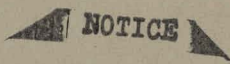


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Digital Simulation of Two Models of the Biological Disposition of Inhaled Plutonium

March 1976

Prepared for the U.S. Energy
Research and Development Administration
under Contract E(45-1):1830

 **Battelle**
Pacific Northwest Laboratories

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DIGITAL SIMULATION OF TWO
MODELS OF THE BIOLOGICAL
DISPOSITION OF INHALED PLUTONIUM

by

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and

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Information Systems Technology

March 1976

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ABSTRACT

Two mathematical models which describe the retention and translocation of inhaled plutonium were simulated on BNW's minicomputer system MINERVA. Equation parameters are obtained by matching the simulation to data gathered by several studies at BNW. Interactive graphics techniques are described which facilitate the data fitting process.

This document is meant to serve as a progress report on a continuing effort towards development of mathematical models to describe the disposition of inhaled plutonium. The tabular and graphical results found in the appendices of this report do not represent what we feel are the best possible data fits but only samples of output available from the model. At this time we feel that additional model development will probably be required to best fit the data.

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BIOLOGY MODEL DOCUMENTATION

INTRODUCTION

Two biology models have been implemented on the BNW MINERVA System. Both of these models simulate the flow of inhaled plutonium through the organs of the body. The first model was developed by Dionne and Stuart⁽¹⁾ and originally programmed on the BNW hybrid computer. The second was derived from the block diagram of a model developed by the ICRP Task Group.⁽²⁾ The simulation programs for both models are quite similar and emphasize user-oriented control and display techniques.

THE MINERVA SYSTEM

The Battelle MINERVA System consists of a PDP-11/35 minicomputer with 24K of core and a Vector General graphics display terminal. Program and data storage is maintained on two removable disk packs which together have a storage capacity of 2.4 million bytes. The system has the capability to produce hard copy output of graphs and data appearing on the Vector General display. The output medium for these displays is either an electrostatic printer/plotter or a CalComp plotter. The major advantage of this system for the two Biology models which are being simulated is fast real-time man-machine interaction.

THE MODEL

Both models were developed using a series of first order linear differential equations. These equations simulate the flow of material between various organs of the body after initially being inhaled into the lungs. The general form of these equations is

$$(dN/dt)_i = f_k \lambda_j N_j - \lambda_i N_i$$

where

$(dN/dt)_i$ is the time rate of change of burden in the i^{th} organ,

f_k is the fractional uptake parameter. (In the Dionne-Stuart model, $k = i, j$ specifying the fractional uptake by the i^{th} organ from the j^{th} organ. In the ICRP model k specifies the fractional amount leaving the j^{th} compartment.)

λ^j is the biological elimination rate of the j organ, and

λ^i is the biological elimination rate of the i^{th} organ.

DIONNE - STUART EQUATIONS (5) (See Table 1 for Parameter Values)

Pulmonary

The equation describing the varying biological half-time of the deep lung is

$$\dot{\lambda}^{PV} = -(\lambda)(\lambda^{PV}).$$

λ is the term which affects the variability.

The equations describing the varying portion of the deep lung burden is

$$\dot{N}_{PV} = -\lambda^{PV} N_{PV}.$$

where N_{PV} is a term describing the amount of material. This portion has an initial rapid half-time of 50 days and it continually lengthens with a half-time of one year (λ). The material leaving the lung through this compartment enters the GI tract. One year after deposition no further material leaves this compartment.

The remaining material in the deep lung is described by the following equation.

$$\dot{N}_{PC} = -\lambda^{PC} N_{PC}$$

The material leaving the lung by this pathway enters the lymph nodes, blood stream, and GI tract. The biological half-time for this pathway is 4 years.

$$N_P = N_{PV} + N_{PC}$$

Lymph Nodes

The uptake of material in the lymph nodes is complicated by the fact that only 30% of the material received by the lymph nodes leaves them. Let N_{TB1} represent the amount of material leaving the trachea-bronchial lymph nodes and entering the bloodstream, while N_{TB2} represents the amount retained in the tracheabronchial lymph nodes. The rate of change of material in the first compartment is

$$\dot{N}_{TB1} = f_{TB,NPC} \lambda^{PC} N_{PC} - \lambda^{TB1} N_{TB1}$$

The rate of change of material in the second tracheabronchial lymph node compartment is described by

$$\dot{N}_{TB2} = f_{TB,TB} \lambda^{TB1} N_{TB1} - \lambda^{TB2} N_{TB2}$$

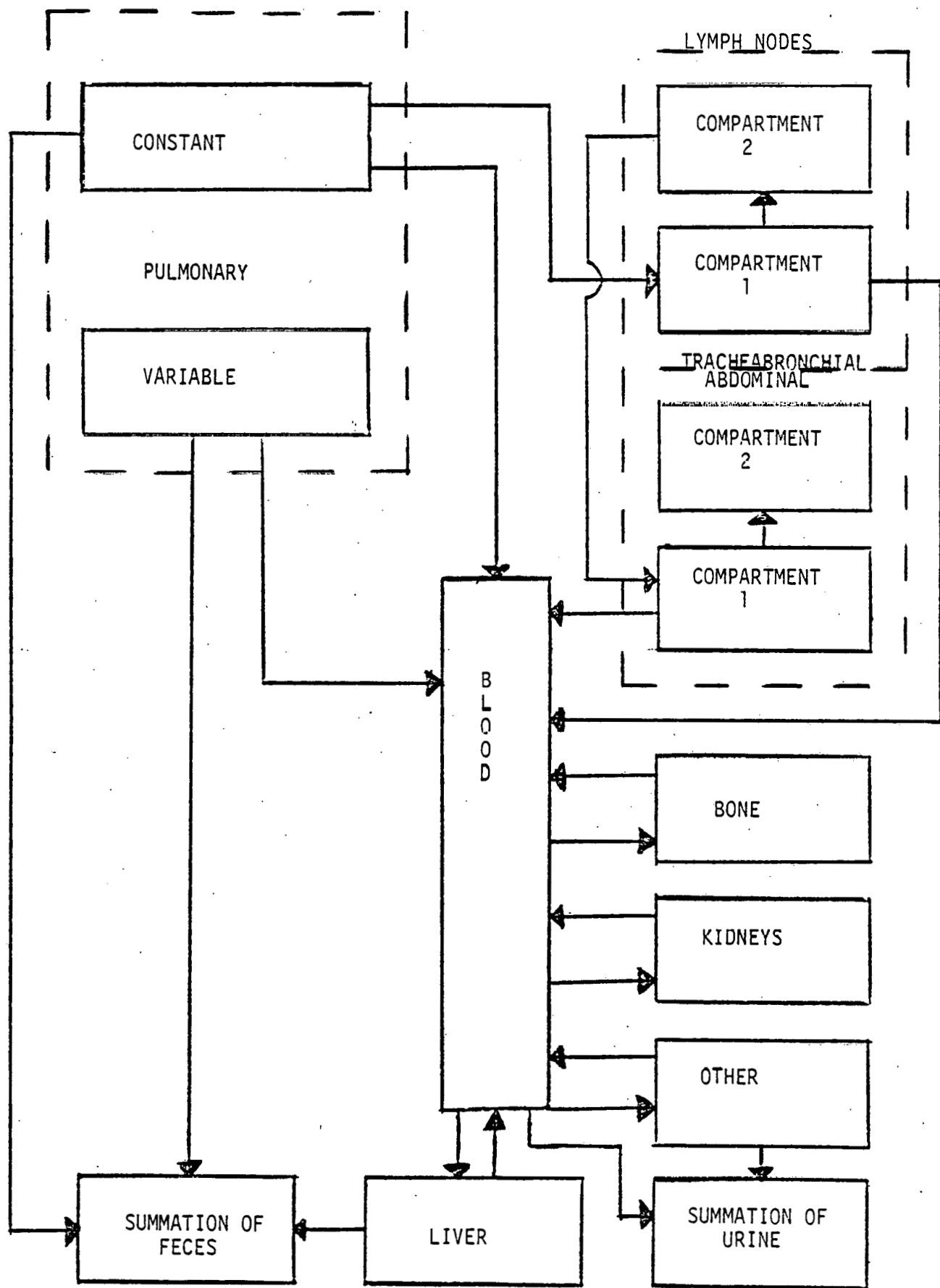
and the total amount of material in the tracheabronchial lymph nodes at any time is

$$N_{TB} = N_{TB1} + N_{TB2}$$

Similarly, for the abdominal lymph nodes, the rate of change of material in the first compartment is

$$\dot{N}_{A1} = f_{A,TB} \lambda^{TB2} N_{TB2} - \lambda^{A1} N_{A1}$$

The rate of change of material in the second abdominal lymph node compartment is described by



DIONNE - STUART MODEL BLOCK DIAGRAM

TABLE 1. Equation Parameters, Dionne-Stuart Model

Compartment	Value	Compartment	Value
Pulmonary		Blood	
$\lambda^{PV}(0)$	5.	$N_{BL}(0)$	0
λ	1 yr	$f_{BL,NPC}$	40%
$N_{PV}(0)$	6.		
λ^{PV}	1 Year	$f_{BL,TB1}$	80%
$N_{PC}(0)$	94.	$f_{BL,A1}$	30%
λ^{PC}	2 yrs	$f_{BL,B0}$	100%
		$f_{BL,LV}$	100%
Lymph Nodes		$f_{BL,KI}$	1%
$N_{TB1}(0)$	0	$f_{BL,OT}$	100%
λ^{TB1}	1. yrs		
$f_{TB,NPC}$	60%	Bone	
$N_{TB2}(0)$	0		
λ^{TB2}	5 years	$N_{B0}(0)$	.216
$f_{TB,TB}$	20%	λ^{B0}	100 years
$N_{A1}(0)$	0	$f_{B0,BL}$	58%
λ^{A1}	1 yr		
$f_{A,TB2}$	100%	Other	
$N_{A2}(0)$	0	$N_{OT}(0)$	0
$f_{A,A}$	70%	λ^{OT}	100 years
		$f_{OT,BL}$	5%

TABLE 1. Equation Parameters, Dionne-Stuart Model (continued)

<u>Compartment</u>	<u>Value</u>	<u>Compartment</u>	<u>Value</u>
Liver		Kidneys	
$N_{LV}(0)$	.6	N_{KI}	.017
λ_{LV}	40 yrs	λ_{KI}	40 yrs
$f_{LV,BL}$	34%	$f_{KI,BL}$	.3%
Urine		Feces	
$\Sigma N_{UR}(0)$	0	$\Sigma N_{FE}(0)$	0
$f_{UR,KI}$	99%	$f_{FE,LV}$	0%
$f_{UR,BL}$	2.7%	$f_{FE,NPV}$	85%
		$f_{FE,NPC}$	0%

$$\dot{N}_{A2} = f_{A,A} \lambda^{A1} N_{A1}$$

and the total amount of material in the abdominal lymph nodes at any time is

$$N_A = N_{A1} + N_{A2}$$

Blood

The amount of material in blood at any time is the sum of the material going to blood from any organ. Because blood has a fast biological half-time with respect to the rest of the organs in the long-term model it transfers the material immediately, and in the proper proportion, to the organs it feeds.

$$\begin{aligned} \dot{N}_{BL} = & f_{BL,NPC} \lambda^{PC} N_{PC} + (1 - f_{FE,NPV}) \lambda^{PV} N_{PV} + f_{BL,TB1} \lambda^{TB1} N_{TB1} + f_{BL,A1} \lambda^{A1} N_{A1} \\ & + f_{BL,BO} \lambda^{BO} N_{BO} + f_{BL,LV} \lambda^{LV} N_{LV} + f_{BL,KI} \lambda^{KI} N_{KI} + f_{BL,OT} \lambda^{OT} N_{OT} \end{aligned}$$

Systemic Organs

The equations describing the buildup and decay of material in the systemic organs are all similar. They are fed by blood and send their material back to blood with long half-times.

Bone

$$\dot{N}_{BO} = f_{BO,BL} \dot{N}_{BL} - \lambda^{BO} N_{BO}$$

Other

$$\dot{N}_{OT} = f_{OT,BL} \dot{N}_{BL} - \lambda^{OT} N_{OT}$$

Liver

$$\dot{N}_{LV} = f_{LV,BL} \dot{N}_{BL} - \lambda^{LV} N_{LV}$$

Kidneys

$$\dot{N}_{KI} = f_{KI,BL} \dot{N}_{BL} - \lambda^{KI} N_{KI}$$

Initial material in the systemic compartments comes from the soluble portion of the material which is deposited in the nasopharynx-trachea-bronchial compartment of the short-term model.

Excretion

The equations which describe the amount of material excreted are designed to yield the total excreted since the initial uptake.

Urine

$$\dot{N}_{UR} = f_{UR,KI} \lambda^{KI} N_{KI} + f_{UR,BL} \dot{N}_{BL}$$

Feces

$$\dot{N}_{FE} = f_{FE,LV} \lambda^{LV} N_{LV} + f_{FE,NPV} \lambda^{PV} N_{PV} + f_{FE,NPC} \lambda^{PC} N_{PC}$$

Whole Body

The amount of material in the whole body at any time is simply the sum of amount of material in all the compartments.

$$N_{WB} = N_P + N_{TB} + N_A + N_{BO} + N_{OT} + N_{LV} + N_{KI}$$

EQUATIONS FOR ICRP MODEL (See Table 2 for Parameter Values)

Nasopharynx

Two differential equations describe the flow of material from this compartment.

$$\dot{N}_{NPA} = -\lambda^{NPA} N_{NPA}$$

$$\dot{N}_{NPB} = -\lambda^{NPB} N_{NPB}$$

where N_{NPA} and N_{NPB} describe the amount of material. N_{NPA} determines the portion passing into the blood while N_{NPB} describes the amount entering the gastrointestinal tract. The total for the nasopharynx at any time is

$$N_{NP} = N_{NPA} + N_{NPB}$$

Tracheabronchial

This compartment also has two equations describing the flow of material. N_{TBC} for material entering the blood and N_{TBD} for the gastrointestinal tract. These equations are given by

$$\dot{N}_{TBC} = -\lambda^{TBC} N_{TBC} \quad \text{and}$$

$$\dot{N}_{TBD} = -\lambda^{TBD} N_{TBD}$$

and the total for the tracheabronchial is

$$N_{TB} = N_{TBC} + N_{TBD}.$$

Pulmonary

The pulmonary compartment contains four paths for material flow.

Two of these

$$\dot{N}_{PF} = -\lambda^{PF} N_{PF} \quad \text{and}$$

$$\dot{N}_{PG} = -\lambda^{PG} N_{PG}$$

describe the flow of material into the gastrointestinal tract, while

$$\dot{N}_{PE} = -\lambda^{PE} N_{PE}$$

describes that entering the blood and

$$\dot{N}_{PH} = -\lambda^{PH} N_{PH}$$

describes the flow into the lymph nodes. The total amount of material in the pulmonary compartment is given by

$$N_P = N_{PE} + N_{PF} + N_{PG} + N_{PH}.$$

Lung

The material dispersed from the lungs after initial inhalation is the sum of the material in the nasopharynx, tracheabronchial and pulmonary compartments and is given by

$$N_{LU} = N_{NP} + N_{TB} + N_P$$

Gastrointestinal Tract

The GI tract is divided into four compartments: the stomach, the small intestine, the upper large intestine and the lower large intestine. The equations for these compartments describe the buildup and removal of material. They are given by

Stomach

$$\dot{N}_{ST} = F_b \lambda^{NPB} N_{NPB} + F_d \lambda^{TBD} N_{TBD} + F_f \lambda^{PF} N_{PF} + F_g \lambda^{PG} N_{PG} - \lambda^{ST} N_{ST}$$

Small Intestine

$$\dot{N}_{SI} = \lambda^{ST} N_{ST} - \lambda^{SI} N_{SI}$$

Upper Large Intestine

$$\dot{N}_{ULI} = \lambda^{SI} N_{SI} - \lambda^{ULI} N_{ULI}$$

Lower Large Intestine

$$\dot{N}_{LLI} = \lambda^{ULI} N_{ULI} - \lambda^{LLI} N_{LLI}$$

Lymph Nodes

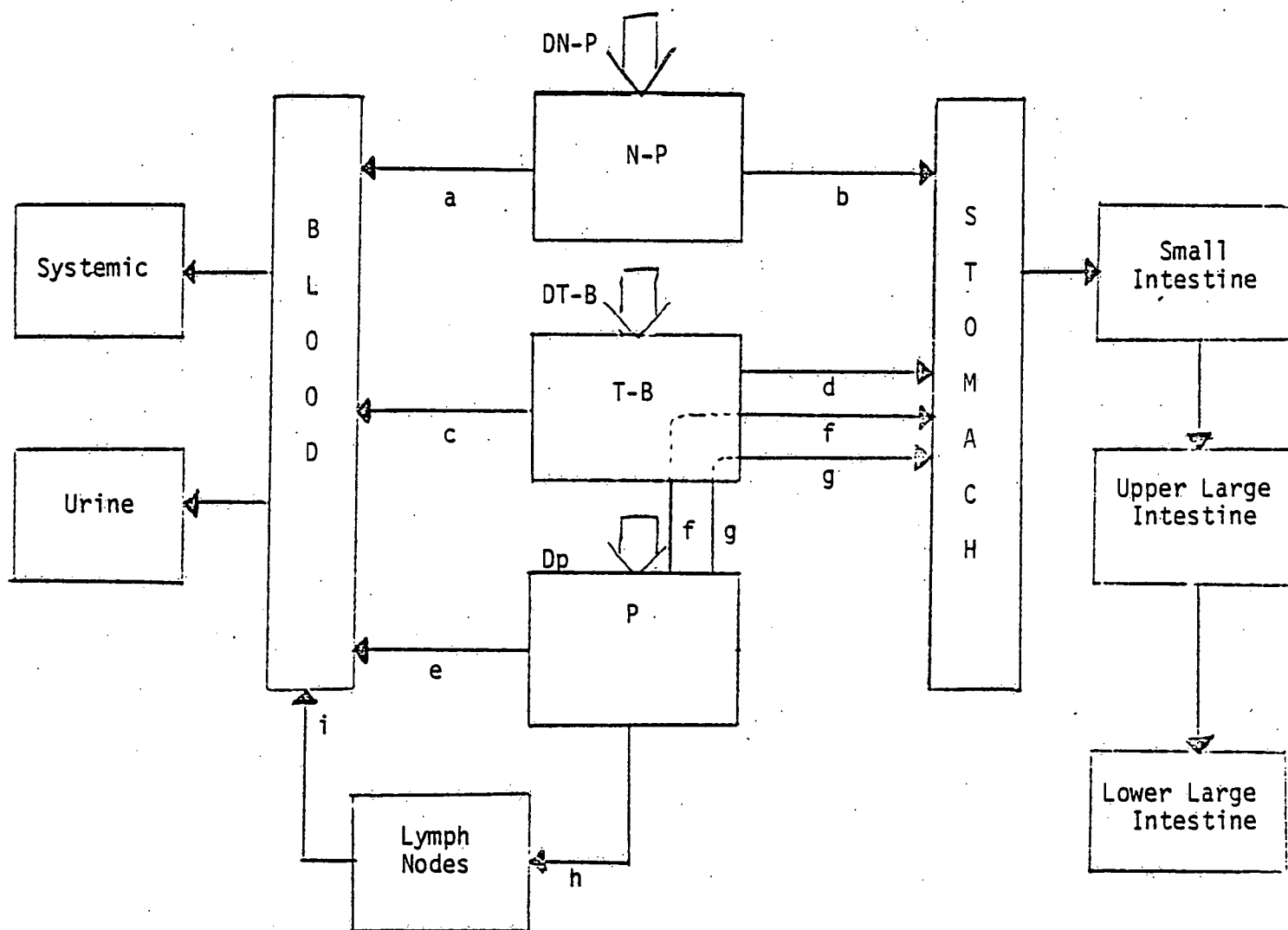
The lymph nodes compartment is fed by the pulmonary compartment and drains into the blood. The equation is

$$\dot{N}_{LY} = F_h \lambda^{PH} N_P - \lambda^{LY} N_{LY}$$

Blood

The equation which determines the amount of material in the blood is

$$\dot{N}_{BL} = F_a \lambda^{NPA} N_{NPA} + F_c \lambda^{TBC} N_{TBC} + F_e \lambda^{PE} N_{PE} + F_i \lambda^{LY} N_{LY} - \lambda^{BL} N_{BL}$$



ICRP Model Block Diagram

TABLE 2. Equation Parameters, ICRP Model

<u>Compartment</u>	<u>Classification</u> ⁽¹⁾		
	D	W	Y
Nasopharynx			
$N_p (0)$	30.	30.	30.
$N_{PA} (0)$	15.	3.	.3
λ^{NPA}	.01 ⁽²⁾	.01	.01
$N_{PB} (0)$	15.	27.	27.7
λ^{NPB}	.01	.4	.4
Tracheabronchial			
$N_{TB} (0)$	8.	8.	8.
$N_{TBC} (0)$	7.6	4.	.08
λ^{TBC}	.01	.01	.01
$N_{TBD} (0)$	.4	4.	7.92
λ^{TBD}	.2	.2	.2
Pulmonary			
$N_p (0)$	25.	25.	25.
$N_{PE} (0)$	20.	3.75	1.25
λ^{PE}	.5	50.	500.
$N_{PF} (0)$	--	10.	10.
λ^{PF}	--	50.	500.
$N_{PG} (0)$	--	10.	10.
λ^{PG}	--	50.	500.

TABLE 2. Equation Parameters, ICRP Model (continued)

<u>Compartment</u>	<u>D</u>	<u>W</u>	<u>Y</u>
Pulmonary (cont.)			
$N_{PH}(0)$	5.	1.25	3.75
λ^{PH}	.5	50.	500.
Lymph Nodes			
$N_{LY}(0)$	0.	0.	0.
λ^{LY}	.5	50.	1000.
Stomach			
$N_{ST}(0)^*$	0.	0.	0.
λ^{ST^*}	1. hr	1. hr	1. hr
F_b	.5	.9	.99
F_d	.05	.5	.99
F_f	--	.4	.4
F_g	--	.4	.4
Small Intestine			
$N_{SI}(0)^*$	0.	0.	0.
λ^{SI^*}	4. hrs	4. hrs	4. hrs
Upper Large Intestine			
$N_{ULI}(0)^*$	0.	0.	0.
λ^{ULI^*}	13. hrs	13. hrs	13. hrs
Lower Large Intestine			
$N_{LLI}(0)^*$	0.	0.	0.

TABLE 2. Equation Parameters, ICRP Model (continued)

<u>Compartment</u>	D	W	Y
Lower Large Intestine (cont.)			
λ_{LLI}	24. hrs	24. hrs	24. hrs
Blood			
$N_{BL} (0)^*$	0	0	0
λ_{BL}^*	8. hrs	8. hrs	8. hrs
F_a	.5	.1	.01
F_c	.95	.5	.01
F_e	.8	.15	.05
F_i	1.	1.	.9
Systemic			
F_{SYBL}^*	.8	.8	.8
Urine			
F_{URBL}^*	.2	.2	.2

* Additional parameters inserted into original ICRP model.

- (1) The classification of inhaled materials as D, W or Y refers to their retention in the Pulmonary compartment; i.e., brief (days), moderate (weeks), or prolonged (years), respectively. (ICRP Task Group on Lung Dynamics Classification.)
- (2) All removal half-times are in days unless otherwise listed.

The blood compartment feeds the systemic and urine compartments with equations

Systemic

$$\dot{N}_{SY} = F_{SYBL} \lambda^{BL} N_{BL} \quad \text{and}$$

Urine

$$\dot{N}_{UR} = F_{URBL} \dot{N}_{BL}$$

Whole Body

The amount of material in the whole body is given by the sum of all compartments except urine and is given by

$$N_{WB} = N_{LU} + N_{LY} + N_{ST} + N_{SI} + N_{ULI} + N_{LLI} + N_{BL} + N_{SY}$$

DATA (See Appendices A and B)

Experimental data for the Dionne-Stuart model was gathered by D. Craig.⁽³⁾ This data is composed of results on 58 dogs, 23 of which were exposed by inhalation to ^{238}Pu crushed microspheres and the remainder were exposed by inhalation to $^{238}\text{PuO}_2$ from calcined oxalate. The time span for which this data is available is from 7 to 2133 days with the majority of the data points falling in the lower half of the range. This data consists of burden values for the lungs, tracheobronchial lymph nodes, abdominal lymph nodes, skeleton (bone), liver, kidneys, urine and feces.

The ICRP model is being used to simulate experimental data values collected by J. Ballou⁽⁴⁾ on dogs and rats exposed by inhalation to ^{239}Pu . This data is available between 1 and 100 days. Feces and urine data were gathered daily for most of the time period while data points for blood,

lungs, liver, tracheabronchial lymph nodes, skeleton and residual soft tissue are available only at widely scattered points within the time period.

THE COMPUTER PROGRAMS (See Appendix E for Users' Manual)

The computer programs which simulate both of these models are highly user oriented. All control of the models is handled using simple commands through a keyboard attached to the Vector General graphics display CRT. These commands allow the user to: set the control mode, modify any of the equation parameters, and choose any two of the equations for display.

In the compute mode the computer solves the differential equations continuously while plotting the two solutions which were selected for display. When the equations have been solved to the end of the simulation, the initial conditions are reset and the solving is restarted. During the compute mode the user is free to choose new equations for display or modify the equation parameters. These changes will be implemented when the current simulation is completed and the initial conditions are reset. This process of continuously monitoring the solutions of the differential equations while modifying equation parameters allows the user to rapidly assess the implications of his modification on the rest of the model.

The design of the computer simulation programs allows a high degree of interaction between the keyboard monitor which accepts and interprets commands and the differential equation solver. This interaction is obtained by requiring that the differential equation solver interrogate the keyboard monitor after each iteration on the time step. The result of this procedure is that commands inputted from the VG keyboard are responded to very

rapidly, thus giving the user the impression that the two modules are operating simultaneous.

SOLUTION METHOD

Both biology models use the modified Euler method. The main consideration for the choice of this method was speed of solution. Also the Euler method is self-starting and due to the characteristics of the system of equations is still within the required accuracy constraints.

The modified Euler method is a predictor-corrector method. The predictor used is:

$$Y_{i+1}^{(p)} = Y_i + h Y_i'$$

and the corrector step is

$$Y_{i+1}^{(c)} = Y_i + h(Y_i' + Y_{i+1}^{(p)'})/2.$$

A variable integration step size was also incorporated into the method. The step size to be used is determined by an estimate of the truncation error as follows:

$$E_{n+1} = \max_i \frac{Y_{i, n+1}^{(p)} - Y_{i, n+1}^{(c)}}{14 D_i}$$

$$D_i = \max_i (1/Y_{i, n+1}^{(c)}, 1, 1.0)$$

where $Y_{i, n+1}^{(p)}$ is the predicted value for equation i at the $n+1$ step and $Y_{i, n+1}^{(c)}$ is the corrected value for equation i at the same time step.

There are two internal parameters which determine when to change the step size. These are the upper bound $\bar{E}$ and the lower bound $\underline{E}$ on the truncation error. The integration step will be halved, left as it is, or doubled according to the following inequalities:

- a) If $E_{n+1} \geq \bar{E}$ the interval is reduced to $\Delta t/2$ or $t_{\min}$ the minimum allowable value of the integration step.
- b) If $\underline{E} \leq E_{n+1} < \bar{E}$ the integration step remains fixed.
- c) If $E_{n+1} < \underline{E}$ for four successive steps the step size is increased to $2\Delta t$ or $\Delta t_{\max}$ the maximum allowable value of the step-size.

METHOD

Three different sets of parameters can be modified while running these simulation models. They are the initial conditions on the differential equations, the fractional uptake parameters, and the biological elimination rates. The procedure followed in attempting to fit the model to the experimental data points involves adjusting the different sets of parameters until the solution curves match the data points. The process is started by first picking some likely candidates for the parameters and then running the model and examining the fit between the actual and predicted results. As the simulation is running modifications can be made to any of the parameters and the effects can be monitored immediately. Since the effect of changes made to one compartment not only alter the solution curve in that compartment but also in all the compartments chained to that compartment, the ability to rapidly examine any of the solution curves is essential for the practical use of these simulation models. This ability to rapidly monitor the effects of parameter changes on the simulation was a prime consideration in the design of the programs. Consequently the time required to fit the model to the data is minimized by this (interactive) approach over other methods of solution.

ACKNOWLEDGEMENT

The authors wish to thank Dr. D. K. Craig and Dr. J. E. Ballou for gathering and preparing the data used in analyzing these models.

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- 3 Craig, D., "SNS/BER Biomedical Working Group Material," Prepared for a Meeting Held in Davis, CA, Feb. 6-7, 1975, Battelle-Northwest, Richland, WA (See Appendix A).
- 4 Experimental Data on Rats and Dogs gathered by J. Ballou, Battelle-Northwest (see Appendix B).

APPENDIX A

Summarized Data From Dogs Exposed by Inhalation to ²³⁸Pu Crushed Microspheres

Mean Days	Dog #	% Initial Body Burden									
		Lung	TBLN	ALN	Fe	SK	LV	KI	Ur	Other	WB
7	940	93.78	.31	.10	--	2.45	.66	0	--	2.40	99.49
28	950	90.00	.89	.11	0	2.11	.67	0	0	6.00	100.00
29	948	97.50	.66	.01	0	.97	.31	.01	0	.51	100.00
31	938	94.12	1.71	.01	0	1.30	.64	.06	0	2.15	100.00
50	427	92.87	2.32	0	2.85	1.10	.33	.01	.06	.45	97.09
56	941	96.06	1.89	.01	.61	1.00	.46	.01	.02	.24	99.37
57	947	84.4	5.8	.30	5.62	2.10	.60	0	.38	1.00	94.00
57	946	85.69	10.53	.01	.57	1.38	.94	.02	.01	.86	99.42
60	466	94.97	2.18	0	1.47	.83	.25	.03	.05	.22	98.48
63	464	94.37	3.60	0	.75	.86	.24	.01	.05	.12	99.20
81	422	93.45	3.38	0	1.55	1.08	.31	.01	.08	.12	98.37
87	446	87.84	7.27	0	1.97	1.59	.89	.03	.14	.26	97.89
91	937	83.07	9.20	0	4.54	1.40	1.07	0	.13	.80	95.33
92	1041	90.01	5.06	.06	.86	2.15	1.13	.04	.04	.59	99.10
92	945	81.34	14.40	.02	.38	1.57	1.58	.02	.02	.66	99.60
106	437	82.13	9.00	0	5.13	1.30	1.95	.03	.25	.22	94.62
650	485	68.81	6.86	.02	1.78	8.23	6.20	.12	2.83	5.16	95.39
1031	500	37.12	13.42	.06	3.65	23.67	11.99	.18	1.21	8.12	95.14
1572	497	13.96	2.63	.05	11.26	39.03	26.4	.13	3.93	2.72	84.81
1834	481	12.44	21.95	1.07	2.00	35.64	22.84	.25	.49	3.33	97.51
2116	482	6.35	17.99	5.72	4.66	44.10	14.93	.29	1.70	4.19	93.64
2277	494	2.58	8.20	3.69	6.69	42.90	28.70	.16	4.54	2.60	88.77
2316	488	8.29	15.93	.75	3.01	39.16	28.13	.18	1.45	3.11	95.54

Summarized Data from Dogs Exposed by Inhalation
to $^{238}\text{PuO}_2$ from Calcined Oxalate

Mean Days	Dog #	% Initial Body Burden									
		Lung	TBLN	ALN	Fe	SK	LV	KI	Ur	Other	WB
8	1032	96.59	.34	.20	--	.16	1.7	.01	--	.65	99.65
27	390	89.11	4.06	.1	--	2.31	1.26	.03	--	.49	97.36
27	921	92.05	.68	0	0	2.05	.45	0	0	3.64	100.00
28	930	98.01	.63	.02	.38	.34	.08	.02	0	.39	99.62
28	931	94.89	1.83	.01	1.14	.35	.05	0	0	1.74	98.86
29	924	95.28	.75	.14	.64	.46	.30	.01	0	2.69	99.35
30	403	89.26	2.01	.02	--	1.82	1.39	.04	--	.52	95.16
35	408	87.79	1.36	.01	--	3.17	1.69	.04	--	.68	94.97
54	942	91.12	5.03	.07	.84	1.07	.76	.02	.01	1.07	99.15
54	933	92.92	4.78	.03	.51	.83	.39	.01	.01	.78	99.48
56	929	90.06	7.44	0	.87	.56	.26	.15	.02	.62	99.12
56	932	95.93	2.53	.01	.38	.39	.18	0	.01	.56	99.61
56	395	85.46	2.35	.03	--	3.42	.87	.05	--	.82	93.33
56	450	84.95	3.86	.03	--	3.70	.42	.04	--	.55	93.43
57	923	84.89	8.94	0	4.07	.43	0	0	.18	1.91	95.74
61	393	90.00	1.67	.04	--	2.80	.96	.05	--	.58	96.71
70	460	83.14	2.44	0	--	4.21	1.79	.05	--	.67	92.82
76	442	86.68	3.30	.03	--	3.04	1.29	.05	--	2.36	95.55
77	399	87.78	4.48	.02	--	2.13	1.00	.06	--	.78	95.55
78	922	88.78	6.05	.01	.78	2.19	.93	.02	.06	1.16	99.16
78	935	91.90	3.90	.05	.52	1.30	.75	.02	.06	1.71	99.42
89	925	87.89	3.98	.08	3.72	1.20	.08	0	.04	3.16	96.24
90	926	86.58	10.51	.23	0	1.07	.65	.01	0	.83	100.00
91	934	91.66	4.84	1.69	.05	.95	.45	.01	0	.33	99.94
94	449	85.35	3.20	.02	--	4.23	.30	.07	--	.46	93.42
126	413	72.85	7.89	.04	--	5.93	2.19	.93	--	.99	89.47
186	400	70.37	3.93	.04	--	11.89	4.08	.18	--	1.12	92.59
687	492	3.98	3.91	.15	5.73	59.10	21.40	.19	2.03	3.52	92.24
1076	404	29.44	9.58	.17	5.66	29.42	21.17	.16	1.14	3.27	93.20
1663	469	32.04	4.55	.22	4.32	38.18	15.85	.59	1.50	2.72	94.18
1768	445	5.75	9.50	.07	5.02	51.43	21.44	.24	2.20	4.36	92.78

Summarized Data from Dogs Exposed by Inhalation to $^{238}\text{PuO}_2$ from Calcined Oxalate (cont.)

Mean Days	Dog #	% Initial Body Burden									
		Lung	TBLN	ALN	Fe	SK	LV	KI	Ur	Other	WB
1825	438	6.68	10.18	2.11	4.77	40.02	30.70	.18	1.47	3.72	93.77
1867	453	16.04	8.27	.11	3.50	45.12	21.00	.34	1.78	3.83	94.72
2133	405	21.47	10.44	.28	6.50	31.13	26.14	.30	1.63	2.11	91.87

APPENDIX B

Summarized Data From Dogs Exposed by
Inhalation to $^{239}\text{Pu}(\text{NO}_3)_4$ (Low Dose)

% Body Burden at Death

Days	Lung	TB Nodes	Fe*	SK	LV	BL	Ur*	Residual** Soft Tissue	Systemic***
1	<u>76.0</u>	<u>0.06</u>	22.1	<u>1.6</u>	<u>0.28</u>	<u>1.85</u>	0.43	<u>1.4</u>	<u>3.28</u>
2	_____	_____	16.6	_____	_____	_____	0.14	_____	_____
3	<u>86.0</u>	<u>0.09</u>	11.9	<u>5.8</u>	<u>1.2</u>	<u>1.98</u>	0.08	<u>1.6</u>	<u>8.6</u>
4	_____	_____	1.6	_____	_____	_____	0.08	_____	_____
5	_____	_____	2.98	_____	_____	_____	0.09	_____	_____
6	_____	_____	1.50	_____	_____	_____	0.07	_____	_____
7	<u>76.0</u>	<u>0.14</u>	0.68	<u>12.8</u>	<u>4.0</u>	<u>1.28</u>	0.06	<u>2.2</u>	<u>19.0</u>
8	_____	_____	0.77	_____	_____	_____	0.058	_____	_____
9	_____	_____	0.56	_____	_____	_____	0.054	_____	_____
10	_____	_____	0.48	_____	_____	_____	0.03	_____	_____
11	_____	_____	0.48	_____	_____	_____	0.038	_____	_____
12	_____	_____	0.48	_____	_____	_____	0.031	_____	_____
13	_____	_____	0.33	_____	_____	_____	0.0297	_____	_____
14	<u>49.0</u>	<u>0.20</u>	0.41	<u>30.7</u>	<u>13.0</u>	<u>0.76</u>	0.06	<u>2.6</u>	<u>46.3</u>
15	_____	_____	0.498	_____	_____	_____	0.029	_____	_____
16	_____	_____	0.35	_____	_____	_____	0.023	_____	_____
17	_____	_____	0.367	_____	_____	_____	0.031	_____	_____
18	_____	_____	0.223	_____	_____	_____	0.024	_____	_____
19	_____	_____	0.31	_____	_____	_____	0.027	_____	_____
20	_____	_____	0.52	_____	_____	_____	0.038	_____	_____
21	_____	_____	0.32	_____	_____	_____	0.027	_____	_____
22	_____	_____	0.178	_____	_____	_____	0.025	_____	_____
23	_____	_____	0.133	_____	_____	_____	0.027	_____	_____
24	_____	_____	0.188	_____	_____	_____	0.019	_____	_____
25	_____	_____	0.15	_____	_____	_____	0.022	_____	_____
26	_____	_____	0.179	_____	_____	_____	0.028	_____	_____
27	_____	_____	0.27	_____	_____	_____	0.016	_____	_____
28	_____	_____	0.128	_____	_____	_____	0.022	_____	_____
29	_____	_____	0.167	_____	_____	_____	0.024	_____	_____

Summarized Data From Dogs Exposed by Inhalation to $^{239}\text{Pu}(\text{NO}_3)_4$ (Low Dose) (continued)

% Body Burden at Death									
Days	Lung	TB Nodes	Fe*	SK	LV	BL	Ur*	Residual** Soft Tissue	Systemic***
30	35.0	0.40	0.144	48.2	10.0	0.32	0.025	2.6	60.8
31	—	—	0.169	—	—	—	0.016	—	—
32	—	—	0.119	—	—	—	0.012	—	—
33	—	—	0.132	—	—	—	0.024	—	—
34	—	—	0.156	—	—	—	0.023	—	—
35	—	—	0.170	—	—	—	0.0213	—	—
36	—	—	0.405	—	—	—	0.022	—	—
37	—	—	0.089	—	—	—	0.017	—	—
38	—	—	0.139	—	—	—	0.016	—	—
39	—	—	0.177	—	—	—	0.0143	—	—
40	—	—	0.152	—	—	—	0.018	—	—
41	—	—	—	—	—	—	—	—	—
42	—	—	—	—	—	—	—	—	—
43	—	—	—	—	—	—	—	—	—
44	—	—	—	—	—	—	—	—	—
45	—	—	—	—	—	—	—	—	—
46	—	—	—	—	—	—	—	—	—
47	—	—	—	—	—	—	—	—	—
48	—	—	—	—	—	—	—	—	—
49	—	—	—	—	—	—	—	—	—
50	—	—	—	—	—	—	—	—	—
51	—	—	—	—	—	—	—	—	—
52	—	—	—	—	—	—	—	—	—
53	—	—	—	—	—	—	—	—	—
54	—	—	—	—	—	—	—	—	—
55	—	—	—	—	—	—	—	—	—
56	—	—	—	—	—	—	—	—	—
57	—	—	—	—	—	—	—	—	—
58	—	—	—	—	—	—	—	—	—
59	—	—	—	—	—	—	—	—	—
60	—	—	—	—	—	—	—	—	—
61	—	—	—	—	—	—	—	—	—

Summarized Data From Dogs Exposed by Inhalation to $^{239}\text{Pu}(\text{NO}_3)_4$ (Low Dose) (continued)

Days	Lung	TB Nodes	Fe*	SK	LV	BL	Ur*	% Body Burden at Death	
								Residual** Soft Tissue	Systemic***
62	<u>41.0</u>	<u>4.52</u>		<u>2.1</u>	<u>10.6</u>	<u>0.19</u>		<u>2.1</u>	<u>55.1</u>
70	—	—		—	—	—		—	—
71	—	—		—	—	—		—	—
74	—	—		—	—	—		—	—
81	—	—		—	—	—		—	—
88	—	—		—	—	—		—	—
95	—	—		—	—	—		—	—
100	<u>49.0</u>	<u>0.77</u>		<u>2.3</u>	<u>12.4</u>	<u>0.12</u>		<u>2.3</u>	<u>48.1</u>

* Feces and urine in % body burden.

** Includes only muscle picked from skeleton so total for all organs doesn't equal 100%.

*** Systemic equals sum of liver, skeleton and residual soft tissue.

APPENDIX C

Sample Tabular
and Graphical Results

Dionne-Stuart Model

--LUNGS

VARYING HALF TIME --
THP = 1.0 YR(S)
DEEP LUNG VARYING --
THPU = 1.0 YR(S)
DEEP LUNG CONSTANT--
THPC = 2.0 YR(S)

--LYMPH NODES (TBLN)

FIRST COMPARTMENT --
THTB = 1.0 YR(S)
FTBNPC = 60.0 %
SECOND COMPARTMENT--
FTBTB = 20.0 %

--LYMPH NODES (ALN)

FIRST COMPARTMENT --
THA1 = 1.0 YR(S)
FANPC = 100.0 %
SECOND COMPARTMENT--
FAA = 70.0 %

BLOOD --
FBLNPC = 40.0 %
FBLTB1 = 80.0 %
FBLA1 = 30.0 %
FBLBO = 100.0 %
FBLLO = 100.0 %
FBLKI = 1.0 %
FBLLO = 100.0 %

--SKELETON

THBO = 100.0 YR(S)
FBOBL = 58.0 %

--LIVER

THLU = 40.0 YR(S)
FLUBL = 34.0 %

--KIDNEY

THKI = 40.0 YR(S)
FKIBL = 0.3 %

--OTHER

THOT = 100.0 YR(S)
FOTBL = 5.0 %

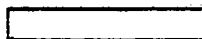
--URINE (Σ)

FURKI = 99.0 %
FURBL = 2.7 %

--FECES (Σ)

FFELU = 0.0 %
FFENPU = 85.0 %
FFENPC = 0.0 %

--WHOLE BODY



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RESULTS FROM PLUTONIUM INHALATION MODEL

11:19:38

FRACTIONAL UPTAKE CONSTANTS

FTBNPC = 60.0 %
 FANPC = 100.0 %
 FBLNPC = 40.0 %
 FBLA1 = 30.0 %
 FBLLV = 100.0 %
 FBLUT = 100.0 %
 FLVEL = 34.0 %
 FOTBL = 5.0 %
 FURBL = 2.7 %
 FFENPV = 85.0 %

FTBTB = 20.0 %
 FFA = 70.0 %
 FBLTB1 = 80.0 %
 FBLBO = 100.0 %
 FBLKI = 1.0 %
 FBOBL = 58.0 %
 FKIEL = 0.3 %
 FURKI = 99.0 %
 FFELV = 0.0 %
 FFENPC = 0.0 %

BIOLOGICAL HALF-TIMES

THP = 1.0 YR(S)
 THPC = 2.0 YR(S)
 THA1 = 1.0 YR(S)
 THLV = 40.0 YR(S)
 THOT = 100.0 YR(S)

THPV = 1.0 YR(S)
 THTB = 1.0 YR(S)
 THBO = 100.0 YR(S)
 THKI = 40.0 YR(S)
 THTB2 = 5.0 YR(S)

TIME = 0.0 YR(S)

LPV = 5.00000
 NPV = 6.00000
 NTB1 = 0.00000
 NA1 = 0.00000
 NBLD = 0.00000
 NLV = 0.60000
 NUR = 0.00000
 NTOT = 100.83300

NPC = 94.00000
 NTB2 = 0.00000
 NA2 = 0.00000
 NBO = 0.21600
 NKI = 0.01700
 NFE = 0.00000

NP = 100.00000
 NTB = 0.00000
 NA = 0.00000
 NOT = 0.00000

TIME = 1.0 YR(S)

LPV = 2.50016
 NPV = 0.16451
 NTB1 = 11.67929
 NA1 = 0.03944
 NBLD = 15.94061
 NLV = 5.93374
 NUR = 0.42878
 NTOT = 95.44405

NPC = 66.46857
 NTB2 = 0.92038
 NA2 = 0.00525
 NBO = 9.37842
 NKI = 0.06386
 NFE = 4.96017

NP = 66.63308
 NTB = 12.60028
 NA = 0.04468
 NOT = 0.78999

TIME = 2.0 YR(S)

LPV = 1.25080
 NPV = 0.02737
 NTB1 = 14.09316
 NA1 = 0.20115
 NBLD = 14.70928
 NLV = 11.05376
 NUR = 0.04060
 NTOT = 94.90765

NPC = 47.00365
 NTB2 = 2.53555
 NA2 = 0.05896
 NBO = 18.26868
 NKI = 0.10884
 NFE = 5.07673

NP = 47.03102
 NTB = 16.62871
 NA = 0.26011
 NOT = 1.55652

TIME = 3.0 YR(S)

LPV = 0.62598
NPV = 0.01114
NTB1 = 12.88315
NA1 = 0.43753
NBLD = 12.30771
NLV = 15.42865
NUR = 1.21656
NTOT = 94.52590

NPC = 33.24033
NTB2 = 3.97353
NA2 = 0.21243
NBO = 25.97124
NKI = 0.14725
NFE = 5.09053

NP = 33.25146
NTB = 16.85668
NA = 0.64996
NOT = 2.22066

TIME = 4.0 YR(S)

LPV = 0.31328
NPV = 0.00710
NTB1 = 10.57046
NA1 = 0.67601
NBLD = 9.82809
NLV = 18.88721
NUR = 1.51772
NTOT = 94.22130

NPC = 23.50709
NTB2 = 4.97807
NA2 = 0.48368
NBO = 32.17822
NKI = 0.17757
NFE = 5.09397

NP = 23.51419
NTB = 15.54853
NA = 1.15969
NOT = 2.75587

TIME = 5.0 YR(S)

LPV = 0.15714
NPV = 0.00566
NTB1 = 8.20441
NA1 = 0.87074
NBLD = 7.68350
NLV = 21.50108
NUR = 1.75644
NTOT = 93.98137

NPC = 16.62826
NTB2 = 5.54233
NA2 = 0.86146
NBO = 36.99568
NKI = 0.20045
NFE = 5.09518

NP = 16.63392
NTB = 13.74673
NA = 1.73220
NOT = 3.17130

TIME = 6.0 YR(S)

LPV = 0.07888
NPV = 0.00506
NTB1 = 6.16826
NA1 = 1.00356
NBLD = 5.95886
NLV = 23.41927
NUR = 1.94334
NTOT = 93.79395

NPC = 11.76340
NTB2 = 5.74678
NA2 = 1.31908
NBO = 40.66373
NKI = 0.21719
NFE = 5.09570

NP = 11.76846
NTB = 11.91503
NA = 2.32264
NOT = 3.48763

TIME = 7.0 YR(S)

LPV = 0.03960
NPV = 0.00478
NTB1 = 4.54644
NA1 = 1.07493
NBLD = 4.64402
NLV = 24.79557
NUR = 2.08971
NTOT = 93.64735

NPC = 8.32183
NTB2 = 5.68865
NA2 = 1.82596
NBO = 43.43351
NKI = 0.22915
NFE = 5.09594

NP = 8.32661
NTB = 10.23509
NA = 2.90089
NOT = 3.72653

TIME = 8.0 YR(S)

LPV = 0.01988
NPV = 0.00465
NTB1 = 3.30808
NA1 = 1.09432
NBLD = 3.65862
NLV = 25.76234
NUR = 2.20532
NTOT = 93.53162

NPC = 5.88714
NTB2 = 5.45429
NA2 = 3.35432
NBO = 45.52227
NKI = 0.23751
NFE = 5.09605

NP = 5.89179
NTB = 8.76237
NA = 3.44864
NOT = 3.90672

TIME = 9.0 YR(S)

LPV = 0.00998
 NPV = 0.00458
 NTB1 = 2.38631
 NA1 = 1.07407
 NBLD = 2.92994
 NLV = 26.42519
 NUR = 2.29803
 NTOT = 93.43887

NPC = 4.16477
 NTB2 = 5.11189
 NA2 = 2.88191
 NBO = 47.10379
 NKI = 0.24318
 NFE = 5.09611

NP = 4.16935
 NTB = 7.49820
 NA = 3.95598
 NOT = 4.04318

TIME = 10.0 YR(S)

LPV = 0.00501
 NPV = 0.00455
 NTB1 = 1.71128
 NA1 = 1.02615
 NBLD = 2.39513
 NLV = 26.86500
 NUR = 2.37385
 NTOT = 93.36302

NPC = 2.94630
 NTB2 = 4.71169
 NA2 = 3.39244
 NBO = 48.31133
 NKI = 0.24689
 NFE = 5.09613

NP = 2.95085
 NTB = 6.42297
 NA = 4.41859
 NOT = 4.14740

TIME = 11.0 YR(S)

LPV = 0.00251
 NPV = 0.00453
 NTB1 = 1.22223
 NA1 = 0.96069
 NBLD = 2.00394
 NLV = 27.14216
 NUR = 2.43729
 NTOT = 93.29956

NPC = 2.00431
 NTB2 = 4.28894
 NA2 = 3.87506
 NBO = 49.24450
 NKI = 0.24316
 NFE = 5.09615

NP = 2.08884
 NTB = 5.51117
 NA = 4.83576
 NOT = 4.22796

TIME = 12.0 YR(S)

LPV = 0.00126
 NPV = 0.00452
 NTB1 = 0.87047
 NA1 = 0.88561
 NBLD = 1.71797
 NLV = 27.30117
 NUR = 2.49168
 NTOT = 93.24516

NPC = 1.47451
 NTB2 = 3.86725
 NA2 = 4.32327
 NBO = 49.97674
 NKI = 0.25040
 NFE = 5.09616

NP = 1.47904
 NTB = 4.73772
 NA = 5.20889
 NOT = 4.29121

TIME = 13.0 YR(S)

LPV = 0.00063
 NPV = 0.00452
 NTB1 = 0.61073
 NA1 = 0.80672
 NBLD = 1.50855
 NLV = 27.37450
 NUR = 2.53943
 NTOT = 93.19741

NPC = 1.04312
 NTB2 = 3.46164
 NA2 = 4.73391
 NBO = 50.56164
 NKI = 0.25088
 NFE = 5.09616

NP = 1.04764
 NTB = 4.08037
 NA = 5.54062
 NOT = 4.34175

TIME = 14.0 YR(S)

LPV = 0.00032
 NPV = 0.00452
 NTB1 = 0.43918
 NA1 = 0.72806
 NBLD = 1.35462
 NLV = 27.38573
 NUR = 2.58231
 NTOT = 93.15453

NPC = 0.73794
 NTB2 = 3.09103
 NA2 = 5.10617
 NBO = 51.03814
 NKI = 0.25082
 NFE = 5.09616

NP = 0.74246
 NTB = 3.52021
 NA = 5.83423
 NOT = 4.38294

TIME = 15.0 YR(S)

LPV = 0.00016
 NPV = 0.00452
 NTB1 = 0.31143
 NA1 = 0.65230
 NBLD = 1.24087
 NLV = 27.35194
 NUR = 2.62160
 NTOT = 93.11523

NPC = 0.52204
 NTB2 = 2.73009
 NA2 = 5.44087
 NBO = 51.43445
 NKI = 0.25037
 NFE = 5.09616

NP = 0.52656
 NTB = 3.04152
 NA = 6.09317
 NOT = 4.41722

TIME = 16.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.22068
 NA1 = 0.58109
 NBLD = 1.15623
 NLV = 27.28550
 NUR = 2.65821
 NTOT = 93.07862

NPC = 0.36931
 NTB2 = 2.41065
 NA2 = 5.73986
 NBO = 51.77103
 NKI = 0.24963
 NFE = 5.09616

NP = 0.37383
 NTB = 2.63134
 NA = 6.32095
 NOT = 4.44635

TIME = 17.0 YR(S)

LPV = 0.00004
 NPV = 0.00452
 NTB1 = 0.15630
 NA1 = 0.51530
 NBLD = 1.09270
 NLV = 27.19537
 NUR = 2.69281
 NTOT = 93.04401

NPC = 0.26126
 NTB2 = 2.12267
 NA2 = 6.00559
 NBO = 52.06270
 NKI = 0.24868
 NFE = 5.09616

NP = 0.26578
 NTB = 2.27898
 NA = 6.52089
 NOT = 4.47161

TIME = 18.0 YR(S)

LPV = 0.00002
 NPV = 0.00452
 NTB1 = 0.11083
 NA1 = 0.45531
 NBLD = 1.04341
 NLV = 27.08794
 NUR = 2.72589
 NTOT = 93.01094

NPC = 0.18511
 NTB2 = 1.86501
 NA2 = 6.24071
 NBO = 52.32002
 NKI = 0.24758
 NFE = 5.09616

NP = 0.18962
 NTB = 1.97585
 NA = 6.69602
 NOT = 4.49391

TIME = 19.0 YR(S)

LPV = 0.00001
 NPV = 0.00452
 NTB1 = 0.07857
 NA1 = 0.40116
 NBLD = 1.00688
 NLV = 26.96816
 NUR = 2.75781
 NTOT = 92.97901

NPC = 0.13115
 NTB2 = 1.63576
 NA2 = 6.44814
 NBO = 52.55123
 NKI = 0.24638
 NFE = 5.09616

NP = 0.13566
 NTB = 1.71433
 NA = 6.84930
 NOT = 4.51396

TIME = 20.0 YR(S)

LPV = 0.00001
 NPV = 0.00452
 NTB1 = 0.05569
 NA1 = 0.35264
 NBLD = 0.97847
 NLV = 26.83949
 NUR = 2.78883
 NTOT = 92.94799

NPC = 0.09292
 NTB2 = 1.43268
 NA2 = 6.63068
 NBO = 52.76205
 NKI = 0.24510
 NFE = 5.09616

NP = 0.09744
 NTB = 1.48837
 NA = 6.98332
 NOT = 4.53224

TIME = 21.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.03947
 NA1 = 0.30942
 NBLD = 0.95609
 NLV = 26.70446
 NUR = 2.81914
 NTOT = 92.91769

NPC = 0.06583
 NTB2 = 1.25338
 NA2 = 6.79098
 NBO = 52.95672
 NKI = 0.24376
 NFE = 5.09616

NP = 0.07035
 NTB = 1.29285
 NA = 7.10040
 NOT = 4.54914

TIME = 22.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.02797
 NA1 = 0.27110
 NBLD = 0.93820
 NLV = 26.56496
 NUR = 2.84889
 NTOT = 92.88794

NPC = 0.04664
 NTB2 = 1.09553
 NA2 = 6.93153
 NBO = 53.13840
 NKI = 0.24239
 NFE = 5.09616

NP = 0.05116
 NTB = 1.12350
 NA = 7.20262
 NOT = 4.56491

TIME = 23.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.01982
 NA1 = 0.23724
 NBLD = 0.92370
 NLV = 26.42239
 NUR = 2.87817
 NTOT = 92.85866

NPC = 0.03305
 NTB2 = 0.95685
 NA2 = 7.05459
 NBO = 53.30945
 NKI = 0.24100
 NFE = 5.09616

NP = 0.03756
 NTB = 0.97667
 NA = 7.29183
 NOT = 4.57977

TIME = 24.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.01404
 NA1 = 0.20741
 NBLD = 0.91176
 NLV = 26.27781
 NUR = 2.90707
 NTOT = 92.82976

NPC = 0.02341
 NTB2 = 0.83523
 NA2 = 7.16223
 NBO = 53.47167
 NKI = 0.23959
 NFE = 5.09616

NP = 0.02793
 NTB = 0.84927
 NA = 7.36963
 NOT = 4.59386

TIME = 25.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.00995
 NA1 = 0.18118
 NBLD = 0.90179
 NLV = 25.13203
 NUR = 2.93566
 NTOT = 92.80118

NPC = 0.01659
 NTB2 = 0.72871
 NA2 = 7.25629
 NBO = 53.62643
 NKI = 0.23817
 NFE = 5.09616

NP = 0.02110
 NTB = 0.73866
 NA = 7.43747
 NOT = 4.60731

TIME = 26.0 YR(S)

LPV = 0.00000
 NPV = 0.00452
 NTB1 = 0.00705
 NA1 = 0.15618
 NBLD = 0.89336
 NLV = 25.98565
 NUR = 2.96396
 NTOT = 92.77287

NPC = 0.01175
 NTB2 = 0.63553
 NA2 = 7.33843
 NBO = 53.77481
 NKI = 0.23675
 NFE = 5.09616

NP = 0.01627
 NTB = 0.64258
 NA = 7.49661
 NOT = 4.62021

TIME = 27.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00500
NA1 = 0.13882
NBLD = 0.88613
NLV = 25.83914
NUR = 2.99204
NTOT = 92.74480

NPC = 0.00833
NTB2 = 0.55489
NA2 = 7.41013
NBO = 53.91764
NKI = 0.23532
NFE = 5.09616

NP = 0.01284
NTB = 0.55908
NA = 7.54815
NOT = 4.63263

TIME = 28.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00354
NA1 = 0.12039
NBLD = 0.87985
NLV = 25.69287
NUR = 3.01990
NTOT = 92.71694

NPC = 0.00590
NTB2 = 0.48296
NA2 = 7.47267
NBO = 54.05557
NKI = 0.23391
NFE = 5.09616

NP = 0.01042
NTB = 0.48650
NA = 7.59306
NOT = 4.64463

TIME = 29.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00251
NA1 = 0.10497
NBLD = 0.87433
NLV = 25.54712
NUR = 3.04759
NTOT = 92.68925

NPC = 0.00418
NTB2 = 0.42087
NA2 = 7.52721
NBO = 54.18913
NKI = 0.23250
NFE = 5.09616

NP = 0.00870
NTB = 0.42338
NA = 7.63218
NOT = 4.65625

TIME = 30.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00178
NA1 = 0.09150
NBLD = 0.86944
NLV = 25.40212
NUR = 3.07510
NTOT = 92.66173

NPC = 0.00296
NTB2 = 0.36670
NA2 = 7.57476
NBO = 54.31877
NKI = 0.23110
NFE = 5.09616

NP = 0.00748
NTB = 0.36848
NA = 7.66626
NOT = 4.66753

TIME = 31.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00126
NA1 = 0.07974
NBLD = 0.86505
NLV = 25.25805
NUR = 3.10247
NTOT = 92.63437

NPC = 0.00210
NTB2 = 0.31946
NA2 = 7.61621
NBO = 54.44482
NKI = 0.22971
NFE = 5.09616

NP = 0.00661
NTB = 0.32072
NA = 7.69595
NOT = 4.67850

TIME = 32.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00089
NA1 = 0.06948
NBLD = 0.86109
NLV = 25.11505
NUR = 3.12970
NTOT = 92.60713

NPC = 0.00149
NTB2 = 0.27828
NA2 = 7.65232
NBO = 54.56760
NKI = 0.22833
NFE = 5.09616

NP = 0.00600
NTB = 0.27917
NA = 7.72180
NOT = 4.68919

TIME = 33.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00063
NA1 = 0.05053
NBLD = 0.85747
NLV = 24.97323
NUR = 3.15681
NTOT = 92.58003

NPC = 0.00105
NTB2 = 0.24238
NA2 = 7.68379
NBO = 54.68733
NKI = 0.22696
NFE = 5.09616

NP = 0.00557
NTB = 0.24301
NA = 7.74432
NOT = 4.69961

TIME = 34.0 YR(S)

LPV = 3.00000
NPV = 3.00452
NTB1 = 0.00045
NA1 = 0.05273
NBLD = 0.85416
NLV = 24.83268
NUR = 3.18380
NTOT = 92.55304

NPC = 0.00075
NTB2 = 0.21110
NA2 = 7.71120
NBO = 54.80423
NKI = 0.22561
NFE = 5.09616

NP = 0.00526
NTB = 0.21154
NA = 7.76393
NOT = 4.70979

TIME = 35.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00032
NA1 = 0.04593
NBLD = 0.85110
NLV = 24.69346
NUR = 3.21068
NTOT = 92.52617

NPC = 0.00053
NTB2 = 0.18384
NA2 = 7.73507
NBO = 54.91849
NKI = 0.22427
NFE = 5.09616

NP = 0.00504
NTB = 0.18416
NA = 7.78100
NOT = 4.71974

TIME = 36.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00022
NA1 = 0.04000
NBLD = 0.84825
NLV = 24.55564
NUR = 3.23746
NTOT = 92.49938

NPC = 0.00037
NTB2 = 0.16009
NA2 = 7.75587
NBO = 55.03024
NKI = 0.22294
NFE = 5.09616

NP = 0.00489
NTB = 0.16032
NA = 7.79587
NOT = 4.72948

TIME = 37.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00016
NA1 = 0.03484
NBLD = 0.84559
NLV = 24.41926
NUR = 3.26414
NTOT = 92.47271

NPC = 0.00027
NTB2 = 0.13941
NA2 = 7.77398
NBO = 55.13963
NKI = 0.22163
NFE = 5.09616

NP = 0.00478
NTB = 0.13957
NA = 7.80882
NOT = 4.73901

TIME = 38.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00011
NA1 = 0.03034
NBLD = 0.84309
NLV = 24.28436
NUR = 3.29072
NTOT = 92.44612

NPC = 0.00019
NTB2 = 0.12140
NA2 = 7.78976
NBO = 55.24678
NKI = 0.22033
NFE = 5.09616

NP = 0.00470
NTB = 0.12151
NA = 7.82009
NOT = 4.74835

TIME = 39.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00000
NA1 = 0.02642
NBLO = 0.84073
NLV = 24.15035
NUR = 3.31722
NTOT = 92.41963

NPC = 0.00013
NTB2 = 0.10571
NA2 = 7.80349
NBO = 55.35178
NKI = 0.21905
NFE = 5.09616

NP = 0.00465
NTB = 0.10579
NA = 7.82991
NOT = 4.75750

TIME = 40.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00006
NA1 = 0.02300
NBLO = 0.83849
NLV = 24.01906
NUR = 3.34364
NTOT = 92.39321

NPC = 0.00009
NTB2 = 0.09204
NA2 = 7.81545
NBO = 55.45472
NKI = 0.21779
NFE = 5.09616

NP = 0.00461
NTB = 0.09210
NA = 7.83846
NOT = 4.76647

TIME = 41.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00004
NA1 = 0.02003
NBLO = 0.83636
NLV = 23.88870
NUR = 3.36998
NTOT = 92.36687

NPC = 0.00007
NTB2 = 0.08014
NA2 = 7.82587
NBO = 55.55569
NKI = 0.21654
NFE = 5.09616

NP = 0.00458
NTB = 0.08018
NA = 7.84590
NOT = 4.77527

TIME = 42.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00003
NA1 = 0.01744
NBLO = 0.83433
NLV = 23.75988
NUR = 3.39623
NTOT = 92.34061

NPC = 0.00005
NTB2 = 0.06978
NA2 = 7.83494
NBO = 55.65477
NKI = 0.21530
NFE = 5.09616

NP = 0.00456
NTB = 0.06981
NA = 7.85238
NOT = 4.78391

TIME = 43.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00002
NA1 = 0.01519
NBLO = 0.83238
NLV = 23.63260
NUR = 3.42242
NTOT = 92.31442

NPC = 0.00003
NTB2 = 0.06076
NA2 = 7.84283
NBO = 55.75201
NKI = 0.21408
NFE = 5.09616

NP = 0.00455
NTB = 0.06078
NA = 7.85802
NOT = 4.79239

TIME = 44.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00001
NA1 = 0.01322
NBLO = 0.83051
NLV = 23.50686
NUR = 3.44853
NTOT = 92.28831

NPC = 0.00002
NTB2 = 0.05290
NA2 = 7.84971
NBO = 55.84747
NKI = 0.21287
NFE = 5.09616

NP = 0.00454
NTB = 0.05292
NA = 7.86293
NOT = 4.80071

TIME = 45.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00001
NA1 = 0.01151
NBLD = 0.82871
NLV = 23.38267
NUR = 3.47457
NTOT = 92.26227

NPC = 0.00002
NTB2 = 0.04606
NA2 = 7.85570
NBO = 55.94122
NKI = 0.21168
NFE = 5.09616

NP = 0.00453
NTB = 0.04607
NA = 7.86721
NOT = 4.80889

TIME = 46.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00001
NA1 = 0.01003
NBLD = 0.82697
NLV = 23.26001
NUR = 3.50054
NTOT = 92.23629

NPC = 0.00001
NTB2 = 0.04010
NA2 = 7.86091
NBO = 56.03329
NKI = 0.21051
NFE = 5.09616

NP = 0.00453
NTB = 0.04011
NA = 7.87093
NOT = 4.81692

TIME = 47.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00001
NA1 = 0.00873
NBLD = 0.82528
NLV = 23.13888
NUR = 3.52645
NTOT = 92.21039

NPC = 0.00001
NTB2 = 0.03492
NA2 = 7.86545
NBO = 56.12373
NKI = 0.20935
NFE = 5.09616

NP = 0.00452
NTB = 0.03492
NA = 7.87418
NOT = 4.82481

TIME = 48.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00000
NA1 = 0.00760
NBLD = 0.82364
NLV = 23.01927
NUR = 3.55229
NTOT = 92.18455

NPC = 0.00001
NTB2 = 0.03040
NA2 = 7.86940
NBO = 56.21259
NKI = 0.20821
NFE = 5.09616

NP = 0.00452
NTB = 0.03040
NA = 7.87700
NOT = 4.83256

TIME = 49.0 YR(S)

LPV = 0.00000
NPV = 0.00452
NTB1 = 0.00000
NA1 = 0.00662
NBLD = 0.82205
NLV = 22.90117
NUR = 3.57807
NTOT = 92.15877

NPC = 0.00000
NTB2 = 0.02647
NA2 = 7.87284
NBO = 56.29990
NKI = 0.20708
NFE = 5.09616

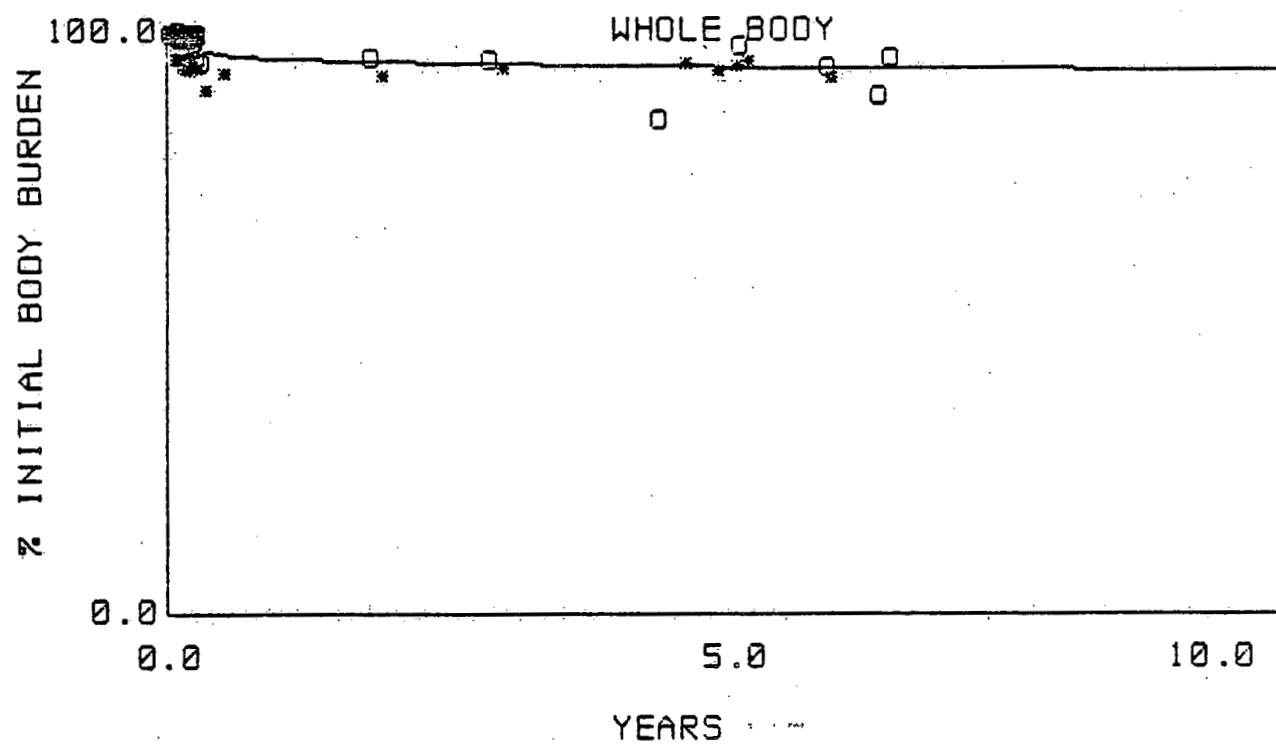
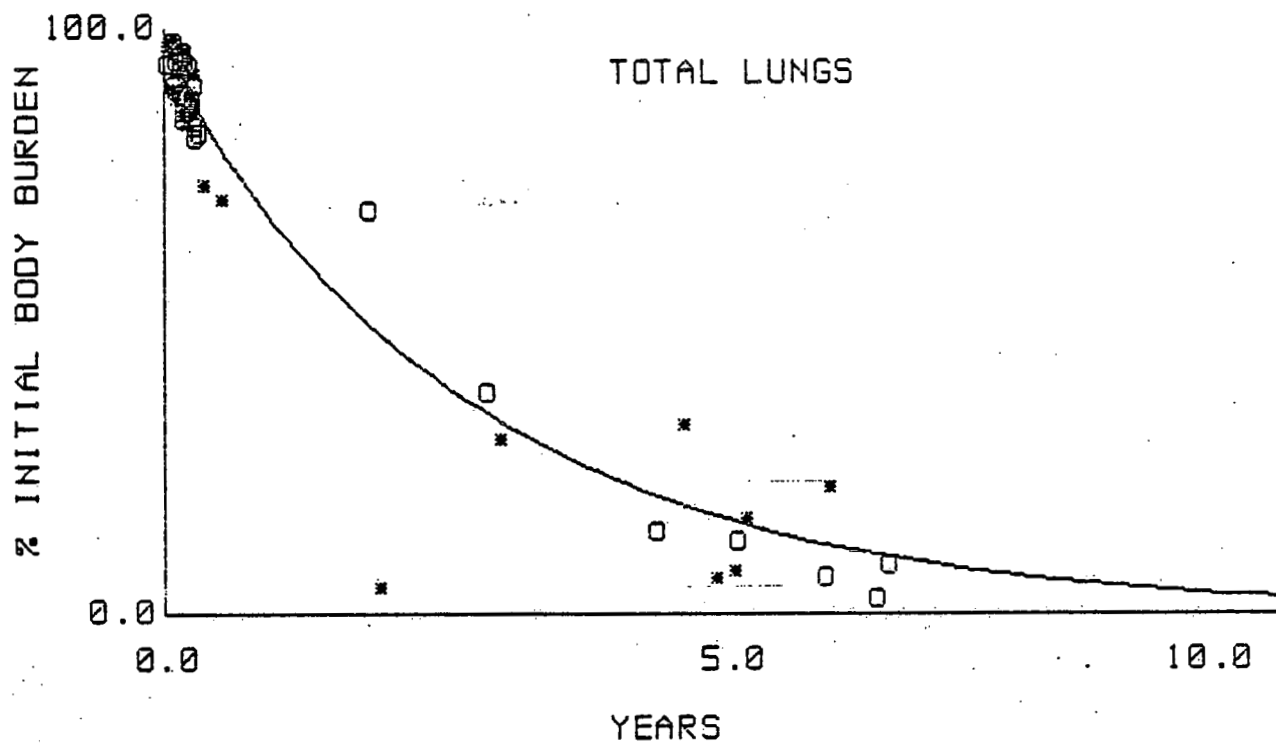
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NOT = 4.84018

TIME = 50.0 YR(S)

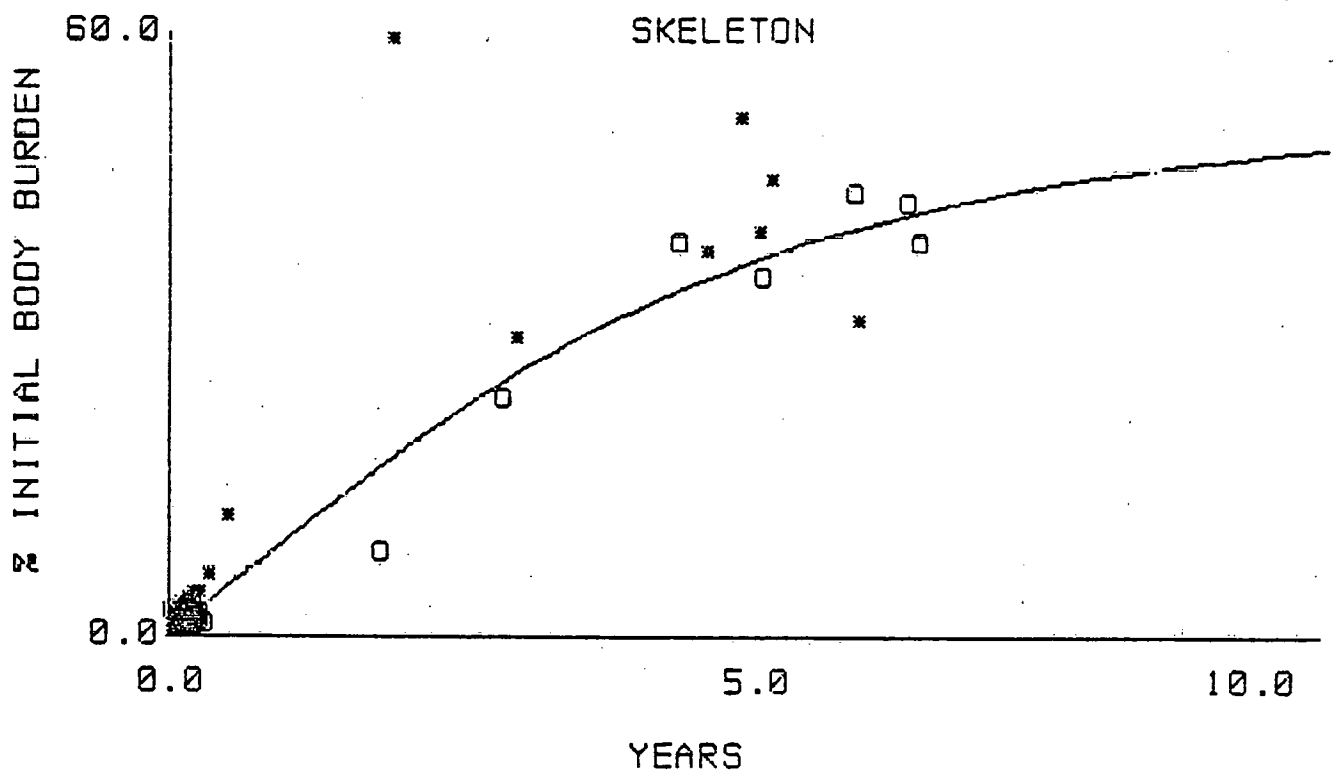
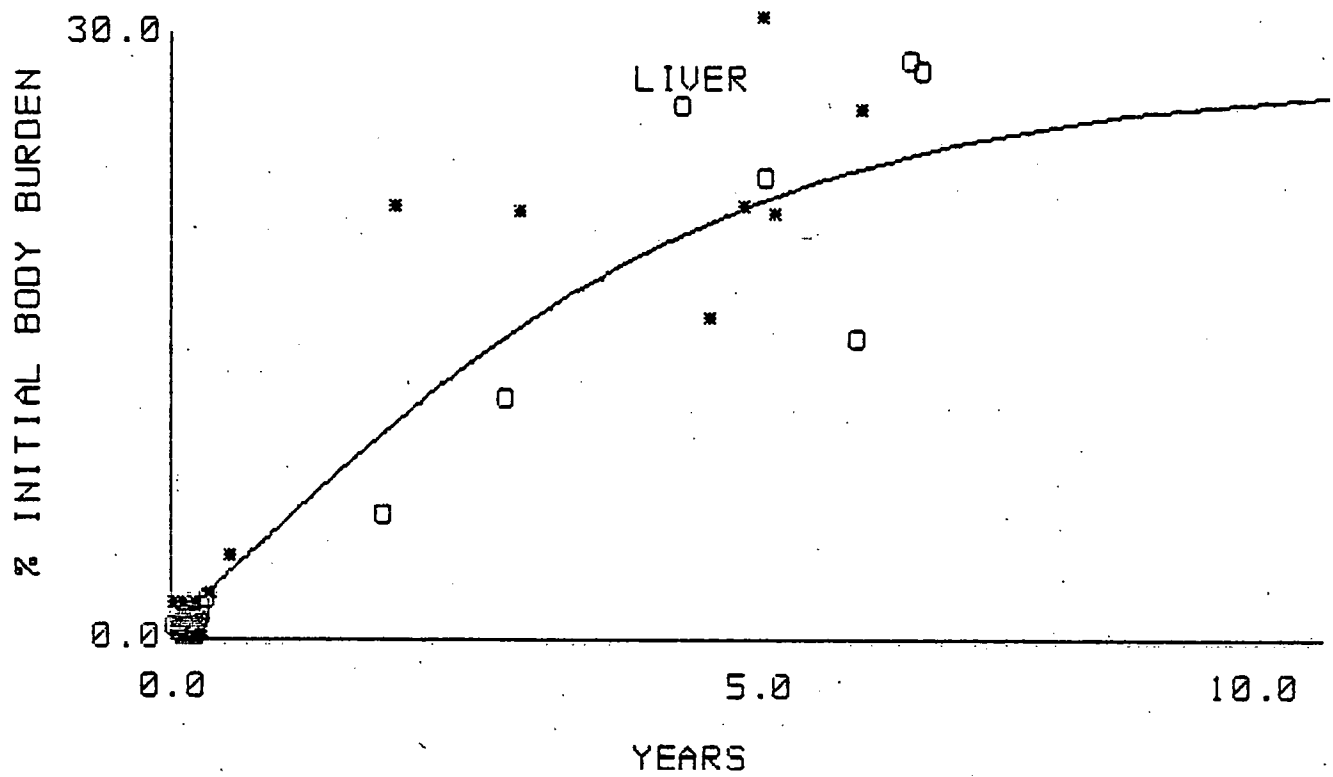
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NPV = 0.00452
NTB1 = 0.00000
NA1 = 0.00576
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NUR = 3.60379
NTOT = 92.13306

NPC = 0.00000
NTB2 = 0.02305
NA2 = 7.87584
NBO = 56.38570
NKI = 0.20596
NFE = 5.09616

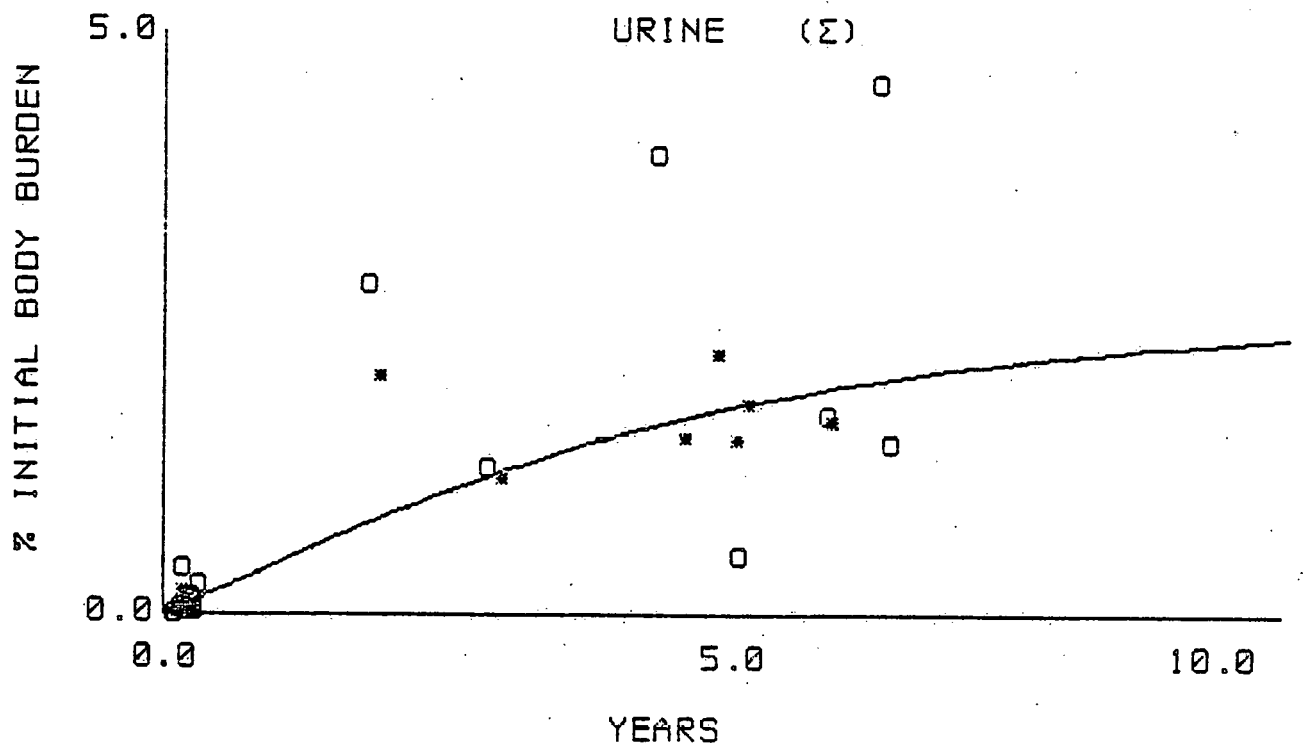
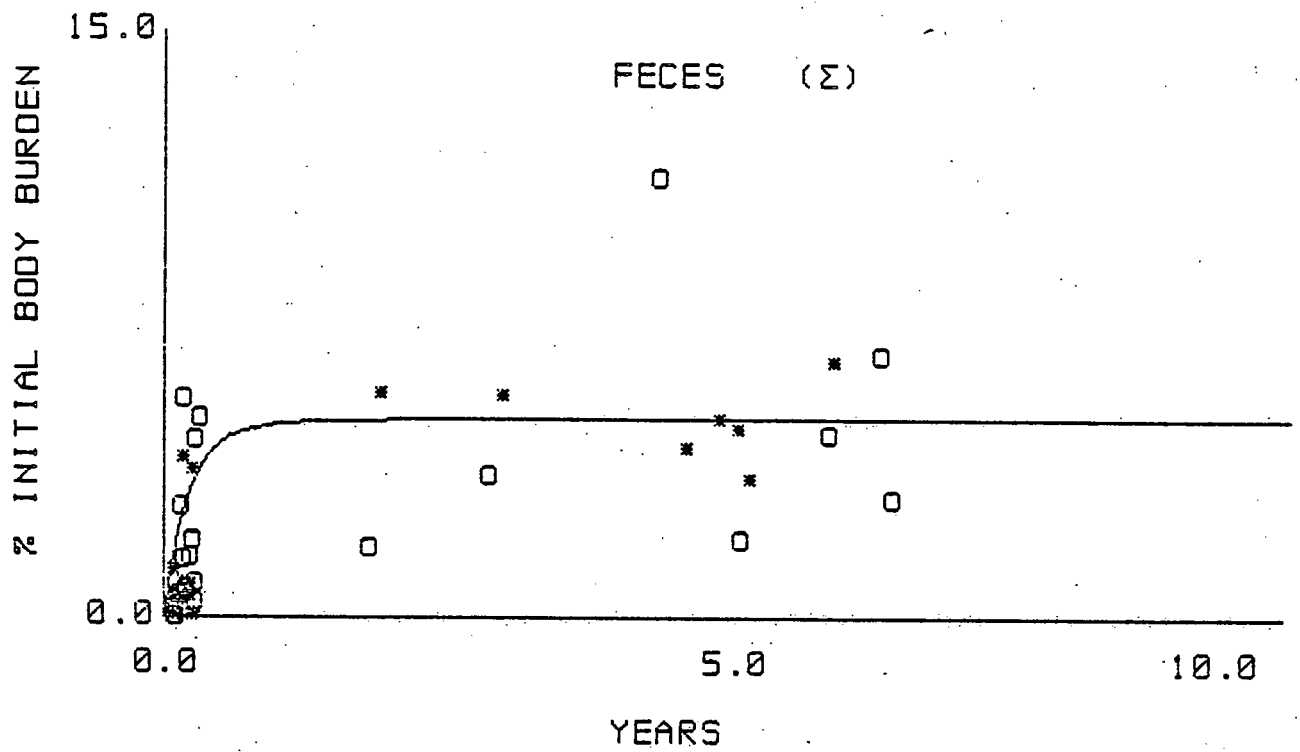
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NTB = 0.02305
NA = 7.88160
NOT = 4.84767



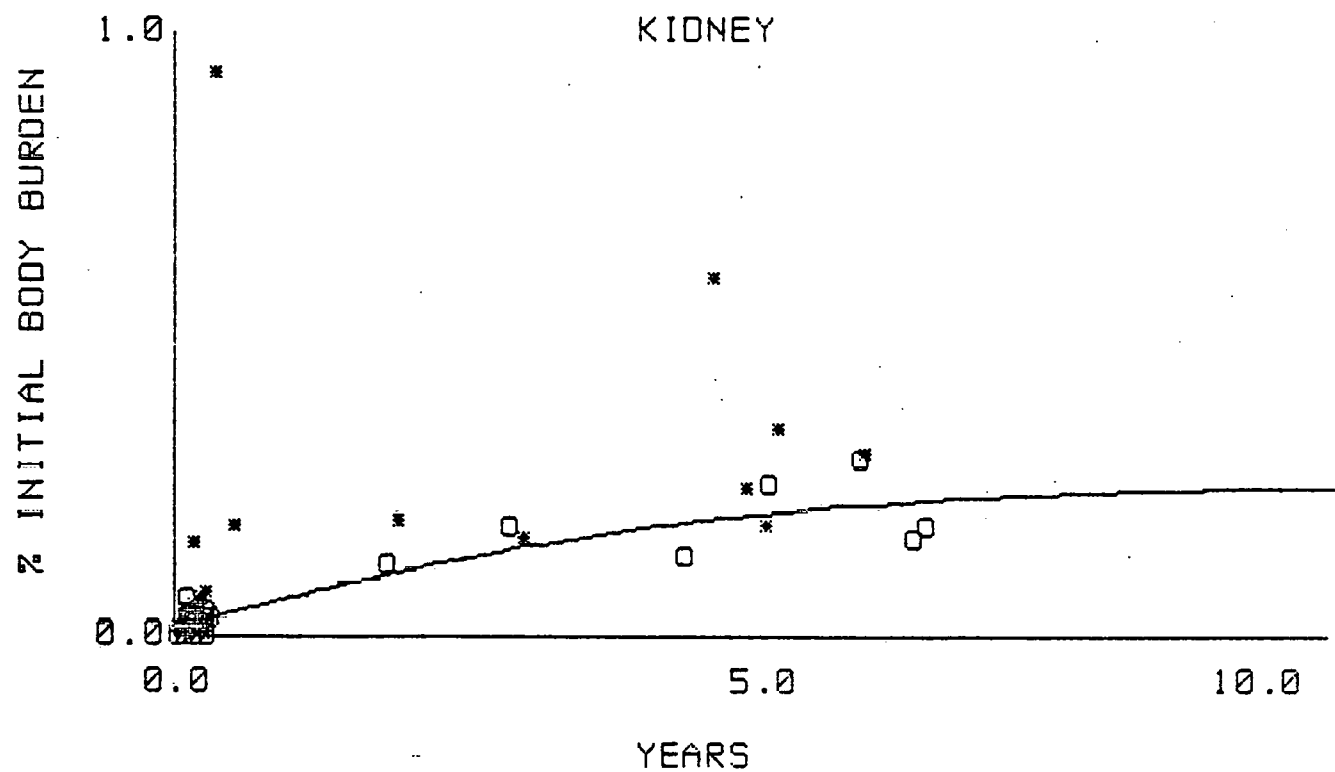
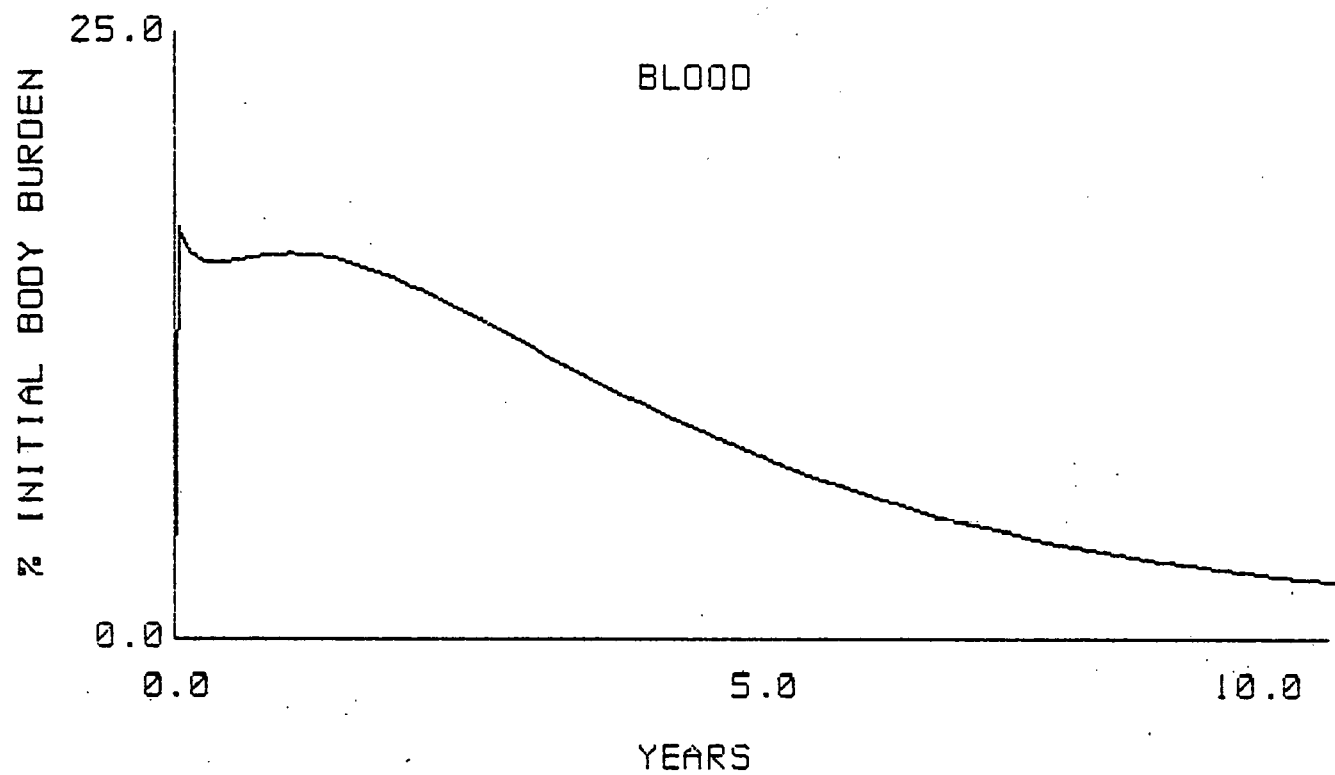
(C)OMP (H)OLD (I)NIT (R)ESET (W)RITE



(C)OMP (H)OLD (I)NIT (R)ESET (W)RITE



(C)OMP (H)OLD (I)NIT (R)ESET (W)RITE



(C)OMP (H)OLD (I)NIT (R)ESET (W)RITE

- * The curve displayed at the top of the previous page, and the corresponding tabular data for the blood equation, show the time rate of change of ^{238}Pu in the blood. Since the blood has a very rapid biological half-time with respect to the remainder of the modeled organs it acts mainly as a transport mechanism, transferring material immediately to the organs it feeds. For this reason the curve and tabular data do not correspond to the amount of material in the blood but only the time rate of change of ^{238}Pu passing through the blood. The amount of material in the blood at any instant in time is negligible because of the instantaneous transfer assumption.

APPENDIX D

Sample Tabular and Graphical Results

ICRP Model

--LUNGS

NASOPHARYNX

DNP=30.00%

THNPA= 0.01 DAY(S)

THNPS= 0.40 DAY(S)

FA= 0.04

FB= 0.96

TRACHEABRONCHIAL

DTB= 0.00%

THTSC= 0.01 DAY(S)

THTSO= 0.20 DAY(S)

FC= 0.70

FO= 0.30

PULMONARY

DP=70.00%

THPE=10.00 DAY(S)

THPF= 1.00 DAY(S)

THPS= 1.00 DAY(S)

THPH=10.00 DAY(S)

FE= 0.92

FF= 0.00

FG= 0.00

FH= 0.08

--LYMPH NODES

THL= 6.00 DAY(S)

FI= 1.00

GASTROINTESTINAL TRACT

STOMACH

TST= 1.00 HOUR(S)

SMALL INTESTINE

TSI= 4.00 HOUR(S)

UPPER LARGE INTESTINE

TULI=13.00 HOUR(S)

-- LOWER LARGE INTESTINE (FECES)

TLLI=24.00 HOUR(S)

--BLOOD

THBL= 8.00 HOUR(S)

FSYBL= 0.55

FURBL= 0.45

--SYSTEMIC

LIVER

SKELETON

SOFT RESIDUAL TISSUE

--URINE

--WHOLE BODY

(C)OMP

(H)OLO

(I)NIT

(R)ESET

(W)RITE

28-OCT-75

RESULTS FROM ICRP MODEL

10:14:17

INITIAL DEPOSITIONS

DNP = 30.00 % DTB = 0.00 % DP = 70.00 %

FRACTION UPTAKE PARAMETERS %

FA	=	4.00 %	FB	=	96.00 %	FC	=	70.00 %	FD	=	30.00 %
FE	=	92.00 %	FF	=	0.00 %	FG	=	0.00 %	FH	=	8.00 %
FI	=	100.00 %	FSYBL	=	55.00 %	FURBL	=	45.00 %			

BIOLOGICAL HALF-TIMES

THNPA	=	0.01 DAY(S)	THNPB	=	0.40 DAY(S)
THTBC	=	0.01 DAY(S)	THTBD	=	0.20 DAY(S)
THPE	=	10.00 DAY(S)	THPF	=	1.00 DAY(S)
THPG	=	1.00 DAY(S)	THPH	=	10.00 DAY(S)
THL	=	6.00 DAY(S)			
TST	=	1.00 HR(S)	TSI	=	4.00 HR(S)
TULI	=	13.00 HR(S)	TLLI	=	24.00 HR(S)
THBL	=	8.00 HR(S)			

TIME = 0.0 DAY(S)

2-p

NNPA	=	1.20000
NTBC	=	0.00000
NPE	=	64.40000
NPG	=	0.00000
NLU	=	100.00000
NST	=	0.00000
NULI	=	0.00000
NLY	=	0.00000
NSY	=	0.00000
NTOT	=	100.00000

NNPB	=	28.80000
NTBD	=	0.00000
NPF	=	0.00000
NPH	=	5.60000
NSI	=	0.00000
NLLI	=	0.00000
NBL	=	0.00000
NUR	=	0.00000

NNP	=	30.00000
NTB	=	0.00000
NP	=	70.00000
NGI	=	0.00000

TIME = 1.0 DAY(S)

NNPA	=	0.00000
NTBC	=	0.00000
NPE	=	64.74316
NPG	=	0.00000
NLU	=	76.06712
NST	=	0.42540
NULI	=	9.45334
NLY	=	0.03057
NSY	=	1.41830
NTOT	=	92.85963

NNPB	=	5.69412
NTBD	=	0.00000
NPF	=	0.00000
NPH	=	5.62984
NSI	=	2.34152
NLLI	=	8.49139
NBL	=	1.77236
NUR	=	0.79756

NNP	=	5.69412
NTB	=	0.00000
NP	=	70.37299
NGI	=	20.71166

TIME = 2.0 DAY(S)

NNPA	=	0.00000
NTBC	=	0.00000
NPE	=	69.51147
NPG	=	0.00000
NLU	=	76.71628
NST	=	0.08669
NULI	=	4.46575
NLY	=	0.06409
NSY	=	4.08842
NTOT	=	80.69247

NNPB	=	1.16032
NTBD	=	0.00000
NPF	=	0.00000
NPH	=	6.04447
NSI	=	0.48740
NLLI	=	11.92413
NBL	=	2.16724
NUR	=	0.97526

NNP	=	1.16032
NTB	=	0.00000
NP	=	75.55595
NGI	=	16.96396

TIME = 3.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 73.96777
 NPG = 0.00000
 NLU = 80.63418
 NST = 0.01751
 NULI = 1.36330
 NLY = 0.09991
 NSY = 7.41716
 NTOT = 70.73219

NNPB = 0.23443
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 6.43198
 NSI = 0.09851
 NLLI = 8.02388
 NBL = 2.34557
 NUR = 1.05551

NNP = 0.23443
 NTB = 0.00000
 NP = 80.39973
 NGI = 9.50319

TIME = 4.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 75.45895
 NPG = 0.00000
 NLU = 82.06751
 NST = 0.00351
 NULI = 0.35272
 NLY = 0.13281
 NSY = 10.94678
 NTOT = 64.68816

NNPB = 0.04693
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 6.56164
 NSI = 0.01972
 NLLI = 4.07718
 NBL = 2.39978
 NUR = 1.07990

NNP = 0.04693
 NTB = 0.00000
 NP = 82.02058
 NGI = 4.45312

TIME = 5.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 74.64857
 NPG = 0.00000
 NLU = 81.14893
 NST = 0.00069
 NULI = 0.08293
 NLY = 0.16053
 NSY = 14.41569
 NTOT = 61.01173

NNPB = 0.00919
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 6.49118
 NSI = 0.00386
 NLLI = 1.81093
 NBL = 2.37643
 NUR = 1.06940

NNP = 0.00919
 NTB = 0.00000
 NP = 81.13974
 NGI = 1.89841

TIME = 6.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 72.65816
 NPG = 0.00000
 NLU = 78.97790
 NST = 0.00012
 NULI = 0.01723
 NLY = 0.18347
 NSY = 17.77476
 NTOT = 58.48217

NNPB = 0.00165
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 6.31810
 NSI = 0.00069
 NLLI = 0.73106
 NBL = 2.31477
 NUR = 1.04165

NNP = 0.00165
 NTB = 0.00000
 NP = 78.97626
 NGI = 0.74910

TIME = 7.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 70.13485
 NPG = 0.00000
 NLU = 76.23385
 NST = 0.00002
 NULI = 0.00363
 NLY = 0.20211
 NSY = 21.03435
 NTOT = 56.53040

NNPB = 0.00031
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 6.09868
 NSI = 0.00013
 NLLI = 0.29005
 NBL = 2.23586
 NUR = 1.00614

NNP = 0.00031
 NTB = 0.00000
 NP = 76.23354
 NGI = 0.29383

TIME = 8.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 67.43246
NPG = 0.00000
NLU = 73.29623
NST = 0.00000
NULI = 0.00078
NLY = 0.21726
NSY = 24.22008
NTOT = 54.86147

NNPB = 0.00006
NTBD = 0.00000
NPF = 0.00000
NPH = 5.86369
NSI = 0.00003
NLLI = 0.11456
NBL = 2.15106
NUR = 0.96798

NNP = 0.00006
NTB = 0.00000
NP = 73.29617
NGI = 0.11537

TIME = 9.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 64.69167
NPG = 0.00000
NLU = 70.31704
NST = 0.00000
NULI = 0.00019
NLY = 0.22927
NSY = 27.34145
NTOT = 53.36761

NNPB = 0.00001
NTBD = 0.00000
NPF = 0.00000
NPH = 5.62536
NSI = 0.00002
NLLI = 0.04717
NBL = 2.06486
NUR = 0.92919

NNP = 0.00001
NTB = 0.00000
NP = 70.31702
NGI = 0.04738

TIME = 10.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 61.96369
NPG = 0.00000
NLU = 67.35184
NST = 0.00000
NULI = 0.00005
NLY = 0.23898
NSY = 30.41260
NTOT = 51.98030

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 5.38814
NSI = 0.00001
NLLI = 0.01759
NBL = 1.97893
NUR = 0.89052

NNP = 0.00000
NTB = 0.00000
NP = 67.35184
NGI = 0.01765

TIME = 11.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 59.27200
NPG = 0.00000
NLU = 64.42609
NST = 0.00000
NULI = 0.00001
NLY = 0.24637
NSY = 33.42712
NTOT = 50.69254

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 5.15408
NSI = 0.00000
NLLI = 0.00640
NBL = 1.89401
NUR = 0.85230

NNP = 0.00000
NTB = 0.00000
NP = 64.42609
NGI = 0.00641

TIME = 12.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 56.64000
NPG = 0.00000
NLU = 61.56609
NST = 0.00000
NULI = 0.00000
NLY = 0.25125
NSY = 36.36882
NTOT = 49.50848

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 4.92529
NSI = 0.00000
NLLI = 0.00296
NBL = 1.81006
NUR = 0.81489

NNP = 0.00000
NTB = 0.00000
NP = 61.56609
NGI = 0.00297

TIME = 13.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 54.06079
 NPG = 0.00000
 NLU = 58.76172
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.25453
 NSY = 39.25335
 NTOT = 48.39258

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 4.70093
 NSI = 0.00000
 NLLI = 0.00116
 NEL = 1.72924
 NUR = 0.77816

NNP = 0.00000
 NTB = 0.00000
 NP = 58.76172
 NGI = 0.00116

TIME = 14.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 51.54731
 NPG = 0.00000
 NLU = 56.02969
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.25597
 NSY = 42.06421
 NTOT = 47.35653

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 4.48237
 NSI = 0.00000
 NLLI = 0.00051
 NEL = 1.64962
 NUR = 0.74233

NNP = 0.00000
 NTB = 0.00000
 NP = 56.02969
 NGI = 0.00051

TIME = 15.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 49.10226
 NPG = 0.00000
 NLU = 53.37203
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.25589
 NSY = 44.79978
 NTOT = 46.38992

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 4.26976
 NSI = 0.00000
 NLLI = 0.00021
 NEL = 1.57209
 NUR = 0.70744

NNP = 0.00000
 NTB = 0.00000
 NP = 53.37203
 NGI = 0.00021

TIME = 16.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 46.72041
 NPG = 0.00000
 NLU = 50.78305
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.25458
 NSY = 47.46581
 NTOT = 45.48258

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 4.06264
 NSI = 0.00000
 NLLI = 0.00009
 NEL = 1.49648
 NUR = 0.67342

NNP = 0.00000
 NTB = 0.00000
 NP = 50.78305
 NGI = 0.00009

TIME = 17.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 44.42493
 NPG = 0.00000
 NLU = 48.28796
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.25188
 NSY = 50.03659
 NTOT = 44.64640

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 3.86304
 NSI = 0.00000
 NLLI = 0.00004
 NEL = 1.42353
 NUR = 0.64059

NNP = 0.00000
 NTB = 0.00000
 NP = 48.28796
 NGI = 0.00004

TIME = 18.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 42.18327
NPG = 0.00000
NLU = 45.85138
NST = 0.00000
NULI = 0.00000
NLY = 0.24844
NSY = 52.54791
NTOT = 43.85074

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 3.66811
NSI = 0.00000
NLLI = 0.00001
NBL = 1.35225
NUR = 0.60851

NNP = 0.00000
NTB = 0.00000
NP = 45.85138
NGI = 0.00001

TIME = 19.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 40.03968
NPG = 0.00000
NLU = 43.52139
NST = 0.00000
NULI = 0.00000
NLY = 0.24385
NSY = 54.95074
NTOT = 43.12320

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 3.48171
NSI = 0.00000
NLLI = 0.00001
NBL = 1.28400
NUR = 0.57780

NNP = 0.00000
NTB = 0.00000
NP = 43.52139
NGI = 0.00001

TIME = 20.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 37.95654
NPG = 0.00000
NLU = 41.25710
NST = 0.00000
NULI = 0.00000
NLY = 0.23870
NSY = 57.28654
NTOT = 42.43353

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 3.30057
NSI = 0.00000
NLLI = 0.00000
NBL = 1.21764
NUR = 0.54794

NNP = 0.00000
NTB = 0.00000
NP = 41.25710
NGI = 0.00000

TIME = 21.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 35.96174
NPG = 0.00000
NLU = 39.08885
NST = 0.00000
NULI = 0.00000
NLY = 0.23281
NSY = 59.52430
NTOT = 41.79630

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 3.12711
NSI = 0.00000
NLLI = 0.00000
NBL = 1.15404
NUR = 0.51932

NNP = 0.00000
NTB = 0.00000
NP = 39.08885
NGI = 0.00000

TIME = 22.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 34.03990
NPG = 0.00000
NLU = 36.99989
NST = 0.00000
NULI = 0.00000
NLY = 0.22647
NSY = 61.68092
NTOT = 41.19857

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.95999
NSI = 0.00000
NLLI = 0.00000
NBL = 1.09273
NUR = 0.49173

NNP = 0.00000
NTB = 0.00000
NP = 36.99989
NGI = 0.00000

TIME = 23.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 32.19464
NPG = 0.00000
NLU = 34.99418
NST = 0.00000
NULI = 0.00000
NLY = 0.21969
NSY = 63.75230
NTOT = 40.64047

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.79953
NSI = 0.00000
NLLI = 0.00000
NBL = 1.03382
NUR = 0.46522

NNP = 0.00000
NTB = 0.00000
NP = 34.99418
NGI = 0.00000

TIME = 24.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 30.43352
NPG = 0.00000
NLU = 33.07991
NST = 0.00000
NULI = 0.00000
NLY = 0.21259
NSY = 65.72994
NTOT = 40.12252

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.64639
NSI = 0.00000
NLLI = 0.00000
NBL = 0.97755
NUR = 0.43990

NNP = 0.00000
NTB = 0.00000
NP = 33.07991
NGI = 0.00000

TIME = 25.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 28.73605
NPG = 0.00000
NLU = 31.23483
NST = 0.00000
NULI = 0.00000
NLY = 0.20527
NSY = 67.63660
NTOT = 39.63373

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.49879
NSI = 0.00000
NLLI = 0.00000
NBL = 0.92330
NUR = 0.41548

NNP = 0.00000
NTB = 0.00000
NP = 31.23483
NGI = 0.00000

TIME = 26.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 27.13192
NPG = 0.00000
NLU = 29.49122
NST = 0.00000
NULI = 0.00000
NLY = 0.19775
NSY = 69.43905
NTOT = 39.18497

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.35930
NSI = 0.00000
NLLI = 0.00000
NBL = 0.87199
NUR = 0.39239

NNP = 0.00000
NTB = 0.00000
NP = 29.49122
NGI = 0.00000

TIME = 27.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 25.58303
NPG = 0.00000
NLU = 27.80764
NST = 0.00000
NULI = 0.00000
NLY = 0.19016
NSY = 71.17977
NTOT = 38.75864

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.22461
NSI = 0.00000
NLLI = 0.00000
NBL = 0.82242
NUR = 0.37009

NNP = 0.00000
NTB = 0.00000
NP = 27.80764
NGI = 0.00000

TIME = 28.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 24.12240
NPG = 0.00000
NLU = 26.21999
NST = 0.00000
NULI = 0.00000
NLY = 0.18252
NSY = 72.82183
NTOT = 38.36681

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 2.09760
NSI = 0.00000
NLLI = 0.00000
NBL = 0.77566
NUR = 0.34905

NNP = 0.00000
NTB = 0.00000
NP = 26.21999
NGI = 0.00000

TIME = 29.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 22.72232
NPG = 0.00000
NLU = 24.69818
NST = 0.00000
NULI = 0.00000
NLY = 0.17489
NSY = 74.39613
NTOT = 37.99736

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.97585
NSI = 0.00000
NLLI = 0.00000
NBL = 0.73061
NUR = 0.32887

NNP = 0.00000
NTB = 0.00000
NP = 24.69818
NGI = 0.00000

TIME = 30.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 21.39561
NPG = 0.00000
NLU = 23.25610
NST = 0.00000
NULI = 0.00000
NLY = 0.16731
NSY = 75.88830
NTOT = 37.65422

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.86049
NSI = 0.00000
NLLI = 0.00000
NBL = 0.68830
NUR = 0.30973

NNP = 0.00000
NTB = 0.00000
NP = 23.25610
NGI = 0.00000

TIME = 31.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 20.13631
NPG = 0.00000
NLU = 21.88729
NST = 0.00000
NULI = 0.00000
NLY = 0.15983
NSY = 77.30496
NTOT = 37.33410

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.75098
NSI = 0.00000
NLLI = 0.00000
NBL = 0.64792
NUR = 0.29157

NNP = 0.00000
NTB = 0.00000
NP = 21.88729
NGI = 0.00000

TIME = 32.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 18.93606
NPG = 0.00000
NLU = 20.58267
NST = 0.00000
NULI = 0.00000
NLY = 0.15245
NSY = 78.65544
NTOT = 37.03362

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.64661
NSI = 0.00000
NLLI = 0.00000
NBL = 0.60943
NUR = 0.27424

NNP = 0.00000
NTB = 0.00000
NP = 20.58267
NGI = 0.00000

TIME = 33.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 17.80985
 NPG = 0.00000
 NLU = 19.35853
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.14526
 NSY = 79.92291
 NTOT = 36.75675

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 1.54868
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.57330
 NUR = 0.25798

NNP = 0.00000
 NTB = 0.00000
 NP = 19.35853
 NGI = 0.00000

TIME = 34.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 16.72710
 NPG = 0.00000
 NLU = 18.18163
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.13819
 NSY = 81.14163
 NTOT = 36.49333

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 1.45453
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.53855
 NUR = 0.24235

NNP = 0.00000
 NTB = 0.00000
 NP = 18.18163
 NGI = 0.00000

TIME = 35.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 15.71939
 NPG = 0.00000
 NLU = 17.08629
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.13137
 NSY = 82.27615
 NTOT = 36.25250

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 1.36690
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.50619
 NUR = 0.22779

NNP = 0.00000
 NTB = 0.00000
 NP = 17.08629
 NGI = 0.00000

TIME = 36.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 14.75487
 NPG = 0.00000
 NLU = 16.03791
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.12472
 NSY = 83.36217
 NTOT = 36.02423

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 1.28303
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.47521
 NUR = 0.21385

NNP = 0.00000
 NTB = 0.00000
 NP = 16.03791
 NGI = 0.00000

TIME = 37.0 DAY(S)

NNPA = 0.00000
 NTBC = 0.00000
 NPE = 13.85130
 NPG = 0.00000
 NLU = 15.05576
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.11830
 NSY = 84.37975
 NTOT = 35.81335

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 1.20446
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.44618
 NUR = 0.20078

NNP = 0.00000
 NTB = 0.00000
 NP = 15.05576
 NGI = 0.00000

TIME = 38.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 12.99508
NPG = 0.00000
NLU = 14.12508
NST = 0.00000
NULI = 0.00000
NLY = 0.11210
NSY = 65.34415
NTOT = 35.61556

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.13001
NSI = 0.00000
NLLI = 0.00000
NEL = 0.41867
NUR = 0.18840

NNP = 0.00000
NTB = 0.00000
NP = 14.12508
NGI = 0.00000

TIME = 39.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 12.18709
NPG = 0.00000
NLU = 13.24684
NST = 0.00000
NULI = 0.00000
NLY = 0.10613
NSY = 66.25434
NTOT = 35.43091

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 1.05975
NSI = 0.00000
NLLI = 0.00000
NEL = 0.39270
NUR = 0.17671

NNP = 0.00000
NTB = 0.00000
NP = 13.24684
NGI = 0.00000

TIME = 40.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 11.42935
NPG = 0.00000
NLU = 12.42321
NST = 0.00000
NULI = 0.00000
NLY = 0.10041
NSY = 67.10805
NTOT = 35.25957

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.99386
NSI = 0.00000
NLLI = 0.00000
NEL = 0.36833
NUR = 0.16575

NNP = 0.00000
NTB = 0.00000
NP = 12.42321
NGI = 0.00000

TIME = 41.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 10.70861
NPG = 0.00000
NLU = 11.63980
NST = 0.00000
NULI = 0.00000
NLY = 0.09489
NSY = 67.92016
NTOT = 35.09789

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.93118
NSI = 0.00000
NLLI = 0.00000
NEL = 0.34515
NUR = 0.15532

NNP = 0.00000
NTB = 0.00000
NP = 11.63980
NGI = 0.00000

TIME = 42.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 10.03982
NPG = 0.00000
NLU = 10.91285
NST = 0.00000
NULI = 0.00000
NLY = 0.08966
NSY = 68.67386
NTOT = 34.94947

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.87303
NSI = 0.00000
NLLI = 0.00000
NEL = 0.32364
NUR = 0.14564

NNP = 0.00000
NTB = 0.00000
NP = 10.91285
NGI = 0.00000

01-P

TIME = 43.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 9.40068
NPG = 0.00000
NLU = 10.21812
NST = 0.00000
NULI = 0.00000
NLY = 0.00460
NSY = 89.39420
NTOT = 34.00048

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.81745
NSI = 0.00000
NLLI = 0.00000
NBL = 0.30307
NUR = 0.13638

NNP = 0.00000
NTB = 0.00000
NP = 10.21812
NGI = 0.00000

TIME = 44.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 8.80774
NPG = 0.00000
NLU = 9.57363
NST = 0.00000
NULI = 0.00000
NLY = 0.07983
NSY = 90.06255
NTOT = 34.67891

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.76589
NSI = 0.00000
NLLI = 0.00000
NBL = 0.28399
NUR = 0.12780

NNP = 0.00000
NTB = 0.00000
NP = 9.57363
NGI = 0.00000

TIME = 45.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 8.24534
NPG = 0.00000
NLU = 8.96232
NST = 0.00000
NULI = 0.00000
NLY = 0.07524
NSY = 90.69655
NTOT = 34.55675

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.71699
NSI = 0.00000
NLLI = 0.00000
NBL = 0.26589
NUR = 0.11965

NNP = 0.00000
NTB = 0.00000
NP = 8.96232
NGI = 0.00000

TIME = 46.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 7.71923
NPG = 0.00000
NLU = 8.39047
NST = 0.00000
NULI = 0.00000
NLY = 0.07090
NSY = 91.28970
NTOT = 34.44330

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.67124
NSI = 0.00000
NLLI = 0.00000
NBL = 0.24895
NUR = 0.11203

NNP = 0.00000
NTB = 0.00000
NP = 8.39047
NGI = 0.00000

TIME = 47.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 7.22537
NPG = 0.00000
NLU = 7.85367
NST = 0.00000
NULI = 0.00000
NLY = 0.06677
NSY = 91.04652
NTOT = 34.33747

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.62829
NSI = 0.00000
NLLI = 0.00000
NBL = 0.23304
NUR = 0.10487

NNP = 0.00000
NTB = 0.00000
NP = 7.85367
NGI = 0.00000

11-P

TIME = 48.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 6.75931
NPG = 0.00000
NLU = 7.34707
NST = 0.00000
NULI = 0.00000
NLY = 0.06283
NSY = 92.37206
NTOT = 34.23815

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.58777
NSI = 0.00000
NLLI = 0.00000
NBL = 0.21803
NUR = 0.09812

NNP = 0.00000
NTB = 0.00000
NP = 7.34707
NGI = 0.00000

TIME = 49.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 6.32711
NPG = 0.00000
NLU = 6.87729
NST = 0.00000
NULI = 0.00000
NLY = 0.05913
NSY = 92.85947
NTOT = 34.14663

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.55018
NSI = 0.00000
NLLI = 0.00000
NBL = 0.20411
NUR = 0.09185

NNP = 0.00000
NTB = 0.00000
NP = 6.87729
NGI = 0.00000

TIME = 50.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 5.91440
NPG = 0.00000
NLU = 6.42870
NST = 0.00000
NULI = 0.00000
NLY = 0.05557
NSY = 93.32491
NTOT = 34.05957

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.51430
NSI = 0.00000
NLLI = 0.00000
NBL = 0.19081
NUR = 0.08587

NNP = 0.00000
NTB = 0.00000
NP = 6.42870
NGI = 0.00000

TIME = 51.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 5.53473
NPG = 0.00000
NLU = 6.01601
NST = 0.00000
NULI = 0.00000
NLY = 0.05226
NSY = 93.75314
NTOT = 33.97998

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.48128
NSI = 0.00000
NLLI = 0.00000
NBL = 0.17858
NUR = 0.08036

NNP = 0.00000
NTB = 0.00000
NP = 6.01601
NGI = 0.00000

TIME = 52.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 5.17365
NPG = 0.00000
NLU = 5.62354
NST = 0.00000
NULI = 0.00000
NLY = 0.04908
NSY = 94.16044
NTOT = 33.90454

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.44988
NSI = 0.00000
NLLI = 0.00000
NBL = 0.16694
NUR = 0.07513

NNP = 0.00000
NTB = 0.00000
NP = 5.62354
NGI = 0.00000

TIME = 53.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 4.83847
NPG = 0.00000
NLU = 5.25920
NST = 0.00000
NULI = 0.00000
NLY = 0.04611
NSY = 94.53855
NTOT = 33.83486

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.42874
NSI = 0.00000
NLLI = 0.00000
NBL = 0.15614
NUR = 0.07026

NNP = 0.00000
NTB = 0.00000
NP = 5.25920
NGI = 0.00000

TIME = 54.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 4.52299
NPG = 0.00000
NLU = 4.91629
NST = 0.00000
NULI = 0.00000
NLY = 0.04329
NSY = 94.89445
NTOT = 33.76950

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.39330
NSI = 0.00000
NLLI = 0.00000
NBL = 0.14597
NUR = 0.06569

NNP = 0.00000
NTB = 0.00000
NP = 4.91629
NGI = 0.00000

TIME = 55.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 4.22737
NPG = 0.00000
NLU = 4.59457
NST = 0.00000
NULI = 0.00000
NLY = 0.04062
NSY = 95.22797
NTOT = 33.70850

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.36760
NSI = 0.00000
NLLI = 0.00000
NBL = 0.13644
NUR = 0.06140

NNP = 0.00000
NTB = 0.00000
NP = 4.59497
NGI = 0.00000

TIME = 56.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 3.95207
NPG = 0.00000
NLU = 4.29573
NST = 0.00000
NULI = 0.00000
NLY = 0.03812
NSY = 95.53859
NTOT = 33.65189

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.34366
NSI = 0.00000
NLLI = 0.00000
NBL = 0.12756
NUR = 0.05740

NNP = 0.00000
NTB = 0.00000
NP = 4.29573
NGI = 0.00000

TIME = 57.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 3.69159
NPG = 0.00000
NLU = 4.01259
NST = 0.00000
NULI = 0.00000
NLY = 0.03574
NSY = 95.83251
NTOT = 33.59847

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.32101
NSI = 0.00000
NLLI = 0.00000
NBL = 0.11916
NUR = 0.05362

NNP = 0.00000
NTB = 0.00000
NP = 4.01259
NGI = 0.00000

TIME = 58.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 3.45159
NPG = 0.00000
NLU = 3.75173
NST = 0.00000
NULI = 0.00000
NLY = 0.03353
NSY = 96.10332
NTOT = 33.54944

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.30014
NSI = 0.00000
NLLI = 0.00000
NBL = 0.11142
NUR = 0.05014

NNP = 0.00000
NTB = 0.00000
NP = 3.75173
NGI = 0.00000

TIME = 59.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 3.22315
NPG = 0.00000
NLU = 3.50343
NST = 0.00000
NULI = 0.00000
NLY = 0.03142
NSY = 96.36110
NTOT = 33.50286

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.28027
NSI = 0.00000
NLLI = 0.00000
NBL = 0.10405
NUR = 0.04683

NNP = 0.00000
NTB = 0.00000
NP = 3.50343
NGI = 0.00000

TIME = 60.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 3.01255
NPG = 0.00000
NLU = 3.27452
NST = 0.00000
NULI = 0.00000
NLY = 0.02946
NSY = 96.59875
NTOT = 33.46007

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.26196
NSI = 0.00000
NLLI = 0.00000
NBL = 0.09726
NUR = 0.04377

NNP = 0.00000
NTB = 0.00000
NP = 3.27452
NGI = 0.00000

TIME = 61.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 2.81360
NPG = 0.00000
NLU = 3.05826
NST = 0.00000
NULI = 0.00000
NLY = 0.02760
NSY = 96.82330
NTOT = 33.41972

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.24466
NSI = 0.00000
NLLI = 0.00000
NBL = 0.09084
NUR = 0.04088

NNP = 0.00000
NTB = 0.00000
NP = 3.05826
NGI = 0.00000

TIME = 62.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 2.62838
NPG = 0.00000
NLU = 2.85694
NST = 0.00000
NULI = 0.00000
NLY = 0.02586
NSY = 97.03234
NTOT = 33.38224

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.22856
NSI = 0.00000
NLLI = 0.00000
NBL = 0.08487
NUR = 0.03819

NNP = 0.00000
NTB = 0.00000
NP = 2.85694
NGI = 0.00000

TIME = 63.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 2.45524
NPG = 0.00000
NLU = 2.66874
NST = 0.00000
NULI = 0.00000
NLY = 0.02422
NSY = 97.22776
NTOT = 33.34729

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.21350
NSI = 0.00000
NLLI = 0.00000
NBL = 0.07928
NUR = 0.03568

NNP = 0.00000
NTB = 0.00000
NP = 2.66874
NGI = 0.00000

TIME = 64.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 2.29245
NPG = 0.00000
NLU = 2.49179
NST = 0.00000
NULI = 0.00000
NLY = 0.02267
NSY = 97.41151
NTOT = 33.31449

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.19934
NSI = 0.00000
NLLI = 0.00000
NBL = 0.07403
NUR = 0.03331

NNP = 0.00000
NTB = 0.00000
NP = 2.49179
NGI = 0.00000

TIME = 65.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 2.14213
NPG = 0.00000
NLU = 2.32840
NST = 0.00000
NULI = 0.00000
NLY = 0.02124
NSY = 97.58118
NTOT = 33.28427

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.18627
NSI = 0.00000
NLLI = 0.00000
NBL = 0.06918
NUR = 0.03113

NNP = 0.00000
NTB = 0.00000
NP = 2.32840
NGI = 0.00000

TIME = 66.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.99895
NPG = 0.00000
NLU = 2.17277
NST = 0.00000
NULI = 0.00000
NLY = 0.01987
NSY = 97.74281
NTOT = 33.25552

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.17382
NSI = 0.00000
NLLI = 0.00000
NBL = 0.06456
NUR = 0.02905

NNP = 0.00000
NTB = 0.00000
NP = 2.17277
NGI = 0.00000

TIME = 67.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.86778
NPG = 0.00000
NLU = 2.03020
NST = 0.00000
NULI = 0.00000
NLY = 0.01860
NSY = 97.89088
NTOT = 33.22923

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.16242
NSI = 0.00000
NLLI = 0.00000
NBL = 0.06032
NUR = 0.02715

NNP = 0.00000
NTB = 0.00000
NP = 2.03020
NGI = 0.00000

SL-P

TIME = 68.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.74334
NPG = 0.00000
NLU = 1.89493
NST = 0.00000
NULI = 0.00000
NLY = 0.01740
NSY = 98.03136
NTOT = 33.20432

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.15159
NSI = 0.00000
NLLI = 0.00000
NBL = 0.05630
NUR = 0.02534

NNP = 0.00000
NTB = 0.00000
NP = 1.89493
NGI = 0.00000

TIME = 69.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.62831
NPG = 0.00000
NLU = 1.76990
NST = 0.00000
NULI = 0.00000
NLY = 0.01629
NSY = 98.16122
NTOT = 33.18134

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.14159
NSI = 0.00000
NLLI = 0.00000
NBL = 0.05259
NUR = 0.02367

NNP = 0.00000
NTB = 0.00000
NP = 1.76990
NGI = 0.00000

TIME = 70.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.52100
NPG = 0.00000
NLU = 1.65326
NST = 0.00000
NULI = 0.00000
NLY = 0.01524
NSY = 98.29237
NTOT = 33.15992

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.13226
NSI = 0.00000
NLLI = 0.00000
NBL = 0.04913
NUR = 0.02211

NNP = 0.00000
NTB = 0.00000
NP = 1.65326
NGI = 0.00000

TIME = 71.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.42018
NPG = 0.00000
NLU = 1.54368
NST = 0.00000
NULI = 0.00000
NLY = 0.01426
NSY = 98.39620
NTOT = 33.13982

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.12349
NSI = 0.00000
NLLI = 0.00000
NBL = 0.04587
NUR = 0.02064

NNP = 0.00000
NTB = 0.00000
NP = 1.54368
NGI = 0.00000

TIME = 72.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.33760
NPG = 0.00000
NLU = 1.45391
NST = 0.00000
NULI = 0.00000
NLY = 0.01345
NSY = 98.48948
NTOT = 33.12342

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.11631
NSI = 0.00000
NLLI = 0.00000
NBL = 0.04316
NUR = 0.01942

NNP = 0.00000
NTB = 0.00000
NP = 1.45391
NGI = 0.00000

TIME = 73.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 1.29784
NPG = 0.00000
NLU = 1.41069
NST = 0.00000
NULI = 0.00000
NLY = 0.01305
NSY = 98.53458
NTOT = 33.11568

NNPB = 0.00000
NTEB = 0.00000
NPF = 0.00000
NPH = 0.11286
NSI = 0.00000
NLLI = 0.00000
NBL = 0.04168
NUR = 0.01876

NNP = 0.00000
NTB = 0.00000
NP = 1.41069
NGI = 0.00000

TIME = 74.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 1.25807
NPG = 0.00000
NLU = 1.36747
NST = 0.00000
NULI = 0.00000
NLY = 0.01265
NSY = 98.57967
NTOT = 33.10795

NNPB = 0.00000
NTEB = 0.00000
NPF = 0.00000
NPH = 0.10940
NSI = 0.00000
NLLI = 0.00000
NBL = 0.04020
NUR = 0.01809

NNP = 0.00000
NTB = 0.00000
NP = 1.36747
NGI = 0.00000

TIME = 75.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 1.21831
NPG = 0.00000
NLU = 1.32425
NST = 0.00000
NULI = 0.00000
NLY = 0.01225
NSY = 98.62477
NTOT = 33.10021

NNPB = 0.00000
NTEB = 0.00000
NPF = 0.00000
NPH = 0.10594
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03872
NUR = 0.01743

NNP = 0.00000
NTB = 0.00000
NP = 1.32425
NGI = 0.00000

TIME = 76.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 1.17855
NPG = 0.00000
NLU = 1.28103
NST = 0.00000
NULI = 0.00000
NLY = 0.01186
NSY = 98.66987
NTOT = 33.09248

NNPB = 0.00000
NTEB = 0.00000
NPF = 0.00000
NPH = 0.10248
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03724
NUR = 0.01676

NNP = 0.00000
NTB = 0.00000
NP = 1.28103
NGI = 0.00000

TIME = 77.0 DAY(S)

NNPA = 0.00000
NTEC = 0.00000
NPE = 1.13878
NPG = 0.00000
NLU = 1.23781
NST = 0.00000
NULI = 0.00000
NLY = 0.01146
NSY = 98.71497
NTOT = 33.08474

NNPB = 0.00000
NTEB = 0.00000
NPF = 0.00000
NPH = 0.09902
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03577
NUR = 0.01610

NNP = 0.00000
NTB = 0.00000
NP = 1.23781
NGI = 0.00000

TIME = 78.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.09902
NPG = 0.00000
NLU = 1.19459
NST = 0.00000
NULI = 0.00000
NLY = 0.01106
NSY = 98.76006
NTOT = 33.07700

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.09557
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03429
NUR = 0.01543

NNP = 0.00000
NTB = 0.00000
NP = 1.19459
NGI = 0.00000

TIME = 79.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.05926
NPG = 0.00000
NLU = 1.15137
NST = 0.00000
NULI = 0.00000
NLY = 0.01066
NSY = 98.80516
NTOT = 33.06927

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.09211
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03281
NUR = 0.01476

NNP = 0.00000
NTB = 0.00000
NP = 1.15137
NGI = 0.00000

TIME = 80.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 1.01949
NPG = 0.00000
NLU = 1.10815
NST = 0.00000
NULI = 0.00000
NLY = 0.01026
NSY = 98.85026
NTOT = 33.06153

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.08865
NSI = 0.00000
NLLI = 0.00000
NBL = 0.03133
NUR = 0.01410

NNP = 0.00000
NTB = 0.00000
NP = 1.10815
NGI = 0.00000

TIME = 81.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 0.97973
NPG = 0.00000
NLU = 1.06493
NST = 0.00000
NULI = 0.00000
NLY = 0.00987
NSY = 98.89536
NTOT = 33.05379

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.08519
NSI = 0.00000
NLLI = 0.00000
NBL = 0.02985
NUR = 0.01343

NNP = 0.00000
NTB = 0.00000
NP = 1.06493
NGI = 0.00000

TIME = 82.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 0.93997
NPG = 0.00000
NLU = 1.02170
NST = 0.00000
NULI = 0.00000
NLY = 0.00947
NSY = 98.94045
NTOT = 33.04606

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.08174
NSI = 0.00000
NLLI = 0.00000
NBL = 0.02837
NUR = 0.01277

NNP = 0.00000
NTB = 0.00000
NP = 1.02170
NGI = 0.00000

TIME = 83.0 DAY(S)

NNPA = 0.00000
 NTEC = 0.00000
 NPE = 0.90020
 NPG = 0.00000
 NLU = 0.97848
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.00907
 NSY = 98.98555
 NTOT = 33.03832

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 0.07828
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.02690
 NUR = 0.01210

NNP = 0.00000
 NTB = 0.00000
 NP = 0.97848
 NGI = 0.00000

TIME = 84.0 DAY(S)

NNPA = 0.00000
 NTEC = 0.00000
 NPE = 0.86044
 NPG = 0.00000
 NLU = 0.93526
 NST = 0.00000
 NULI = 0.00000
 NLY = 0.00867
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 NTOT = 33.03059

NNPB = 0.00000
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NNP = 0.00000
 NTB = 0.00000
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TIME = 85.0 DAY(S)

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 NLY = 0.00827
 NSY = 99.07574
 NTOT = 33.02285

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 0.07136
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NNP = 0.00000
 NTB = 0.00000
 NP = 0.89284
 NGI = 0.00000

TIME = 86.0 DAY(S)

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 NPE = 0.78091
 NPG = 0.00000
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 NULI = 0.00000
 NLY = 0.00788
 NSY = 99.12084
 NTOT = 33.01511

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 NPF = 0.00000
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 NSI = 0.00000
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 NBL = 0.02246
 NUR = 0.01011

NNP = 0.00000
 NTB = 0.00000
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 NGI = 0.00000

TIME = 87.0 DAY(S)

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 NPE = 0.74115
 NPG = 0.00000
 NLU = 0.80560
 NST = 0.00000
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 NLY = 0.00748
 NSY = 99.16594
 NTOT = 33.00738

NNPB = 0.00000
 NTBD = 0.00000
 NPF = 0.00000
 NPH = 0.06445
 NSI = 0.00000
 NLLI = 0.00000
 NBL = 0.02098
 NUR = 0.00944

NNP = 0.00000
 NTB = 0.00000
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 NGI = 0.00000

TIME = 88.0 DAY(S)

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NPE = 0.70139
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NLU = 0.76238
NST = 0.00000
NULI = 0.00000
NLY = 0.00708
NSY = 99.21104
NTOT = 32.99964

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.00099
NSI = 0.00000
NLLI = 0.00000
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NUR = 0.00378

NNP = 0.00000
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NGI = 0.00000

TIME = 89.0 DAY(S)

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NTBC = 0.00000
NPE = 0.66163
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NST = 0.00000
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NLY = 0.00668
NSY = 99.25613
NTOT = 32.99191

NNPB = 0.00000
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NPH = 0.05753
NSI = 0.00000
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NBL = 0.01803
NUR = 0.00811

NNP = 0.00000
NTB = 0.00000
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TIME = 90.0 DAY(S)

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NLU = 0.67594
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TIME = 91.0 DAY(S)

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NTBC = 0.00000
NPE = 0.58210
NPG = 0.00000
NLU = 0.63272
NST = 0.00000
NULI = 0.00000
NLY = 0.00588
NSY = 99.34633
NTOT = 32.97643

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.05062
NSI = 0.00000
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NBL = 0.01507
NUR = 0.00678

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NTB = 0.00000
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TIME = 92.0 DAY(S)

NNPA = 0.00000
NTBC = 0.00000
NPE = 0.54234
NPG = 0.00000
NLU = 0.58949
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NULI = 0.00000
NLY = 0.00549
NSY = 99.39143
NTOT = 32.96870

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.04716
NSI = 0.00000
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NBL = 0.01359
NUR = 0.00612

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NPE = 0.50257
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NLU = 0.54627
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NLY = 0.00509
NSY = 99.43652
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NPE = 0.46281
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NLU = 0.50305
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NULI = 0.00000
NLY = 0.00469
NSY = 99.48162
NTOT = 32.95322

NNPB = 0.00000
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NPF = 0.00000
NPH = 0.04024
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NUR = 0.00479

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NP = 0.50305
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NTBC = 0.00000
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NULI = 0.00000
NLY = 0.00429
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NPH = 0.03679
NSI = 0.00000
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NBL = 0.00915
NUR = 0.00412

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NTB = 0.00000
NP = 0.45983
NGI = 0.00000

TIME = 96.0 DAY(S)

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NTBC = 0.00000
NPE = 0.38328
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NLU = 0.41661
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NULI = 0.00000
NLY = 0.00389
NSY = 99.57182
NTOT = 32.93775

NNPB = 0.00000
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TIME = 97.0 DAY(S)

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NPE = 0.34352
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NLY = 0.00350
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NLU = 0.33017
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NULI = 0.00000
NLY = 0.00310
NSY = 99.66201
NTOT = 32.92228

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TIME = 99.0 DAY(S)

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NLU = 0.28695
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NULI = 0.00000
NLY = 0.00270
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NTOT = 32.91454

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NTBD = 0.00000
NPF = 0.00000
NPH = 0.02296
NSI = 0.00000
NLLI = 0.00000
NBL = 0.00324
NUR = 0.00146

NNP = 0.00000
NTB = 0.00000
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NPE = 0.22423
NPG = 0.00000
NLU = 0.24373
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NULI = 0.00000
NLY = 0.00230
NSY = 99.75220
NTOT = 32.90681

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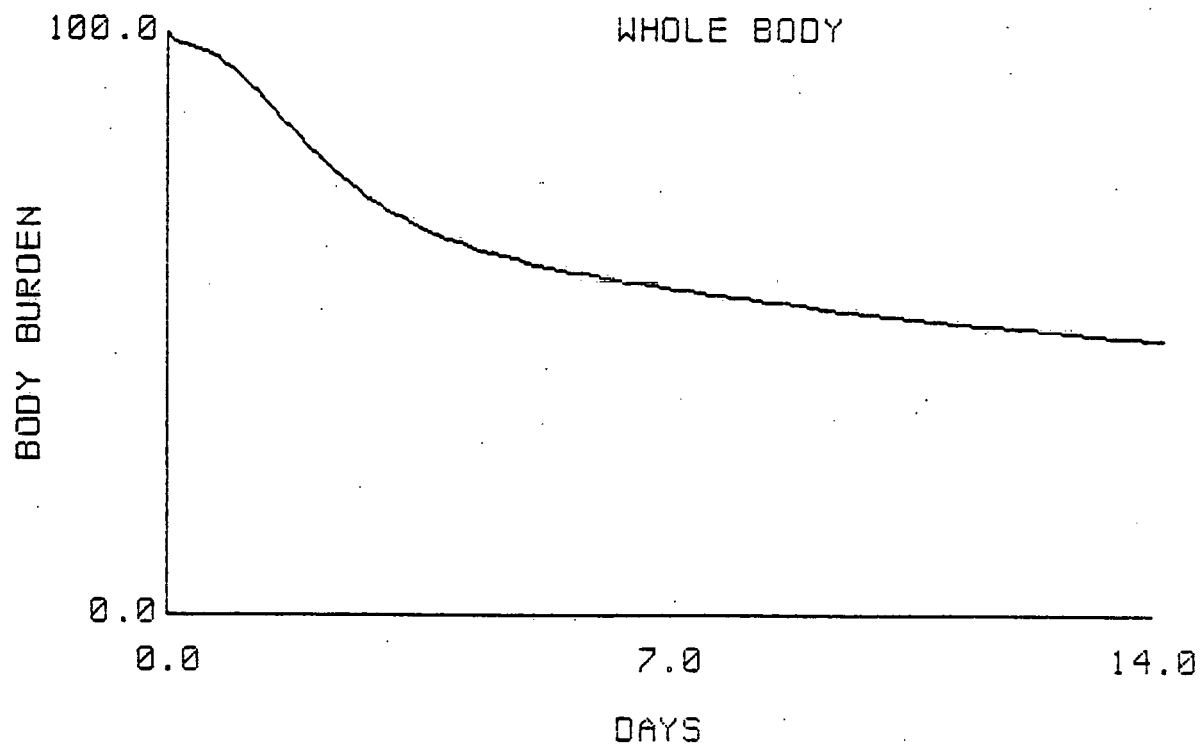
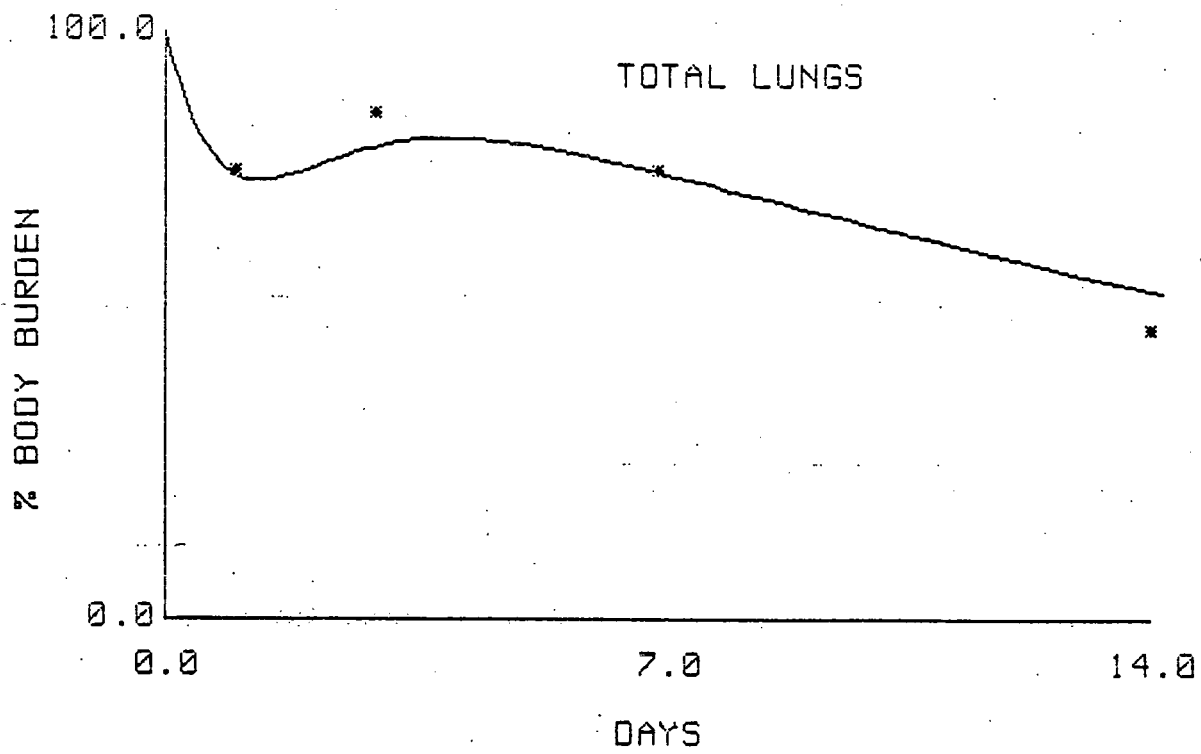
NNP = 0.00000
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NGI = 0.00000

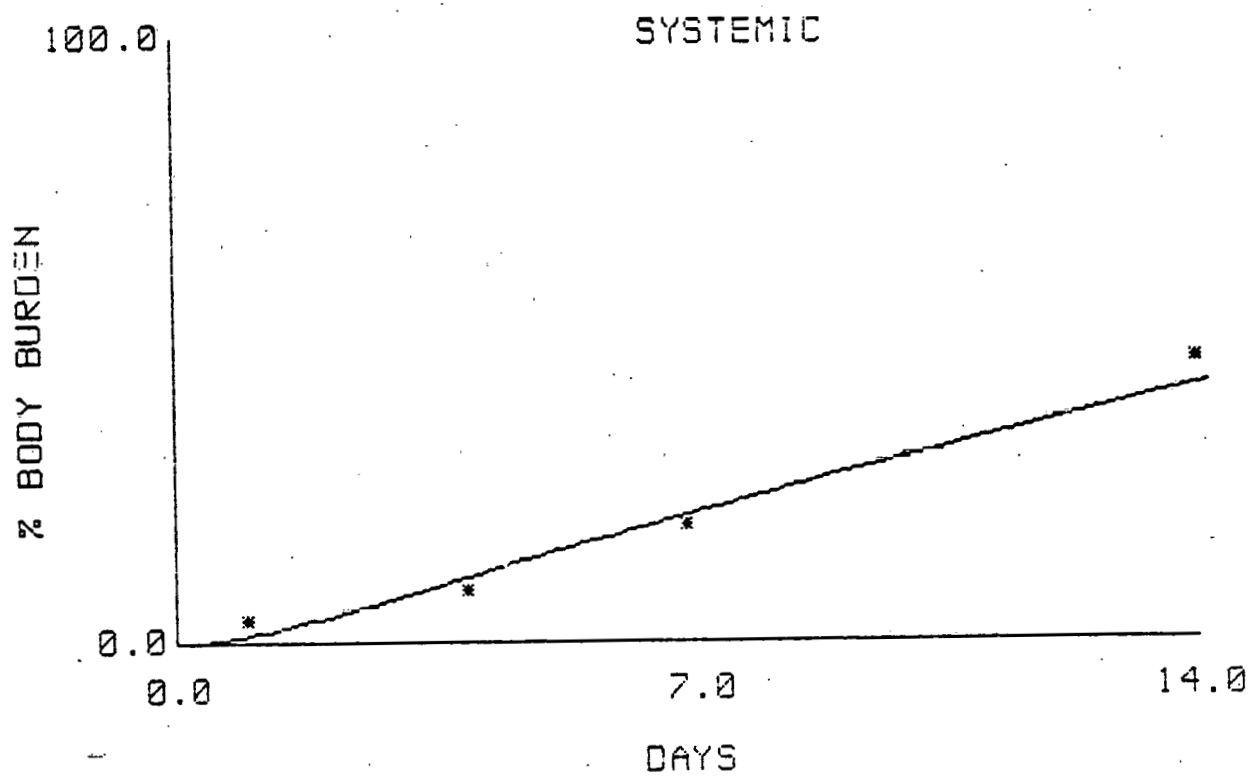
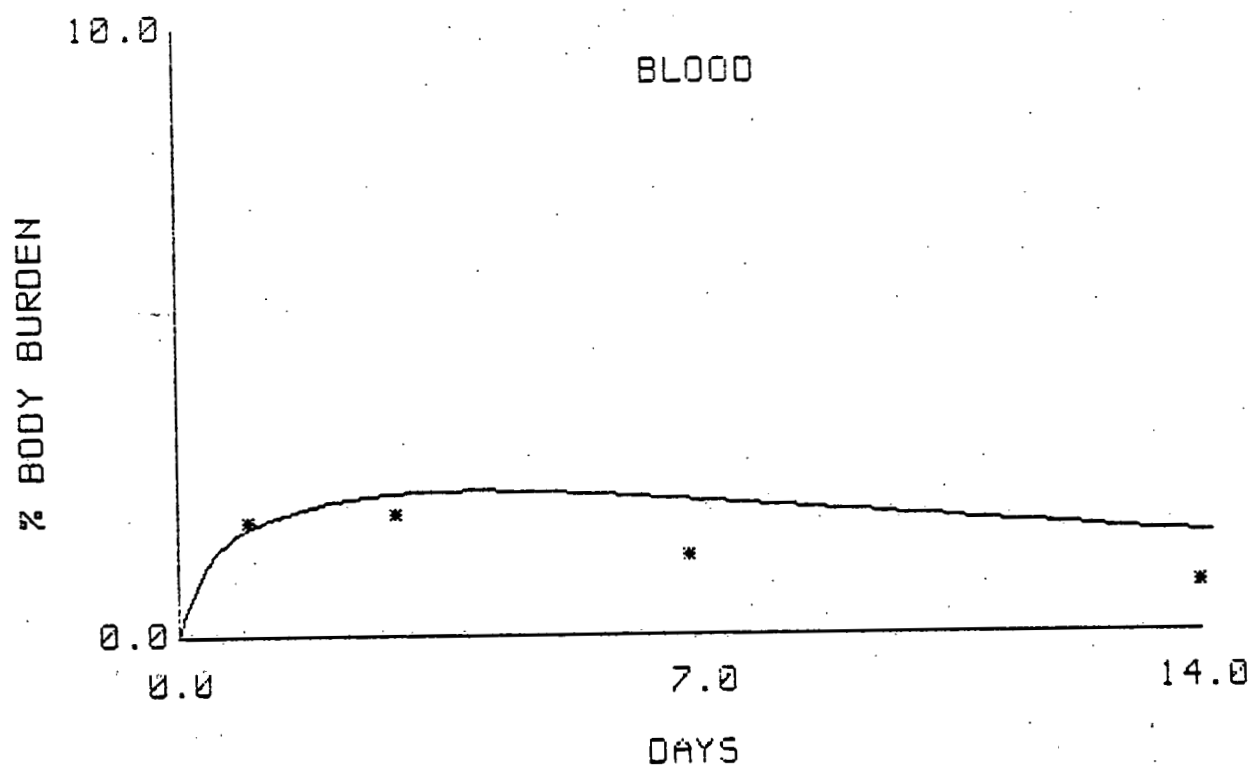
TIME = 101.0 DAY(S)

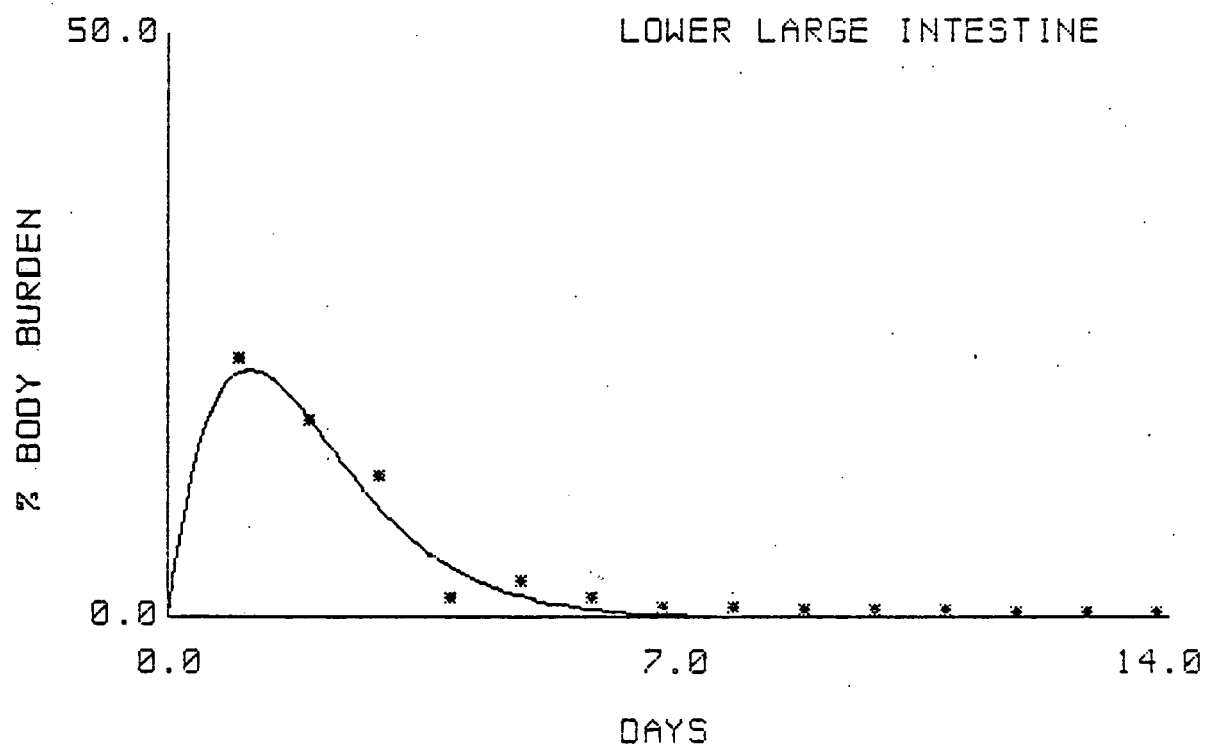
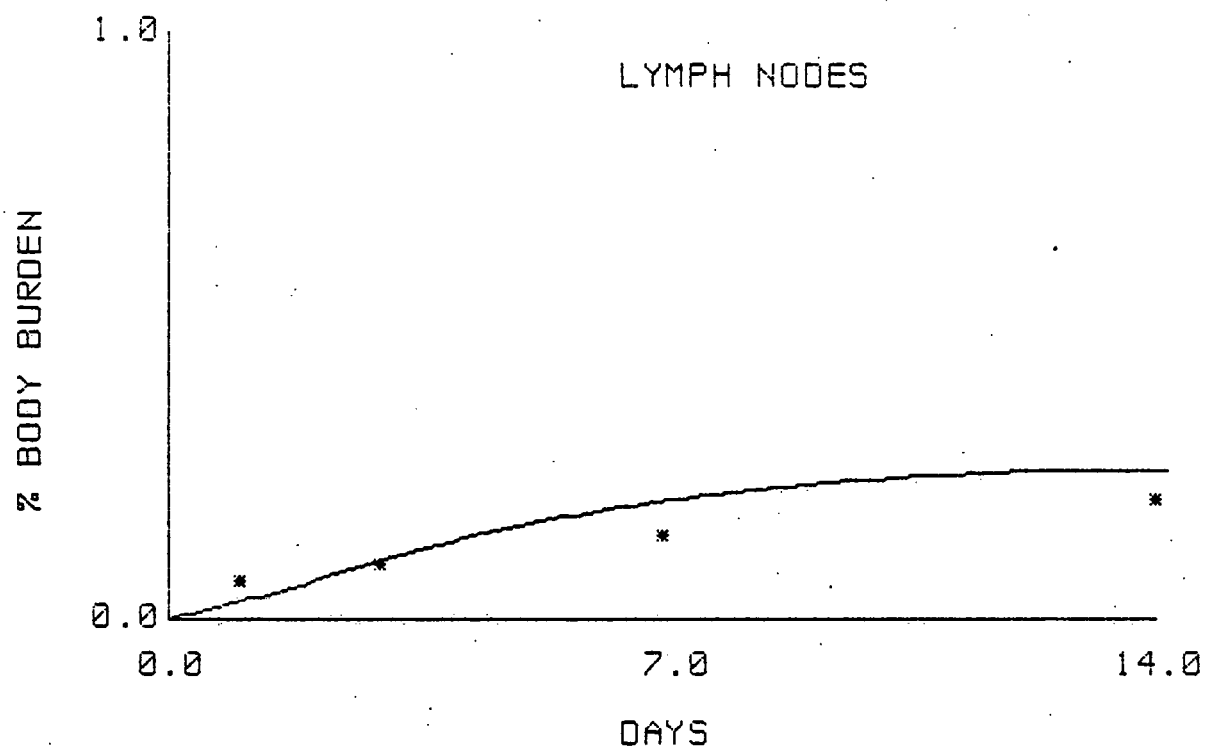
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NULI = 0.00000
NLY = 0.00190
NSY = 99.79731
NTOT = 32.89907

NNPB = 0.00000
NTBD = 0.00000
NPF = 0.00000
NPH = 0.01604
NSI = 0.00000
NLLI = 0.00000
NBL = 0.00028
NUR = 0.00013

NNP = 0.00000
NTB = 0.00000
NP = 0.20051
NGI = 0.00000







APPENDIX E

Biology Models User Documentation

BIOLOGY MODELS

Both biology models run on the RT-11 version 2 system. The save files for both models reside on the Biometrics disk pack.

- 1) The Dionne-Stuart model, using D. Craig's data, is named BIO1. To evoke the model type:

RU DK1:BIO1

The model will then request the default parameters by typing:

ENTER PARAMETER FILE:

The user should then enter the name of a disk file which contains the model parameters he wishes to use. The model will then read the parameter list and wait in the HOLD mode for instructions from the VG keyboard.

- 2) The ICRP model, using J. Ballou's data, is named DOG1. To evoke the model type:

RU DK1:DOG1

The model will then request the default parameters by typing:

ENTER PARAMETER FILE:

The user should then enter the name of a disk file which contains the model parameters he wishes to use. The model will then read the parameter list and wait in the HOLD mode for instructions from the VG keyboard.

VECTOR GENERAL KEYBOARD INSTRUCTIONS

- 1) The simulation mode is controlled by a number of VG keys:
 - H - halts the simulation
 - I - initializes the differential equations (i.e., sets initial conditions, and resets start time and time step).

- R - resets the default parameters and initializes the system.
- C - sets computer in the compute mode to begin the simulation.
- W - writes the simulation results after one run has been completed.

ctrl C - return to RT-11 monitor.

ctrl P - output hardcopy of data and graphs currently displayed on VG screen

2) One PDP-11/35 console switch is used by both these models:

- 0 - switch 0 extends the simulated run time for both the models. For BIO1 the run time is extended from 10 years to 5 years for DOG1 it is extended from 14 days to 100 days.

Notes:

- 1) When a ctrl C is entered from the VG keyboard both models will write the current differential equation parameters to a disk file before exiting to the RT-11 monitor. In this way, parameter modifications which were made while trying to fit the data can be used as the starting point for the next session. Both models retain the two previous parameter sets. These are stored on the BIOMETRICS disk pack under the names *DAT.NEW and *DAT.OLD where the * indicates PLT for BIO1 and ICR for DOG1.
- 2) When a ctrl P is entered from the VG keyboard, both models will continue solving the differential equations until the end of the simulation. Following this, hard-copy output will be produced

on the Gould electrostatic printer. Once the hardcopy has been outputted, control will be returned to the model. The model will then wait in the hold mode for further instructions.

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