13th International Congress of the International Radiation Protection Association

TS2b.8

Estimation of Radionuclide Biokinetics Dependence on Intake Conditions for Internal Exposure

Kotaro TANI[1], Yuki FUJIMICHI[1], Satoshi IWAI[2], Toshiso KOSAKO[1]

[1]The University of Tokyo

[2]Japan Nuclear Technology Institute

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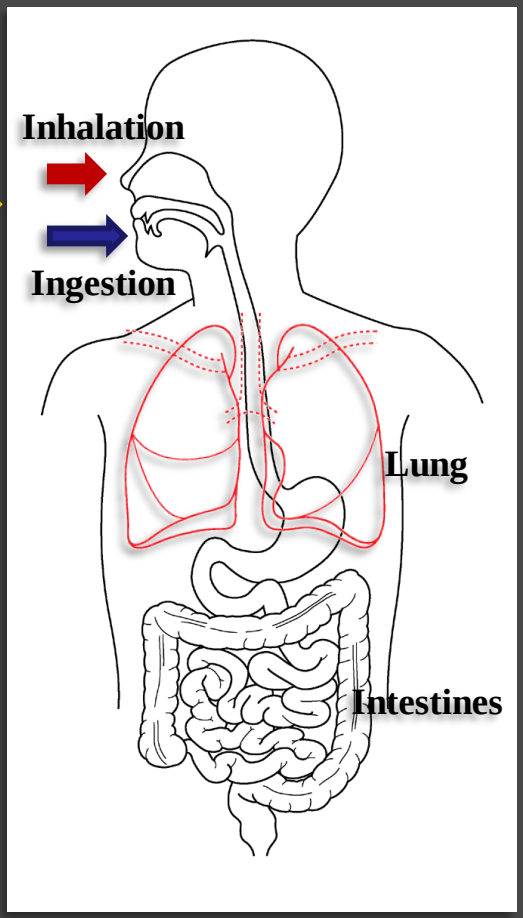
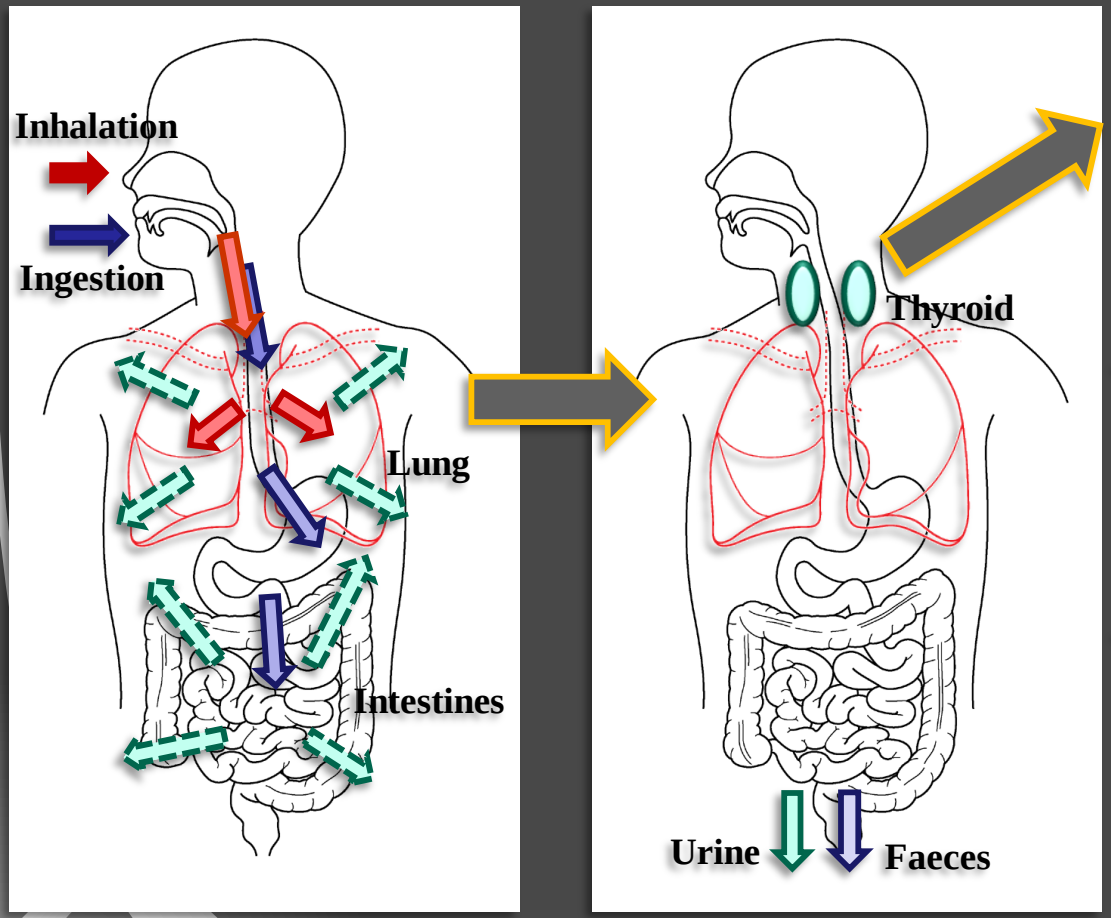
Internal contamination of public



- Internal contamination of public by…
  - Inhalation in radioactive clouds
  - Inhalation of resuspended radioactivity from soil
  - Ingestion of food or drinking water

  ⇒ **Some pathways** and **over a long period**
- **I-131** and **Cs-137** mainly became a problem in the Chernobyl and Fukushima accident

Biokinetics and internal dose evaluation



1. **Activity in the specific organ by *in vivo* measurement**
   - Thyroid for I-131
   - Whole body for Cs-137
2. **Total intake**
   - By the retention function
3. **Internal dose**
   - By the dose coefficient (Sv/Bq)

Problem and purpose

- **Problem**
  - Acute inhalation (general worker's intake situation)
    has been mainly assumed in dose evaluations

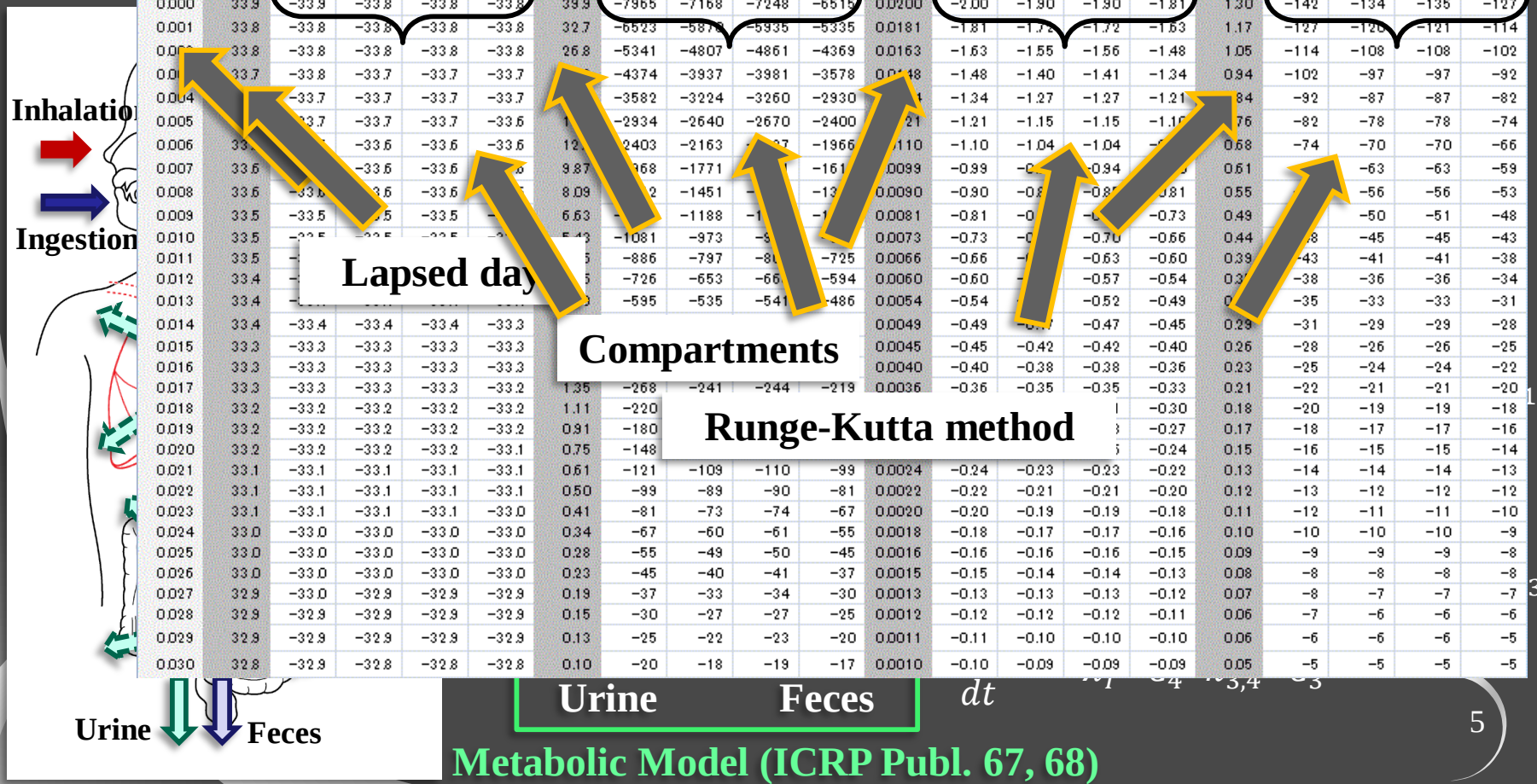
  ⇒ Retention function may change
  due to the difference in intake situations

- **Purpose**
  - Analyze the retention function of I-131 and Cs-137
    based on assuming some intake conditions
  - Discuss about the application of biokinetics
    to internal dose evaluation

Biokinetic models

Human Respiratory Tract Model (ICRP Publ. 66)

Human Alimentary Tract Model (ICRP Publ. 100)



xi(ti)	ET1	ε1	ε2	ε3	ε4	ET2	ε1	ε2	ε3	ε4	ETseq	ε1	ε2	ε3	ε4	BB1	ε1	ε2	ε3	ε4
0.000	33.9	-33.9	-33.8	-33.8	-33.8	39.9	-7965	-7168	-7248	-6515	0.0200	-2.00	-1.90	-1.90	-1.81	1.30	-142	-134	-135	-127
0.001	33.8	-33.8	-33.8	-33.8	-33.8	32.7	-6523	-5870	-5935	-5335	0.0181	-1.81	-1.72	-1.72	-1.63	1.17	-127	-120	-121	-114
0.002	33.8	-33.8	-33.8	-33.8	-33.8	26.8	-5341	-4807	-4861	-4369	0.0163	-1.63	-1.55	-1.56	-1.48	1.05	-114	-108	-108	-102
0.003	33.7	-33.8	-33.7	-33.7	-33.7	21.9	-4374	-3937	-3981	-3578	0.0148	-1.48	-1.40	-1.41	-1.34	0.94	-102	-97	-97	-92
0.004	33.7	-33.7	-33.7	-33.7	-33.7	17.9	-3582	-3224	-3260	-2930	0.0134	-1.34	-1.27	-1.27	-1.21	0.84	-92	-87	-87	-82
0.005	33.7	-33.7	-33.7	-33.7	-33.6	14.6	-2934	-2640	-2670	-2400	0.0121	-1.21	-1.15	-1.15	-1.10	0.76	-82	-78	-78	-74
0.006	33.6	-33.6	-33.6	-33.6	-33.6	12.0	-2403	-2163	-2187	-1966	0.0110	-1.10	-1.04	-1.04	-0.99	0.68	-74	-70	-70	-66
0.007	33.6	-33.6	-33.6	-33.6	-33.6	9.87	-1968	-1771	-1791	-1611	0.0099	-0.99	-0.94	-0.94	-0.90	0.61	-66	-63	-63	-59
0.008	33.6	-33.6	-33.6	-33.6	-33.6	8.09	-1612	-1451	-1467	-1319	0.0090	-0.90	-0.86	-0.86	-0.81	0.55	-59	-56	-56	-53
0.009	33.5	-33.5	-33.5	-33.5	-33.5	6.63	-1321	-1188	-1202	-1081	0.0081	-0.81	-0.77	-0.77	-0.73	0.49	-53	-50	-51	-48
0.010	33.5	-33.5	-33.5	-33.5	-33.5	5.43	-1081	-973	-984	-886	0.0073	-0.73	-0.70	-0.70	-0.66	0.44	-48	-45	-45	-43
0.011	33.5	-33.5	-33.5	-33.5	-33.5	4.45	-886	-797	-806	-725	0.0066	-0.66	-0.63	-0.63	-0.60	0.39	-43	-41	-41	-38
0.012	33.4	-33.4	-33.4	-33.4	-33.4	3.64	-726	-653	-661	-594	0.0060	-0.60	-0.57	-0.57	-0.54	0.32	-38	-36	-36	-34
0.013	33.4	-33.4	-33.4	-33.4	-33.4	2.98	-595	-535	-541	-486	0.0054	-0.54	-0.52	-0.52	-0.49	0.26	-35	-33	-33	-31
0.014	33.4	-33.4	-33.4	-33.4	-33.3	2.44					0.0049	-0.49	-0.47	-0.47	-0.45	0.29	-31	-29	-29	-28
0.015	33.3	-33.3	-33.3	-33.3	-33.3	2.00					0.0045	-0.45	-0.42	-0.42	-0.40	0.26	-28	-26	-26	-25
0.016	33.3	-33.3	-33.3	-33.3	-33.3	1.64					0.0040	-0.40	-0.38	-0.38	-0.36	0.23	-25	-24	-24	-22
0.017	33.3	-33.3	-33.3	-33.3	-33.2	1.35	-268	-241	-244	-219	0.0036	-0.36	-0.35	-0.35	-0.33	0.21	-22	-21	-21	-20
0.018	33.2	-33.2	-33.2	-33.2	-33.2	1.11	-220								-0.30	0.18	-20	-19	-19	-18
0.019	33.2	-33.2	-33.2	-33.2	-33.2	0.91	-180								-0.27	0.17	-18	-17	-17	-16
0.020	33.2	-33.2	-33.2	-33.2	-33.1	0.75	-148								-0.24	0.15	-16	-15	-15	-14
0.021	33.1	-33.1	-33.1	-33.1	-33.1	0.61	-121	-109	-110	-99	0.0024	-0.24	-0.23	-0.23	-0.22	0.13	-14	-14	-14	-13
0.022	33.1	-33.1	-33.1	-33.1	-33.1	0.50	-99	-89	-90	-81	0.0022	-0.22	-0.21	-0.21	-0.20	0.12	-13	-12	-12	-12
0.023	33.1	-33.1	-33.1	-33.1	-33.0	0.41	-81	-73	-74	-67	0.0020	-0.20	-0.19	-0.19	-0.18	0.11	-12	-11	-11	-10
0.024	33.0	-33.0	-33.0	-33.0	-33.0	0.34	-67	-60	-61	-55	0.0018	-0.18	-0.17	-0.17	-0.16	0.10	-10	-10	-10	-9
0.025	33.0	-33.0	-33.0	-33.0	-33.0	0.28	-55	-49	-50	-45	0.0016	-0.16	-0.16	-0.16	-0.15	0.09	-9	-9	-9	-8
0.026	33.0	-33.0	-33.0	-33.0	-33.0	0.23	-45	-40	-41	-37	0.0015	-0.15	-0.14	-0.14	-0.13	0.08	-8	-8	-8	-8
0.027	32.9	-33.0	-32.9	-32.9	-32.9	0.19	-37	-33	-34	-30	0.0013	-0.13	-0.13	-0.13	-0.12	0.07	-8	-7	-7	-7
0.028	32.9	-32.9	-32.9	-32.9	-32.9	0.15	-30	-27	-27	-25	0.0012	-0.12	-0.12	-0.12	-0.11	0.06	-7	-6	-6	-6
0.029	32.9	-32.9	-32.9	-32.9	-32.9	0.13	-25	-22	-23	-20	0.0011	-0.11	-0.10	-0.10	-0.10	0.06	-6	-6	-6	-5
0.030	32.8	-32.9	-32.8	-32.8	-32.8	0.10	-20	-18	-19	-17	0.0010	-0.10	-0.09	-0.09	-0.09	0.05	-5	-5	-5	-5

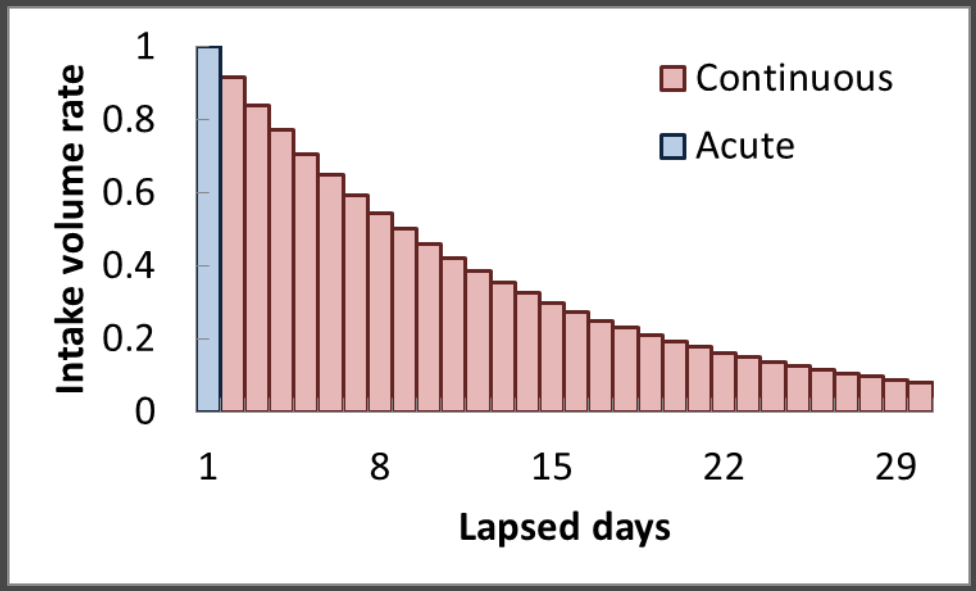
I_1

dt

$\cdot C_2$

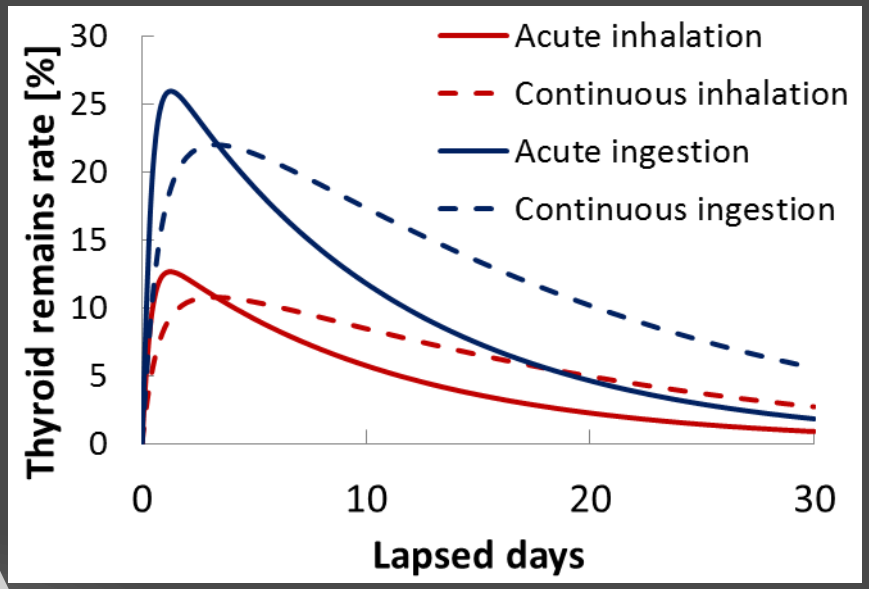
Conditions of biokinetic analyses

- Intake conditions
  - Inhalation or ingestion
  - Acute or continuous intake
    1. **Acute inhalation**
    2. **Continuous inhalation**
    3. **Acute ingestion**
    4. **Continuous ingestion**



- Basic conditions
  - I-131
    - Type F, f_1 = 1.0
    - AMAD = 1μm
    - Metabolic parameters for 1 year old child
  - Cs-137
    - Type F, f_1 = 1.0
    - AMAD = 1μm
    - Metabolic parameters for adult

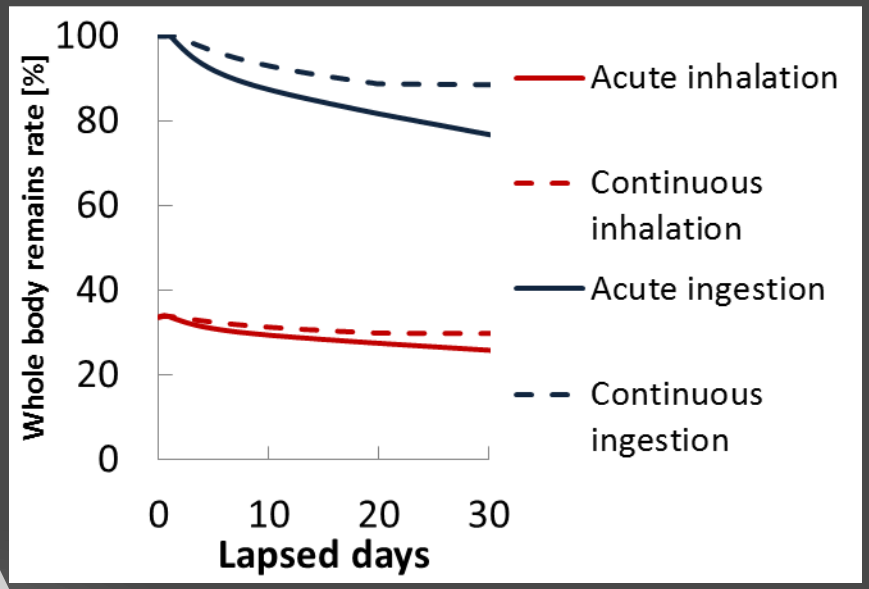
Thyroid retention functions (I-131)



Thyroid remains rate [%]

	Inhalation		Ingestion	
	Acute	Cont.	Acute	Cont.
1 day after	13	8.5 (0.65)	26	17 (0.67)
5 days	9.2	10 (1.1)	19	21 (1.1)
10 days	5.7	8.5 (1.5)	12	17 (1.5)
20 days	2.3	5.0 (2.2)	4.6	10 (2.2)
30 days	0.89	2.7 (3.1)	1.8	5.6 (3.1)

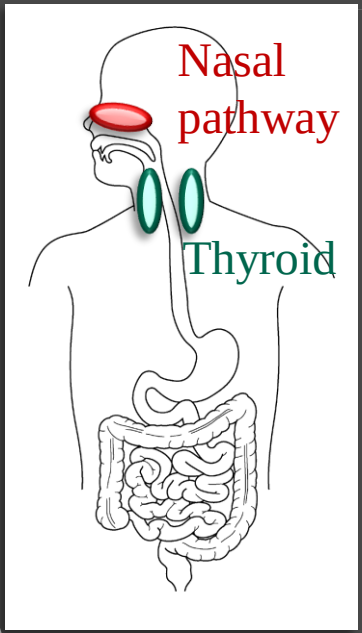
Whole body retention function (Cs-137)



Whole body remains rate [%]

	Inhalation		Ingestion	
	Acute	Cont.	Acute	Cont.
1 day after	34	34 (1.0)	100	100 (1.0)
5 days	31	33 (1.1)	92	96 (1.0)
10 days	29	31 (1.1)	87	93 (1.1)
20 days	28	30 (1.1)	82	89 (1.1)
30 days	26	30 (1.2)	77	89 (1.2)

Separation of inhalation and ingestion



Percentage of remains rate of nasal pathway and thyroid after inhalation [%]

	Acute			Continuous		
	Nasal pathway (R_N)	Thyroid (R_T)	R_T/R_N	Nasal pathway (R_N)	Thyroid (R_T)	R_T/R_N
5 hours after	27	5.5	0.20	50	2.8	0.055
10 hours	22	9.1	0.41	40	4.9	0.12
15 hours	18	11	0.63	35	6.5	0.19
20 hours	14	12	0.85	31	7.6	0.25
24 hours	11	12	1.1	27	8.5	0.31

Measure the activities of nasal pathway and thyroid (M_N, M_T)

Estimate thyroid activities caused by inhalation (A_{INH}) and ingestion (A_{ING})

$$A_{INH} = \frac{R_T}{R_N} M_N \qquad A_{ING} = M_T - A_{INH}$$

Evaluate internal dose separately

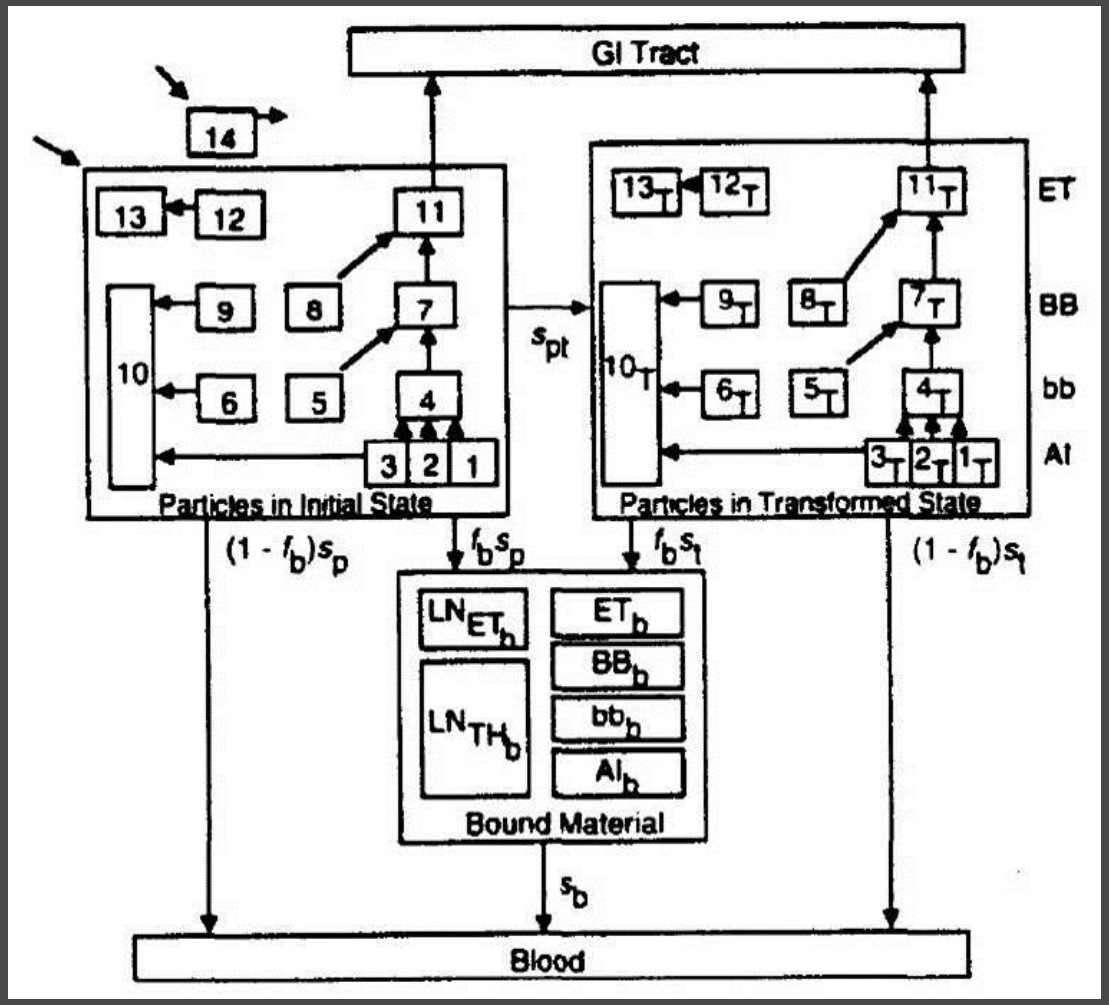
Conclusion

- In internal dose evaluation,
  it is important to consider the biokinetics of intake conditions

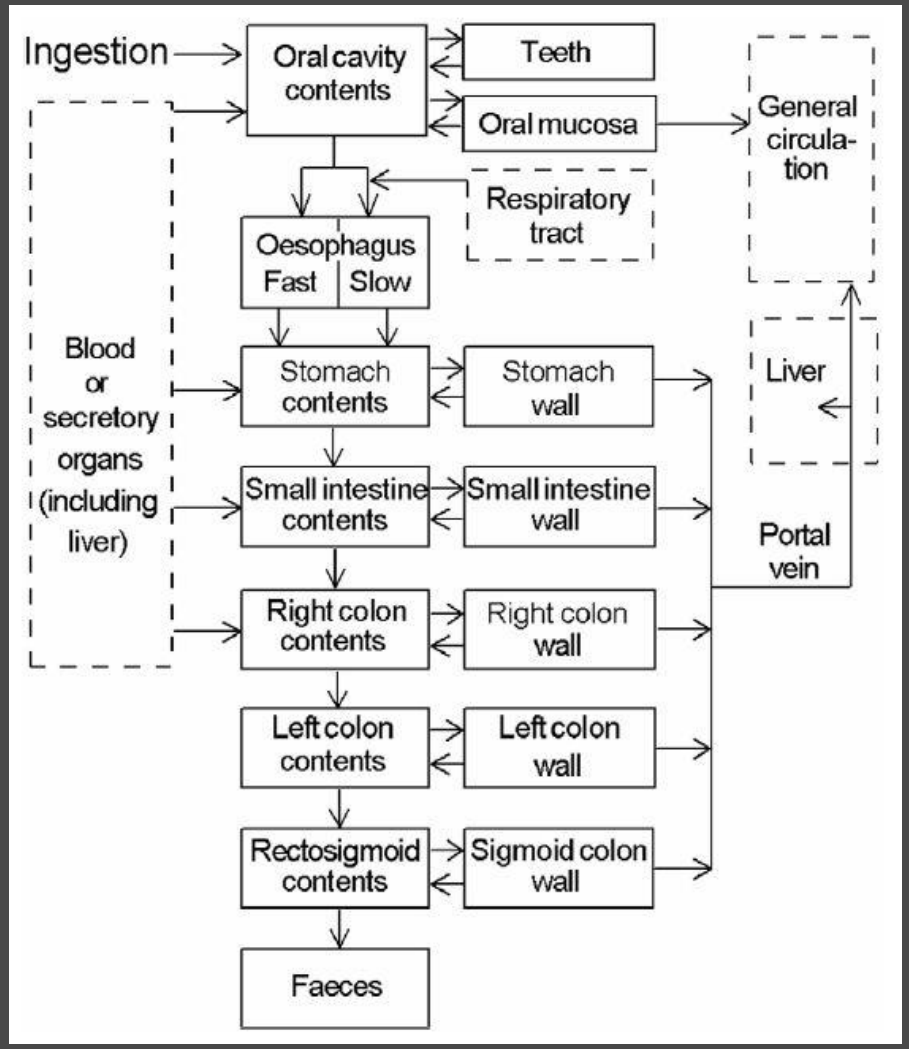
1. Thyroid retention functions of **I-131** vary **0.65 to 3.1** times on the range from 1 day after to 30 days after, although whole body retention functions of **Cs-137** are almost same (**1.0-1.2 times**)

2. Considering the **I-131** **deposition to** **nasal pathway**, thyroid deposition activity can be **separated** by **inhalation** and **ingestion** and evaluated internal dose separately

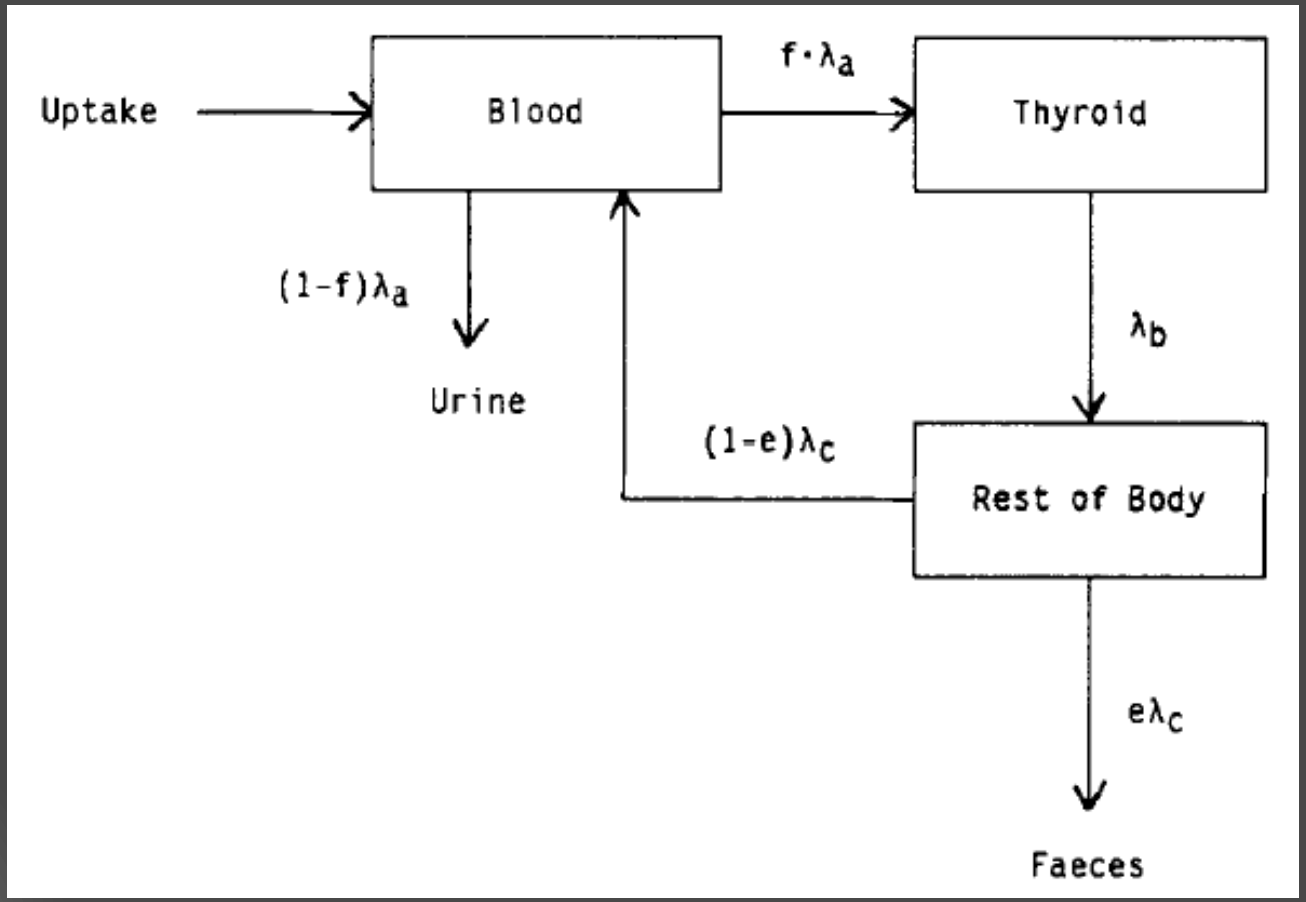
The Human Respiratory Tract Model



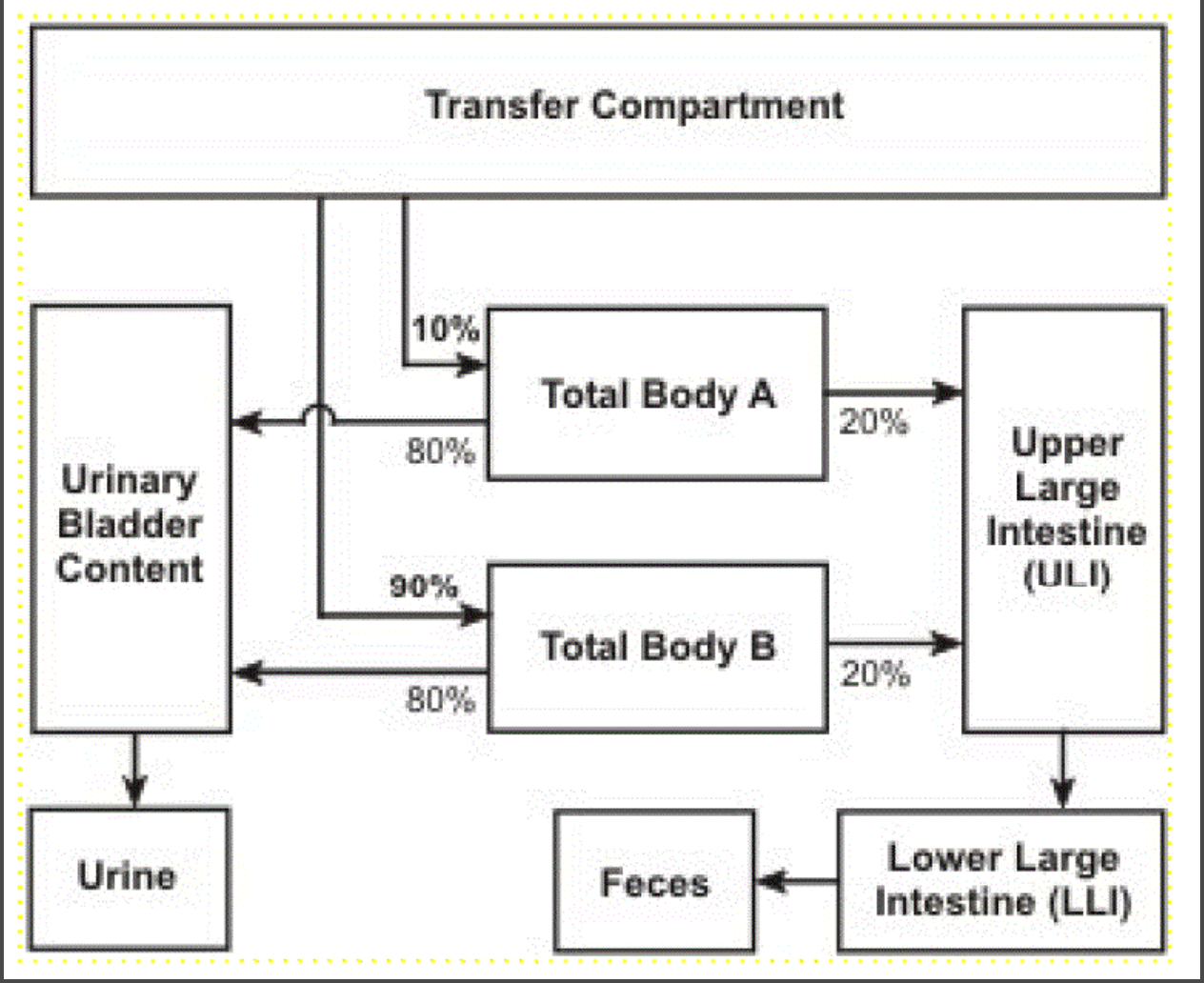
The Human Alimentary Tract Model



Biokinetic Model (Iodine)



Biokinetic Model (Cesium)



Visualization of Biokinetics (I-131)