**Appendix A: PBPK Model Code** (note: parameter values in Tables 2 and 3 are transferred to the model during runtime using the Excel addin, and therefore values in code below may not match tables)

Program: Chromium Model

!PBPK model for chromium in humans

INITIAL

! Physiological parameters

!Blood flows

CONSTANT QCC = 15.6 ! Cardiac output (L/h/kg)

CONSTANT QBC = 0.05 ! Fraction QCC, bone

CONSTANT QLC = 0.065 ! Fraction QCC, liver

CONSTANT QKC = 0.19 ! Fraction QCC, kidney

CONSTANT QPTC = 0.19 ! FRACTION QCC, PORTAL

CONSTANT QSC = 0.19 ! FRACTION QPTC, STOMACH

CONSTANT QDC = 0.07 ! FRACTION QPTC, DUODENUM

CONSTANT QJC = 0.35 ! FRACTION QPTC, JEJUNUM

CONSTANT QIC = 0.39 ! FRACTION QPTC, ILEUM

!Tissue volume

CONSTANT VBC = 0.14 ! Bone volume fraction in adult (L/kg)

CONSTANT VLC = 0.025 ! Liver volume fraction in adult (L/kg)

CONSTANT VKC = 0.0042 ! Kidney volume fraction in adult (L/kg)

CONSTANT VSC = 0.0021 ! Stomach Volume in adult (L/kg)

CONSTANT VDC = 0.00077 ! DUODENUM VOLUME FRACTION

CONSTANT VJC = 0.0038 ! JEJUNUM VOLUME FRACTION

CONSTANT VIC = 0.0042 ! ILEUM VOLUME FRACTION

CONSTANT VBLC = 0.073 ! blood volume

CONSTANT HCT = 0.434 ! Hematocrit

CONSTANT FPT = 0.205 ! fraction blood volume in portal system

!LUMEN TO LUMEN TRANSIT (Cr & GI contents)

CONSTANT KLSD = 1.2 ! LUMEN STOM TO LUMEN DUOD (/hr)

CONSTANT KLDJ = 4.3 ! LUMEN DUOD TO LUMEN JEJ (/hr)

CONSTANT KLJI = 0.94 ! LUMEN JEJ TO LUMEN IL (/hr)

CONSTANT KLIL = 0.63 ! Ileum lumen to L. int (/h)

CONSTANT KFX = 0.039 ! L int to feces (/hr)

! lumen volumes (unitless fraction BW)

CONSTANT VSLC = 0.0034 ! stomach lumen

CONSTANT VDLC = 0.00038 ! duodenum lumen

CONSTANT VJLC = 0.0018 ! jejunum lumen

CONSTANT VILC = 0.0026 ! ileum lumen

!STOMACH UPTAKE

CONSTANT VMABS3S = 0. ! absorption in stom (L/hr)

CONSTANT VMABS6S = 0. ! absorption in stom (L/hr)

CONSTANT KMABS3S = 1000000. ! dose-dependent absorption of cr3, stomach

CONSTANT KMABS6S = 1000000. ! dose-dependent absorption of cr6, stomach

!SI UPTAKE

CONSTANT VMABS3 = 250 ! absorption in SI (L/hr per cm)

CONSTANT KMABS3 = 1000000. ! dose-dependent absorption of cr6

CONSTANT RAD3 = 1. ! Relative absorption of Cr3 across SI (duod=1 by definition)

CONSTANT RAJ3 = 0.1 ! Relative absorption of Cr3 across SI

CONSTANT RAI3 = 0.024 ! Relative absorption of Cr3 across SI

CONSTANT RAD6 = 1. ! Relative absorption of Cr6 across SI (duod=1 by definition)

CONSTANT RAJ6 = 0.3 ! Relative absorption of Cr3 across SI

CONSTANT RAI6 = 0.022 ! Relative absorption of Cr3 across SI

CONSTANT VMABS6 = 50. ! absorption in SI (L/hr per cm)

CONSTANT KMABS6 = 1000000. ! dose-dependent absorption of cr6

CONSTANT KSLOUGH1 = 0.0029 ! GI SLOUGHING (/hr); oral cavity & stomach

CONSTANT KSLOUGH2 = 0.029 ! GI SLOUGHING (/hr); SI

CONSTANT LD = 22.4 ! length duodenum (cm)

CONSTANT LJ = 104 ! length jejunum (cm)

CONSTANT LI = 154 ! length ileum (cm)

! CR6 REDUCTION

CONSTANT KRED = 71. ! All tissues/fluid except GI (/h)

!CONSTANT KREDGIT = 71. ! GI tissue (/h)!

CONSTANT KREDRC = 71. ! RBC (/h)

CONSTANT KREDBP = 0.66 ! Plasma (/h)

CONSTANT KMREDGIT = 0.000004 ! MM CONSTANT (MG); NEED ESTIMATES OF AD6 TO PLOT VS RBC:PLASMA TO ID KM

CONSTANT VKREDGIT = 71 ! V/K RATIO FOR GIT REDUCTION (mg/hr); SET = TO RBC RATE AT LOW DOSES

VMREDGIT = VKREDGIT\*KMREDGIT ! MAX RATE FOR GIT REDUCTION

CONSTANT KREDGIFC = 44.5 ! pH-scalable 2nd order rate constant based on modeling of ex vivo data (L/mg\*hr)

CONSTANT CRE0 = 20 ! Concentration of reducing equivalents in stomach contents based on modeling of ex vivo (mg/L gut contents)

CONSTANT PHS = 2.5 ! pH stomach lumen

CONSTANT PHD = 6. ! pH duodenum lumen

CONSTANT PHJ = 6.5 ! pH jejunum lumen

CONSTANT PHI = 7. ! pH ileum lumen

KREDSL = KREDGIFC\*EXP(-PHS) ! 2nd order rate constant for reduction in stomach lumen conc (L/mg\*hr)

KREDDL = KREDGIFC\*EXP(-PHD) ! 2nd order rate constant for reduction in duodenum lumen conc (L/mg\*hr)

KREDJL = KREDGIFC\*EXP(-PHJ) ! 2nd order rate constant for reduction in jejunum lumen conc (L/mg\*hr)

KREDIL = KREDGIFC\*EXP(-PHI) ! 2nd order rate constant for reduction in ileum lumen conc (L/mg\*hr)

!GI Fluid & Material Volume Rates

CONSTANT RFOODC = 0.00067 ! Rate of food consumption (L/hr\*kg)

RFOOD = RFOODC\*WBODY ! Rate of food consumption (L/hr)

CONSTANT RDRINKC = 0.00057 ! Rate of drinking water consumption in the adult rat (L/h\*kg)

RDRINK = RDRINKC\*WBODY ! Rate of drinking water consumption in the adult rat (L/h)

CONSTANT RGIFC = 0.0010 ! Rate of GI fluid production (L/hr\*kg)

RGIF = RGIFC\*WBODY ! Rate of GI fluid production (L/hr)

CONSTANT RSALC = 0.00063 ! Rate of Saliva production (L/hr\*kg)

RSAL = RSALC\*WBODY ! Rate of Saliva production (L/hr)

! TISSUE TRANSFER TO & FROM PLASMA; not scaled since multiplied by blood flows

CONSTANT KIN6 = 2. ! Cr6 from plasma to tissue (mg/hr)

CONSTANT KRBCIN6 = 8. ! Cr6 from plasma to tissue (mg/hr)

CONSTANT KOUT6 = 2. ! Cr6 from GI tissue to plasma (mg/hr)

CONSTANT KRBCIN3 = 0.0008 ! Cr3 from plasma to tissue (L/hr)

CONSTANT KRBCOUT3 = 0.0015 ! Cr3 from tissue to plasma (L/hr)

CONSTANT KINTCROTC = 0.016 ! T-Cr from plasma to other tissue

CONSTANT KINTCRBC = 0.25 ! T-Cr from plasma to tissue

CONSTANT KINTCRLC = 0.081 ! T-Cr from plasma to liver

CONSTANT KINTCRK = 0.08 ! T-Cr from plasma to kidney

CONSTANT KOUT3 = 0.0022 ! Cr3 from GI tissue to plasma

CONSTANT KOUTCCRGI = 0. ! C-Cr released from GI to portal blood

CONSTANT KOUTCCROTC = 0.0002 ! C-Cr from tissue to plasma;

CONSTANT KOUTCCRLC = 0.0004 ! C-Cr from liver to plasma;

CONSTANT KOUTCCRBC = 0.000057 ! C-Cr from bone to plasma;

CONSTANT KINCCR = 0.04 ! C-Cr from plasma to kidney

CONSTANT SFIN = 0.25 ! Scaling factor (from mouse based on L:K ratios) for systemic tissue uptake Cr3

CONSTANT SFOUT = 40 ! Scaling factor (from mouse based on L:K ratios) for systemic tissue release Cr3

KINTCROT = KINTCROTC\*SFIN

KINTCRB = KINTCRBC\*SFIN

KINTCRL = KINTCRLC\*SFIN

KOUTCCROT = KOUTCCROTC\*SFOUT

KOUTCCRL = KOUTCCRLC\*SFOUT

KOUTCCRB = KOUTCCRBC\*SFOUT

! EXCRETION

CONSTANT KURCc = 0.003 ! Urinary excretion of CCR

CONSTANT UrinCT = 24. ! Urine collection time (hrs), washout period for NTP studies

! EXPOSURE PARAMETERS

CONSTANT WATER3 = 0.0 ! Concentration of Cr3 in drinking water (mg/L)

CONSTANT WATER6 = 0.0 ! Concentration of Cr6 in drinking water (mg/L)

CONSTANT OD3 = 0.0 ! oral Cr3 dose (mg/kg)

CONSTANT OD6 = 0.0 ! oral Cr6 dose (mg/kg)

CONSTANT TINF = 0.05 ! time iv infusion (hr)

CONSTANT TEXPEND = 24 ! Time exposure ends

CONSTANT TSTOP = 48 ! Time simulation ends

CONSTANT DT1 = 0.

CONSTANT DT2 = 4.

CONSTANT DT3 = 8.

CONSTANT DT4 = 12.

CONSTANT DT5 = 16.

CONSTANT DT6 = 20.

CONSTANT DPCT1 = 1.0

CONSTANT DPCT2 = 0.

CONSTANT DPCT3 = 0.

CONSTANT DPCT4 = 0.

CONSTANT DPCT5 = 0.

CONSTANT DPCT6 = 0.

CONSTANT WADULT = 80 ! body weight

WBODY = WADULT

CONSTANT CRDOSE = 0. ! use for single dose studies

END !INITIAL

DYNAMIC

ALGORITHM IALG=2

CINTERVAL CINT=0.01

END !End dynamic

DERIVATIVE

!ODOSE3 = OD3

!ODOSE6 = OD6

Day = t/24

!SCALED FLOW RATES

QC = QCC\*WADULT\*\*0.74 ! Cardiac output in the adult (L/Day)

QCG = (QC\*((WBODY/WADULT)\*\*0.67))/24\*(1-HCT) ! Cardiac plasma output as a function of age-specific bw (L/h)

QL = QLC\*QCG ! plasma flow to liver (L/h)

QK = QKC\*QCG ! plasma flow to kidney (L/h)

QB = QBC\*QCG ! plasma flow to bone (L/h)

QRBC = (QC\*((WBODY/WADULT)\*\*0.67))/24\*(HCT) ! RBC flow in systemic blood

QPT = QPTC\*QCG ! Fraction QCC, PORTAL

QS = QSC\*QPT ! plasma flow to STOM (L/h)

QD = QDC\*QPT ! plasma flow to DUOD (L/h)

QJ = QJC\*QPT ! plasma flow to JEJ (L/h)

QI = QIC\*QPT ! plasma flow to IL (L/h)

QPTRBC = QPT\*HCT/(1-HCT) ! rbc flow in portal system

QOT = QCG-(QL+QK+QB+QPT) ! plasma flow to other tissues

! TISSUE VOLUMES (L)

VL = VLC\*WBODY ! liver volume (L)

VK = VKC\*WBODY ! kidney volume (L)

VS = VSC\*WBODY ! stomach volume (L)

VD = VDC\*WBODY ! duodenum volume (L)

VJ = VJC\*WBODY ! jejunum volume (L)

VI = VIC\*WBODY ! ileum volume (L)

VB = VBC\*WBODY ! Bone volume (L)

VBL = VBLC\*WBODY ! Blood volume (L)

VRBC = VBL\*HCT ! Red blood cell volume (L)

VRBCSYS = VRBC\*(1-FPT) ! volume rbc in systemic blood (L)

VRBCPT = VRBC\*FPT ! volume roc in portal blood (L)

VBP = VBL\*(1-HCT) ! Blood plasma volume (L)

VBPSYS = VBP\*(1-FPT) ! volume plasma in systemic blood (L)

VBPPT = VBP\*FPT ! volume plasma in portal blood (L)

VOT = WBODY-VB-VL-VK-VS-VD-VJ-VI-VBL ! Volume of other tissue (L)

! Lumen Volumes (L)

VSL = VSLC\*WBODY

VDL = VDLC\*WBODY

VJL = VJLC\*WBODY

VIL = VILC\*WBODY

! ===================================================================================

KURC = KURCc\*WBODY\*\*0.75 ! Urinary Excretion Cr3, storage/excretion pool

!DOSING RATES

INGST3 = WATER3\*RDRINK ! Rate of ingestion of Cr3 in the adult rat (mg/h)

INGST6 = WATER6\*RDRINK ! Rate of ingestion of Cr6 in the adult rat (mg/h)

! On/off switch for Cr(III & VI) exposure (mg/h)

IF (t.LE.Texpend) THEN

DW3 = INGST3

DW6 = INGST6

OAMT31 = OD3\*WBODY\*PULSE(DT1,24,TINF)\*DPCT1

OAMT32 = OD3\*WBODY\*PULSE(DT2,24,TINF)\*DPCT2

OAMT33 = OD3\*WBODY\*PULSE(DT3,24,TINF)\*DPCT3

OAMT34 = OD3\*WBODY\*PULSE(DT4,24,TINF)\*DPCT4

OAMT35 = OD3\*WBODY\*PULSE(DT5,24,TINF)\*DPCT5

OAMT36 = OD3\*WBODY\*PULSE(DT6,24,TINF)\*DPCT6

OAMT61 = OD6\*WBODY\*PULSE(DT1,24,TINF)\*DPCT1

OAMT62 = OD6\*WBODY\*PULSE(DT2,24,TINF)\*DPCT2

OAMT63 = OD6\*WBODY\*PULSE(DT3,24,TINF)\*DPCT3

OAMT64 = OD6\*WBODY\*PULSE(DT4,24,TINF)\*DPCT4

OAMT65 = OD6\*WBODY\*PULSE(DT5,24,TINF)\*DPCT5

OAMT66 = OD6\*WBODY\*PULSE(DT6,24,TINF)\*DPCT6

ORATE6 = (OAMT61+OAMT62+OAMT63+OAMT64+OAMT65+OAMT66)/TINF !oral amount (mg)

ORATE3 = (OAMT31+OAMT32+OAMT33+OAMT34+OAMT35+OAMT36)/TINF !oral amount (mg)

ELSE

DW3=0.0

DW6=0.0

ORATE6 = 0.

ORATE3 = 0.

ENDIF

RING6 = DW6+ORATE6 ! Rate Cr6 ingested (mg/hr)

RING3 = DW3+ORATE3 ! Rate Cr3 ingested (mg/hr)

AING6 = INTEG(RING6,0.) ! Amount Cr6 ingested (mg)

AING3 = INTEG(RING3,0.) ! Amount Cr3 ingested (mg)

AING = AING6 + AING3 ! Total amount ingested (mg)

! \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* Stomach \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

! Stomach Lumen

RRESL = RREPROD - RREDSL - RTRANSS ! Rate of change in stomach reducing equivalents (mg/hr)

ARESLA = INTEG(RRESL, 0.) ! Amount of reducing equivalents (mg)

ARESL = MAX(ARESLA,0.)

RREPROD = CRE0\*(RGIF+RDRINK+RFOOD+RSAL) ! rate reducing equivalents produced, in terms of stomach contents, including transit of dw, saliva, food from oral lumen (mg/hr)

RTRANSS = KLSD\*ARESL ! rate reducing equivalents transit to duodenum (mg/hr)

CRESL = ARESL/VSL ! Concentration of reducing equivalents in stomach lumen (mg/L)

RSL6 = RING6-RREDSL-RABSS6-R2D6+RSLFS6 ! Rate change in stomach lumen Cr6 (mg/hr)

ASL6A = INTEG(RSL6,0.0) ! amount in stomach lumen (mg)

ASL6 = MAX(ASL6A,0.)

RREDSL = CSL6\*KREDSL\*CRESL\*VSL ! reduction rate (mg/hr)

RABSS6 = VMABS6S\*CSL6/(KMABS6S+CSL6) ! absorption rate Cr6 (mg/hr)

ABSS6 = INTEG(RABSS6, 0.) ! amount Cr6 absorbed (mg)

R2D6 = KLSD\*ASL6 ! rate transfer to duodenum (mg/hr)

A2D6 = INTEG(R2D6, 0.) ! amt cr6 transferred to SI per L tissue (mg/L)

AMT2D6 = A2D6/(VD+VJ+VI) ! amt cr6 transferred to SI per L tissue (mg/L)

CSL6 = ASL6/VSL ! concentration Cr6 in stomach lumen (mg/L)

RSL3 = RING3+RREDSL-RABSS3-R2D3+RSLFS3 ! Rate change in stomach lumen Cr3 (mg/hr)

ASL3A = INTEG(RSL3,0.) ! amount in stomach lumen (mg)

ASL3 = MAX(ASL3A,0.)

RABSS3 = VMABS3S\*CSL3/(KMABS3S+CSL3) ! absorption rate (mg/hr)

ABSS3 = INTEG(RABSS3, 0.) ! amount Cr3 absorbed (mg)

R2D3 = KLSD\*ASL3 ! rate transit to duodenum (mg/hr)

A2D3 = INTEG(R2D3, 0.) ! amt cr3 transferred to SI (mg)

AMT2D3 = A2D3/(VD+VJ+VI) ! amt cr3 transferred to SI per L tissue (mg/L)

CSL3 = ASL3/VSL ! concentration of Cr3 in stomach lumen (mg/L)

ASL = ASL3 + ASL6 ! total amount Cr in stom lumen (mg)

CSL = ASL/VSL ! concentration Cr in stom lumen (mg/L)

! Stomach Tissue

RS6 = RABSS6 - RREDS - RS6OUT - RSLFS6 ! rate change in stomach epith (mg/hr)

AS6A = INTEG(RS6,0.) ! amount in stomach epith (mg)

AS6 = MAX(AS6A,0.)

CS6 = AS6/VS ! concentration in stomach epith (mg/L)

RS6OUT = KOUT6\*CS6\*QS ! rate Cr6 to plasma (mg/hr)

! RREDS = AS6\*KREDGIT ! reduction rate (mg/hr)

RREDS = CS6\*VMREDGIT/(KMREDGIT+CS6)

RSLFS6 = AS6\*KSLOUGH1 ! cell sloughing (mg/hr)

RS3 = RABSS3 + RREDS - RS3OUT - RSOUTTCR - RSLFS3 ! rate change in stomach epith (mg/hr)

AS3A = INTEG(RS3,0.) ! amount in stomach epith (mg)

AS3 = MAX(AS3A,0.)

CS3 = AS3/VS ! concentration in stomach epith (mg/L)

RSOUTTCR = KOUT3\*CS3\*QS ! rate Cr3 to plasma as T-Cr (mg/hr)

RS3OUT = KOUTCCRGI\*CS3\*QS ! rate C-Cr to plasma (mg/hr)

RSLFS3 = AS3\*KSLOUGH1 ! cell sloughing

AS = AS3 + AS6 ! total amount (mg)

CS = AS/VS ! total concentration (mg)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* DUODENUM \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

! Duodenum Lumen

RREDL = RTRANSS - RREDDL - RTRANSD ! Rate of change in duod reducing equivalents (mg/hr)

AREDLA = INTEG(RREDL, 0.) ! Amount of reducing equivalents (mg)

AREDL = MAX(AREDLA,0.)

RTRANSD = KLDJ\*AREDL ! rate reducing equivalents transit to jejunum (mg/hr)

CREDL = AREDL/VDL ! Concentration of reducing equivalents in duod lumen (mg/L)

RDL6 = R2D6 - RREDDL - RABSD6 - R2J6 ! rate change in Cr6 duod lumen (mg/hr)

ADL6a = INTEG(RDL6,0.) ! amount Cr6 (mg)

ADL6 = MAX(ADL6A,0.)

RREDDL = CDL6\*KREDDL\*CREDL\*VDL ! rate reduction (mg/hr)

RABSD6 = RAD6\*LD\*(VMABS6\*CDL6/(KMABS6+CDL6)) ! rate Cr6 absorption (mg/hr)

ABSD6 = INTEG(RABSD6, 0.) ! amount Cr6 absorbed (mg)

AMTABSD6 = ABSD6/VD ! amount Cr6 absorbed per L tissue (mg/L)

R2J6 = KLDJ\*ADL6 ! rate transit to jejunum (mg/hr)

CDL6 = ADL6/VDL ! concentration Cr6 in duod lumen (mg/L)

RDL3 = R2D3 + RREDDL - RABSD3 - R2J3 ! rate change in Cr3 duod lumen (mg/hr)

ADL3A = INTEG(RDL3,0.) ! amount Cr3 (mg)

ADL3 = MAX(ADL3A,0.)

RABSD3 = RAD3\*LD\*(VMABS3\*CDL3/(KMABS3+CDL3)) ! rate absorption (mg/hr);

ABSD3 = INTEG(RABSD3, 0.) ! amount Cr3 absorbed (mg)

AMTABSD3 = ABSD3/VD ! amount Cr6 absorbed per L tissue (mg/L)

R2J3 = KLDJ\*ADL3 ! rate transit to jejunum (mg/hr)

CDL3 = ADL3/VDL ! concentration Cr3 in duodenum lumen (mg/L)

ADL = ADL3 + ADL6 ! total Cr amount (mg)

CDL = ADL/VDL ! total Cr conc (mg/L)

! Duodenum Tissue

RD6 = RABSD6 - RREDD - RD6OUT - RSLFD6 ! rate change in Cr6 duod epith (mg/hr)

AD6A = INTEG(RD6,0.) ! amount Cr6 (mg)

AD6 = MAX(AD6A,0.)

CD6 = AD6/VD ! concentration Cr6 (mg/L)

! RREDD = AD6\*KREDGIT ! rate reduction (mg/hr)

RREDD = CD6\*VMREDGIT/(KMREDGIT+CD6)

AREDD = INTEG(RREDD, 0.) ! amount reduced (mg)

AMTREDD = AREDD/VD ! amount reduced per L tissue (mg/L)

RD6OUT = KOUT6\*CD6\*QD ! rate out to plasma (mg/hr)

RSLFD6 = KSLOUGH2\*AD6 ! rate transit to jejunum (mg/hr)

RD3 = RABSD3 + RREDD - RD3OUT - RDOUTTCR - RSLFD3 ! rate change in Cr3 duod epith (mg/hr)

AD3A = INTEG(RD3,0.) ! amount Cr3 (mg)

AD3 = MAX(AD3A,0.)

CD3 = AD3/VD ! concentration Cr3 (mg/L)

RSLFD3 = KSLOUGH2\*AD3 ! rate sloughed (mg/hr)

RDOUTTCR = KOUT3\*CD3\*QD ! rate Cr3 out to plasma as T-Cr (mg/hr)

RD3OUT = KOUTCCRGI\*CD3\*QD ! rate C-Cr out to plasma (mg/hr)

AD = AD3 + AD6 ! total Cr amount (mg)

CD = AD/VD ! total Cr concentration (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* JEJUNUM \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

! Jejunum Lumen

RREJL = RTRANSD - RREDJL - RTRANSJ ! Rate of change in jej reducing equivalents (mg/hr)

AREJLA = INTEG(RREJL, 0.) ! Amount of reducing equivalents (mg)

AREJL = MAX(AREJLA,0.)

RTRANSJ = KLJI\*AREJL ! rate reducing equivalents transit to ileum (mg/hr)

CREJL = AREJL/VJL ! Concentration of reducing equivalents in jej lumen (mg/L)

RJL6 = R2J6-RREDJL-RABSJ6-R2I6 ! rate change in Cr6 jej lumen (mg/hr)

AJL6A = INTEG(RJL6,0.) ! amount Cr6 (mg)

AJL6 = MAX(AJL6A,0.)

RREDJL = CJL6\*KREDJL\*CREJL\*VJL ! rate reduced (mg/hr)

RABSJ6 = RAJ6\*LJ\*(VMABS6\*CJL6/(KMABS6+CJL6)) ! rate absorption (mg/hr)

ABSJ6 = INTEG(RABSJ6, 0.) ! amount Cr6 absorbed (mg)

AMTABSJ6 = ABSJ6/VJ ! amount Cr6 absorbed per L tissue (mg/L)

R2I6 = KLJI\*AJL6 ! rate transit to ileum (mg/hr)

CJL6 = AJL6/VJL ! concentration cr6 in jej lumen (mg/L)

RJL3 = R2J3+RREDJL-RABSJ3-R2I3 ! rate change in Cr3 jej lumen (mg/hr)

AJL3A = INTEG(RJL3,0.) ! amount Cr3 (mg)

AJL3 = MAX(AJL3A,0.)

RABSJ3 = RAJ3\*LJ\*(VMABS3\*CJL3/(KMABS3+CJL3)) ! rate absorption (mg/hr)

ABSJ3 = INTEG(RABSJ3, 0.) ! amount Cr3 absorbed (mg)

AMTABSJ3 = ABSJ3/VJ ! amount Cr3 absorbed per L tissue (mg/L)

R2I3 = KLJI\*AJL3 ! rate transit to ileum (mg/hr)

CJL3 = AJL3/VJL ! concentration cr3 in jej lumen (mg/L)

AJL = AJL3 + AJL6 ! total Cr amount (mg)

CJL = AJL/VJL ! total Cr conc (mg/L)

! Jejunum Tissue

RJ6 = RABSJ6-RREDJ-RJ6OUT-RSLFJ6 ! rate change in Cr6 jej epith (mg/hr)

AJ6A = INTEG(RJ6,0.) ! amount Cr6 (mg)

AJ6 = MAX(AJ6A,0.)

CJ6 = AJ6/VJ ! concentration Cr6 (mg/L)

! RREDJ = AJ6\*KREDGIT ! rate reduced (mg/hr)

RREDJ = CJ6\*VMREDGIT/(KMREDGIT+CJ6)

AREDJ = INTEG(RREDJ, 0.) ! amount reduced (mg)

AMTREDJ = AREDJ/VJ ! amount reduced per L tissue (mg/L)

RSLFJ6 = KSLOUGH2\*AJ6 ! rate sloughed (mg/hr)

RJ6OUT = KOUT6\*CJ6\*QJ ! rate out to plasma (mg/hr)

RJ3 = RABSJ3+RREDJ-RJ3OUT-RJOUTTCR-RSLFJ3 ! rate change in Cr3 jej epith (mg/hr)

AJ3A = INTEG(RJ3,0.) ! amount Cr3 (mg)

AJ3 = MAX(AJ3A,0.)

CJ3 = AJ3/VJ ! concentration Cr3 (mg/L)

RSLFJ3 = KSLOUGH2\*AJ3 ! rate sloughed (mg/hr)

RJOUTTCR = KOUT3\*CJ3\*QJ ! rate Cr3 out to plasma as TCRP (mg/hr)

RJ3OUT = KOUTCCRGI\*CJ3\*QJ ! rate CCR out to plasma (mg/hr)

AJ = AJ3 + AJ6 ! total amount Cr (mg)

CJ = AJ/VJ ! total concentration Cr (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* ILEUM \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

! Ileum Lumen

RREIL = RTRANSJ - RREDIL - RTRANSI ! Rate of change in ileum reducing equivalents (mg/hr)

AREILA = INTEG(RREIL, 0.) ! Amount of reducing equivalents (mg)

AREIL = MAX(AREILA,0.)

RTRANSI = KLIL\*AREIL ! rate reducing equivalents transit to l. intest (mg/hr)

CREIL = AREIL/VIL ! Concentration of reducing equivalents in ileum lumen (mg/L)

RIL6 = R2I6-RREDIL-RABSI6-R2LI6 ! rate change in Cr6 ileum lumen (mg/hr)

AIL6A = INTEG(RIL6,0.) ! amount Cr6 (mg)

AIL6 = MAX(AIL6A,0.)

RREDIL = CIL6\*KREDIL\*CREIL\*VIL ! rate reduced (mg/hr)

RABSI6 = RAI6\*LI\*(VMABS6\*CIL6/(KMABS6+CIL6)) ! rate Cr6 absorption (mg/hr)

ABSI6 = INTEG(RABSI6, 0.) ! amount Cr6 absorbed (mg)

AMTABSI6 = ABSI6/VI ! amount Cr6 absorbed per L tissue (mg/L)

R2LI6 = KLIL\*AIL6 ! rate Cr6 to LI (mg/hr)

CIL6 = AIL6/VIL ! concentration Cr6 in ileum lumen (mg/L)

RIL3 = R2I3+RREDIL-RABSI3-R2LI3 ! rate change in Cr3 ileum lumen (mg/hr)

AIL3A = INTEG(RIL3,0.) ! amount Cr3 in lumen (mg)

AIL3 = MAX(AIL3A,0.)

RABSI3 = RAI3\*LI\*(VMABS3\*CIL3/(KMABS3+CIL3)) ! rate Cr3 absorbed (mg/hr)

ABSI3 = INTEG(RABSI3, 0.) ! amount Cr3 absorbed (mg)

AMTABSI3 = ABSI3/VI ! amount Cr3 absorbed per L tissue (mg/L)

R2LI3 = KLIL\*AIL3 ! rate Cr3 to LI (mg/hr)

CIL3 = AIL3/VIL ! concentration of Cr3 in ileum lumen (mg/L)

AIL = AIL3+AIL6 ! total amount Cr in ileum lumen (mg)

CIL = AIL/VIL ! total concentration Cr in ileum lumen (mg/L)

! Ileum Tissue

RI6 = RABSI6-RREDI-RI6OUT-RSLFI6 ! rate change in Cr6 ileum epith (mg/hr)

AI6A = INTEG(RI6,0.) ! amount Cr6 (mg)

AI6 = MAX(AI6A,0.)

CI6 = AI6/VI ! concentration Cr6 (mg/L)

! RREDI = AI6\*KREDGIT ! rate reduced (mg/hr)

RREDI = CI6\*VMREDGIT/(KMREDGIT+CI6)

AREDI = INTEG(RREDI, 0.) ! amount reduced (mg)

AMTREDI = AREDI/VI ! amount reduced per L tissue (mg/L)

RSLFI6 = KSLOUGH2\*AI6 ! rate sloughed (mg/hr)

RI6OUT = KOUT6\*CI6\*QI ! rate out to plasma (mg/hr)

RI3 = RABSI3+RREDI-RI3OUT-RIOUTTCR-RSLFI3 ! rate change in Cr3 ileum epith (mg/hr)

AI3A = INTEG(RI3,0.) ! amount Cr3 (mg)

AI3 = MAX(AI3A,0.)

CI3 = AI3/VI ! concentration Cr3 (mg/L)

RSLFI3 = KSLOUGH2\*AI3 ! rate sloughed (mg/hr)

RIOUTTCR = KOUT3\*CI3\*QI ! rate Cr3 out to plasma as T-CR (mg/hr)

RI3OUT = KOUTCCRGI\*CI3\*QI ! rate C-CR out to plasma (mg/hr)

AI = AI3+AI6 ! total Cr amount (mg)

CI = AI/VI ! total Cr concentration (mg/L)

AMTABS6 = (ABSD6+ABSJ6+ABSI6)/(VD+VJ+VI) ! amount Cr6 absorbed in SI per L SI (mg/L)

AMTABS3 = (ABSD3+ABSJ3+ABSI3)/(VD+VJ+VI) ! amount Cr3 absorbed in SI per L SI (mg/L)

! ABSORPTION IN LG INTESTINE ASSUMED TO BE NEGLIGIBLE; COMPARTMENT ADDED FOR TRANSIT TO MATCH FECAL EXCRETION DATA

! LG Intestine lumen, nonphysiologic

RLIL6 = R2LI6-RFX6 ! rate of change Cr6 in LI lumen (mg/hr)

ALIL6 = INTEG(RLIL6, 0.) ! amount Cr6 LI lumen (mg)

RFX6 = KFX\*ALIL6 ! rate Cr6 fecal excretion (mg/hr)

AFX6 = INTEG(RFX6, 0.) ! amount Cr6 excreted in feces (mg)

RLIL3 = R2LI3-RFX3 ! rate of change Cr3 in LI lumen (mg/hr)

ALIL3 = INTEG(RLIL3, 0.) ! amount Cr3 LI lumen (mg)

RFX3 = KFX\*ALIL3 ! rate Cr3 fecal excretion (mg/hr)

AFX3 = INTEG(RFX3, 0.) ! amount Cr3 excreted in feces (mg)

ALIL = ALIL6+ALIL3

!---------------------------------------------

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* PORTAL BLOOD \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

! Portal Plasma

RPT6 = (RSYS2PT6-RPT2SYS6)+(RS6OUT+RD6OUT+RJ6OUT+RI6OUT)-RPT6IN-RL6INPT-RREDPTP !rate change in Cr6 portal plasma (mg/hr)

APT6A = INTEG(RPT6, 0.) ! amount Cr6 (mg)

APT6 = MAX(APT6A,0.)

CPT6 = APT6/VBPPT ! concentration Cr6 (mg/L)

RPT6IN = KRBCIN6\*CPT6 ! rate Cr6 from plasma to RBC (mg/hr)

RREDPTP = KRED\*APT6 ! rate reduced (mg/hr)

RSYS2PT6 = CBP6\*QPT ! rate Cr6 in from systemic plasma (mg/hr)

RPT2SYS6 = CPT6\*QPT !-RL6INPT ! rate Cr6 out to systemic plasma (mg/hr)

RPT3 = (RSYS2PT3-RPT2SYS3)+(RSOUTTCR+RDOUTTCR+RJOUTTCR+RIOUTTCR)-RPT3IN-RL3INPT+RREDPTP ! rate change in Cr3 portal plasma (mg/hr)

APT3A = INTEG(RPT3, 0.) ! amount Cr as TCR (mg)

APT3 = MAX(APT3A,0.)

CPT3 = APT3/VBPPT ! concentration Cr as TCR (mg/L)

RPT3IN = KRBCIN3\*CPT3 ! rate to RBC (mg/hr)

RPT3OUT = KRBCOUT3\*CPTRBC3 ! rate from RBC (mg/hr)

RSYS2PT3 = CTCRP\*QPT ! rate Cr3 in from systemic plasma (mg/hr)

RPT2SYS3 = CPT3\*QPT !-RL3INPT ! rate Cr3 out to systemic plasma (mg/hr)

RPTCCR = (RS3OUT+RD3OUT+RJ3OUT+RI3OUT+RPT3OUT)-QPT\*(CPTCCR-CCCRP) ! rate of change in T-Cr in portal plasma (mg/hr)

APTCCRA = INTEG(RPTCCR, 0.) ! amount T-Cr portal plasma (mg)

APTCCR = MAX(APTCCRA,0.)

CPTCCR = APTCCR/VBPPT ! concentration T-Cr portal plasma (mg/L)

! Portal RBC

RPTRBC6 = QPTRBC\*(CRBC6-CPTRBC6)+RPT6IN-RREDPTC ! rate of change of Cr6 in RBC (mg/hr)

APTRBC6A = INTEG(RPTRBC6,0.) ! Amount Cr6 (mg)

APTRBC6 = MAX(APTRBC6A,0.)

CPTRBC6 = APTRBC6/VRBCPT ! Concentration Cr6 (mg/L)

RREDPTC = KREDRC\*APTRBC6 ! rate reduced (mg/hr)

RPTRBC3 = QPTRBC\*(CRBC3-CPTRBC3)+(RPT3IN-RPT3OUT)+RREDPTC ! rate of change of Cr3 in RBC (mg/hr)

APTRBC3A = INTEG(RPTRBC3,0.) ! Amount Cr3 (mg)

APTRBC3 = MAX(APTRBC3A,0.)

CPTRBC3 = APTRBC3/VRBCPT ! Concentration Cr3 (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* LIVER \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

RL6 = RL6IN+RL6INPT-RREDLIV ! Rate of change of Cr6 liver (mg/hr)

AL6A = INTEG(RL6,0.) ! Amount Cr6 (mg)

AL6 = MAX(AL6A,0.)

CL6 = AL6/VL ! Concentration Cr6 (mg/L)

RL6IN = KIN6\*CBP6\*QL ! Rate Cr6 from systemic plasma (mg/hr)

RL6INPT = KIN6\*CPT6\*QPT ! rate T-Cr in from portal plasma (mg Cr/hr)

RREDLIV = KRED\*AL6 ! Rate of reduction of Cr6 to Cr3 (mg/h)

RL3 = RL3IN+RL3INPT+RREDLIV-RL3OUT ! rate of T-Cr in liver (mg Cr/hr)

AL3A = INTEG(RL3, 0.) ! mass of T-Cr in liver (mg Cr/L)

AL3 = MAX(AL3A,0.)

CL3 = AL3/VL ! conc of T-Cr in liver (mg Cr/L)

RL3IN = CTCRP\*KINTCRL\*QL ! rate T-Cr in from systemic plasma (mg Cr/hr)

RL3INPT = CPT3\*KINTCRL\*QPT ! rate T-Cr in from portal plasma (mg Cr/hr)

RL3OUT = KOUTCCRL\*CL3\*(QL+QPT) ! rate CCr released to plasma (mg Cr/hr)

AL = AL6 + AL3 ! Amount of chromium in liver (mg)

CL = AL/VL ! Total concentration in liver (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* SYSTEMIC PLASMA \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

!Three forms of Cr in plasma: Cr6, T-Cr=distribution pool Cr3, C-Cr=storage/excretion pool Cr3

RBP6 = (RPT2SYS6-RSYS2PT6)-RL6IN-RK6IN-RB6IN-ROT6IN-RIN6-RREDP ! rate change Cr6 plasma (mg/hr)

ABP6A = INTEG(RBP6, 0.) ! amount Cr6 (mg)

ABP6 = MAX(ABP6A,0.)

CBP6 = ABP6/VBPSYS ! concentration Cr6 (mg/L)

RREDP = KRED\*ABP6 ! rate reduced (mg/hr)

RTCRP = (RPT2SYS3-RSYS2PT3)-RL3IN-RK3IN-RIN3-ROT3IN-RB3IN+RREDP ! rate change in plasma T-Cr (mg/hr)

ATCRPA = INTEG(RTCRP, 0.) ! amount T-Cr (mg Cr)

ATCRP = MAX(ATCRPA,0.)

CTCRP = ATCRP/VBP ! concentration T-Cr (mg Cr/L)

RCCRP = (RL3OUT+ROUT3+ROT3OUT+RB3OUT)-RKCCRIN+QPT\*(CPTCCR-CCCRP) ! Rate change in plasma C-Cr (mg/hr); only kidney assumed to take up C-Cr from plasma

ACCRPA = INTEG(RCCRP, 0.) ! amount C-Cr (mg Cr)

ACCRP = MAX(ACCRPA,0.)

CCCRP = ACCRP/VBPSYS ! concentration C-Cr (mg Cr)

ABP = ABP6 + ATCRP + ACCRP ! Concentration of chromium in plasma (mg/L)

CBP = ABP/VBPSYS ! Total amount of chromium in plasma (mg)

ABL = ABP+ARBC ! Total amount of chromium in blood (mg)

CBL = ABL/VBL ! Concentration of chromium in blood (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* Systemic RBC \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

RRBC6 = QPTRBC\*(CPTRBC6-CRBC6)+RIN6-RREDRC ! rate of change Cr6 in RBC (mg/hr)

ARBC6A = INTEG(RRBC6,0.) ! Amount Cr6 (mg)

ARBC6 = MAX(ARBC6A,0.)

CRBC6 = ARBC6/VRBCSYS ! Concentration Cr6 (mg/L)

RIN6 = KRBCIN6\*CBP6 ! Rate Cr6 in from plasma (mg/hr)

RREDRC = KREDRC\*ARBC6 ! Rate reduced (mg/hr)

RRBC3 = QPTRBC\*(CPTRBC3-CRBC3)+(RIN3-ROUT3)+RREDRC ! rate of change Cr3 in RBC (mg/hr)

ARBC3A = INTEG(RRBC3,0.) ! Amount of Cr3 (mg)

ARBC3 = MAX(ARBC3A,0.)

CRBC3 = ARBC3/VRBCSYS ! Concentration Cr3 (mg/L)

RIN3 = KRBCIN3\*CTCRP ! Rate in from plasma (mg/hr)

ROUT3 = KRBCOUT3\*CRBC3 ! Rate out to plasma (mg/hr)

ARBC = (ARBC3+ARBC6)+(APTRBC3+APTRBC6) ! Total amount of Cr in systemic & portal RBC (mg)

CRBC = ARBC/VRBC ! Total concentration of chromium in RBC (mg/L)

RBC2P = (CRBC3+CRBC6)/(CBP+0.000000001)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* KIDNEY \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

RK6 = RK6IN-RREDK ! Rate of change in Cr6 kidney (mg/hr)

AK6A = INTEG(RK6,0.) ! Amount of Cr6 (mg)

AK6 = MAX(AK6A,0.)

CK6 = AK6/VK ! Concentration Cr6 (mg/L)

RK6IN = KIN6\*CBP6\*QK ! rate in from plasma (mg/hr)

RREDK = KRED\*AK6 ! Rate of reduction (mg/hr)

RK3 = RK3IN+RREDK+RKCCRIN-RURC ! Rate of change in Cr3 kidney (mg/hr)

AK3A = INTEG(RK3, 0.) ! Amount Cr (mg)

AK3 = MAX(AK3A,0.)

CK3 = AK3/VK ! Concentration Cr (mg Cr/L)

RK3IN = CTCRP\*KINTCRK\*QK ! Rate T-CR from plasma (mg/hr), assumed converted to C-CR for excretion

RKCCRIN = CCCRP\*KINCCR\*QK ! Rate C-CR from plasma (mg/hr)

RURC = KURC\*CK3 ! Urinary Excretion C-Cr

AK = AK3+AK6 ! Amount of Cr in kidney (mg)

CK = AK/VK ! Concentration Cr in kidney (mg/L)

IF(CL\*CK.GT.0) LKRatio = CL/CK ! ratio of liver:kidney concentration

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* OTHER TISSUES \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

ROT6 = ROT6IN-RREDOT ! Rate of change in Cr6 other tissues (mg/h)

AOT6A = INTEG(ROT6,0.) ! Amount of Cr6 (mg)

AOT6 = MAX(AOT6A,0.)

COT6 = AOT6/VOT ! Concentration Cr6 (mg/L)

ROT6IN = KIN6\*CBP6\*QOT ! Rate Cr6 in from plasma (mg/hr)

RREDOT = KRED\*AOT6 ! Rate of reduction (mg/hr)

ROT3 = ROT3IN - ROT3OUT + RREDOT ! Rate of change in Cr3 (mg/hr)

AOT3A = INTEG(ROT3,0.) ! Amount of Cr3 (mg)

AOT3 = MAX(AOT3A,0.)

COT3 = AOT3/VOT ! Concentration of Cr3 (mg/L)

ROT3IN = CTCRP\*KINTCROT\*QOT ! rate T-Cr in from plasma (mg/hr)

ROT3OUT = COT3\*KOUTCCROT\*QOT ! rate C-Cr released to plasma (mg/hr)

AOT = AOT6+AOT3 ! Total amount of chromium in other tissues (mg)

COT = AOT/VOT ! Total concentration in other tissues (mg/L)

!\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* BONE \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

RB6 = RB6IN-RREDB ! Rate of change in Cr6 bone (mg/hr)

AB6A = INTEG(RB6,0.) ! Amount of Cr6 (mg)

AB6 = MAX(AB6A,0.)

CB6 = AB6/VB ! Concentration Cr6 (mg/L)

RB6IN = KIN6\*CBP6\*QB ! rate in from plasma (mg/hr)

RREDB = KRED\*AB6 ! Rate of reduction (mg/hr)

RB3 = RB3IN+RREDB-RB3OUT ! Rate of change in Cr3 bone (mg/hr)

AB3A = INTEG(RB3,0.) ! Amount Cr3 (mg)

AB3 = MAX(AB3A,0.)

CB3 = AB3/VB ! Concentration Cr3 (mg/L)

RB3IN = CTCRP\*KINTCRB\*QB ! rate T-Cr in from plasma (mg/hr)

RB3OUT = CB3\*KOUTCCRB\*QB ! rate C-Cr released to plasma (mg/hr)

AB = AB3+AB6 ! Total Cr in bone (mg)

CB = AB/VB ! Total Cr concentration in bone (mg/L)

!Urinary Excretion

AURX = INTEG(RURC,0.) ! Total amount of chromium in urine (mg)

AURXDELAY = DELAY(AURX, 0, UrinCT, 5000, 1) ! Delay for calculating excretion over collection time

AURXPERDAY = AURX-AURXDELAY ! Cr excreted in urine over collection time (mg)

IF(AING.GT.0) FracABS = (BB+AURX)/AING ! Fraction Cr absorbed

!Fecal Excretion

RSLF3 = RSLFD3+RSLFJ3+RSLFI3 ! Rate Cr3 sloughed from SI (mg/hr)

ASLF3 = INTEG(RSLF3, 0.) ! Amount Cr3 sloughed from SI (mg)

RSLF6 = RSLFD6+RSLFJ6+RSLFI6 ! Rate Cr6 sloughed from SI (mg/hr)

ASLF6 = INTEG(RSLF6, 0.) ! Amount Cr6 sloughed from SI (mg)

RFX = RFX3+RFX6+RSLF3+RSLF6 ! Total rate Cr excreted in feces (mg/hr)

AFX = INTEG(RFX, 0.) ! total amount Cr excreted in feces (mg)

! Total excretion

RX = RURC + RFX ! Total rate of excretion of Cr (mg/day)

AX = AURX + AFX ! Total amount of Cr excreted (mg)

! Mass balance

FLOWCHECK = QCG-(QL+QK+QOT+QPT+QB) ! plasma flow (L/hr)

VOLUMECHECK = WBODY-(VL+VK+VS+VD+VJ+VI+VB+VOT+VBL) ! tissue volume (L)

BB6 = AL6+AK6+AS6+AD6+AJ6+AI6+AOT6+AB6+ARBC6+ABP6+APT6+APTRBC6 ! amount (mg)

BB3 = AL3+AK3+AS3+AD3+AJ3+AI3+AOT3+AB3+ARBC3+APTRBC3+ATCRP+APT3+ACCRP+APTCCR ! amount (mg)

Lumen = ASL3+ASL6+ADL3+ADL6+AJL3+AJL6+AIL3+AIL6+ALIL3+ALIL6 ! amount (mg)

BB = BB3+BB6 ! amount (mg)

BBLumen = BB+Lumen ! amount (mg)

MASSCHECK = AING-BB-AX-Lumen ! amount (mg)

TERMT(T.GT.Tstop)

END !DERIVATIVE

END !PROGRAM