

State of the Art Modelling and Measurement of Internal Dose from Contaminated Food

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Disclaimer

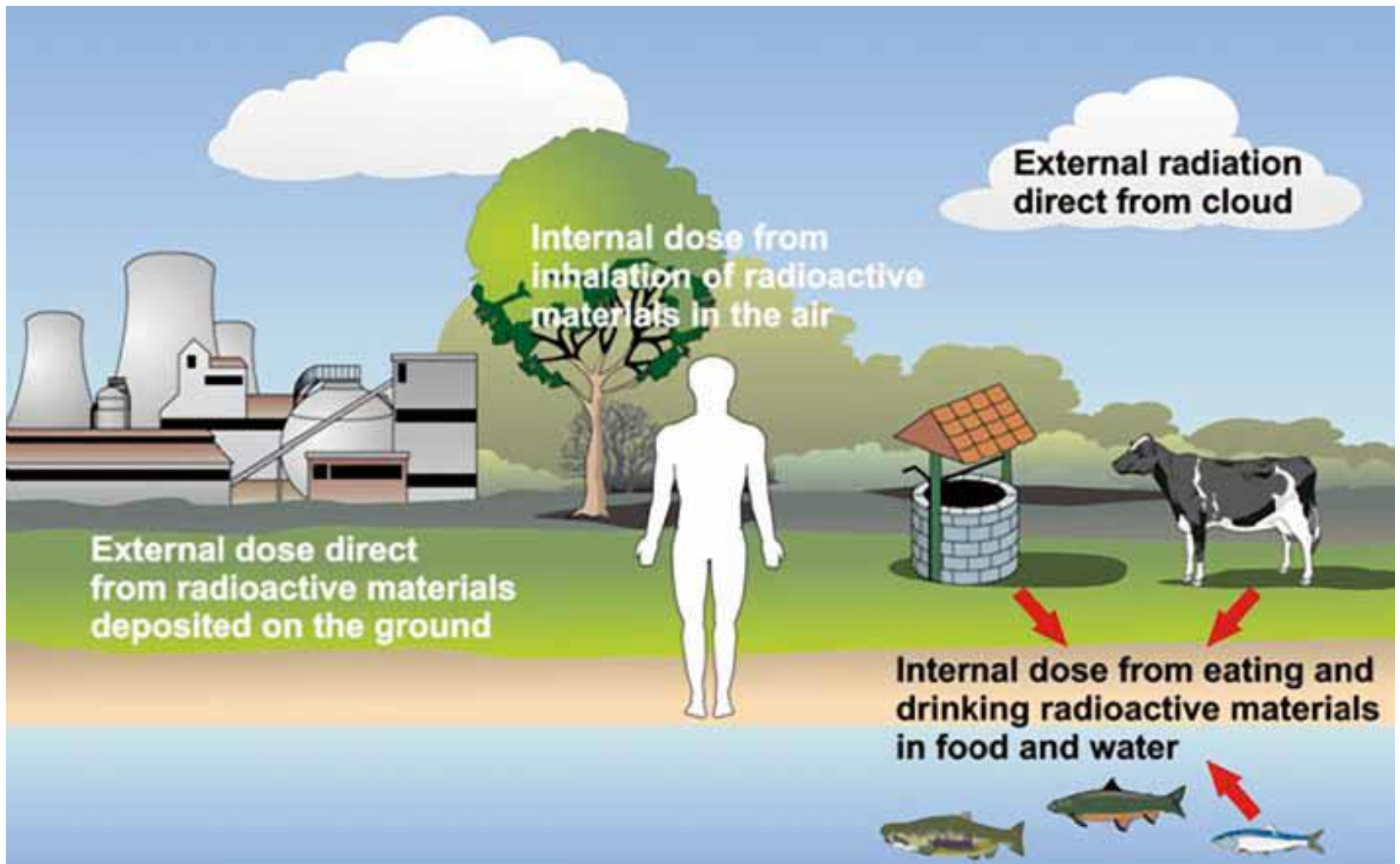
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Especially, the draft information may still be changed.

Measurements and Models in Internal Dosimetry

- Internal dose cannot be measured
- For internal dose assessment models are needed
- Measurements are needed to determine input parameters (for example, ingested activity)
- Measurements can be used to verify model results

Exposure of Man



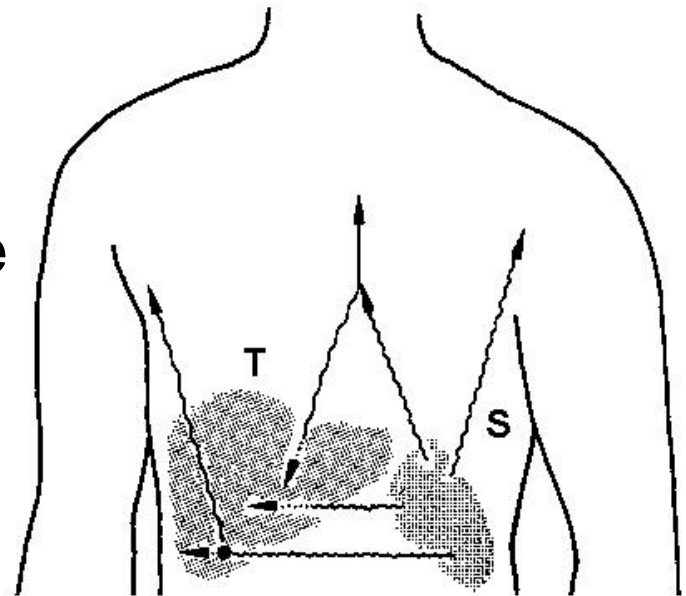
Determination of Ingested Activity

- Measurement of ingested food (and drinking water)
 - for example meal duplicates
 - costly, only possible for some individuals
- Measurement of time-dependent specific activity in food categories in various regions and assumptions on food consumption rates
 - Uncertainties of assumed consumption rates and origin of the food
- Determination of time-dependent specific activity in food categories from measurement results of the source term with radioecological models and assumptions on food consumption rates
 - Additional uncertainties from the use of radioecological models

Models for Internal Dosimetry

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

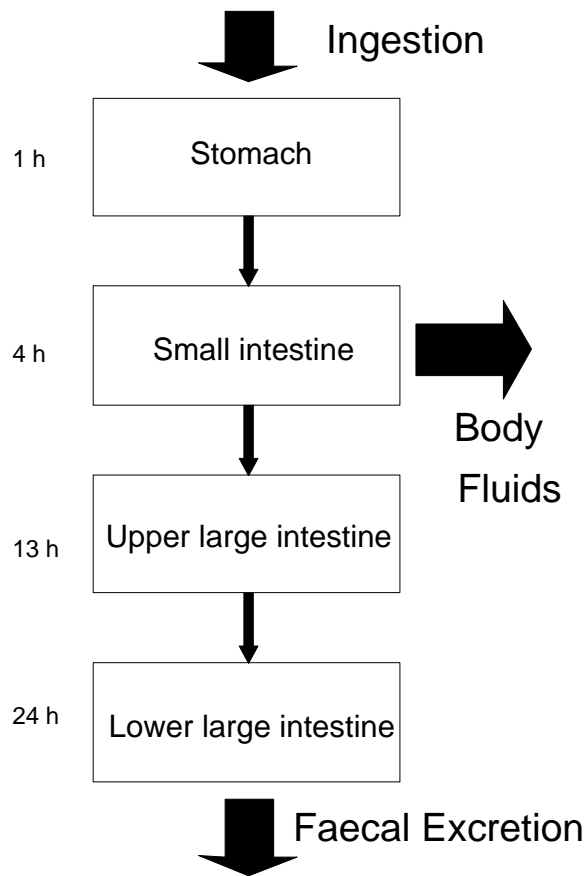
Dosimetric Models are used to calculate the doses to target tissues (T) caused by nuclear transformations in source regions



(Main) Content of this Presentation

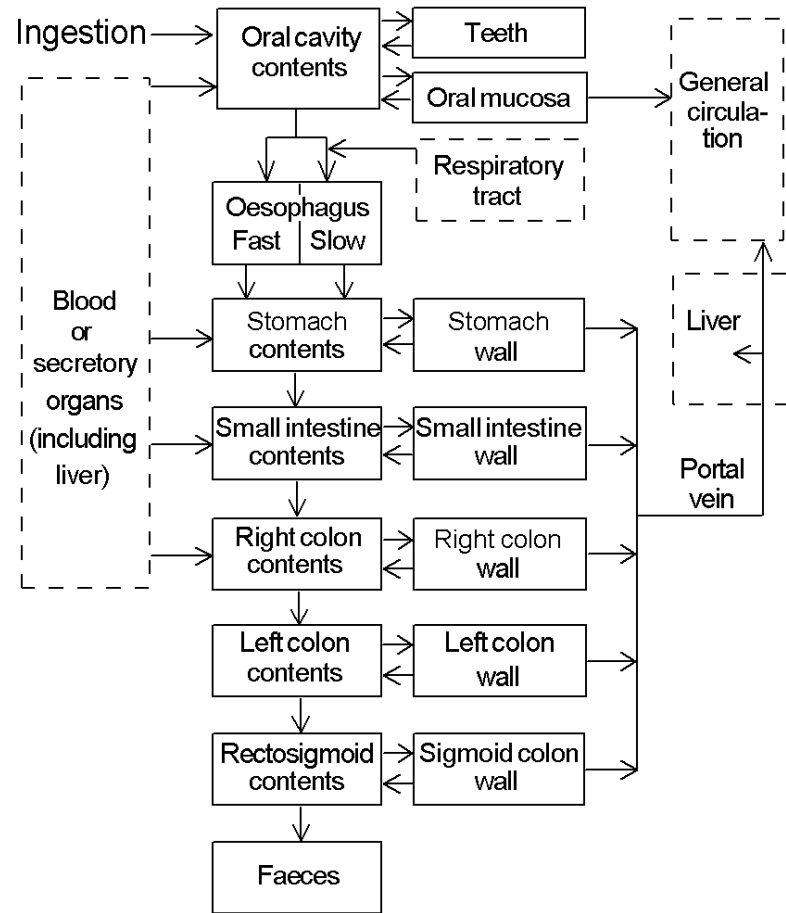
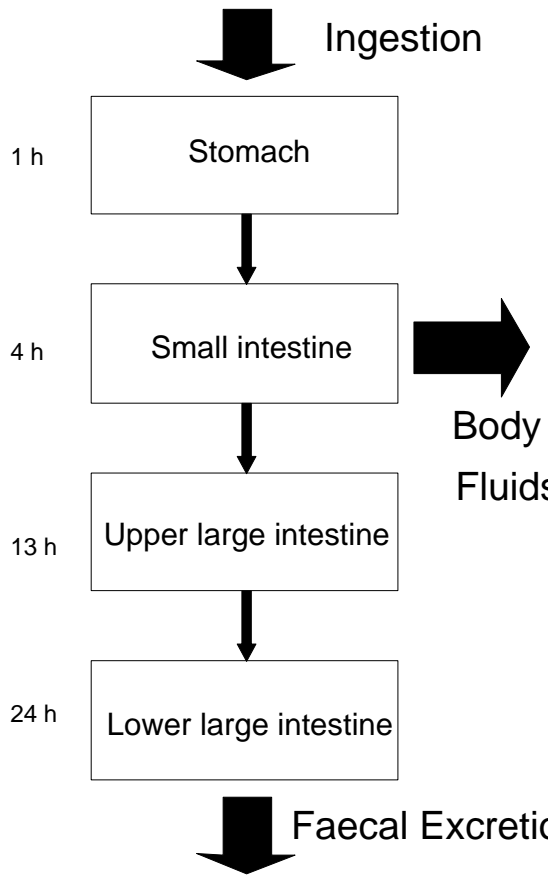
- Biokinetic and dosimetric models underlying the present dose coefficients (ICRP Publications 68 and 72)
- Outlook to future biokinetic and dosimetric models (ICRP OIR and EIR Publications)
- Expected changes of dose coefficients
also indicating uncertainties

Biokinetic Model for the Alimentary Tract (ICRP 30)



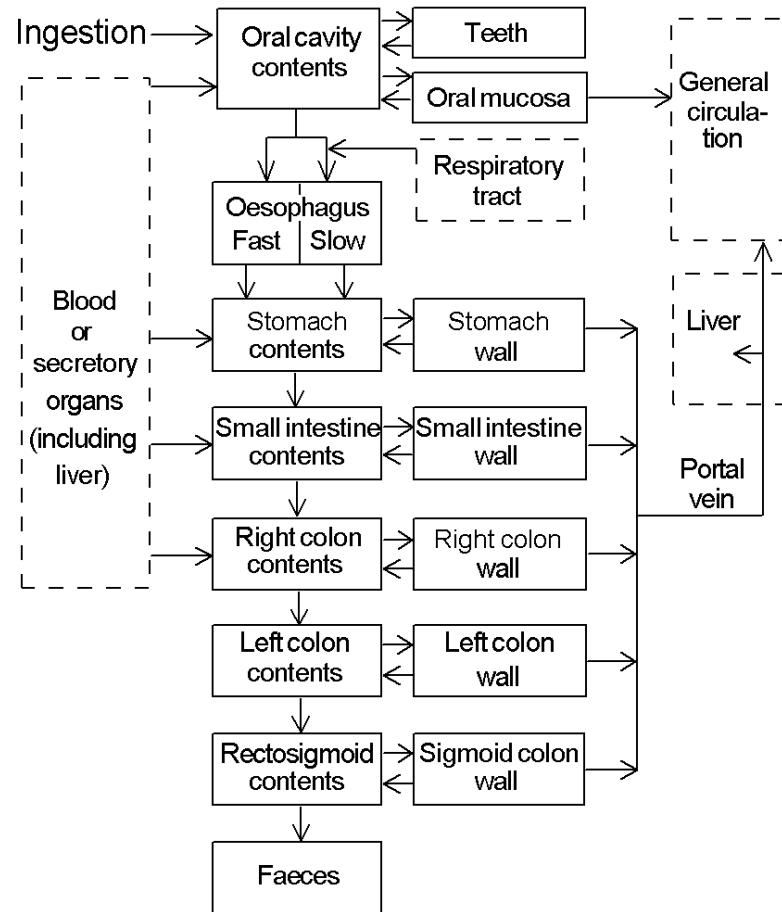
- Four compartments
- Transfer rates through the tract independent of age, sex, and ingested material
- Absorption to blood (only) from the small intestine; its fraction (f_1) is dependent on the solubility of the element and its compound

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



Biokinetic Model 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 possible retention in the walls; its total fraction (f_A) is dependent on the solubility of the element and its compound



f_A Values

- The range of f_A (and f_1) values is between 10^{-5} and 0.99
- f_A values are larger for infants (mostly by a factor of 2 or 10)
- Examples of f_A values (for adult members of the public, according to ICRP 72) are

Iodine	0.99
Caesium	0.99
Strontium	0.3
Plutonium	$5 \cdot 10^{-4}$

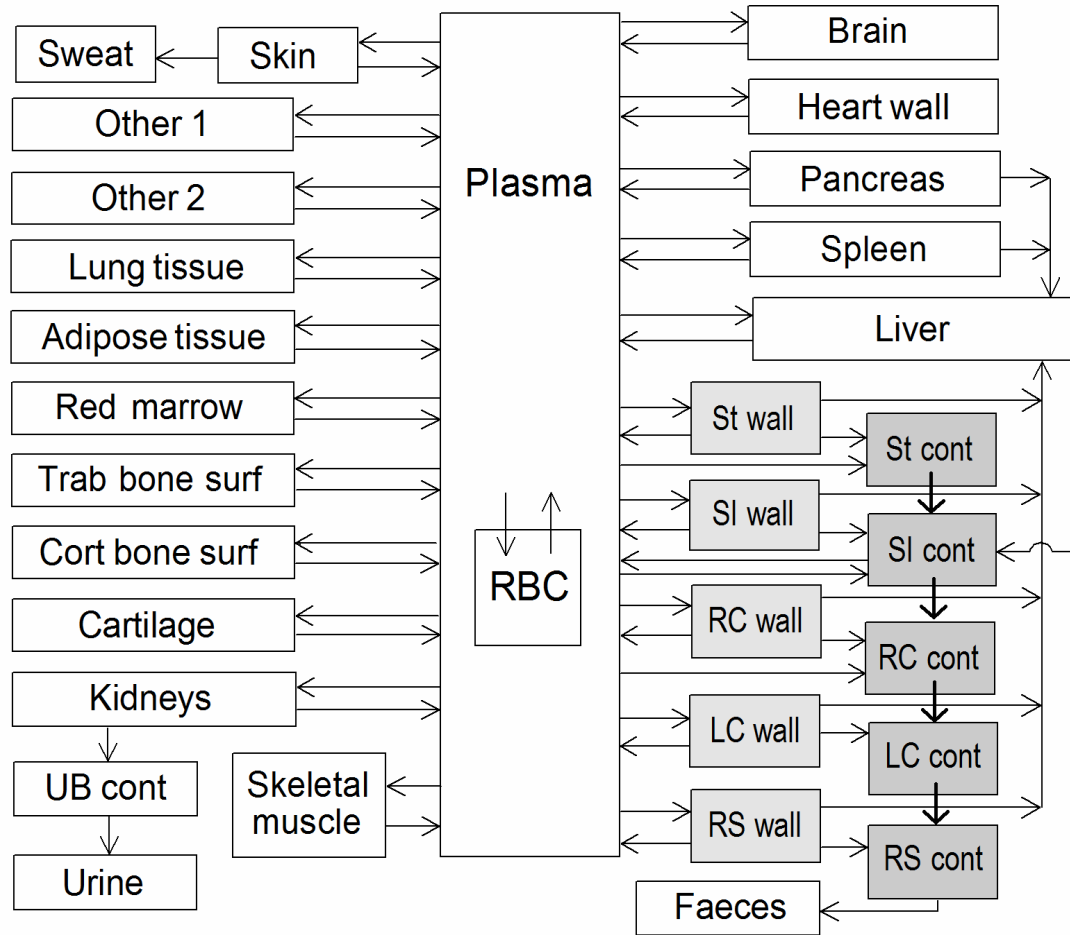
Age- and Sex-Dependence of Caesium Biokinetics

Biological half-times according to ICRP 67

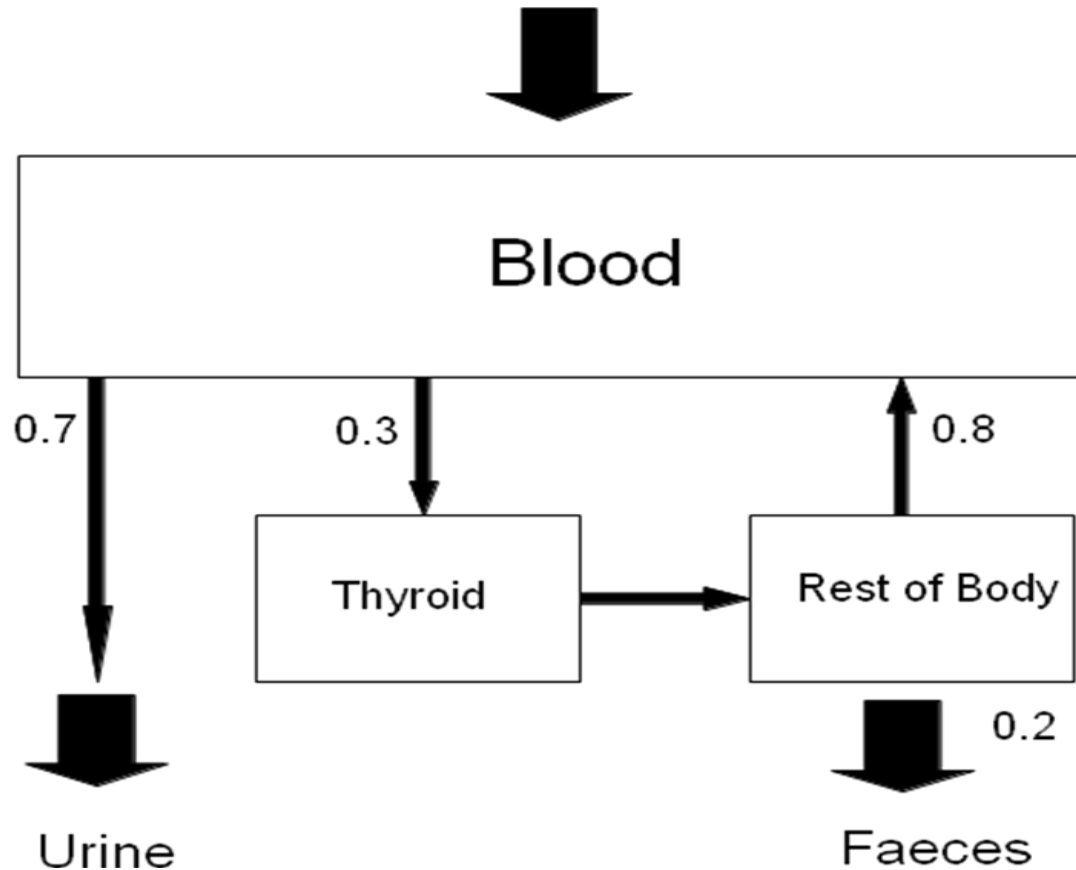
Age	Distribution (%)		Biological Half-Time (d)	
	Comp. 1	Comp. 2	Comp. 1	Comp. 2
adult	10	90	2	110
15 y	13	87	2.2	93
10 y	30	70	5.8	50
5 y	45	55	9.1	30
1 y	-	100	-	13
infant	-	100	-	16

The long-term biological half-time is about 25% lower for adult females compared to adult males

Draft Biokinetic Model for Systemic Caesium (ICRP OIR Report Part 3)



Biokinetic Model for Systemic Iodine (ICRP 67)

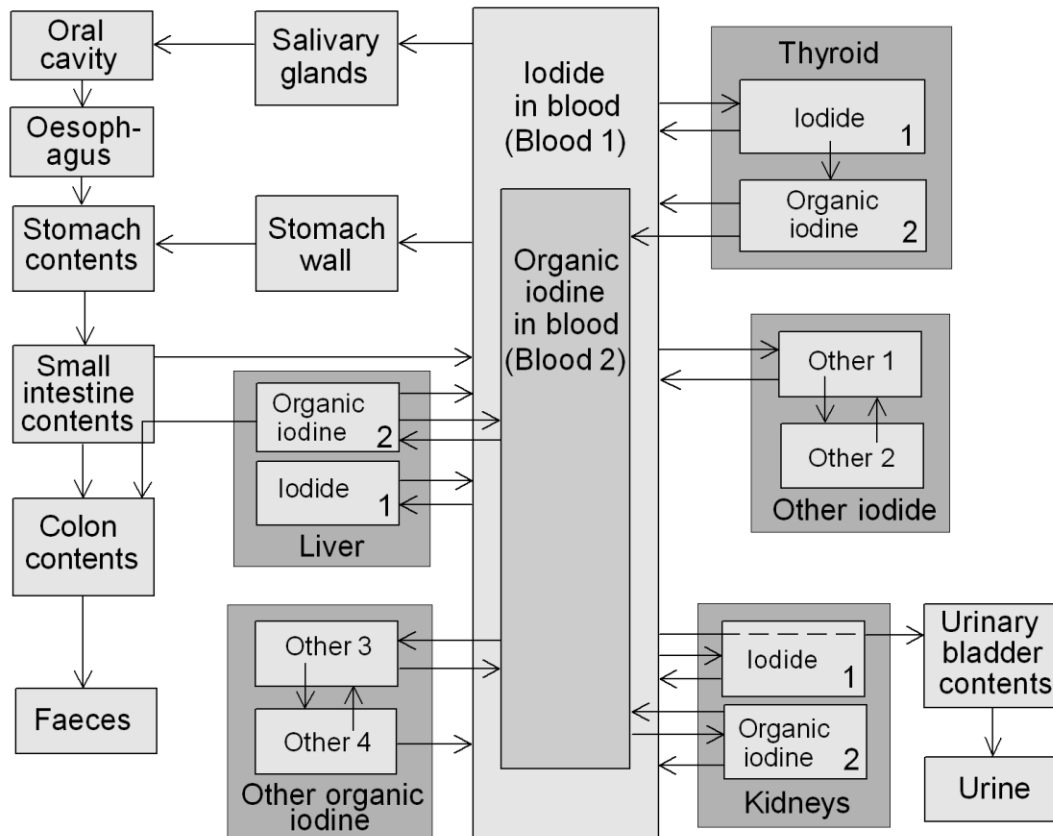


Age-Dependence of Iodine Biokinetics

Biological half-times (d) according to ICRP 67

Age	Thyroid	Rest of Body
adult	80	12
15 y	67	6.7
10 y	58	5.8
5 y	23	2.3
1 y	15	1.5
infant	11.2	1.12

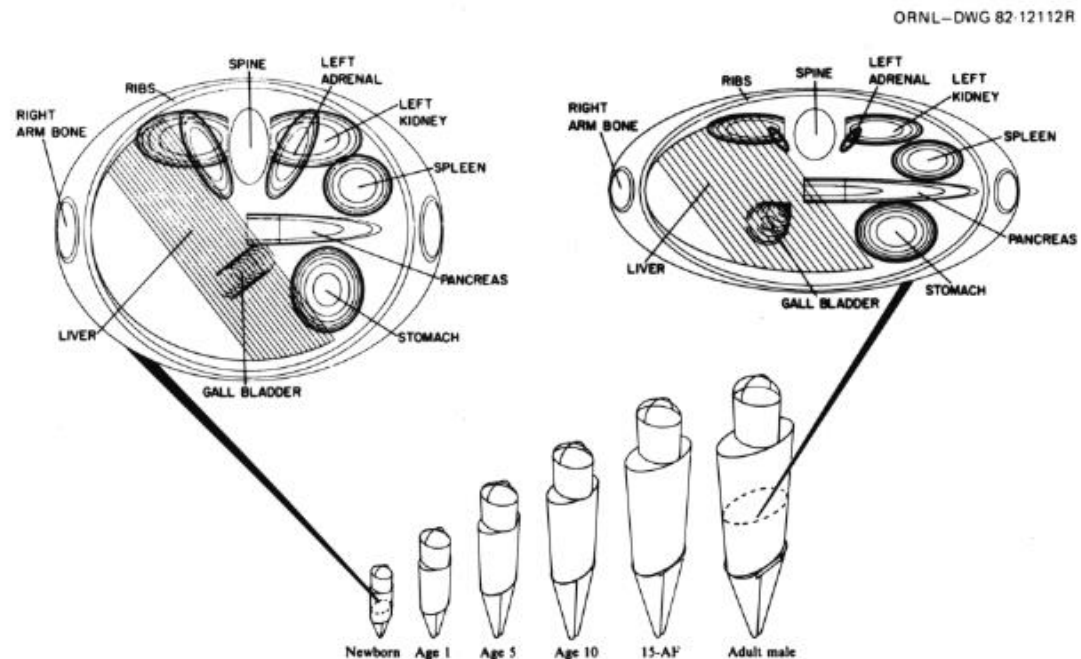
Draft Biokinetic Model for Systemic Iodine (ICRP OIR Report Part 3)



Dosimetric Models of ICRP Publication 72

In most cases the general assumption for absorbed fractions $AF(T \leftarrow S)$ was $AF(T \leftarrow S) = 1$ for $S = T$ and $AF(T \leftarrow S) = 0$ for $S \neq T$ for α and β radiation.

For γ radiation mathematical phantoms were used for the calculation of $AF(T \leftarrow S)$:



Dosimetric Models for the ICRP OIR Reports



Much more realistic voxel phantoms are used for the calculation of absorbed fractions for electrons and γ radiation.

These are 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

Adult voxel phantoms have been issued as ICRP Publication 110



Doses to the Walls of the Alimentary Tract

The dosimetry for the Human Alimentary Tract according to ICRP Publication 100 is similar to that for the Human Respiratory Tract according to ICRP Publication 66:

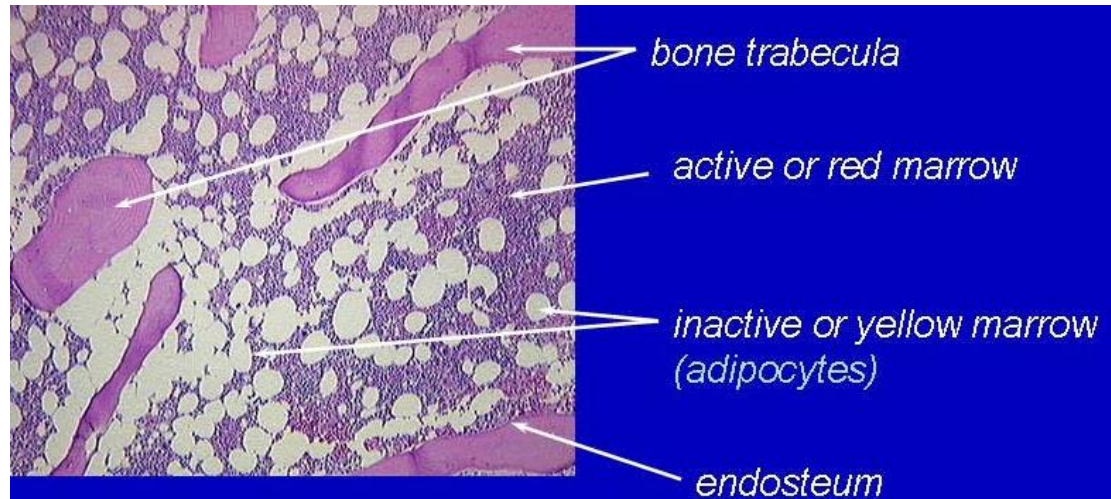
- The target tissues are not the whole wall of the components of the tract but radiosensitive layers of them in a depth between 60-100 μm (stomach wall) and 280-300 μm (colon walls)

Therefore no dose to the walls from α emitters in the contents of the tract

- The dose to the colon is calculated (approximately) as the mass-weighted average of the doses to the three colon sections

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.



Comparison of present and (draft) future ingestion dose coefficients for workers

Effective doses (Sv/Bq) for soluble forms, calculated with the tissue weighting factors and the concept of ICRP 60 (ICRP 68) and ICRP 103 (Draft OIR), respectively

Radionuclide	ICRP 68	Draft OIR
⁹⁰ Sr	2.8E-08	2.4E-08
¹³¹ I	2.2E-08	1.6E-08
¹³⁴ Cs	1.9E-08	1.4E-08
¹³⁷ Cs	1.3E-08	1.3E-08

Dose Assessment by Bioassay Measurements

The internal dose assessed by application of models can be verified by measurements

- Verification of biokinetic parameters
for example, effective half-life of iodine in the thyroid or of caesium in total body
- Verification of assumed intake (rates)

Summary

- Internal dose cannot be measured => (biokinetic and dosimetric) models are needed
- Models need input which can be assessed by measurements, (radioecological) models and assumptions
- The assessed doses can be verified / adjusted by (bioassay) measurements (and assumptions)