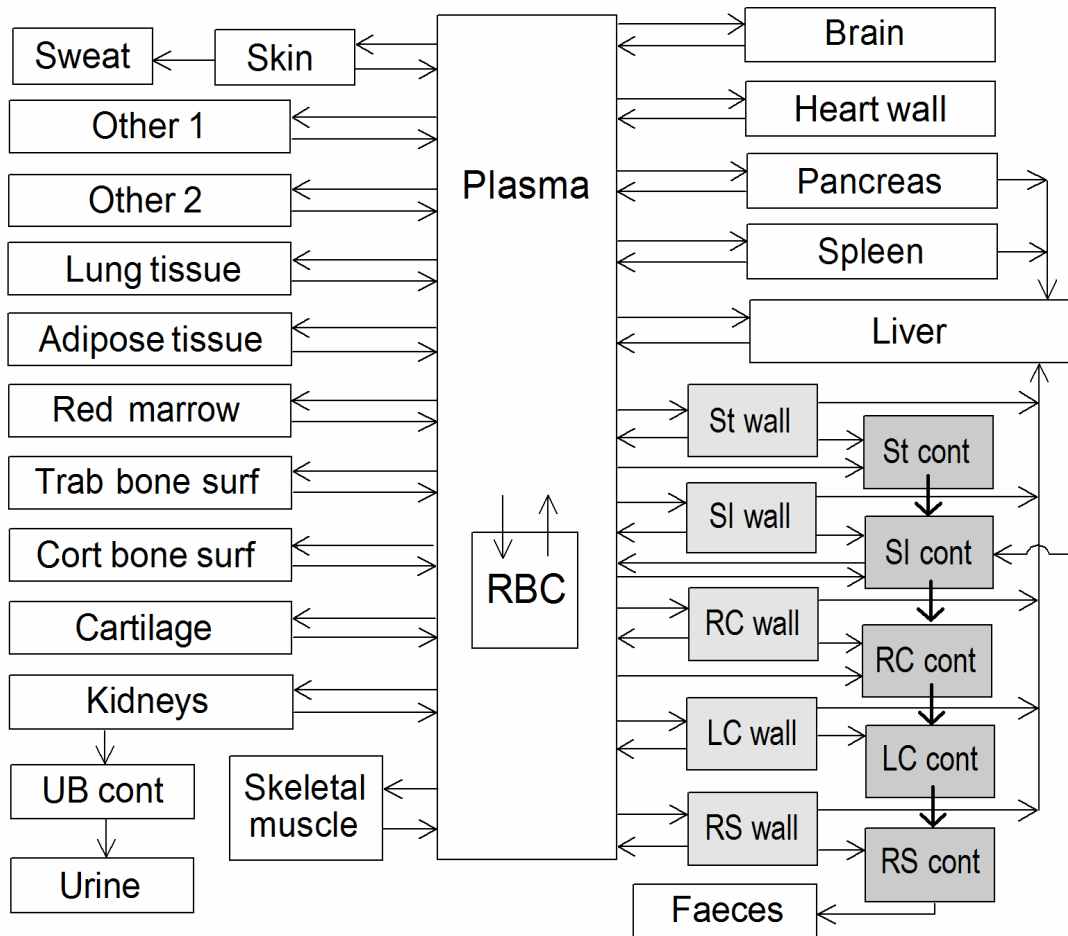
Generic Biokinetic Systemic Model (ICRP 67)



Caesium:	Comp. 1	10%
biological half-time 2 d	Comp. 2	90%
d		biological half-time 110

Excretion: 80% urine, 20% faeces

Systemic Models in the OIR Series

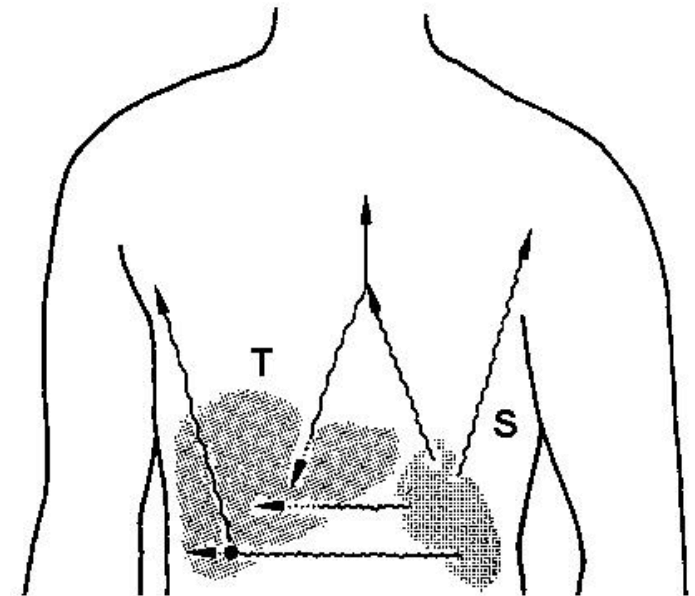


- Complex recycling models on a physiological basis
- Independent daughter kinetics

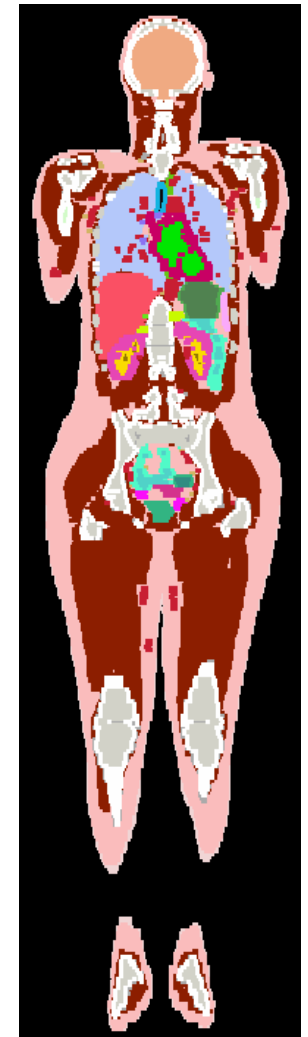
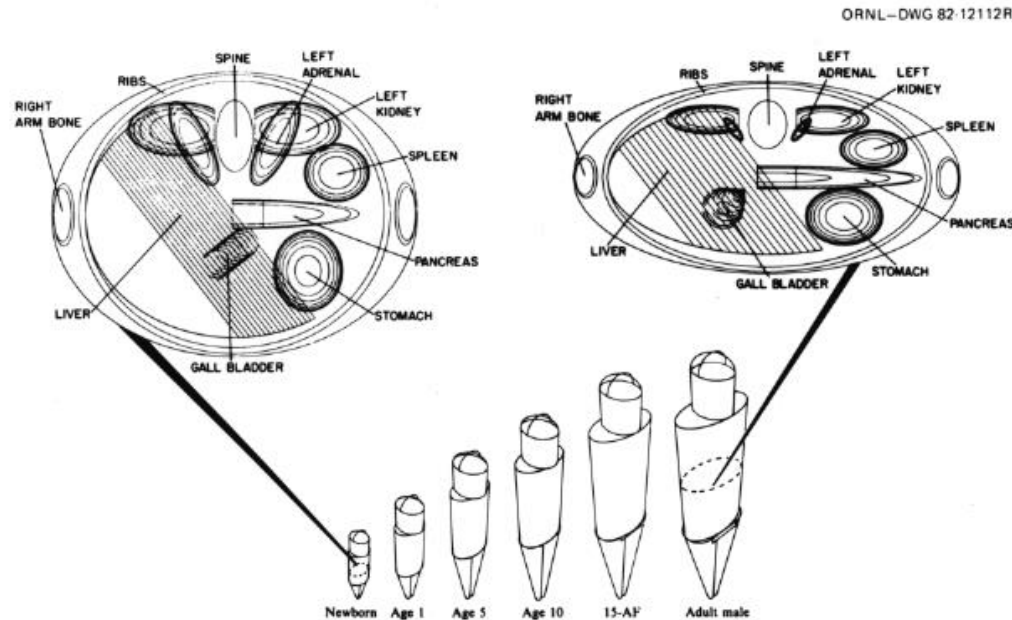
Dosimetric Models

Dosimetric models are used to calculate the doses to target tissues (T) caused by nuclear transformations in a source region S.

For penetrating radiation anthropomorphic phantoms are needed.



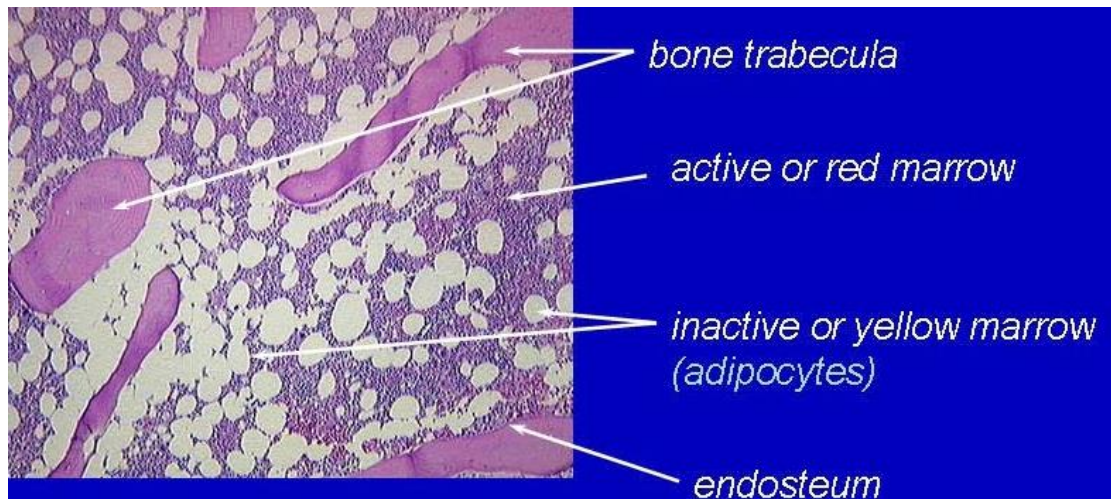
Move from Mathematical to Voxel Phantoms



Mathematical phantoms have been replaced by voxel phantoms (ICRP Publication 110), based on medical images of actual subjects and adjusted to the dimensions and organ masses of the male and female reference adults defined in ICRP Publication 89.

New Dosimetry for the Skeleton

- Target tissues are the red bone marrow and the endosteal tissues with a thickness of 50 μm (instead of 10 μm for bone surfaces in the former assumptions)
- Absorbed fractions are calculated on the basis of micro-CT images of the skeleton with fluence-to-dose response functions which are coupled with the particle fluence inside specific bone regions.



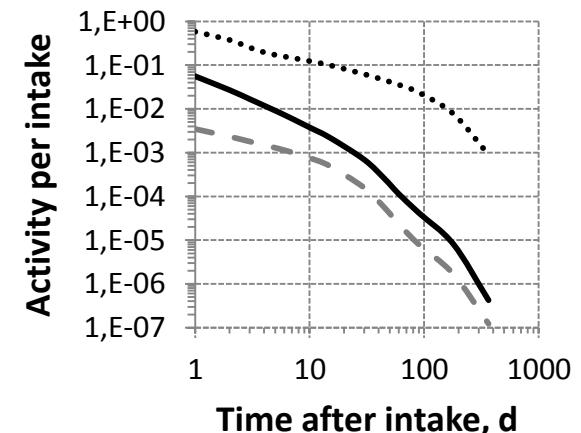
Further Dosimetric Changes

- The voxel phantoms are also used for calculation of SAF values for β radiation (with β spectrum data given in ICRP Publication 107).
- According to ICRP Publication 100 doses to the walls of the alimentary tract are calculated for radiation sensitive cells in a depth between 60-100 μm (stomach wall) and 280-300 μm (colon walls).
- The effective dose is calculated with the radiation and tissue weighting factors of ICRP Publication 103, using sex-averaged organ doses.

Content of the OIR Element Sections

- Radioisotopes with most relevant decay characteristics and chemical forms in the workplace
- Lung absorption parameters
- Absorption from the alimentary tract
- Systemic distribution, retention, and excretion
- Individual monitoring data
- Effective dose coefficients and bioassay data (dose per content) for the most relevant radioisotopes

More doses and bioassay data will be given electronically.



Status of OIR Reports

Part 1 has been published as Publication 130
Models

Part 2 is in press as Publication 134
H, C, P, S, Ca, Fe, Co, Zn, Sr, Y, Zr, Nb, Mo, Tc

Part 3 (final?) version from January 2017 to be submitted
to the MC for final approval
Ru, Sb, Te, I, Cs, Ba, Ir, Pb, Bi, Po, Rn, Ra, Th, U

Part 4 will be submitted to the MC for final approval next
time
15 lanthanides and 10 actinides

Part 5 will be published (much) later
(all?) other elements

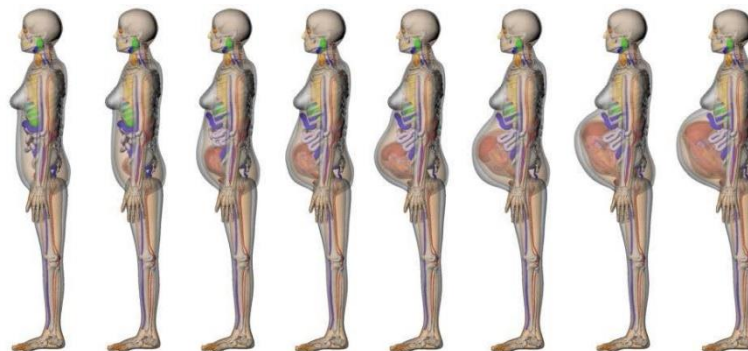
EIR Reports

Such as ICRP Publication 68 is updated by the OIR report series, ICRP Publication 72 with age-dependent doses for members of the public will be updated accordingly.

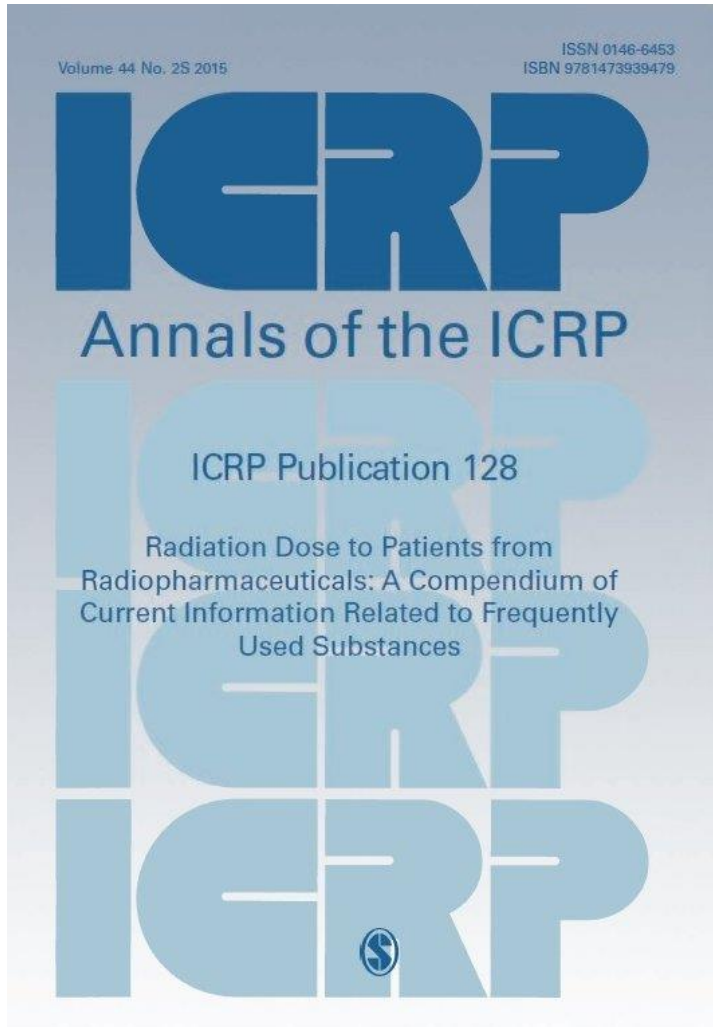
This is being performed by the preparation of the Environmental Intake of Radionuclides (EIR) series.

The EIR series will include revisions of Publication 88 (doses to the embryo and foetus) and Publication 95 (doses to infants by ingestion of mothers' milk).

For this, SAF values for reference children, pregnant and fetusses are needed.



Radiopharmaceutical Reports



Age-dependent doses to patients from radiopharmaceuticals administered in (diagnostic) nuclear medicine

Compilation of the latest information for frequently used radiopharmaceuticals in ICRP Publication 128

Special Characteristics in the Radiopharmaceutical Reports

- MIRD Terminology
- Organ doses in Gy
- Biokinetic models in general more simple
- If applicable, different sets of model parameters dependent on specific diseases
- Non-linear kinetics for the urinary bladder content considering filling and voiding of the bladder

Revision of ICRP Publication 128

Harmonisation with OIR and EIR documents

- Common MIRD/ICRP terminology
- Same dosimetric models (SAF values, methodology to calculate effective dose)
- Use of HATM (and revised HRTM)
- More complex biokinetic models for systemic activity if appropriate

Will be done during the next 3 years.

Conclusions

ICRP continues to develop state of the art biokinetic and dosimetric models for the calculation of (internal) dose coefficients and bioassay data for reference persons.

The role of EURADOS can be to give guidance in the application of the more and more complex models in specific cases for dose assessment.