

Package ‘httk’

February 14, 2020

Version 2.0.0

Date 2020-02-10

Title High-Throughput Toxicokinetics

Description Functions and data tables for simulation and statistical analysis of chemical toxicokinetics (“TK”) as in Pearce et al. (2017) <doi:10.18637/jss.v079.i04>. Chemical-specific in vitro data have been obtained from relatively high throughput experiments. Both physiologically-based (“PBTK”) and empirical (e.g., one compartment) “TK” models can be parameterized for several hundred chemicals and multiple species. These models are solved efficiently, often using compiled (C-based) code. A Monte Carlo sampler is included for simulating biological variability (Ring et al., 2017 <doi:10.1016/j.envint.2017.06.004>) and measurement limitations. Calibrated methods are included for predicting tissue:plasma partition coefficients and volume of distribution (Pearce et al., 2017 <doi:10.1007/s10928-017-9548-7>). These functions and data provide a set of tools for in vitro-in vivo extrapolation (“IVIVE”) of high throughput screening data (e.g., Tox21, ToxCast) to real-world exposures via reverse dosimetry (also known as “RTK”) (Wetmore et al., 2015 <doi:10.1093/toxsci/kfv171>).

Depends R (>= 2.10)

Imports deSolve, msm, data.table, survey, mvtnorm, truncnorm, stats, graphics, utils, magrittr, purrr, methods

Suggests ggplot2, knitr, rmarkdown, R.rsp, GGally, gplots, scales, EnvStats, MASS, RColorBrewer, TeachingDemos, classInt, ks, stringr, reshape, reshape2, gdata, viridis, CensRegMod, gmodels, colorspace, cowplot, ggrepel, dplyr, forcats, smatr, gtools, gridExtra

License GPL-3

LazyData true

Encoding UTF-8

VignetteBuilder knitr, R.rsp

RoxygenNote 7.0.2

URL <https://www.epa.gov/chemical-research/rapid-chemical-exposure-and-dose-research>

BugReports <https://github.com/USEPA/CompTox-ExpoCast-httpk>

NeedsCompilation yes

Author John Wambaugh [aut, cre] (<<https://orcid.org/0000-0002-4024-534X>>),
 Robert Pearce [aut] (<<https://orcid.org/0000-0003-3168-4049>>),
 Caroline Ring [aut] (<<https://orcid.org/0000-0002-0463-1251>>),
 Greg Honda [aut] (<<https://orcid.org/0000-0001-7713-9850>>),
 Mark Sfeir [aut], Matt Linakis [aut] (<<https://orcid.org/0000-0003-0526-2395>>),
 Jimena Davis [ctb], James Sluka [ctb] (<<https://orcid.org/0000-0002-5901-1404>>),
 Nisha Sipes [ctb] (<<https://orcid.org/0000-0003-4203-6426>>),
 Barbara Wetmore [ctb],
 Woodrow Setzer [ctb] (<<https://orcid.org/0000-0002-6709-9186>>)

Maintainer John Wambaugh <wambaugh.john@epa.gov>

R topics documented:

httpk-package	5
add_chemtable	6
age_dist_smooth	7
age_draw_smooth	8
armitage_estimate_sarea	9
armitage_eval	10
armitage_input	12
available_rblood2plasma	13
blood_mass_correct	14
blood_weight	15
bmiage	15
body_surface_area	16
bone_mass_age	17
brain_mass	18
calc_analytic_css	18
calc_analytic_css_1comp	21
calc_analytic_css_3comp	22
calc_analytic_css_3compss	23
calc_analytic_css_pbtk	25
calc_css	26
calc_elimination_rate	29
calc_hep_bioavailability	30
calc_hep_clearance	31
calc_hep_fu	33
calc_ionization	34
calc_krbc2pu	35
calc_mc_css	36
calc_mc_oral_equiv	40
calc_mc_tk	43
calc_rblood2plasma	46
calc_stats	47
calc_total_clearance	49
calc_vdist	51
chem.invivo.PK.aggregate.data	52
chem.invivo.PK.data	53
chem.invivo.PK.summary.data	56

chem.lists	59
chem.physical_and_invitro.data	60
ckd_epi_eq	61
concentration_data_Linakis2020	62
convert_httkpop_lcomp	63
create_mc_samples	63
EPA.ref	66
estimate_gfr	67
estimate_gfr_ped	67
estimate_hematocrit	68
export_pbt_k_jarnac	69
export_pbt_k_sbml	70
Frank2018invivo	71
gen_age_height_weight	71
gen_height_weight	73
get_cheminfo	73
get_chem_id	75
get_gfr_category	75
get_invitroPK_param	76
get_lit_cheminfo	77
get_lit_css	78
get_lit_oral_equiv	80
get_physchem_param	81
get_rblood2plasma	82
get_weight_class	83
hematocrit_infants	84
honda.ivive	84
howgate	86
httkpop	86
httkpop_biotophys_default	87
httkpop_direct_resample	87
httkpop_direct_resample_inner	89
httkpop_generate	90
httkpop_mc	92
httkpop_virtual_indiv	93
in.list	94
invitro_mc	96
is.httk	97
is_in_inclusive	99
johnson	99
kidney_mass_children	100
liver_mass_children	101
load_sipes2017	101
lump_tissues	102
lung_mass_children	104
mcnally_dt	104
metabolism_data_Linakis2020	105
monte_carlo	106
nhanes_mec_svy	108
Obach2008	109
onlyp	110
pancreas_mass_children	110

parameterize_1comp	111
parameterize_3comp	113
parameterize_gas_pbtck	115
parameterize_pbtck	119
parameterize_schmitt	121
parameterize_steadystate	123
pc.data	125
pharma	126
physiology.data	127
predict_partitioning_schmitt	128
propagate_invitrouv_1comp	130
propagate_invitrouv_3comp	130
propagate_invitrouv_pbtck	131
reset_httk	131
rfun	132
r_left_censored_norm	133
scale_dosing	133
sipes2017	134
skeletal_muscle_mass	135
skeletal_muscle_mass_children	136
skin_mass_bosgra	136
solve_1comp	137
solve_3comp	141
solve_gas_pbtck	144
solve_model	148
solve_pbtck	151
spleen_mass_children	155
spline_heightweight	156
spline_hematocrit	157
spline_serumcreat	158
supptab1_Linakis2020	158
supptab2_Linakis2020	159
Tables.Rdata.stamp	160
tissue.data	160
tissue_masses_flows	161
tissue_scale	162
wambaugh2019	162
wambaugh2019.nhanes	164
wambaugh2019.raw	165
wambaugh2019.seem3	167
wambaugh2019.tox21	167
well_param	168
Wetmore.data	169
Wetmore2012	170
wfl	170

Description

Functions and data tables for simulation and statistical analysis of chemical toxicokinetics ("TK") as in Pearce et al. (2017) <doi:10.18637/jss.v079.i04>. Chemical-specific in vitro data have been obtained from relatively high throughput experiments. Both physiologically-based ("PBTK") and empirical (e.g., one compartment) "TK" models can be parameterized for several hundred chemicals and multiple species. These models are solved efficiently, often using compiled (C-based) code. A Monte Carlo sampler is included for simulating biological variability (Ring et al., 2017 <doi:10.1016/j.envint.2017.06.004>) and measurement limitations. Calibrated methods are included for predicting tissue:plasma partition coefficients and volume of distribution (Pearce et al., 2017 <doi:10.1007/s10928-017-9548-7>). These functions and data provide a set of tools for in vitro-in vivo extrapolation ("IVIVE") of high throughput screening data (e.g., Tox21, ToxCast) to real-world exposures via reverse dosimetry (also known as "RTK") (Wetmore et al., 2015 <doi:10.1093/toxsci/kfv171>).

Author(s)

John Wambaugh, Robert Pearce, Caroline Ring, Gregory Honda, Nisha Sipes, Jimena Davis, Barbara Wetmore, Woodrow Setzer, Mark Sfeir

See Also

PowerPoint Presentation: High-Throughput Toxicokinetics (HTTK) R package

Pearce et al. (2017): httk: R Package for High-Throughput Toxicokinetics

Wetmore et al. (2015): Incorporating High-Throughput Exposure Predictions With Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing

Wambaugh et al. (2015): Toxicokinetic Triage for Environmental Chemicals

Pearce et al. (2017): Evaluation and calibration of high-throughput predictions of chemical distribution to tissues

Ring et al. (2017): Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability

Sipes et al. (2017): An Intuitive Approach for Predicting Potential Human Health Risk with the Tox21 10k Library

Wambaugh et al. (2018): Evaluating In Vitro-In Vivo Extrapolation of Toxicokinetics

Honda et al. (2019): Using the concordance of in vitro and in vivo data to evaluate extrapolation assumptions

Wambaugh et al. (2019): Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization EPA's ExpoCast (Exposure Forecasting) Project

add_chemtable	<i>Add a table of chemical information for use in making htk predictions.</i>
---------------	---

Description

This function adds chemical-specific information to the table `chem.physical_and_invitro.data`. This table is queried by the model parameterization functions when attempting to parameterize a model, so adding sufficient data to this table allows additional chemicals to be modeled.

Usage

```
add_chemtable(  
  new.table,  
  data.list,  
  current.table = NULL,  
  reference = NULL,  
  species = NULL,  
  overwrite = F  
)
```

Arguments

<code>new.table</code>	Object of class <code>data.frame</code> containing one row per chemical, with each chemical minimally described by a CAS number.
<code>data.list</code>	This list identifies which properties are to be read from the table. Each item in the list should point to a column in the table <code>new.table</code> . Valid names in the list are: 'Compound', 'CAS', 'DSTox.GSID', 'SMILES.desalt', 'Reference', 'Species', 'MW', 'logP', 'pKa_Donor', 'pKa_Accept', 'logMA', 'Clint', 'Clint.pValue', 'Funbound.plasma', 'Fgutabs', 'Rblood2plasma'.
<code>current.table</code>	This is the table to which data are being added.
<code>reference</code>	This is the reference for the data in the new table. This may be omitted if a column in <code>data.list</code> gives the reference value for each chemical.
<code>species</code>	This is the species for the data in the new table. This may be omitted if a column in <code>data.list</code> gives the species value for each chemical or if the data are not species-specific (e.g., MW).
<code>overwrite</code>	If <code>overwrite=TRUE</code> then data in <code>current.table</code> will be replaced by any data in <code>new.table</code> that is for the same chemical and property. If <code>overwrite=FALSE</code> (DEFAULT) then new data for the same chemical and property are ignored. Funbound.plasma values of 0 (below limit of detection) are overwritten either way.

Value

<code>data.frame</code>	A new <code>data.frame</code> containing the data in <code>current.table</code> augmented by <code>new.table</code>
-------------------------	---

Author(s)

John Wambaugh

Examples

```
my.new.data <- as.data.frame(c("A","B","C"),stringsAsFactors=FALSE)
my.new.data <- cbind(my.new.data,as.data.frame(c("111-11-2","222-22-0","333-33-5"),
  stringsAsFactors=FALSE))
my.new.data <- cbind(my.new.data,as.data.frame(c("DTX1","DTX2","DTX3"),
  stringsAsFactors=FALSE))
my.new.data <- cbind(my.new.data,as.data.frame(c(200,200,200)))
my.new.data <- cbind(my.new.data,as.data.frame(c(2,3,4)))
my.new.data <- cbind(my.new.data,as.data.frame(c(0.01,0.02,0.3)))
my.new.data <- cbind(my.new.data,as.data.frame(c(0,10,100)))
colnames(my.new.data) <- c("Name","CASRN","DTXSID","MW","LogP","Fup","CLint")

chem.physical_and_invitro.data <- add_chemtable(my.new.data,
  current.table=chem.physical_and_invitro.data,
  data.list=list(
    Compound="Name",
    CAS="CASRN",
    DTXSID="DTXSID",
    MW="MW",
    logP="LogP",
    Funbound.plasma="Fup",
    Clint="CLint"),
  species="Human",
  reference="MyPaper 2015")
parameterize_steadystate(chem.name="C")
calc_css(chem.name="B")
```

age_dist_smooth

Smoothed age distributions by race and gender.

Description

Distributions of ages in months, computed from NHANES data smoothed using `survey::svsmooth()`, for each combination of race/ethnicity and gender.

Usage

```
age_dist_smooth
```

Format

A `data.table` object with three variables:

`gender` Gender: Male or Female

`reth` Race/ethnicity

`smth` A list of `svsmooth` objects, each encoding a weighted smoothed distribution of ages.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

age_draw_smooth	<i>Draws ages from a smoothed distribution for a given gender/race combination</i>
-----------------	--

Description

Draws ages from a smoothed distribution for a given gender/race combination

Usage

```
age_draw_smooth(g, r, nsamp, agelim_months)
```

Arguments

<code>g</code>	Gender. Either 'Male' or 'Female'.
<code>r</code>	Race/ethnicity. One of 'Mexican American', 'Other Hispanic', 'Non-Hispanic Black', 'Non-Hispanic White', 'Other'.
<code>nsamp</code>	Number of ages to draw.
<code>agelim_months</code>	Two-element numeric vector giving the minimum and maximum ages in months to include.

Value

A named list with members 'ages_months' and 'ages_years', each numeric of length `nsamp`, giving the sampled ages in months and years.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

armitage_estimate_sarea

Estimate well surface area

Description

Estimate geometry surface area of plastic in well plate based on well plate format suggested values from Corning. `option.plastic == T` (default) give nonzero surface area (sarea, m²) `option.bottom == T` (default) includes surface area of the bottom of the well in determining sarea. Optionally include user values for working volume (`v_working`, m³) and surface area.

Usage

```
armitage_estimate_sarea(
  tcdata = NA,
  this.well_number = 384,
  this.cell_yield = NA,
  this.v_working = NA
)
```

Arguments

<code>tcdata</code>	A data table with <code>well_number</code> corresponding to plate format, optionally include <code>v_working</code> , <code>sarea</code> , <code>option.bottom</code> , and <code>option.plastic</code>
<code>this.well_number</code>	For single value, plate format default is 384, used if <code>is.na(tcdata) == T</code>
<code>this.cell_yield</code>	For single value, optionally supply <code>cell_yield</code> , otherwise estimated based on well number
<code>this.v_working</code>	For single value, optionally supply working volume, otherwise estimated based on well number (m ³)

Value

`tcdata`, A data table with `well_number`, `sarea` (surface area, m²), `cell_yield` (# cells), `v_working` (m³), `v_total` (m³) per well

Author(s)

Greg Honda

armitage_eval

*Evaluate the updated Armitage model***Description**

Evaluate the Armitage model for chemical distribution in vitro. Takes input as data table or vectors of values. Outputs a data table. Updates over the model published in Armitage et al. 2014 include binding to plastic walls and lipid and protein compartments in cells.

Usage

```
armitage_eval(
  casrn.vector = NA_character_,
  nomconc.vector = 1,
  this.well_number = 384,
  this.FBSf = NA_real_,
  tcdata = NA,
  this.sarea = NA_real_,
  this.v_total = NA_real_,
  this.v_working = NA_real_,
  this.cell_yield = NA_real_,
  this.Tsys = 37,
  this.Tref = 298.15,
  this.option.kbsa2 = F,
  this.option.swat2 = F,
  this.pseudooct = 0.01,
  this.memblip = 0.04,
  this.nlom = 0.2,
  this.P_nlom = 0.035,
  this.P_dom = 0.05,
  this.P_cells = 1,
  this.csalt = 0.15,
  this.celldensity = 1,
  this.cellmass = 3,
  this.f_oc = 1
)
```

Arguments

casrn.vector	For vector or single value, CAS number
nomconc.vector	For vector or single value, micromolar nominal concentration (e.g. AC50 value)
this.well_number	For single value, plate format default is 384, used if is.na(tcdata)==T
this.FBSf	Fraction fetal bovine serum, must be entered by user.
tcdata	A data.table with casrn, nomconc, MP, gkow, gkaw, gswat, sarea, v_total, v_working. Otherwise supply single values to this.params.
this.sarea	Surface area per well (m ²)
this.v_total	Total volume per well (m ³)
this.v_working	Working volume per well (m ³)

<code>this.cell_yield</code>	Number of cells per well
<code>this.Tsys</code>	System temperature (oC)
<code>this.Tref</code>	Reference temperature (K)
<code>this.option.kbsa2</code>	Use alternative bovine-serum-albumin partitioning model
<code>this.option.swat2</code>	Use alternative water solubility correction
<code>this.pseudooct</code>	Pseudo-octanol cell storage lipid content
<code>this.memblip</code>	Membrane lipid content of cells
<code>this.nlom</code>	Structural protein content of cells
<code>this.P_nlom</code>	Proportionality constant to octanol structural protein
<code>this.P_dom</code>	Proportionality constant to octanol dom
<code>this.P_cells</code>	Proportionality constant to octanol storage lipid
<code>this.csalt</code>	Ionic strength of buffer, mol/L
<code>this.celldensity</code>	Cell density kg/L, g/mL
<code>this.cellmass</code>	Mass per cell, ng/cell
<code>this.f_oc</code>	1, everything assumed to be like proteins

Value

tcdata

Author(s)

Greg Honda

References

Armitage, J. M.; Wania, F.; Arnot, J. A. Environ. Sci. Technol. 2014, 48, 9770-9779. <https://doi.org/10.1021/es501955g>
 Honda et al. PloS one 14.5 (2019): e0217564. <https://doi.org/10.1371/journal.pone.0217564>

Examples

```
temp <- armitage_eval(casrn.vector = c("80-05-7", "81-81-2"), this.FBSf = 0.1,
  this.well_number = 384, nomconc = 10)
print(temp$cfree.invitro)
```

armitage_input	<i>Armitage et al. (2014) Model Inputs from Honda et al. (2019)</i>
----------------	---

Description

Armitage et al. (2014) Model Inputs from Honda et al. (2019)

Usage

armitage_input

Format

A data frame with 53940 rows and 10 variables:

MP

MW

casrn

compound_name

gkaw

gkow

gswat

Author(s)

Greg Honda

Source

<http://www.diamondse.info/>

References

Armitage, J. M.; Wania, F.; Arnot, J. A. Environ. Sci. Technol. 2014, 48, 9770-9779. [dx.doi.org/10.1021/es501955g](https://doi.org/10.1021/es501955g)

Honda, Gregory S., et al. "Using the Concordance of In Vitro and In Vivo Data to Evaluate Extrapolation Assumptions", PloS ONE 14.5 (2019): e0217564.

`available_rblood2plasma`

Find the best available ratio of the blood to plasma concentration constant.

Description

This function finds the best available constant ratio of the blood concentration to the plasma concentration, using `get_rblood2plasma` and `calc_rblood2plasma`.

Usage

```
available_rblood2plasma(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  species = "Human",  
  adjusted.Funbound.plasma = T,  
  suppress.messages = F  
)
```

Arguments

<code>chem.cas</code>	Either the CAS number or the chemical name must be specified.
<code>chem.name</code>	Either the chemical name or the CAS number must be specified.
<code>dtxsid</code>	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXIDs
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
<code>adjusted.Funbound.plasma</code>	Whether or not to use Funbound.plasma adjustment if calculating Rblood2plasma.
<code>suppress.messages</code>	Whether or not to display relevant warning messages to user.

Details

Either retrieves a measured blood:plasma concentration ratio from the `chem.physical_and_invitro.data` table or calculates it using the red blood cell partition coefficient predicted with Schmitt's method

If available, in vivo data (from `chem.physical_and_invitro.data`) for the given species is returned, substituting the human in vivo value when missing for other species. In the absence of in vivo data, the value is calculated with `calc_rblood2plasma` for the given species. If `Funbound.plasma` is unavailable for the given species, the human `Funbound.plasma` is substituted. If none of these are available, the mean human `Rblood2plasma` from `chem.physical_and_invitro.data` is returned. details than the description above ~~

Author(s)

Robert Pearce

Examples

```
available_rblood2plasma(chem.name="Bisphenol A",adjusted.funbound.plasma=FALSE)
available_rblood2plasma(chem.name="Bisphenol A",species="Rat")
```

blood_mass_correct	<i>Find average blood masses by age.</i>
--------------------	--

Description

If blood mass from `blood_weight` is negative or very small, then just default to the mean blood mass by age. (Geigy Scientific Tables, 7th ed.)

Usage

```
blood_mass_correct(blood_mass, age_months, age_years, gender, weight)
```

Arguments

blood_mass	A vector of blood masses in kg to be replaced with averages.
age_months	A vector of ages in months.
age_years	A vector of ages in years.
gender	A vector of genders (either 'Male' or 'Female').
weight	A vector of body weights in kg.

Value

A vector of blood masses in kg.

Author(s)

Caroline Ring

References

Geigy Pharmaceuticals, "Scientific Tables", 7th Edition, John Wiley and Sons (1970)

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

blood_weight	<i>Predict blood mass.</i>
--------------	----------------------------

Description

Predict blood mass based on body surface area and gender, using equations from Bosgra et al. 2012

Usage

```
blood_weight(BSA, gender)
```

Arguments

BSA	Body surface area in m ² . May be a vector.
gender	Either 'Male' or 'Female'. May be a vector.

Value

A vector of blood masses in kg the same length as BSA and gender.

Author(s)

Caroline Ring

References

Bosgra, Sieto, et al. "An improved model to predict physiologically based model parameters and their inter-individual variability from anthropometry." *Critical reviews in toxicology* 42.9 (2012): 751-767.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

bmiage	<i>CDC BMI-for-age charts</i>
--------	-------------------------------

Description

Charts giving the BMI-for-age percentiles for boys and girls ages 2-18

Usage

```
bmiage
```

Format

A data.table object with variables

Sex 'Male' or 'Female'

Agemos Age in months

L, M, S LMS parameters; see https://www.cdc.gov/growthcharts/percentile_data_files.htm

P3, P5, P10, P25, P50, P75, P85, P90, P95, **and** P97 BMI percentiles

Details

For children ages 2 to 18, weight class depends on the BMI-for-age percentile.

Underweight <5th percentile

Normal weight 5th-85th percentile

Overweight 85th-95th percentile

Obese \geq 95th percentile

Author(s)

Caroline Ring

Source

http://www.cdc.gov/growthcharts/percentile_data_files.htm

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

body_surface_area	<i>Predict body surface area.</i>
-------------------	-----------------------------------

Description

Predict body surface area from weight, height, and age, using Mosteller's formula for age $>$ 18 and Haycock's formula for age $<$ 18

Usage

```
body_surface_area(BW, H, age_years)
```

Arguments

BW	A vector of body weights in kg.
H	A vector of heights in cm.
age_years	A vector of ages in years.

Value

A vector of body surface areas in cm².

Author(s)

Caroline Ring

References

- Mosteller, R. D. "Simplified calculation of body surface area." N Engl J Med 317 (1987): 1098..
- Haycock, George B., George J. Schwartz, and David H. Wisotsky. "Geometric method for measuring body surface area: a height-weight formula validated in infants, children, and adults." The Journal of pediatrics 93.1 (1978): 62-66.
- Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

bone_mass_age	<i>Predict bone mass</i>
---------------	--------------------------

Description

Predict bone mass from age_years, height, weight, gender, using logistic equations fit to data from Baxter-Jones et al. 2011, or for infants < 1 year, using equation from Koo et al. 2000 (See Price et al. 2003)

Usage

```
bone_mass_age(age_years, age_months, height, weight, gender)
```

Arguments

age_years	Vector of ages in years.
age_months	Vector of ages in months.
height	Vector of heights in cm.
weight	Vector of body weights in kg.
gender	Vector of genders, either 'Male' or 'Female'.

Value

Vector of bone masses.

Author(s)

Caroline Ring

References

- Baxter-Jones, Adam DG, et al. "Bone mineral accrual from 8 to 30 years of age: an estimation of peak bone mass." Journal of Bone and Mineral Research 26.8 (2011): 1729-1739.
- Koo, Winston WK, and Elaine M. Hockman. "Physiologic predictors of lumbar spine bone mass in neonates." Pediatric research 48.4 (2000): 485-489.
- Price, Paul S., et al. "Modeling interindividual variation in physiological factors used in PBPK models of humans." Critical reviews in toxicology 33.5 (2003): 469-503.
- Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

brain_mass	<i>Predict brain mass.</i>
------------	----------------------------

Description

Predict brain mass from gender and age.

Usage

```
brain_mass(gender, age_years)
```

Arguments

gender	Vector of genders, either 'Male' or 'Female'
age_years	Vector of ages in years.

Value

A vector of brain masses in kg.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

calc_analytic_css	<i>Calculate the analytic steady state concentration.</i>
-------------------	---

Description

This function calculates the analytic steady state plasma or venous blood concentrations as a result of infusion dosing for the three compartment and multiple compartment PBTK models.

Usage

```
calc_analytic_css(  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL,  
  parameters = NULL,  
  species = "human",  
  daily.dose = 1,  
  output.units = "uM",  
  model = "pbtk",  
  concentration = "plasma",  
  suppress.messages = F,
```

```

tissue = NULL,
restrictive.clearance = T,
bioactive.free.invivo = F,
IVIVE = NULL,
parameterize.args = list(default.to.human = F, adjusted.Funbound.plasma = T,
  regression = T, minimum.Funbound.plasma = 1e-04),
  ...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_pbt (for model = 'pbt'), parameterize_3comp (for model = '3compartment'), parameterize_1comp (for model = '1compartment') or parameterize_steadystate (for model = '3compartmentss'), overrides chem.name and chem.cas.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
daily.dose	Total daily dose, mg/kg BW.
output.units	Units for returned concentrations, defaults to uM (specify units = "uM") but can also be mg/L.
model	Model used in calculation, 'pbt' for the multiple compartment model, '3compartment' for the three compartment model, '3compartmentss' for the three compartment steady state model, and '1compartment' for one compartment model.
concentration	Desired concentration type, 'blood', 'tissue', or default 'plasma'.
suppress.messages	Whether or not the output message is suppressed.
tissue	Desired tissue concentration (defaults to whole body concentration.)
restrictive.clearance	If TRUE (default), then only the fraction of chemical not bound to protein is available for metabolism in the liver. If FALSE, then all chemical in the liver is metabolized (faster metabolism due to rapid off-binding).
bioactive.free.invivo	If FALSE (default), then the total concentration is treated as bioactive in vivo. If TRUE, the the unbound (free) plasma concentration is treated as bioactive in vivo. Only works with tissue = NULL in current implementation.
IVIVE	Honda et al. (2019) identified four plausible sets of assumptions for <i>in vitro-in vivo</i> extrapolation (IVIVE) assumptions. Argument may be set to "Honda1" through "Honda4". If used, this function overwrites the tissue, restrictive.clearance, and bioactive.free.invivo arguments. See Details below for more information.
parameterize.args	List of arguments passed to model's associated parameterization function, including default.to.human, adjusted.Funbound.plasma, regression, and minimum.Funbound.plasma. The default.to.human argument substitutes missing animal values with human values if true, adjusted.Funbound.plasma returns adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value, regression indicates whether or not to use the regressions in calculating partition coefficients, and minimum.Funbound.plasma is the value to which Monte Carlo

draws less than this value are set (default is 0.0001 – half the lowest measured F_{up} in our dataset).

... Additional parameters passed to parameterize function if parameters is NULL.

Details

Concentrations are calculated for the specified model with constant oral infusion dosing. All tissues other than gut, liver, and lung are the product of the steady state plasma concentration and the tissue to plasma partition coefficient.

	<i>in vivo</i> Conc.	Metabolic Clearance	Bioactive Chemical Conc.	TK Statistic Used*
Honda1	Veinous (Plasma)	Restrictive	Free	Mean Conc.
Honda2	Veinous	Restrictive	Free	Max Conc.
Honda3	Veinous	Non-restrictive	Total	Mean Conc.
Honda4	Veinous	Non-restrictive	Total	Max Conc.
Honda5	Target Tissue	Non-restrictive	Total	Mean Conc.
Honda6	Target Tissue	Non-restrictive	Total	Max Conc.

*Assumption is currently ignored because analytical steady-state solutions are currently used by this function.

Value

Steady state concentration

Author(s)

Robert Pearce, John Wambaugh, and Greg Honda

References

Honda, Gregory S., et al. "Using the Concordance of In Vitro and In Vivo Data to Evaluate Extrapolation Assumptions." 2019. PLoS ONE 14(5): e0217564.

Examples

```
calc_analytic_css(chem.name='Bisphenol-A',output.units='mg/L',
                  model='3compartment',concentration='blood')

calc_analytic_css(chem.name='Bisphenol-A',tissue='liver',species='rabbit',
                  parameterize.args = list(
                    default.to.human=TRUE,
                    adjusted.funbound.plasma=TRUE,
                    regression=TRUE,
                    minimum.funbound.plasma=1e-4),daily.dose=2)

calc_analytic_css(chem.name="bisphenol a",model="1compartment")

calc_analytic_css(chem.cas="80-05-7",model="3compartmentss")

params <- parameterize_pbt(chem.cas="80-05-7")

calc_analytic_css(parameters=params,model="pbt")
```

`calc_analytic_css_1comp`*Calculate the analytic steady state concentration for the one compartment model.*

Description

This function calculates the analytic steady state plasma or venous blood concentrations as a result of infusion dosing.

Usage

```
calc_analytic_css_1comp(  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL,  
  parameters = NULL,  
  hourly.dose = 1/24,  
  concentration = "plasma",  
  suppress.messages = F,  
  recalc.blood2plasma = F,  
  tissue = NULL,  
  restrictive.clearance = T,  
  bioactive.free.invivo = F,  
  ...  
)
```

Arguments

<code>chem.name</code>	Either the chemical name, CAS number, or the parameters must be specified.
<code>chem.cas</code>	Either the chemical name, CAS number, or the parameters must be specified.
<code>dtxsid</code>	EPA's 'DSSTox Structure ID' (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXIDs
<code>parameters</code>	Chemical parameters from <code>parameterize_pbt</code> (for <code>model = 'pbt'</code>), <code>parameterize_3comp</code> (for <code>model = '3compartment'</code>), <code>parameterize_1comp</code> (for <code>model = '1compartment'</code>) or <code>parameterize_steadystate</code> (for <code>model = '3compartmentss'</code>), overrides <code>chem.name</code> and <code>chem.cas</code> .
<code>hourly.dose</code>	Hourly dose rate mg/kg BW/h.
<code>concentration</code>	Desired concentration type, 'blood' or default 'plasma'.
<code>suppress.messages</code>	Whether or not the output message is suppressed.
<code>recalc.blood2plasma</code>	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters. Use this if you have altered hematocrit, <code>Funbound.plasma</code> , or <code>Krbc2pu</code> .
<code>tissue</code>	Desired tissue concentration (defaults to whole body concentration.)
<code>restrictive.clearance</code>	If TRUE (default), then only the fraction of chemical not bound to protein is available for metabolism in the liver. If FALSE, then all chemical in the liver is metabolized (faster metabolism due to rapid off-binding).

bioactive.free.invivo

If FALSE (default), then the total concentration is treated as bioactive in vivo. If TRUE, the the unbound (free) plasma concentration is treated as bioactive in vivo. Only works with tissue = NULL in current implementation.

... Additional parameters passed to parameterize function if parameters is NULL.

Value

Steady state concentration in uM units

Author(s)

Robert Pearce and John Wambaugh

calc_analytic_css_3comp

Calculate the analytic steady state concentration for model 3comp

Description

This function calculates the analytic steady state plasma or venous blood concentrations as a result of infusion dosing.

Usage

```
calc_analytic_css_3comp(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  hourly.dose = 1/24,
  concentration = "plasma",
  suppress.messages = F,
  recalc.blood2plasma = F,
  tissue = NULL,
  restrictive.clearance = T,
  bioactive.free.invivo = FALSE,
  ...
)
```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_pbt (for model = 'pbt'), parameterize_3comp (for model = '3compartment'), parameterize_1comp (for model = '1compartment') or parameterize_steadystate (for model = '3compartmentss'), overrides chem.name and chem.cas.

hourly.dose	Hourly dose rate mg/kg BW/h.
concentration	Desired concentration type, 'blood' or default 'plasma'.
suppress.messages	Whether or not the output message is suppressed.
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters. Use this if you have 'altered hematocrit, Funbound.plasma, or Krbc2pu.
tissue	Desired tissue concentration (defaults to whole body concentration.)
restrictive.clearance	If TRUE (default), then only the fraction of chemical not bound to protein is available for metabolism in the liver. If FALSE, then all chemical in the liver is metabolized (faster metabolism due to rapid off-binding).
bioactive.free.invivo	If FALSE (default), then the total concentration is treated as bioactive in vivo. If TRUE, the the unbound (free) plasma concentration is treated as bioactive in vivo. Only works with tissue = NULL in current implementation.
...	Additional parameters passed to parameterize function if parameters is NULL.

Value

Steady state concentration in uM units

Author(s)

Robert Pearce and John Wambaugh

calc_analytic_css_3compss

Calculate the analytic steady state concentration for the three oom-partment steady-state model

Description

This function calculates the analytic steady state plasma or venous blood concentrations as a result of infusion dosing.

Usage

```
calc_analytic_css_3compss(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  hourly.dose = 1/24,
  concentration = "plasma",
  suppress.messages = F,
  recalc.blood2plasma = F,
  tissue = NULL,
  restrictive.clearance = T,
```

```

    bioactive.free.invivo = FALSE,
    ...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_pbt (for model = 'pbt'), parameterize_3comp (for model = '3compartment'), parameterize_1comp (for model = '1compartment') or parameterize_steadystate (for model = '3compartmentss'), overrides chem.name and chem.cas.
hourly.dose	Hourly dose rate mg/kg BW/h.
concentration	Desired concentration type, 'blood' or default 'plasma'.
suppress.messages	Whether or not the output message is suppressed.
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters. Use this if you have 'altered hematocrit, Funbound.plasma, or Krbc2pu.
tissue	Desired tissue concentration (defaults to whole body concentration.)
restrictive.clearance	If TRUE (default), then only the fraction of chemical not bound to protein is available for metabolism in the liver. If FALSE, then all chemical in the liver is metabolized (faster metabolism due to rapid off-binding).
bioactive.free.invivo	If FALSE (default), then the total concentration is treated as bioactive in vivo. If TRUE, the the unbound (free) plasma concentration is treated as bioactive in vivo. Only works with tissue = NULL in current implementation.
...	Additional parameters passed to parameterize function if parameters is NULL.

Value

Steady state concentration in uM units

Author(s)

Robert Pearce and John Wambaugh

`calc_analytic_css_pbtk`*Calculate the analytic steady state concentration for model pbtk.*

Description

This function calculates the analytic steady state plasma or venous blood concentrations as a result of infusion dosing.

Usage

```
calc_analytic_css_pbtk(  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL,  
  parameters = NULL,  
  hourly.dose = 1/24,  
  concentration = "plasma",  
  suppress.messages = F,  
  recalc.blood2plasma = F,  
  tissue = NULL,  
  restrictive.clearance = T,  
  bioactive.free.invivo = FALSE,  
  ...  
)
```

Arguments

<code>chem.name</code>	Either the chemical name, CAS number, or the parameters must be specified.
<code>chem.cas</code>	Either the chemical name, CAS number, or the parameters must be specified.
<code>dtxsid</code>	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
<code>parameters</code>	Chemical parameters from <code>parameterize_pbtk</code> (for <code>model = 'pbtk'</code>), <code>parameterize_3comp</code> (for <code>model = '3compartment'</code>), <code>parameterize_1comp</code> (for <code>model = '1compartment'</code>) or <code>parameterize_steadystate</code> (for <code>model = '3compartmentss'</code>), overrides <code>chem.name</code> and <code>chem.cas</code> .
<code>hourly.dose</code>	Hourly dose rate mg/kg BW/h.
<code>concentration</code>	Desired concentration type, 'blood', 'tissue', or default 'plasma'.
<code>suppress.messages</code>	Whether or not the output message is suppressed.
<code>recalc.blood2plasma</code>	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters. Use this if you have 'altered hematocrit, Funbound.plasma, or Krbc2pu.
<code>tissue</code>	Desired tissue concentration (defaults to whole body concentration.)
<code>restrictive.clearance</code>	If TRUE (default), then only the fraction of chemical not bound to protein is available for metabolism in the liver. If FALSE, then all chemical in the liver is metabolized (faster metabolism due to rapid off-binding).

```

bioactive.free.invivo
    If FALSE (default), then the total concentration is treated as bioactive in vivo.
    If TRUE, the the unbound (free) plasma concentration is treated as bioactive in
    vivo. Only works with tissue = NULL in current implementation.
...
    Additional parameters passed to parameterize function if parameters is NULL.

```

Value

Steady state concentration in uM units

Author(s)

Robert Pearce and John Wambaugh

calc_css

Find the steady state concentration and the day it is reached.

Description

This function finds the day a chemical comes within the specified range of the analytical steady state venous blood or plasma concentration(from calc_analytic_css) for the multiple compartment, three compartment, and one compartment models, the fraction of the true steady state value reached on that day, the maximum concentration, and the average concentration at the end of the simulation.

Usage

```

calc_css(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  species = "Human",
  f = 0.01,
  daily.dose = 1,
  doses.per.day = 3,
  days = 21,
  output.units = "uM",
  suppress.messages = F,
  tissue = "plasma",
  model = "pbt",
  default.to.human = F,
  f.change = 1e-05,
  adjusted.funbound.plasma = T,
  regression = T,
  well.stirred.correction = T,
  restrictive.clearance = T,
  dosing = NULL,
  ...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or parameters must be specified.
chem.cas	Either the chemical name, CAS number, or parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_pbt function, overrides chem.name and chem.cas.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
f	Fractional distance from the final steady state concentration that the average concentration must come within to be considered at steady state.
daily.dose	Total daily dose, mg/kg BW.
doses.per.day	Number of doses per day.
days	Initial number of days to run simulation that is multiplied on each iteration.
output.units	Units for returned concentrations, defaults to uM (specify units = "uM") but can also be mg/L.
suppress.messages	Whether or not to suppress messages.
tissue	Desired tissue concentration (defaults to whole body concentration.)
model	Model used in calculation, 'pbt' for the multiple compartment model, '3compartment' for the three compartment model, and '1compartment' for the one compartment model.
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
f.change	Fractional change of daily steady state concentration reached to stop calculating.
adjusted.funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
well.stirred.correction	Uses correction in calculation of hepatic clearance for well-stirred model if TRUE for model 1compartment elimination rate. This assumes clearance relative to amount unbound in whole blood instead of plasma, but converted to use with plasma concentration.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
dosing	The dosing object for more complicated scenarios. Defaults to repeated daily.dose spread out over doses.per.day
...	Additional arguments passed to model solver (default of solve_pbt).

Value

frac	Ratio of the mean concentration on the day steady state is reached (based on doses.per.day) to the analytical C _{ss} (based on infusion dosing).
max	The maximum concentration of the simulation.
avg	The average concentration on the final day of the simulation.
the.day	The day the average concentration comes within 100 * p percent of the true steady state concentration.

Author(s)

Robert Pearce, John Wambaugh

Examples

```
calc_css(chem.name='Bisphenol-A',doses.per.day=5,f=.001,output.units='mg/L')

parms <- parameterize_3comp(chem.name='Bisphenol-A')
parms$Funbound.plasma <- .07
calc_css(parameters=parms,model='3compartment')

out <- solve_pbt(chem.name = "Bisphenol A",
  days = 50,
  daily.dose=1,
  doses.per.day = 3)
plot.data <- as.data.frame(out)
css <- calc_analytic_css(chem.name = "Bisphenol A")
## Not run:
library("ggplot2")
c.vs.t <- ggplot(plot.data,aes(time, Cplasma)) + geom_line() +
  geom_hline(yintercept = css) + ylab("Plasma Concentration (uM)") +
  xlab("Day") + theme(axis.text = element_text(size = 16), axis.title =
  element_text(size = 16), plot.title = element_text(size = 17)) +
  ggtitle("Bisphenol A")

print(c.vs.t)

## End(Not run)

# Make a plot for all chemicals (takes a while):
## Not run:
days <- NULL
avg <- NULL
max <- NULL
for(this.cas in get_cheminfo(model="pbt")){
  css.info <- calc_css(chem.cas = this.cas, doses.per.day = 1,suppress.messages=T)
  days[[this.cas]] <- css.info[["the.day"]]
  avg[[this.cas]] <- css.info[["avg"]]
  max[[this.cas]] <- css.info[["max"]]
}
days.data <- as.data.frame(days)
hist <- ggplot(days.data, aes(days)) +
  geom_histogram(fill = "blue", binwidth = 1/6) + scale_x_log10() +
  ylab("Number of Chemicals") + xlab("Days") + theme(axis.text =
  element_text(size = 16), axis.title = element_text(size = 16))
print(hist)
avg.max.data <- as.data.frame(cbind(avg, max))
avg.vs.max <- ggplot(avg.max.data, aes(avg, max)) + geom_point() +
  geom_abline() + scale_x_log10() + scale_y_log10() +
  xlab("Average Concentration at Steady State (uM)") +
  ylab("Max Concentration at Steady State (uM)") +
  theme(axis.text = element_text(size = 16),
  axis.title = element_text(size = 16))
print(avg.vs.max)
```

```
## End(Not run)
```

calc_elimination_rate *Calculate the elimination rate for a one compartment model.*

Description

This function calculates an elimination rate from the three compartment steady state model where elimination is entirely due to metabolism by the liver and glomerular filtration in the kidneys.

Usage

```
calc_elimination_rate(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  species = "Human",
  suppress.messages = F,
  default.to.human = F,
  restrictive.clearance = T,
  adjusted.Funbound.plasma = T,
  regression = T,
  well.stirred.correction = T,
  clint.pvalue.threshold = 0.05,
  minimum.Funbound.plasma = 1e-04
)
```

Arguments

chem.cas	Either the cas number or the chemical name must be specified.
chem.name	Either the chemical name or the cas number must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_steadystate or 1compartment function, overrides chem.name and chem.cas.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
suppress.messages	Whether or not the output message is suppressed.
default.to.human	Substitutes missing animal values with human values if true.
restrictive.clearance	In calculating elimination rate, protein binding is not taken into account (set to 1) in liver clearance if FALSE.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.

`well.stirred.correction`
Uses correction in calculation of hepatic clearance for -stirred model if TRUE. This assumes clearance relative to amount unbound in whole blood instead of plasma, but converted to use with plasma concentration.

`clint.pvalue.threshold`
Hepatic clearance for chemicals where the in vitro clearance assay result has a p-values greater than the threshold are set to zero.

`minimum.Funbound.plasma`
Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Details

Elimination rate calculated by dividing the total clearance (using the default -stirred hepatic model) by the volume of distribution. When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

Elimination rate
Units of 1/h.

Author(s)

John Wambaugh

Examples

```
calc_elimination_rate(chem.name="Bisphenol A")
calc_elimination_rate(chem.name="Bisphenol A",species="Rat")
calc_elimination_rate(chem.cas="80-05-7")
```

`calc_hep_bioavailability`
Calculate first pass metabolism

Description

For models that don't described first pass blood flow from the gut, need to calculate a hepatic bioavailability, that is, the fraction of chemical systemically available after metabolism during the first pass through the liver (Rowland, 1973).

Usage

```
calc_hep_bioavailability(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  parameters = NULL,
```

```

    restrictive.clearance = T,
    flow.34 = T
  )

```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from the appropriate parameterization function for the model indicated by argument model
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
flow.34	A logical constraint

Value

A data.table whose columns are the parameters of the HTTK model specified in model.

Author(s)

John Wambaugh

References

Rowland, Malcolm, Leslie Z. Benet, and Garry G. Graham. "Clearance concepts in pharmacokinetics." Journal of pharmacokinetics and biopharmaceutics 1.2 (1973): 123-136.

calc_hep_clearance	<i>Calculate the hepatic clearance.</i>
--------------------	---

Description

This function calculates the hepatic clearance in plasma for a well-stirred model or other type if specified. Based on Ito and Houston (2004)

Usage

```

calc_hep_clearance(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  species = "Human",
  default.to.human = F,
  hepatic.model = "well-stirred",

```

```

suppress.messages = F,
well.stirred.correction = T,
restrictive.clearance = T,
adjusted.funbound.plasma = T,
...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_steadystate function, overrides chem.name and chem.cas.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing animal values with human values if true.
hepatic.model	Model used in calculating hepatic clearance, unscaled, parallel tube, dispersion, or default well-stirred.
suppress.messages	Whether or not to suppress the output message.
well.stirred.correction	Uses correction in calculation of hepatic clearance for well-stirred model if TRUE for hepatic.model well-stirred. This assumes clearance relative to amount unbound in whole blood instead of plasma, but converted to use with plasma concentration.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
adjusted.funbound.plasma	Uses adjusted funbound.plasma when set to TRUE.
...	Additional parameters passed to parameterize_steadystate if parameters is NULL.

Value

Hepatic Clearance
Units of L/h/kg BW.

Author(s)

John Wambaugh and Robert Pearce

References

Ito, K., & Houston, J. B. (2004). "Comparison of the use of liver models for predicting drug clearance using in vitro kinetic data from hepatic microsomes and isolated hepatocytes." *Pharmaceutical Research*, 21(5), 785-792.

Examples

```
calc_hep_clearance(chem.name="Ibuprofen",hepatic.model='unscaled')  
calc_hep_clearance(chem.name="Ibuprofen",well.stirred.correction=FALSE)
```

calc_hep_fu

Calculate the free chemical in the hepatic clearance assay

Description

Method from Kilford et al. (2008) for fraction of unbound chemical in the hepatocyte intrinsic clearance assay

Usage

```
calc_hep_fu(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  parameters = NULL,  
  Vr = 0.005,  
  pH = 7.4  
)
```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSID
chem.name	Chemical name (spaces and capitalization ignored) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSID
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from the appropriate parameterization function for the model indicated by argument model
Vr	Rratio of cell volume to incubation volume. Default is taken from
pH	pH of the incubation medium.

Value

A numeric fraction between zero and one

Author(s)

John Wambaugh and Robert Pearce

References

Kilford, Peter J., et al. "Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data." *Drug Metabolism and Disposition* 36.7 (2008): 1194-1197.

Wetmore, Barbara A., et al. "Incorporating high-throughput exposure predictions with dosimetry-adjusted in vitro bioactivity to inform chemical toxicity testing." *Toxicological Sciences* 148.1 (2015): 121-136.

calc_ionization	<i>Calculate the ionization.</i>
-----------------	----------------------------------

Description

This function calculates the ionization of a compound at a given pH. The pKa's are either entered as parameters or taken from a specific compound in the package.

Usage

```
calc_ionization(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  pH = NULL,
  pKa_Donor = NA,
  pKa_Accept = NA
)
```

Arguments

chem.cas	Either the chemical name or the CAS number must be specified.
chem.name	Either the chemical name or the CAS number must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from a parameterize_MODEL function, overrides chem.name and chem.cas.
pH	pH where ionization is evaluated.
pKa_Donor	Compound H dissociation equilibrium constant(s). Overwrites chem.name and chem.cas.
pKa_Accept	Compound H association equilibrium constant(s). Overwrites chem.name and chem.cas.

Details

The fractions are calculated by determining the coefficients for each species and dividing the particular species by the sum of all three. The positive, negative and zwitterionic/neutral coefficients are given by:

$$zwitter/neutral = 1$$

$$\text{for}(iin1 : pkabove)negative = negative + 10^{(i * pH - pKa1 - \dots - pKai)}$$

$$\text{for}(iin1 : pkbelow)positive = positive + 10^{(pKa1 + \dots + pKai - i * pH)}$$

where i begins at 1 and ends at the number of points above(for negative) or below(for positive) the neutral/zwitterionic range. The neutral/zwitterionic range is either the pH range between 2 pKa's where the number of acceptors above is equal to the number of donors below, everything above the pKa acceptors if there are no donors, or everything below the pKa donors if there are no acceptors. Each of the terms in the sums represent a different ionization.

Value

```
fraction_neutral
    fraction of compound neutral
fraction_charged
    fraction of compound charged
fraction_negative
    fraction of compound negative
fraction_positive
    fraction of compound positive
fraction_zwitter
    fraction of compound zwitterionic
```

Author(s)

Robert Pearce and John Wambaugh

References

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Examples

```
calc_ionization(chem.name='bisphenola',pH=7.4)
calc_ionization(pKa_Donor=8,pKa_Accept=c(1,4),pH=9)
```

calc_krbc2pu

Back-calculates the Red Blood Cell to Unbound Plasma Partition Coefficient

Description

Given and observed ratio of chemical concentration in blood to plasma, this function calculates a Red Blood Cell to unbound plasma (K_{rbc2pu}) partition coefficient that would be consistent with that observation.

Usage

```
calc_krbc2pu(
  Rb2p,
  Funbound.plasma,
  hematocrit = NULL,
  default.to.human = F,
  species = "Human",
  suppress.messages = T
)
```

Arguments

Rb2p	The chemical blood:plasma concentration ratio
Funbound.plasma	The free fraction of chemical in the presence of plasma protein Rblood2plasma.
hematocrit	Overwrites default hematocrit value in calculating Rblood2plasma.
default.to.human	Substitutes missing animal values with human values if true.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
suppress.messages	Determine whether to display certain usage feedback.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Ruark, Christopher D., et al. "Predicting passive and active tissue: plasma partition coefficients: interindividual and interspecies variability." *Journal of pharmaceutical sciences* 103.7 (2014): 2189-2198.

calc_mc_css

Find the monte carlo steady state concentration.

Description

This function finds the analytical steady state plasma concentration(from calc_analytic_css) using a monte carlo simulation (monte_carlo).

Usage

```
calc_mc_css(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  samples = 1000,
```

```

which.quantile = 0.95,
species = "Human",
suppress.messages = F,
model = "3compartmentss",
httkpop = T,
invitrouv = T,
calcrb2p = T,
censored.params = list(),
vary.params = list(),
return.samples = F,
tissue = NULL,
output.units = "mg/L",
invitro.mc.arg.list = list(adjusted.Funbound.plasma = T, poormetab = T,
  fup.censored.dist = FALSE, fup.lod = 0.01, fup.meas.cv = 0.4, clint.meas.cv = 0.3,
  fup.pop.cv = 0.3, clint.pop.cv = 0.3),
httkpop.generate.arg.list = list(method = "direct resampling", gendernum = NULL,
  agelim_years = NULL, agelim_months = NULL, weight_category = c("Underweight",
  "Normal", "Overweight", "Obese"), gfr_category = c("Normal", "Kidney Disease",
  "Kidney Failure"), reths = c("Mexican American", "Other Hispanic",
  "Non-Hispanic White", "Non-Hispanic Black", "Other")),
convert.httkpop.arg.list = list(),
parameterize.arg.list = list(default.to.human = F, clint.pvalue.threshold = 0.05,
  restrictive.clearance = T, regression = T),
calc.analytic.css.arg.list = list(well.stirred.correction = T,
  adjusted.Funbound.plasma = T, regression = T, IVIVE = NULL, tissue = tissue,
  restrictive.clearance = T, bioactive.free.invivo = FALSE)
)

```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from the appropriate parameterization function for the model indicated by argument model
samples	Number of samples generated in calculating quantiles.
which.quantile	Which quantile from Monte Carlo simulation is requested. Can be a vector.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human"). Species must be set to "Human" to run httkpop model.
suppress.messages	Whether or not to suppress output message.
model	Model used in calculation: 'pbtck' for the multiple compartment model, '3compartment' for the three compartment model, '3compartmentss' for the three compartment steady state model, and '1compartment' for one compartment model. This only applies when httkpop=TRUE and species="Human", otherwise '3compartmentss' is used.

httkpop	Whether or not to use population generator and sampler from httkpop. This is overwrites censored.params and vary.params and is only for human physiology. Species must also be set to 'Human'.
invitrouv	Logical to indicate whether to include in vitro parameters in uncertainty and variability analysis
calcrb2p	Logical determining whether or not to recalculate the chemical ratio of blood to plasma
censored.params	The parameters listed in censored.params are sampled from a normal distribution that is censored for values less than the limit of detection (specified separately for each parameter). This argument should be a list of sub-lists. Each sublist is named for a parameter in "parameters" and contains two elements: "CV" (coefficient of variation) and "LOD" (limit of detection, below which parameter values are censored. New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Censored values are sampled on a uniform distribution between 0 and the limit of detection. Not used with httkpop model.
vary.params	The parameters listed in vary.params are sampled from a normal distribution that is truncated at zero. This argument should be a list of coefficients of variation (CV) for the normal distribution. Each entry in the list is named for a parameter in "parameters". New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Not used with httkpop model.
return.samples	Whether or not to return the vector containing the samples from the simulation instead of the selected quantile.
tissue	Desired steady state tissue concentration.
output.units	Plasma concentration units, either uM or default mg/L.
invitro.mc.arg.list	List of additional parameters passed to invitro_mc
httkpop.generate.arg.list	Additional parameters passed to httkpop_generate .
convert.httkpop.arg.list	Additional parameters passed to the <code>convert_httkpop_*</code> function for the model.
parameterize.arg.list	Additional parameters passed to the <code>parameterize_*</code> function for the model.
calc.analytic.css.arg.list	Additional parameters passed to calc_analytic_css .

Details

All arguments after httkpop only apply if httkpop is set to TRUE and species to "Human".

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Tissue concentrations are calculated for the pbtk model with a default oral infusion dosing. All tissues other than gut, liver, and lung are the product of the steady state plasma concentration and the tissue to plasma partition coefficient.

The six sets of plausible *in vitro-in vivo* extrapolation (IVIVE) assumptions identified by Honda et al. (2019) are:

	<i>in vivo</i> Conc.	Metabolic Clearance	Bioactive Chemical Conc.	TK Statistic Used*
Honda1	Veinous (Plasma)	Restrictive	Free	Mean Conc.
Honda2	Veinous	Restrictive	Free	Max Conc.
Honda3	Veinous	Non-restrictive	Total	Mean Conc.
Honda4	Veinous	Non-restrictive	Total	Max Conc.
Honda5	Target Tissue	Non-restrictive	Total	Mean Conc.
Honda6	Target Tissue	Non-restrictive	Total	Max Conc.

*Assumption is currently ignored because analytical steady-state solutions are currently used by this function.

Author(s)

Caroline Ring, Robert Pearce, and John Wambaugh

References

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* 147.1 (2015): 55-67.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment international* 106 (2017): 105-118.

Honda, Gregory S., et al. "Using the Concordance of In Vitro and In Vivo Data to Evaluate Extrapolation Assumptions." 2019. *PLoS ONE* 14(5): e0217564.

Rowland, Malcolm, Leslie Z. Benet, and Garry G. Graham. "Clearance concepts in pharmacokinetics." *Journal of pharmacokinetics and biopharmaceutics* 1.2 (1973): 123-136.

Examples

```
## Not run:
set.seed(1234)
calc_mc_css(chem.name='Bisphenol A',output.units='uM',method='vi',
            samples=100,return.samples=TRUE)
set.seed(1234)
calc_mc_css(chem.name='2,4-d',which.quantile=.9,httkpop=FALSE,tissue='heart')

set.seed(1234)
calc_mc_css(chem.cas = "80-05-7", which.quantile = 0.5,
            censored.params = list(Funbound.plasma = list(cv = 0.1,
                                                         lod = 0.005)),
            vary.params = list(BW = 0.15, Vliverc = 0.15, Qgfr = 0.15,
                               Qtotal.liverc = 0.15,
                               million.cells.per.gliver = 0.15, Clint = 0.15),
            output.units = "uM", samples = 2000)

params <- parameterize_pbt(chem.cas="80-05-7")
set.seed(1234)
calc_mc_css(parameters=params,model="pbt")

set.seed(1234)
# Standard HTTK Monte Carlo:
calc_mc_css(chem.cas="90-43-7",model="pbt",samples=NSAMP)
set.seed(1234)
```

```

calc_mc_css(chem.cas="90-43-7",
  model="pbtk",
  samples=NSAMP,
  invitro.mc.arg.list = list(adjusted.Funbound.plasma = T,
    poormetab = T,
    fup.censored.dist = FALSE,
    fup.lod = 0.01,
    fup.meas.cv = 0.0,
    clint.meas.cv = 0.0,
    fup.pop.cv = 0.3,
    clint.pop.cv = 0.3))
set.seed(1234)
# HTTK Monte Carlo with no HTTK-Pop physiological variability):
calc_mc_css(chem.cas="90-43-7",model="pbtk",samples=NSAMP,httkpop=F)
set.seed(1234)
# HTTK Monte Carlo with no in vitro uncertainty and variability):
calc_mc_css(chem.cas="90-43-7",model="pbtk",samples=NSAMP,invitrouv=F)
set.seed(1234)
# HTTK Monte Carlo with no HTTK-Pop and no in vitro uncertainty and variability):
calc_mc_css(chem.cas="90-43-7",model="pbtk",samples=NSAMP,httkpop=F,invitrouv=F)
# Should be the same as the mean result:
calc_analytic_css(chem.cas="90-43-7",model="pbtk",output.units="mg/L")
set.seed(1234)
# HTTK Monte Carlo using basic Monte Carlo sampler:
calc_mc_css(chem.cas="90-43-7",
  model="pbtk",
  samples=NSAMP,
  htkpop=F,
  invitrouv=F,
  vary.params=list(Pow=0.3))

## End(Not run)

```

calc_mc_oral_equiv	<i>Calculate Monte Carlo Oral Equivalent Dose</i>
--------------------	---

Description

This functions converts a chemical plasma concentration to an oral equivalent dose using a concentration obtained from calc_mc_css.

Usage

```

calc_mc_oral_equiv(
  conc,
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  which.quantile = 0.95,
  species = "Human",
  input.units = "uM",
  output.units = "mgpkpday",
  suppress.messages = F,

```



```

    return.samples = F,
    concentration = "plasma",
    restrictive.clearance = T,
    bioactive.free.invivo = F,
    tissue = NULL,
    IVIVE = NULL,
    ...
)

```

Arguments

conc	Bioactive in vitro concentration in units of uM.
chem.name	Either the chemical name or the CAS number must be specified.
chem.cas	Either the CAS number or the chemical name must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
which.quantile	Which quantile from Monte Carlo steady-state simulation (calc_mc_css) is requested. Can be a vector. Note that 95th concentration quantile is the same population as the 5th dose quantile.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
input.units	Units of given concentration, default of uM but can also be mg/L.
output.units	Units of dose, default of 'mgpkgpday' for mg/kg BW/ day or 'umolpkgpday' for umol/ kg BW/ day.
suppress.messages	Suppress text messages.
return.samples	Whether or not to return the vector containing the samples from the simulation instead of the selected quantile.
concentration	Desired concentration type, 'blood', 'tissue', or default 'plasma'.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
bioactive.free.invivo	If FALSE (default), then the total concentration is treated as bioactive in vivo. If TRUE, the the unbound (free) plasma concentration is treated as bioactive in vivo. Only works with tissue = NULL in current implementation.
tissue	Desired steady state tissue concentration.
IVIVE	Honda et al. (2019) identified six plausible sets of assumptions for <i>in vitro-in vivo</i> extrapolation (IVIVE) assumptions. Argument may be set to "Honda1" through "Honda6". If used, this function overwrites the tissue, restrictive.clearance, and plasma.binding arguments. See Details below for more information.
...	Additional parameters passed to calc_mc_css for httkpop and variance of parameters.

Details

All arguments after httkpop only apply if httkpop is set to TRUE and species to "Human".

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Tissue concentrations are calculated for the pbtk model with oral infusion dosing. All tissues other than gut, liver, and lung are the product of the steady state plasma concentration and the tissue to plasma partition coefficient.

The six sets of plausible *in vitro-in vivo* extrapolation (IVIVE) assumptions identified by Honda et al. (2019) are:

	<i>in vivo</i> Conc.	Metabolic Clearance	Bioactive Chemical Conc.	TK Statistic Used*
Honda1	Veinous (Plasma)	Restrictive	Free	Mean Conc.
Honda2	Veinous	Restrictive	Free	Max Conc.
Honda3	Veinous	Non-restrictive	Total	Mean Conc.
Honda4	Veinous	Non-restrictive	Total	Max Conc.
Honda5	Target Tissue	Non-restrictive	Total	Mean Conc.
Honda6	Target Tissue	Non-restrictive	Total	Max Conc.

*Assumption is currently ignored because analytical steady-state solutions are currently used by this function.

Value

Equivalent dose in specified units, default of mg/kg BW/day.

Author(s)

John Wambaugh

References

Wetmore, Barbara A., et al. "Incorporating high-throughput exposure predictions with dosimetry-adjusted *in vitro* bioactivity to inform chemical toxicity testing." *Toxicological Sciences* 148.1 (2015): 121-136.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment international* 106 (2017): 105-118.

Honda, Gregory S., et al. "Using the Concordance of *In Vitro* and *In Vivo* Data to Evaluate Extrapolation Assumptions." 2019. *PLoS ONE* 14(5): e0217564.

Rowland, Malcolm, Leslie Z. Benet, and Garry G. Graham. "Clearance concepts in pharmacokinetics." *Journal of pharmacokinetics and biopharmaceutics* 1.2 (1973): 123-136.

Examples

```
## Not run:
calc_mc_oral_equiv(0.1, chem.cas="34256-82-1", which.quantile=c(0.05,0.5,0.95),
  method='vi', samples=100, tissue='brain')

## End(Not run)
```

calc_mc_tk

*Conduct multiple TK simulations using Monte Carlo***Description**

This function finds the analytical steady state plasma concentration(from calc_analytic_css) using a monte carlo simulation (monte_carlo).

Usage

```
calc_mc_tk(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  samples = 1000,
  which.quantile = 0.95,
  species = "Human",
  suppress.messages = F,
  model = "pbtk",
  httkpop = T,
  invitrouv = T,
  calcrb2p = T,
  censored.params = list(),
  vary.params = list(),
  return.samples = F,
  tissue = NULL,
  output.units = "mg/L",
  solvemodel.arg.list = list(times = c(0, 0.25, 0.5, 0.75, 1, 1.5, 2, 2.5, 3, 4, 5)),
  invitro.mc.arg.list = list(adjusted.funbound.plasma = T, poormetab = T,
    fup.censored.dist = FALSE, fup.lod = 0.01, fup.meas.cv = 0.4, clint.meas.cv = 0.3,
    fup.pop.cv = 0.3, clint.pop.cv = 0.3),
  httkpop.generate.arg.list = list(method = "direct resampling", gendernum = NULL,
    agelim_years = NULL, agelim_months = NULL, weight_category = c("Underweight",
    "Normal", "Overweight", "Obese"), gfr_category = c("Normal", "Kidney Disease",
    "Kidney Failure"), reths = c("Mexican American", "Other Hispanic",
    "Non-Hispanic White", "Non-Hispanic Black", "Other")),
  convert.httkpop.arg.list = list(),
  parameterize.arg.list = list(default.to.human = F, clint.pvalue.threshold = 0.05,
    restrictive.clearance = T, regression = T),
  return.all.sims = FALSE
)
```

Arguments

chem.cas	Either the CAS number, parameters, or the chemical name must be specified.
chem.name	Either the chemical parameters, name, or the CAS number must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from parameterize_steadystate. Not used with httkpop model.

<code>samples</code>	Number of samples generated in calculating quantiles.
<code>which.quantile</code>	Which quantile from Monte Carlo simulation is requested. Can be a vector.
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human"). Species must be set to "Human" to run <code>httkpop</code> model.
<code>suppress.messages</code>	Whether or not to suppress output message.
<code>model</code>	Model used in calculation: 'pbtk' for the multiple compartment model, '3compartment' for the three compartment model, '3compartmentss' for the three compartment steady state model, and '1compartment' for one compartment model. This only applies when <code>httkpop=TRUE</code> and <code>species="Human"</code> , otherwise '3compartmentss' is used.
<code>httkpop</code>	Whether or not to use population generator and sampler from <code>httkpop</code> . This is overwrites <code>censored.params</code> and <code>vary.params</code> and is only for human physiology. Species must also be set to 'Human'.
<code>invitrouv</code>	Logical to indicate whether to include in vitro parameters in uncertainty and variability analysis
<code>calcrb2p</code>	Logical determining whether or not to recalculate the chemical ratio of blood to plasma
<code>censored.params</code>	The parameters listed in <code>censored.params</code> are sampled from a normal distribution that is censored for values less than the limit of detection (specified separately for each parameter). This argument should be a list of sub-lists. Each sublist is named for a parameter in "parameters" and contains two elements: "CV" (coefficient of variation) and "LOD" (limit of detection, below which parameter values are censored. New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Censored values are sampled on a uniform distribution between 0 and the limit of detection. Not used with <code>httkpop</code> model.
<code>vary.params</code>	The parameters listed in <code>vary.params</code> are sampled from a normal distribution that is truncated at zero. This argument should be a list of coefficients of variation (CV) for the normal distribution. Each entry in the list is named for a parameter in "parameters". New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Not used with <code>httkpop</code> model.
<code>return.samples</code>	Whether or not to return the vector containing the samples from the simulation instead of the selected quantile.
<code>tissue</code>	Desired steady state tissue concentration.
<code>output.units</code>	Plasma concentration units, either uM or default mg/L.
<code>solvemodel.arg.list</code>	Additional arguments ultimately passed to solve_model
<code>invitro.mc.arg.list</code>	List of additional parameters passed to invitro_mc
<code>httkpop.generate.arg.list</code>	Additional parameters passed to httkpop_generate .
<code>convert.httkpop.arg.list</code>	Additional parameters passed to the <code>convert_httkpop_*</code> function for the model.
<code>parameterize.arg.list</code>	Additional parameters passed to the <code>parameterize_*</code> function for the model.

```
return.all.sims
```

Logical indicating whether to return the results of all simulations, in addition to the default toxicokinetic statistics

Details

All arguments after `httkpop` only apply if `httkpop` is set to TRUE and species to "Human".

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data (volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Tissue concentrations are calculated for the pbtk model with oral infusion dosing. All tissues other than gut, liver, and lung are the product of the steady state plasma concentration and the tissue to plasma partition coefficient.

The six sets of plausible *in vitro-in vivo* extrapolation (IVIVE) assumptions identified by Honda et al. (2019) are:

	<i>in vivo</i> Conc.	Metabolic Clearance	Bioactive Chemical Conc.	TK Statistic Used*
Honda1	Veinous (Plasma)	Restrictive	Free	Mean Conc.
Honda2	Veinous	Restrictive	Free	Max Conc.
Honda3	Veinous	Non-restrictive	Total	Mean Conc.
Honda4	Veinous	Non-restrictive	Total	Max Conc.
Honda5	Target Tissue	Non-restrictive	Total	Mean Conc.
Honda6	Target Tissue	Non-restrictive	Total	Max Conc.

*Assumption is currently ignored because analytical steady-state solutions are currently used by this function.

Author(s)

John Wambaugh

Examples

```
## Not run:
chemname="Abamectin"
times<- c(0,0.25,0.5,0.75,1,1.5,2,2.5,3,4,5)
age.ranges <- seq(6,80,by=10)
forward <- NULL
for (age.lower in age.ranges)
{
  label <- paste("Ages ",age.lower,"-",age.lower+4,sep="")
  set.seed(1234)
  forward[[label]] <- calc_mc_tk(
    chem.name=chemname,
    samples=NSAMP,
    httkpop.generate.arg.list=list(
      method="d",
      agelim_years = c(age.lower, age.lower+9)),
    solvemodel.arg.list = list(
      times=times))
}
```

```
## End(Not run)
```

calc_rblood2plasma	<i>Calculate the constant ratio of the blood concentration to the plasma concentration.</i>
--------------------	---

Description

This function calculates the constant ratio of the blood concentration to the plasma concentration.

Usage

```
calc_rblood2plasma(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  hematocrit = NULL,
  Krbc2pu = NULL,
  Funbound.plasma = NULL,
  default.to.human = F,
  species = "Human",
  adjusted.Funbound.plasma = T,
  suppress.messages = T
)
```

Arguments

chem.cas	Either the CAS number or the chemical name must be specified.
chem.name	Either the chemical name or the CAS number must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXIDs
parameters	Parameters from parameterize_schmitt
hematocrit	Overwrites default hematocrit value in calculating Rblood2plasma.
Krbc2pu	The red blood cell to unbound plasma chemical partition coefficient, typically from predict_partitioning_schmitt
Funbound.plasma	The fraction of chemical unbound (free) in the presence of plasma protein
default.to.human	Substitutes missing animal values with human values if true.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
adjusted.Funbound.plasma	Whether or not to use Funbound.plasma adjustment.
suppress.messages	Determine whether to display certain usage feedback.

Details

The red blood cell (RBC) partition coefficient as predicted by the Schmitt (2008) method is used in the calculation. The value is calculated with the equation: $1 - \text{hematocrit} + \text{hematocrit} * K_{\text{rbc2pu}} * \text{Funbound.plasma}$, summing the red blood cell to plasma and plasma:plasma (equal to 1) partition coefficients multiplied by their respective fractional volumes. When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data (hematocrit and temperature), but substitutes human fraction unbound and tissue volumes.

Author(s)

John Wambaugh and Robert Pearce

References

Schmitt W. "General approach for the calculation of tissue to plasma partition coefficients." *Toxicology In Vitro*, 22, 457-467 (2008).

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Ruark, Christopher D., et al. "Predicting passive and active tissue: plasma partition coefficients: interindividual and interspecies variability." *Journal of pharmaceutical sciences* 103.7 (2014): 2189-2198.

Examples

```
calc_rblood2plasma(chem.name="Bisphenol A")
calc_rblood2plasma(chem.name="Bisphenol A",species="Rat")
```

calc_stats

Calculate toxicokinetic summary statistics.

Description

This function calculates the area under the curve, the mean, and the peak values for the venous blood or plasma concentration of a specified chemical or all chemicals if none is specified for the multiple compartment model with a given number of days, dose, and number of doses per day.

Usage

```
calc_stats(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  route = "oral",
  stats = c("AUC", "peak", "mean"),
  species = "Human",
  days = 28,
  daily.dose = 1,
  dose = NULL,
```

```

doses.per.day = 1,
output.units = "uM",
concentration = "plasma",
tissue = "plasma",
model = "pbt",
default.to.human = F,
adjusted.funbound.plasma = T,
regression = T,
restrictive.clearance = T,
suppress.messages = F,
...
)

```

Arguments

chem.name	Name of desired chemical.
chem.cas	CAS number of desired chemical.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_pbt function, overrides chem.name and chem.cas.
route	String specification of route of exposure for simulation: "oral", "iv", "inhalation", ...
stats	Desired values (either 'AUC', 'mean', 'peak', or a vector containing any combination).
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
days	Length of the simulation.
daily.dose	Total daily dose, mg/kg BW.
dose	Amount of a single dose at time zero, mg/kg BW.
doses.per.day	Number of doses per day.
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
concentration	Desired concentration type, 'blood' or default 'plasma'.
tissue	Desired steady state tissue concentration.
model	Model used in calculation, 'pbt' for the multiple compartment model, '3compartment' for the three compartment model, '3compartmentss' for the three compartment steady state model, and '1compartment' for one compartment model.
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
adjusted.funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
suppress.messages	Whether to suppress output message.
...	Arguments passed to solve function.

Details

Default value of 0 for doses.per.day solves for a single dose.

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

AUC	Area under the plasma concentration curve.
mean.conc	The area under the curve divided by the number of days.
peak.conc	The highest concentration.

Author(s)

Robert Pearce and John Wambaugh

Examples

```
calc_stats(chem.name='Bisphenol-A',days=100,stats='mean',model='3compartment')

calc_stats(chem.name='Bisphenol-A',days=100,stats=c('peak','mean'),species='Rat')

## Not run:
# If you do not specify a chemical, calc_stats runs for all chemicals:
all.peak.conc.stats <- calc_stats(days=10, doses.per.day = 3, stats = "peak")

## End(Not run)

triclosan.stats <- calc_stats(days=10, chem.name = "triclosan")
```

calc_total_clearance	<i>Calculate the total clearance.</i>
----------------------	---------------------------------------

Description

This function calculates the total clearance rate for a one compartment model where clearance is entirely due to metabolism by the liver and glomerular filtration in the kidneys, identical to clearance of three compartment steady state model.

Usage

```
calc_total_clearance(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  species = "Human",
  suppress.messages = F,
  default.to.human = F,
```

```

    well.stirred.correction = T,
    restrictive.clearance = T,
    adjusted.funbound.plasma = T,
    ...
)

```

Arguments

chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
chem.name	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Chemical parameters from parameterize_steadystate function, overrides chem.name and chem.cas.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
suppress.messages	Whether or not the output message is suppressed.
default.to.human	Substitutes missing animal values with human values if true.
well.stirred.correction	Uses correction in calculation of hepatic clearance for well-stirred model if TRUE. This assumes clearance relative to amount unbound in whole blood instead of plasma, but converted to use with plasma concentration.
restrictive.clearance	Protein binding is not taken into account (set to 1) in liver clearance if FALSE.
adjusted.funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE.
...	Additional parameters passed to parameterize_steadystate if parameters is NULL.

Value

Total Clearance
Units of L/h/kg BW.

Author(s)

John Wambaugh

Examples

```
calc_total_clearance(chem.name="Ibuprofen")
```

calc_vdist	<i>Calculate the volume of distribution for a one compartment model.</i>
------------	--

Description

This function predicts partition coefficients for all tissues, then lumps them into a single compartment.

Usage

```
calc_vdist(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  parameters = NULL,  
  default.to.human = F,  
  species = "Human",  
  suppress.messages = F,  
  adjusted.Funbound.plasma = T,  
  regression = T,  
  minimum.Funbound.plasma = 1e-04  
)
```

Arguments

chem.cas	Either the CAS number or the chemical name must be specified when Funbound.plasma is not given in parameter list.
chem.name	Either the chemical name or the CAS number must be specified when Funbound.plasma is not given in parameter list.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from parameterize_3comp, parameterize_pbtok or predict_partitioning_schmitt.
default.to.human	Substitutes missing animal values with human values if true.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
suppress.messages	Whether or not the output message is suppressed.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Details

The effective volume of distribution is calculated by summing each tissues volume times it's partition coefficient relative to plasma. Plasma, and the partitioning into RBCs are also added to get the total volume of distribution in L/KG BW. Partition coefficients are calculated using Schmitt's (2008) method. When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

Volume of distribution
Units of L/ kg BW.

Author(s)

John Wambaugh and Robert Pearce

References

Schmitt W. "General approach for the calculation of tissue to plasma partition coefficients." Toxicology In Vitro, 22, 457-467 (2008). Peyret, T., Poulin, P., Krishnan, K., "A unified algorithm for predicting partition coefficients for PBPK modeling of drugs and environmental chemicals." Toxicology and Applied Pharmacology, 249, 197-207 (2010).

Examples

```
calc_vdist(chem.cas="80-05-7")  
calc_vdist(chem.name="Bisphenol A")  
calc_vdist(chem.name="Bisphenol A",species="Rat")
```

chem.invivo.PK.aggregate.data

Parameter Estimates from Wambaugh et al. (2018)

Description

This table includes 1 and 2 compartment fits of plasma concentration vs time data aggregated from chem.invivo.PK.data, performed in Wambaugh et al. 2018. Data includes volume of distribution (Vdist, L/kg), elimination rate (kelim, 1/h), gut absorption rate (kgutabs, 1/h), fraction absorbed (Fgutabs), and steady state concentration (Css, mg/L).

Usage

```
chem.invivo.PK.aggregate.data
```

Format

```
data.frame
```

Author(s)

John Wambaugh

Source

Wambaugh et al. 2018 Toxicological Sciences, in press

chem.invivo.PK.data *Published toxicokinetic time course measurements*

Description

This data set includes time and dose specific measurements of chemical concentration in tissues taken from animals administered control doses of the chemicals either orally or intravenously. This plasma concentration-time data is from rat experiments reported in public sources. Toxicokinetic data were retrieved from those studies by the Netherlands Organisation for Applied Scientific Research (TNO) using curve stripping (TechDig v2). This data is provided for statistical analysis as in Wambaugh et al. 2018.

Usage

chem.invivo.PK.data

Format

A data.frame containing 597 rows and 13 columns.

Author(s)

Sieto Bosgra

Source

Wambaugh et al. 2018 Toxicological Sciences, in press

References

- Aanderud L, Bakke OM (1983). Pharmacokinetics of antipyrine, paracetamol, and morphine in rat at 71 ATA. Undersea Biomed Res. 10(3):193-201. PMID: 6636344
- Aasmoe L, Mathiesen M, Sager G (1999). Elimination of methoxyacetic acid and ethoxyacetic acid in rat. Xenobiotica. 29(4):417-24. PMID: 10375010
- Ako RA. Pharmacokinetics/pharmacodynamics (PK/PD) of oral diethylstilbestrol (DES) in recurrent prostate cancer patients and of oral dissolving film (ODF)-DES in rats. PhD dissertation, College of Pharmacy, University of Houston, USA, 2011.
- Anadon A, Martinez-Larranaga MR, Fernandez-Cruz ML, Diaz MJ, Fernandez MC, Martinez MA (1996). Toxicokinetics of deltamethrin and its 4'-HO-metabolite in the rat. Toxicol Appl Pharmacol. 141(1):8-16. PMID: 8917670
- Binkerd PE, Rowland JM, Nau H, Hendrickx AG (1988). Evaluation of valproic acid (VPA) developmental toxicity and pharmacokinetics in Sprague-Dawley rats. Fundam Appl Toxicol. 11(3):485-93. PMID: 3146521

- Boralli VB, Coelho EB, Cerqueira PM, Lanchote VL (2005). Stereoselective analysis of metoprolol and its metabolites in rat plasma with application to oxidative metabolism. *J Chromatogr B Analyt Technol Biomed Life Sci.* 823(2):195-202. PMID: 16029965
- Chan MP, Morisawa S, Nakayama A, Kawamoto Y, Sugimoto M, Yoneda M (2005). Toxicokinetics of ¹⁴C-endosulfan in male Sprague-Dawley rats following oral administration of single or repeated doses. *Environ Toxicol.* 20(5):533-41. PMID: 16161119
- Cruz L, Castaneda-Hernandez G, Flores-Murrieta FJ, Garcia-Lopez P, Guizar-Sahagun G (2002). Alteration of phenacetin pharmacokinetics after experimental spinal cord injury. *Proc West Pharmacol Soc.* 45:4-5. PMID: 12434508
- Della Paschoa OE, Mandema JW, Voskuyl RA, Danhof M (1998). Pharmacokinetic-pharmacodynamic modeling of the anticonvulsant and electroencephalogram effects of phenytoin in rats. *J Pharmacol Exp Ther.* 284(2):460-6. PMID: 9454785
- Du B, Li X, Yu Q, A Y, Chen C (2010). Pharmacokinetic comparison of orally disintegrating, beta-cyclodextrin inclusion complex and conventional tablets of nicardipine in rats. *Life Sci J.* 7(2):80-4.
- Farris FF, Dedrick RL, Allen PV, Smith JC (1993). Physiological model for the pharmacokinetics of methyl mercury in the growing rat. *Toxicol Appl Pharmacol.* 119(1):74-90. PMID: 8470126
- Hays SM, Elswick BA, Blumenthal GM, Welsch F, Conolly RB, Gargas ML (2000). Development of a physiologically based pharmacokinetic model of 2-methoxyethanol and 2-methoxyacetic acid disposition in pregnant rats. *Toxicol Appl Pharmacol.* 163(1):67-74. PMID: 10662606
- Igari Y, Sugiyama Y, Awazu S, Hanano M (1982). Comparative physiologically based pharmacokinetics of hexobarbital, phenobarbital and thiopental in the rat. *J Pharmacokinet Biopharm.* 10(1):53-75. PMID: 7069578
- Ito K, Houston JB (2004). Comparison of the use of liver models for predicting drug clearance using in vitro kinetic data from hepatic microsomes and isolated hepatocytes. *Pharm Res.* 21(5):785-92. PMID: 15180335
- Jia L, Wong H, Wang Y, Garza M, Weitman SD (2003). Carbendazim: disposition, cellular permeability, metabolite identification, and pharmacokinetic comparison with its nanoparticle. *J Pharm Sci.* 92(1):161-72. PMID: 12486692
- Kawai R, Mathew D, Tanaka C, Rowland M (1998). Physiologically based pharmacokinetics of cyclosporine A: extension to tissue distribution kinetics in rats and scale-up to human. *J Pharmacol Exp Ther.* 287(2):457-68. PMID: 9808668
- Kim YC, Kang HE, Lee MG (2008). Pharmacokinetics of phenytoin and its metabolite, 4'-HPPH, after intravenous and oral administration of phenytoin to diabetic rats induced by alloxan or streptozotocin. *Biopharm Drug Dispos.* 29(1):51-61. PMID: 18022993
- Kobayashi S, Takai K, Iga T, Hanano M (1991). Pharmacokinetic analysis of the disposition of valproate in pregnant rats. *Drug Metab Dispos.* 19(5):972-6. PMID: 1686245
- Kotegawa T, Laurijssens BE, Von Moltke LL, Cotreau MM, Perloff MD, Venkatakrishnan K, Warrington JS, Granda BW, Harmatz JS, Greenblatt DJ (2002). In vitro, pharmacokinetic, and pharmacodynamic interactions of ketoconazole and midazolam in the rat. *J Pharmacol Exp Ther.* 302(3):1228-37. PMID: 12183684
- Krug AK, Kolde R, Gaspar JA, Rempel E, Balmer NV, Meganathan K, Vojnits K, Baquie M, Waldmann T, Ensenat-Waser R, Jagtap S, Evans RM, Julien S, Peterson H, Zagoura D, Kadereit S, Gerhard D, Sotiriadou I, Heke M, Natarajan K, Henry M, Winkler J, Marchan R, Stoppini L, Bosgra S, Westerhout J, Verwei M, Vilo J, Kortenkamp A, Hescheler J, Hothorn L, Bremer S, van Thriel C, Krause KH, Hengstler JG, Rahnenfuhrer J, Leist M, Sachinidis A (2013). Human embryonic stem cell-derived test systems for developmental neurotoxicity: a transcriptomics approach. *Arch Toxicol.* 87(1):123-43. PMID: 23179753

- Leon-Reyes MR, Castaneda-Hernandez G, Ortiz MI (2009). Pharmacokinetic of diclofenac in the presence and absence of glibenclamide in the rat. *J Pharm Pharm Sci.* 12(3):280-7. PMID: 20067705
- Nagata M, Hidaka M, Sekiya H, Kawano Y, Yamasaki K, Okumura M, Arimori K (2007). Effects of pomegranate juice on human cytochrome P450 2C9 and tolbutamide pharmacokinetics in rats. *Drug Metab Dispos.* 35(2):302-5. PMID: 17132763
- Okiyama M, Ueno K, Ohmori S, Igarashi T, Kitagawa H (1988). Drug interactions between imipramine and benzodiazepines in rats. *J Pharm Sci.* 77(1):56-63. PMID: 2894451
- Pelissier-Alicot AL, Schreiber-Deturmeny E, Simon N, Gantenbein M, Bruguerolle B (2002). Time-of-day dependent pharmacodynamic and pharmacokinetic profiles of caffeine in rats. *Naunyn Schmiedebergs Arch Pharmacol.* 365(4):318-25. PMID: 11919657
- Piersma AH, Bosgra S, van Duursen MB, Hermesen SA, Jonker LR, Kroese ED, van der Linden SC, Man H, Roelofs MJ, Schulp SH, Schwarz M, Uibel F, van Vugt-Lussenburg BM, Westerhout J, Wolterbeek AP, van der Burg B (2013). Evaluation of an alternative in vitro test battery for detecting reproductive toxicants. *Reprod Toxicol.* 38:53-64. PMID: 23511061
- Pollack GM, Li RC, Ermer JC, Shen DD (1985). Effects of route of administration and repetitive dosing on the disposition kinetics of di(2-ethylhexyl) phthalate and its mono-de-esterified metabolite in rats. *Toxicol Appl Pharmacol.* Jun 30;79(2):246-56. PMID: 4002226
- Saadeddin A, Torres-Molina F, Carcel-Trullols J, Araico A, Peris JE (2004). Pharmacokinetics of the time-dependent elimination of all-trans-retinoic acid in rats. *AAPS J.* 6(1):1-9. PMID: 18465253
- Satterwhite JH, Boudinot FD (1991). Effects of age and dose on the pharmacokinetics of ibuprofen in the rat. *Drug Metab Dispos.* 19(1):61-7. PMID: 1673423
- Szymura-Oleksiak J, Panas M, Chrusciel W (1983). Pharmacokinetics of imipramine after single and multiple intravenous administration in rats. *Pol J Pharmacol Pharm.* 35(2):151-7. PMID: 6622297
- Tanaka C, Kawai R, Rowland M (2000). Dose-dependent pharmacokinetics of cyclosporin A in rats: events in tissues. *Drug Metab Dispos.* 28(5):582-9. PMID: 10772639
- Timchalk C, Nolan RJ, Mendrala AL, Dittenber DA, Brzak KA, Mattsson JL (2002). A Physiologically based pharmacokinetic and pharmacodynamic (PBPK/PD) model for the organophosphate insecticide chlorpyrifos in rats and humans. *Toxicol Sci.* Mar;66(1):34-53. PMID: 11861971
- Tokuma Y, Sekiguchi M, Niwa T, Noguchi H (1988). Pharmacokinetics of nilvadipine, a new dihydropyridine calcium antagonist, in mice, rats, rabbits and dogs. *Xenobiotica* 18(1):21-8. PMID: 3354229
- Treiber A, Schneider R, Delahaye S, Clozel M (2004). Inhibition of organic anion transporting polypeptide-mediated hepatic uptake is the major determinant in the pharmacokinetic interaction between bosentan and cyclosporin A in the rat. *J Pharmacol Exp Ther.* 308(3):1121-9. PMID: 14617681
- Tsui BC, Feng JD, Buckley SJ, Yeung PK (1994). Pharmacokinetics and metabolism of diltiazem in rats following a single intra-arterial or single oral dose. *Eur J Drug Metab Pharmacokinet.* 19(4):369-73. PMID: 7737239
- Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* (2015): 228-237.
- Wang Y, Roy A, Sun L, Lau CE (1999). A double-peak phenomenon in the pharmacokinetics of alprazolam after oral administration. *Drug Metab Dispos.* 27(8):855-9. PMID: 10421610
- Wang X, Lee WY, Or PM, Yeung JH (2010). Pharmacokinetic interaction studies of tanshinones with tolbutamide, a model CYP2C11 probe substrate, using liver microsomes, primary hepatocytes and in vivo in the rat. *Phytomedicine.* 17(3-4):203-11. PMID: 19679455

Yang SH, Lee MG (2008). Dose-independent pharmacokinetics of ondansetron in rats: contribution of hepatic and intestinal first-pass effects to low bioavailability. *Biopharm Drug Dispos.* 29(7):414-26. PMID: 18697186

Yeung PK, Alcos A, Tang J (2009). Pharmacokinetics and Hemodynamic Effects of Diltiazem in Rats Following Single vs Multiple Doses In Vivo. *Open Drug Metab J.* 3:56-62.

chem.invivo.PK.summary.data

Summary of published toxicokinetic time course experiments

Description

This data set summarizes the time course data in the chem.invivo.PK.data table. Maximum concentration (Cmax), time integrated plasma concentration for the duration of treatment (AUC.treatment) and extrapolated to zero concentration (AUC.infinity) as well as half-life are calculated. Summary values are given for each study and dosage. These data can be used to evaluate toxicokinetic model predictions.

Usage

chem.invivo.PK.summary.data

Format

A data.frame containing 100 rows and 25 columns.

Author(s)

John Wambaugh

Source

Wambaugh et al. 2018 *Toxicological Sciences*, in press

References

Aanderud L, Bakke OM (1983). Pharmacokinetics of antipyrine, paracetamol, and morphine in rat at 71 ATA. *Undersea Biomed Res.* 10(3):193-201. PMID: 6636344

Aasmoe L, Mathiesen M, Sager G (1999). Elimination of methoxyacetic acid and ethoxyacetic acid in rat. *Xenobiotica.* 29(4):417-24. PMID: 10375010

Ako RA. Pharmacokinetics/pharmacodynamics (PK/PD) of oral diethylstilbestrol (DES) in recurrent prostate cancer patients and of oral dissolving film (ODF)-DES in rats. PhD dissertation, College of Pharmacy, University of Houston, USA, 2011.

Anadon A, Martinez-Larranaga MR, Fernandez-Cruz ML, Diaz MJ, Fernandez MC, Martinez MA (1996). Toxicokinetics of deltamethrin and its 4'-HO-metabolite in the rat. *Toxicol Appl Pharmacol.* 141(1):8-16. PMID: 8917670

Binkerd PE, Rowland JM, Nau H, Hendrickx AG (1988). Evaluation of valproic acid (VPA) developmental toxicity and pharmacokinetics in Sprague-Dawley rats. *Fundam Appl Toxicol.* 11(3):485-93. PMID: 3146521

- Boralli VB, Coelho EB, Cerqueira PM, Lanchote VL (2005). Stereoselective analysis of metoprolol and its metabolites in rat plasma with application to oxidative metabolism. *J Chromatogr B Analyt Technol Biomed Life Sci.* 823(2):195-202. PMID: 16029965
- Chan MP, Morisawa S, Nakayama A, Kawamoto Y, Sugimoto M, Yoneda M (2005). Toxicokinetics of ¹⁴C-endosulfan in male Sprague-Dawley rats following oral administration of single or repeated doses. *Environ Toxicol.* 20(5):533-41. PMID: 16161119
- Cruz L, Castaneda-Hernandez G, Flores-Murrieta FJ, Garcia-Lopez P, Guizar-Sahagun G (2002). Alteration of phenacetin pharmacokinetics after experimental spinal cord injury. *Proc West Pharmacol Soc.* 45:4-5. PMID: 12434508
- Della Paschoa OE, Mandema JW, Voskuyl RA, Danhof M (1998). Pharmacokinetic-pharmacodynamic modeling of the anticonvulsant and electroencephalogram effects of phenytoin in rats. *J Pharmacol Exp Ther.* 284(2):460-6. PMID: 9454785
- Du B, Li X, Yu Q, A Y, Chen C (2010). Pharmacokinetic comparison of orally disintegrating, beta-cyclodextrin inclusion complex and conventional tablets of nicardipine in rats. *Life Sci J.* 7(2):80-4.
- Farris FF, Dedrick RL, Allen PV, Smith JC (1993). Physiological model for the pharmacokinetics of methyl mercury in the growing rat. *Toxicol Appl Pharmacol.* 119(1):74-90. PMID: 8470126
- Hays SM, Elswick BA, Blumenthal GM, Welsch F, Conolly RB, Gargas ML (2000). Development of a physiologically based pharmacokinetic model of 2-methoxyethanol and 2-methoxyacetic acid disposition in pregnant rats. *Toxicol Appl Pharmacol.* 163(1):67-74. PMID: 10662606
- Igari Y, Sugiyama Y, Awazu S, Hanano M (1982). Comparative physiologically based pharmacokinetics of hexobarbital, phenobarbital and thiopental in the rat. *J Pharmacokinet Biopharm.* 10(1):53-75. PMID: 7069578
- Ito K, Houston JB (2004). Comparison of the use of liver models for predicting drug clearance using in vitro kinetic data from hepatic microsomes and isolated hepatocytes. *Pharm Res.* 21(5):785-92. PMID: 15180335
- Jia L, Wong H, Wang Y, Garza M, Weitman SD (2003). Carbendazim: disposition, cellular permeability, metabolite identification, and pharmacokinetic comparison with its nanoparticle. *J Pharm Sci.* 92(1):161-72. PMID: 12486692
- Kawai R, Mathew D, Tanaka C, Rowland M (1998). Physiologically based pharmacokinetics of cyclosporine A: extension to tissue distribution kinetics in rats and scale-up to human. *J Pharmacol Exp Ther.* 287(2):457-68. PMID: 9808668
- Kim YC, Kang HE, Lee MG (2008). Pharmacokinetics of phenytoin and its metabolite, 4'-HPPH, after intravenous and oral administration of phenytoin to diabetic rats induced by alloxan or streptozotocin. *Biopharm Drug Dispos.* 29(1):51-61. PMID: 18022993
- Kobayashi S, Takai K, Iga T, Hanano M (1991). Pharmacokinetic analysis of the disposition of valproate in pregnant rats. *Drug Metab Dispos.* 19(5):972-6. PMID: 1686245
- Kotegawa T, Laurijssens BE, Von Moltke LL, Cotreau MM, Perloff MD, Venkatakrishnan K, Warrington JS, Granda BW, Harmatz JS, Greenblatt DJ (2002). In vitro, pharmacokinetic, and pharmacodynamic interactions of ketoconazole and midazolam in the rat. *J Pharmacol Exp Ther.* 302(3):1228-37. PMID: 12183684
- Krug AK, Kolde R, Gaspar JA, Rempel E, Balmer NV, Meganathan K, Vojnits K, Baquie M, Waldmann T, Ensenat-Waser R, Jagtap S, Evans RM, Julien S, Peterson H, Zagoura D, Kadereit S, Gerhard D, Sotiriadou I, Heke M, Natarajan K, Henry M, Winkler J, Marchan R, Stoppini L, Bosgra S, Westerhout J, Verwei M, Vilo J, Kortenkamp A, Hescheler J, Hothorn L, Bremer S, van Thriel C, Krause KH, Hengstler JG, Rahnenfuhrer J, Leist M, Sachinidis A (2013). Human embryonic stem cell-derived test systems for developmental neurotoxicity: a transcriptomics approach. *Arch Toxicol.* 87(1):123-43. PMID: 23179753

- Leon-Reyes MR, Castaneda-Hernandez G, Ortiz MI (2009). Pharmacokinetic of diclofenac in the presence and absence of glibenclamide in the rat. *J Pharm Pharm Sci.* 12(3):280-7. PMID: 20067705
- Nagata M, Hidaka M, Sekiya H, Kawano Y, Yamasaki K, Okumura M, Arimori K (2007). Effects of pomegranate juice on human cytochrome P450 2C9 and tolbutamide pharmacokinetics in rats. *Drug Metab Dispos.* 35(2):302-5. PMID: 17132763
- Okiyama M, Ueno K, Ohmori S, Igarashi T, Kitagawa H (1988). Drug interactions between imipramine and benzodiazepines in rats. *J Pharm Sci.* 77(1):56-63. PMID: 2894451
- Pelissier-Alicot AL, Schreiber-Deturmeny E, Simon N, Gantenbein M, Bruguerolle B (2002). Time-of-day dependent pharmacodynamic and pharmacokinetic profiles of caffeine in rats. *Naunyn Schmiedebergs Arch Pharmacol.* 365(4):318-25. PMID: 11919657
- Piersma AH, Bosgra S, van Duursen MB, Hermsen SA, Jonker LR, Kroese ED, van der Linden SC, Man H, Roelofs MJ, Schulp SH, Schwarz M, Uibel F, van Vugt-Lussenburg BM, Westerhout J, Wolterbeek AP, van der Burg B (2013). Evaluation of an alternative in vitro test battery for detecting reproductive toxicants. *Reprod Toxicol.* 38:53-64. PMID: 23511061
- Pollack GM, Li RC, Ermer JC, Shen DD (1985). Effects of route of administration and repetitive dosing on the disposition kinetics of di(2-ethylhexyl) phthalate and its mono-de-esterified metabolite in rats. *Toxicol Appl Pharmacol.* Jun 30;79(2):246-56. PMID: 4002226
- Saadeddin A, Torres-Molina F, Carcel-Trullols J, Araico A, Peris JE (2004). Pharmacokinetics of the time-dependent elimination of all-trans-retinoic acid in rats. *AAPS J.* 6(1):1-9. PMID: 18465253
- Satterwhite JH, Boudinot FD (1991). Effects of age and dose on the pharmacokinetics of ibuprofen in the rat. *Drug Metab Dispos.* 19(1):61-7. PMID: 1673423
- Szymura-Oleksiak J, Panas M, Chrusciel W (1983). Pharmacokinetics of imipramine after single and multiple intravenous administration in rats. *Pol J Pharmacol Pharm.* 35(2):151-7. PMID: 6622297
- Tanaka C, Kawai R, Rowland M (2000). Dose-dependent pharmacokinetics of cyclosporin A in rats: events in tissues. *Drug Metab Dispos.* 28(5):582-9. PMID: 10772639
- Timchalk C, Nolan RJ, Mendrala AL, Dittenber DA, Brzak KA, Mattsson JL (2002). A Physiologically based pharmacokinetic and pharmacodynamic (PBPK/PD) model for the organophosphate insecticide chlorpyrifos in rats and humans. *Toxicol Sci.* Mar;66(1):34-53. PMID: 11861971
- Tokuma Y, Sekiguchi M, Niwa T, Noguchi H (1988). Pharmacokinetics of nilvadipine, a new dihydropyridine calcium antagonist, in mice, rats, rabbits and dogs. *Xenobiotica* 18(1):21-8. PMID: 3354229
- Treiber A, Schneider R, Delahaye S, Clozel M (2004). Inhibition of organic anion transporting polypeptide-mediated hepatic uptake is the major determinant in the pharmacokinetic interaction between bosentan and cyclosporin A in the rat. *J Pharmacol Exp Ther.* 308(3):1121-9. PMID: 14617681
- Tsui BC, Feng JD, Buckley SJ, Yeung PK (1994). Pharmacokinetics and metabolism of diltiazem in rats following a single intra-arterial or single oral dose. *Eur J Drug Metab Pharmacokinet.* 19(4):369-73. PMID: 7737239
- Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* (2015): 228-237.
- Wang Y, Roy A, Sun L, Lau CE (1999). A double-peak phenomenon in the pharmacokinetics of alprazolam after oral administration. *Drug Metab Dispos.* 27(8):855-9. PMID: 10421610
- Wang X, Lee WY, Or PM, Yeung JH (2010). Pharmacokinetic interaction studies of tanshinones with tolbutamide, a model CYP2C11 probe substrate, using liver microsomes, primary hepatocytes and in vivo in the rat. *Phytomedicine.* 17(3-4):203-11. PMID: 19679455

Yang SH, Lee MG (2008). Dose-independent pharmacokinetics of ondansetron in rats: contribution of hepatic and intestinal first-pass effects to low bioavailability. *Biopharm Drug Dispos.* 29(7):414-26. PMID: 18697186

Yeung PK, Alcos A, Tang J (2009). Pharmacokinetics and Hemodynamic Effects of Diltiazem in Rats Following Single vs Multiple Doses In Vivo. *Open Drug Metab J.* 3:56-62.

chem.lists

Chemical membership in different research projects

Description

A static list of lists identifying chemical membership in different research projects. While it is our intent to keep these lists up-to-date, the information here is only for convenience and should not be considered to be definitive.

Usage

chem.lists

Format

A list containing ten lists.

Author(s)

John Wambaugh

References

Bucher, J. R. (2008). Guest Editorial: NTP: New Initiatives, New Alignment. *Environ Health Perspect* 116(1).

Judson, R. S., Houck, K. A., Kavlock, R. J., Knudsen, T. B., Martin, M. T., Mortensen, H. M., Reif, D. M., Rotroff, D. M., Shah, I., Richard, A. M. and Dix, D. J. (2010). In Vitro Screening of Environmental Chemicals for Targeted Testing Prioritization: The ToxCast Project. *Environmental Health Perspectives* 118(4), 485-492.

Wambaugh, J. F., Wang, A., Dionisio, K. L., Frame, A., Egeghy, P., Judson, R. and Setzer, R. W. (2014). High Throughput Heuristics for Prioritizing Human Exposure to Environmental Chemicals. *Environmental Science & Technology*, 10.1021/es503583j.

CDC (2014). National Health and Nutrition Examination Survey. Available at: <http://www.cdc.gov/nchs/nhanes.htm>.

chem.physical_and_invitro.data

Physico-chemical properties and in vitro measurements for toxicokinetics

Description

This data set contains the necessary information to make basic, high-throughput toxicokinetic (HTTK) predictions for compounds, including Funbound.plasma, molecular weight (g/mol), logP, logMA (membrane affinity), intrinsic clearance(uL/min/10⁶ cells), and pKa. These data have been compiled from multiple sources, and can be used to parameterize a variety of toxicokinetic models. See variable EPA.ref for information on the reference EPA.

Usage

chem.physical_and_invitro.data

Format

A data.frame containing 565 rows and 33 columns.

Author(s)

John Wambaugh

Source

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." Toxicological Sciences (2015): 228-237.

References

DSStox database ([http:// www.epa.gov/ncct/dsstox](http://www.epa.gov/ncct/dsstox))

EPI Suite, <http://www.epa.gov/opptintr/exposure/pubs/episuite.htm>

Hilal, S., Karickhoff, S. and Carreira, L. (1995). A rigorous test for SPARC's chemical reactivity models: Estimation of more than 4300 ionization pKas. Quantitative Structure-Activity Relationships 14(4), 348-355.

Ito, K. and Houston, J. B. (2004). Comparison of the use of liver models for predicting drug clearance using in vitro kinetic data from hepatic microsomes and isolated hepatocytes. Pharm Res 21(5), 785-92.

Jones, O. A., Voulvoulis, N. and Lester, J. N. (2002). Aquatic environmental assessment of the top 25 English prescription pharmaceuticals. Water research 36(20), 5013-22.

Lau, Y. Y., Sapidou, E., Cui, X., White, R. E. and Cheng, K. C. (2002). Development of a novel in vitro model to predict hepatic clearance using fresh, cryopreserved, and sandwich-cultured hepatocytes. Drug Metabolism and Disposition 30(12), 1446-54.

McGinnity, D. F., Soars, M. G., Urbanowicz, R. A. and Riley, R. J. (2004). Evaluation of fresh and cryopreserved hepatocytes as in vitro drug metabolism tools for the prediction of metabolic clearance. Drug Metabolism and Disposition 32(11), 1247-53, 10.1124/dmd.104.000026.

- Naritomi, Y., Terashita, S., Kagayama, A. and Sugiyama, Y. (2003). Utility of Hepatocytes in Predicting Drug Metabolism: Comparison of Hepatic Intrinsic Clearance in Rats and Humans in Vivo and in Vitro. *Drug Metabolism and Disposition* 31(5), 580-588, 10.1124/dmd.31.5.580.
- Obach, R. S. (1999). Prediction of human clearance of twenty-nine drugs from hepatic microsomal intrinsic clearance data: An examination of in vitro half-life approach and nonspecific binding to microsomes. *Drug Metabolism and Disposition* 27(11), 1350-9.
- Obach, R. S., Lombardo, F. and Waters, N. J. (2008). Trend analysis of a database of intravenous pharmacokinetic parameters in humans for 670 drug compounds. *Drug Metabolism and Disposition* 36(7), 1385-405, 10.1124/dmd.108.020479.
- Paixao, P., Gouveia, L. F., & Morais, J. A. (2012). Prediction of the human oral bioavailability by using in vitro and in silico drug related parameters in a physiologically based absorption model. *International journal of pharmaceutics*, 429(1), 84-98.
- Pirovano, Alessandra, et al. "QSARs for estimating intrinsic hepatic clearance of organic chemicals in humans." *Environmental toxicology and pharmacology* 42 (2016): 190-197.
- Schmitt, W. (2008). General approach for the calculation of tissue to plasma partition coefficients. *Toxicology in vitro : an international journal published in association with BIBRA* 22(2), 457-67, 10.1016/j.tiv.2007.09.010.
- Shibata, Y., Takahashi, H., Chiba, M. and Ishii, Y. (2002). Prediction of Hepatic Clearance and Availability by Cryopreserved Human Hepatocytes: An Application of Serum Incubation Method. *Drug Metabolism and Disposition* 30(8), 892-896, 10.1124/dmd.30.8.892.
- Tonnelier, A., Coecke, S. and Zaldivar, J.-M. (2012). Screening of chemicals for human bioaccumulative potential with a physiologically based toxicokinetic model. *Archives of Toxicology* 86(3), 393-403, 10.1007/s00204-011-0768-0.
- Uchimura, Takahide, et al. "Prediction of human blood-to-plasma drug concentration ratio." *Bio-pharmaceutics & drug disposition* 31.5-6 (2010): 286-297.
- Wetmore, B. A., Wambaugh, J. F., Ferguson, S. S., Sochaski, M. A., Rotroff, D. M., Freeman, K., Clewell, H. J., 3rd, Dix, D. J., Andersen, M. E., Houck, K. A., Allen, B., Judson, R. S., Singh, R., Kavlock, R. J., Richard, A. M. and Thomas, R. S. (2012). Integration of dosimetry, exposure, and high-throughput screening data in chemical toxicity assessment. *Toxicological sciences : an official journal of the Society of Toxicology* 125(1), 157-74, 10.1093/toxsci/kfr254.
- Wetmore, B. A., Wambaugh, J. F., Ferguson, S. S., Li, L., Clewell, H. J., Judson, R. S., Freeman, K., Bao, W., Sochaski, M. A., Chu, T.-M., Black, M. B., Healy, E., Allen, B., Andersen, M. E., Wolfinger, R. D. and Thomas, R. S. (2013). Relative Impact of Incorporating Pharmacokinetics on Predicting In Vivo Hazard and Mode of Action from High-Throughput In Vitro Toxicity Assays. *Toxicological Sciences* 132(2), 327-346, 10.1093/toxsci/kft012.
- Wetmore, B. A., Wambaugh, J. F., Allen, B., Ferguson, S. S., Sochaski, M. A., Setzer, R. W., Houck, K. A., Strobe, C. L., Cantwell, K., Judson, R. S., LeCluyse, E., Clewell, H.J. III, Thomas, R.S., and Andersen, M. E. (2015). "Incorporating High-Throughput Exposure Predictions with Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing" *Toxicological Sciences*, kfv171.

ckd_epi_eq

CKD-EPI equation for GFR.

Description

Predict GFR from serum creatinine, gender, race, and age.

Usage

```
ckd_epi_eq(scr, gender, reth, age_years)
```

Arguments

scr	Vector of serum creatinine values in mg/dL.
gender	Vector of genders (either 'Male' or 'Female').
reth	Vector of races/ethnicities.
age_years	Vector of ages in years.

Details

From Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF, Feldman HI, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009; 150(9):604-612. doi:10.7326/0003-4819-150-9-200905050-00006

Value

Vector of GFR values in mL/min/1.73m².

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

concentration_data_Linakis2020

Concentration data involved in Linakis 2020 vignette analysis.

Description

Concentration data involved in Linakis 2020 vignette analysis.

Usage

```
concentration_data_Linakis2020
```

Format

A data.frame containing x rows and y columns.

Author(s)

Matt Linakis

Source

Matt Linakis

References

DSStox database ([http:// www.epa.gov/ncct/dsstox](http://www.epa.gov/ncct/dsstox))

convert_httkpop_1comp	<i>Converts HHTK-Pop physiology into parameters relevant to the one compartment model</i>
-----------------------	---

Description

Converts HHTK-Pop physiology into parameters relevant to the one compartment model

Usage

```
convert_httkpop_1comp(parameters.dt, httkpop.dt, ...)
```

Arguments

parameters.dt	Data table returned by create_mc_samples
httkpop.dt	Data table returned by httkpop_generate
...	Additional arguments passed to propagate_invitrouv_1comp

Value

A data.table whose columns are the parameters of the HHTK model specified in model.

Author(s)

Caroline Ring, John Wambaugh, and Greg Honda

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

create_mc_samples	<i>Create a data table of draws of parameter values for Monte Carlo</i>
-------------------	---

Description

This function creates a data table of draws of parameter values for use with Monte Carlo methods

Usage

```

create_mc_samples(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  samples = 1000,
  species = "Human",
  suppress.messages = F,
  model = "3compartmentss",
  httkpop = T,
  invitrouv = T,
  calcrb2p = T,
  censored.params = list(),
  vary.params = list(),
  return.samples = F,
  tissue = NULL,
  httkpop.dt = NULL,
  invitro.mc.arg.list = list(adjusted.Funbound.plasma = T, poormetab = T,
    fup.censored.dist = FALSE, fup.lod = 0.01, fup.meas.cv = 0.4, clint.meas.cv = 0.3,
    fup.pop.cv = 0.3, clint.pop.cv = 0.3),
  httkpop.generate.arg.list = list(method = "direct resampling", gendernum = NULL,
    agelim_years = NULL, agelim_months = NULL, weight_category = c("Underweight",
    "Normal", "Overweight", "Obese"), gfr_category = c("Normal", "Kidney Disease",
    "Kidney Failure"), reths = c("Mexican American", "Other Hispanic",
    "Non-Hispanic White", "Non-Hispanic Black", "Other")),
  convert.httkpop.arg.list = list(),
  propagate.invitrouv.arg.list = list(),
  parameterize.arg.list = list(restrictive.clearance = T, default.to.human = F,
    clint.pvalue.threshold = 0.05, regression = T)
)

```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXSIDs
parameters	Parameters from the appropriate parameterization function for the model indicated by argument model
samples	Number of samples generated in calculating quantiles.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human"). Species must be set to "Human" to run httkpop model.
suppress.messages	Whether or not to suppress output message.
model	Model used in calculation: 'pbtk' for the multiple compartment model, '3compartment' for the three compartment model, '3compartmentss' for the three compartment

	steady state model, and '1compartment' for one compartment model. This only applies when <code>httkpop=TRUE</code> and <code>species="Human"</code> , otherwise '3compartmentss' is used.
<code>httkpop</code>	Whether or not to use the Ring et al. (2017) "httkpop" population generator. Species must be 'Human'.
<code>invitrouv</code>	Logical to indicate whether to include in vitro parameters such as intrinsic hepatic clearance rate and fraction unbound in plasma in uncertainty and variability analysis
<code>calcrb2p</code>	Logical determining whether or not to recalculate the chemical ratio of blood to plasma
<code>censored.params</code>	The parameters listed in <code>censored.params</code> are sampled from a normal distribution that is censored for values less than the limit of detection (specified separately for each parameter). This argument should be a list of sub-lists. Each sublist is named for a parameter in "parameters" and contains two elements: "CV" (coefficient of variation) and "LOD" (limit of detection, below which parameter values are censored. New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Censored values are sampled on a uniform distribution between 0 and the limit of detection. Not used with <code>httkpop</code> model.
<code>vary.params</code>	The parameters listed in <code>vary.params</code> are sampled from a normal distribution that is truncated at zero. This argument should be a list of coefficients of variation (CV) for the normal distribution. Each entry in the list is named for a parameter in "parameters". New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the CV. Not used with <code>httkpop</code> model.
<code>return.samples</code>	Whether or not to return the vector containing the samples from the simulation instead of the selected quantile.
<code>tissue</code>	Desired steady state tissue concentration.
<code>httkpop.dt</code>	A data table generated by httkpop_generate . This defaults to NULL, in which case httkpop_generate is called to generate this table.
<code>invitro.mc.arg.list</code>	Additional parameters passed to invitro_mc .
<code>httkpop.generate.arg.list</code>	Additional parameters passed to httkpop_generate .
<code>convert.httkpop.arg.list</code>	Additional parameters passed to the <code>convert_httkpop_*</code> function for the model.
<code>propagate.invitrouv.arg.list</code>	Additional parameters passed to model's associated in vitro uncertainty and variability propagation function
<code>parameterize.arg.list</code>	Additional parameters passed to the <code>parameterize_*</code> function for the model.

Author(s)

Caroline Ring, Robert Pearce, and John Wambaugh

References

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* 147.1 (2015): 55-67.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment international* 106 (2017): 105-118.

Examples

```
## Not run:
calc_mc_css(chem.name='Bisphenol A',output.units='uM',method='vi',
            samples=100,return.samples=TRUE)
calc_mc_css(chem.name='2,4-d',which.quantile=.9,httkpop=FALSE,tissue='heart')

calc_mc_css(chem.cas = "80-05-7", daily.dose = 1, which.quantile = 0.5,
            censored.params = list(Funbound.plasma = list(cv = 0.1,
                                                         lod = 0.005)),
            vary.params = list(BW = 0.15, Vliverc = 0.15, Qgfr = 0.15,
                               Qtotall.liverc = 0.15,
                               million.cells.per.gliver = 0.15, Clint = 0.15),
            output.units = "uM", samples = 2000)

params <- parameterize_pbt(chem.cas="80-05-7")
calc_mc_css(parameters=params,model="pbt")

## End(Not run)
```

EPA.ref

Reference for EPA Physico-Chemical Data

Description

The physico-chemical data in the chem.phys_and_invitro.data table are obtained from EPA's Comptox Chemicals dashboard. This variable indicates the date the Dashboard was accessed.

Usage

EPA.ref

Format

An object of class character of length 1.

Author(s)

John Wambaugh

Source

<https://comptox.epa.gov/dashboard>

estimate_gfr	<i>Predict GFR.</i>
--------------	---------------------

Description

First predict serum creatinine using smoothing spline, then predict GFR using CKD-EPI equation.

Usage

```
estimate_gfr(gfrtmp.dt)
```

Arguments

gfrtmp.dt	A data.table with columns gender, reth, age_years, age_months, BSA_adj, serum_creat.
-----------	--

Value

The same data.table with a gfr_est column added, containing estimated GFR values.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

estimate_gfr_ped	<i>Predict GFR in children.</i>
------------------	---------------------------------

Description

BSA-based equation from Johnson et al. 2006, Clin Pharmacokinet 45(9) 931-56. Used in Wetmore et al. 2014.

Usage

```
estimate_gfr_ped(BSA)
```

Arguments

BSA	Vector of body surface areas in m ² .
-----	--

Value

Vector of GFRs in mL/min/1.73m².

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

estimate_hematocrit	<i>Predict hematocrit using smoothing spline.</i>
---------------------	---

Description

Using precalculated smoothing splines on NHANES log hematocrit vs. age in months (and KDE residuals) by gender and race/ethnicity, generate hematocrit values for individuals specified by age, gender, and race/ethnicity.

Usage

```
estimate_hematocrit(hcttmp_dt)
```

Arguments

hcttmp_dt	A data.table with columns age_years, age_months, gender, reth.
-----------	--

Value

The same data.table with a hematocrit column added.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

export_pbtj_jarnac	<i>Export model to jarnac.</i>
--------------------	--------------------------------

Description

This function exports the multiple compartment PBTK model to a jarnac file.

Usage

```
export_pbtj_jarnac(  
  chem.cas = NULL,  
  chem.name = NULL,  
  species = "Human",  
  initial.amounts = list(Agutlumen = 0),  
  filename = "default.jan",  
  digits = 4  
)
```

Arguments

chem.cas	Either the chemical name or CAS number must be specified.
chem.name	Either the chemical name or CAS number must be specified.
species	Species desired (either "Rat", "Rabbit", "Dog", or default "Human").
initial.amounts	Must specify initial amounts in units of choice.
filename	The name of the jarnac file containing the model.
digits	Desired number of decimal places to round the parameters.

Details

Compartments to enter into the initial.amounts list includes Agutlumen, Aart, Aven, Alung, Agut, Aliver, Akidney, and Arest.

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Author(s)

Robert Pearce

Examples

```
## Not run:  
export_pbtj_jarnac(chem.name='Nicotine',initial.amounts=list(Agutlumen=1),filename='PBTKmodel.jan')  
  
## End(Not run)
```

export_pbt_k_sbml	<i>Export model to sbml.</i>
-------------------	------------------------------

Description

This function exports the multiple compartment PBTk model to an sbml file.

Usage

```
export_pbt_k_sbml(  
  chem.cas = NULL,  
  chem.name = NULL,  
  species = "Human",  
  initial.amounts = list(Agutlumen = 0),  
  filename = "default.xml",  
  digits = 4  
)
```

Arguments

chem.cas	Either the chemical name or CAS number must be specified.
chem.name	Either the chemical name or CAS number must be specified.
species	Species desired (either "Rat", "Rabbit", "Dog", or default "Human").
initial.amounts	Must specify initial amounts in units of choice.
filename	The name of the jarnac file containing the model.
digits	Desired number of decimal places to round the parameters.

Details

Compartments to enter into the initial.amounts list includes Agutlumen, Aart, Aven, Alung, Agut, Aliver, Akidney, and Arest.

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Author(s)

Robert Pearce

Examples

```
## Not run:  
export_pbt_k_sbml(chem.name='Nicotine',initial.amounts=list(Agutlumen=1),filename='PBTkmodel.xml')  
  
## End(Not run)
```

Frank2018invivo

*Literature In Vivo Data on Doses Causing Neurological Effects***Description**

Studies were selected from Table 1 in Mundy et al., 2015, as the studies in that publication were cited as examples of compounds with evidence for developmental neurotoxicity. There were sufficient in vitro toxicokinetic data available for this package for only 6 of the 42 chemicals.

Usage

Frank2018invivo

Format

A data.frame containing 14 rows and 16 columns.

Author(s)

Timothy J. Shafer

References

Frank, Christopher L., et al. "Defining toxicological tipping points in neuronal network development." *Toxicology and Applied Pharmacology* 354 (2018): 81-93.

Mundy, William R., et al. "Expanding the test set: Chemicals with potential to disrupt mammalian brain development." *Neurotoxicology and Teratology* 52 (2015): 25-35.

gen_age_height_weight *Generate ages, heights, and weights for a virtual population using the virtual-individuals method.*

Description

Generate ages, heights, and weights for a virtual population using the virtual-individuals method.

Usage

```
gen_age_height_weight(
  nsamp = NULL,
  gendernum = NULL,
  reths,
  weight_category,
  agelim_years,
  agelim_months
)
```

Arguments

<code>nsamp</code>	The desired number of individuals in the virtual population. <code>nsamp</code> need not be provided if <code>gendernum</code> is provided.
<code>gendernum</code>	Optional: A named list giving the numbers of male and female individuals to include in the population, e.g. <code>list(Male=100,Female=100)</code> . Default is <code>NULL</code> , meaning both males and females are included, in their proportions in the NHANES data. If both <code>nsamp</code> and <code>gendernum</code> are provided, they must agree (i.e., <code>nsamp</code> must be the sum of <code>gendernum</code>).
<code>reth</code>	Optional: a character vector giving the races/ethnicities to include in the population. Default is <code>c('Mexican American', 'Other Hispanic', 'Non-Hispanic White', 'Non-Hispanic Black', 'Other')</code> , to include all races and ethnicities in their proportions in the NHANES data. User-supplied vector must contain one or more of these strings.
<code>weight_category</code>	Optional: The weight categories to include in the population. Default is <code>c('Underweight', 'Normal')</code> . User-supplied vector must contain one or more of these strings.
<code>agelim_years</code>	Optional: A two-element numeric vector giving the minimum and maximum ages (in years) to include in the population. Default is <code>c(0,79)</code> . If <code>agelim_years</code> is provided and <code>agelim_months</code> is not, <code>agelim_years</code> will override the default value of <code>agelim_months</code> .
<code>agelim_months</code>	Optional: A two-element numeric vector giving the minimum and maximum ages (in months) to include in the population. Default is <code>c(0, 959)</code> , equivalent to the default <code>agelim_years</code> . If <code>agelim_months</code> is provided and <code>agelim_years</code> is not, <code>agelim_months</code> will override the default values of <code>agelim_years</code> .

Value

A `data.table` containing variables

`gender` Gender of each virtual individual

`reth` Race/ethnicity of each virtual individual

`age_months` Age in months of each virtual individual

`age_years` Age in years of each virtual individual

`weight` Body weight in kg of each virtual individual

`height` Height in cm of each virtual individual

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

`importFrom survey svymean`

gen_height_weight	<i>Generate heights and weights for a virtual population.</i>
-------------------	---

Description

Generate heights and weights for a virtual population.

Usage

```
gen_height_weight(hbw_dt)
```

Arguments

hbw_dt	A data.table describing the virtual population by race, gender, and age (in years and months). Must have variables gender, reth, age, and age.years.
--------	--

Value

The same data.table with two new variables added: weight and height. Respectively, these give individual body weights in kg, and individual heights in cm.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

get_cheminfo	<i>Retrieve chemical information from HTKK package</i>
--------------	--

Description

This function provides the information specified in "info=" (can be single entry or vector) for all chemicals for which a toxicokinetic model can be parameterized for a given species.

Usage

```
get_cheminfo(  
  info = "CAS",  
  species = "Human",  
  fup.lod.default = 0.005,  
  model = "3compartmentss",  
  default.to.human = F  
)
```

Arguments

<code>info</code>	A single character vector (or collection of character vectors) from "Compound", "CAS", "DTXSID", "logP", "pKa_Donor", "pKa_Accept", "MW", "Clint", "Clint.pValue", "Funbound.plasma", "Structure_Formula", or "Substance_Type". <code>info="all"</code> gives all information for the model and species.
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
<code>fup.lod.default</code>	Default value used for fraction of unbound plasma for chemicals where measured value was below the limit of detection. Default value is 0.0005.
<code>model</code>	Model used in calculation, 'pbt' for the multiple compartment model, '1compartment' for the one compartment model, '3compartment' for three compartment model, '3compartmentss' for the three compartment model without partition coefficients, or 'schmitt' for chemicals with logP and fraction unbound (used in <code>predict_partitioning_schmitt</code>).
<code>default.to.human</code>	Substitutes missing values with human values if true.

Details

When `default.to.human` is set to TRUE, and the species-specific data, `Funbound.plasma` and `Clint`, are missing from `chem.physical_and_invitro.data`, human values are given instead.

Value

`info` Table/vector containing values specified in "info" for valid chemicals.

Author(s)

John Wambaugh and Robert Pearce

Examples

```
## Not run:
# List all CAS numbers for which the 3compartmentss model can be run in humans:
get_cheminfo()

get_cheminfo(info=c('compound', 'funbound.plasma', 'logP'), model='pbt')
# See all the data for humans:
get_cheminfo(info="all")

TP0.cas <- c("741-58-2", "333-41-5", "51707-55-2", "30560-19-1", "5598-13-0",
"35575-96-3", "142459-58-3", "1634-78-2", "161326-34-7", "133-07-3", "533-74-4",
"101-05-3", "330-54-1", "6153-64-6", "15299-99-7", "87-90-1", "42509-80-8",
"10265-92-6", "122-14-5", "12427-38-2", "83-79-4", "55-38-9", "2310-17-0",
"5234-68-4", "330-55-2", "3337-71-1", "6923-22-4", "23564-05-8", "101-02-0",
"140-56-7", "120-71-8", "120-12-7", "123-31-9", "91-53-2", "131807-57-3",
"68157-60-8", "5598-15-2", "115-32-2", "298-00-0", "60-51-5", "23031-36-9",
"137-26-8", "96-45-7", "16672-87-0", "709-98-8", "149877-41-8", "145701-21-9",
"7786-34-7", "54593-83-8", "23422-53-9", "56-38-2", "41198-08-7", "50-65-7",
"28434-00-6", "56-72-4", "62-73-7", "6317-18-6", "96182-53-5", "87-86-5",
"101-54-2", "121-69-7", "532-27-4", "91-59-8", "105-67-9", "90-04-0",
"134-20-3", "599-64-4", "148-24-3", "2416-94-6", "121-79-9", "527-60-6",
"99-97-8", "131-55-5", "105-87-3", "136-77-6", "1401-55-4", "1948-33-0",
```

```

"121-00-6", "92-84-2", "140-66-9", "99-71-8", "150-13-0", "80-46-6", "120-95-6",
"128-39-2", "2687-25-4", "732-11-6", "5392-40-5", "80-05-7", "135158-54-2",
"29232-93-7", "6734-80-1", "98-54-4", "97-53-0", "96-76-4", "118-71-8",
"2451-62-9", "150-68-5", "732-26-3", "99-59-2", "59-30-3", "3811-73-2",
"101-61-1", "4180-23-8", "101-80-4", "86-50-0", "2687-96-9", "108-46-3",
"95-54-5", "101-77-9", "95-80-7", "420-04-2", "60-54-8", "375-95-1", "120-80-9",
"149-30-4", "135-19-3", "88-58-4", "84-16-2", "6381-77-7", "1478-61-1",
"96-70-8", "128-04-1", "25956-17-6", "92-52-4", "1987-50-4", "563-12-2",
"298-02-2", "79902-63-9", "27955-94-8")
httk.TPO.rat.table <- subset(get_cheminfo(info="all",species="rat"),
  CAS %in% TPO.cas)

httk.TPO.human.table <- subset(get_cheminfo(info="all",species="human"),
  CAS %in% TPO.cas)

## End(Not run)

```

get_chem_id

*Retrieve chemical identity from HTK package***Description**

Given one of chem.name, chem.cas (Chemical Abstract Service Registry Number), or DTXSID (DSSTox Substance Identifier <https://comptox.epa.gov/dashboard>) this function checks if the chemical is available and, if so, returns all three pieces of information.

Usage

```
get_chem_id(chem.cas = NULL, chem.name = NULL, dtxsid = NULL)
```

Arguments

chem.cas	CAS registry number
chem.name	Chemical name
dtxsid	DSSTox Substance identifier

Author(s)

John Wambaugh and Robert Pearce

get_gfr_category

*Categorize kidney function by GFR.***Description**

For adults: In general GFR > 60 is considered normal 15 < GFR < 60 is considered kidney disease GFR < 15 is considered kidney failure

Usage

```
get_gfr_category(age_years, age_months, gfr_est)
```

Arguments

age_years	Vector of ages in years.
age_months	Vector of ages in months.
gfr_est	Vector of estimated GFR values in mL/min/1.73m ² .

Details

These values can also be used for children 2 years old and greater (see PEDIATRICS IN REVIEW Vol. 29 No. 10 October 1, 2008 pp. 335-341 (doi: 10.1542/pir.29-10-335))

Value

Vector of GFR categories: 'Normal', 'Kidney Disease', 'Kidney Failure'.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

get_invitroPK_param	<i>Retrieve data from chem.physical_and_invitro.data table</i>
---------------------	--

Description

or fraction unbound in plasma) from the main HTTK data. This function looks for species-specific values.

Usage

```
get_invitroPK_param(  
  param,  
  species,  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL  
)
```

Arguments

param	The in vitro pharmacokinetic parameter needed.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs

Value

The value of the parameter, if found

Author(s)

John Wambaugh and Robert Pearce

get_lit_cheminfo

Get literature Chemical Information.

Description

This function provides the information specified in "info=" for all chemicals with data from the Wetmore et al. (2012) and (2013) publications and other literature.

Usage

```
get_lit_cheminfo(info = "CAS", species = "Human")
```

Arguments

info	A single character vector (or collection of character vectors) from "Compound", "CAS", "MW", "Raw.E", "r2", "p.val", "Concentration..uM.", "Css_lower_5th_perc.mg.L.", "Css_median_perc.mg.L.", "Css_upper_5th_perc.mg.L.", and "Species".
species	Species desired (either "Rat" or default "Human").

Value

info Table/vector containing values specified in "info" for valid chemicals.

Author(s)

John Wambaugh

References

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Sochaski, M.A., Rotroff, D.M., Freeman, K., Clewell, H.J., Dix, D.H., Andersen, M.E., Houck, K.A., Allen, B., Judson, R.S., Sing, R., Kavlock, R.J., Richard, A.M., and Thomas, R.S., "Integration of Dosimetry, Exposure and High-Throughput Screening Data in Chemical Toxicity Assessment," *Toxicological Sciences* 125 157-174 (2012)

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Li, L., Clewell, H.J. III, Judson, R.S., Freeman, K., Bao, W., Sochaski, M.A., Chu T.-M., Black, M.B., Healy, E., Allen, B., Andersen M.E., Wolfinger, R.D., and Thomas R.S., "The Relative Impact of Incorporating Pharmacokinetics on Predicting in vivo Hazard and Mode-of-Action from High-Throughput in vitro Toxicity Assays" *Toxicological Sciences*, 132:327-346 (2013).

Wetmore, B. A., Wambaugh, J. F., Allen, B., Ferguson, S. S., Sochaski, M. A., Setzer, R. W., Houck, K. A., Strobe, C. L., Cantwell, K., Judson, R. S., LeCluyse, E., Clewell, H.J. III, Thomas, R.S., and Andersen, M. E. (2015). "Incorporating High-Throughput Exposure Predictions with Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing" *Toxicological Sciences*, kfv171.

Examples

```
## Not run:
get_lit_cheminfo()
get_lit_cheminfo(info=c('CAS', 'MW'))

## End(Not run)
```

get_lit_css

Get literature Css

Description

This function retrieves a steady-state plasma concentration as a result of infusion dosing from the Wetmore et al. (2012) and (2013) publications and other literature.

Usage

```
get_lit_css(
  chem.cas = NULL,
  chem.name = NULL,
  daily.dose = 1,
  which.quantile = 0.95,
  species = "Human",
  clearance.assay.conc = NULL,
  output.units = "mg/L",
  suppress.messages = F
)
```

Arguments

chem.cas	Either the cas number or the chemical name must be specified.
chem.name	Either the chemical name or the CAS number must be specified.
daily.dose	Total daily dose infused in units of mg/kg BW/day. Defaults to 1 mg/kg/day.
which.quantile	Which quantile from the SimCYP Monte Carlo simulation is requested. Can be a vector.
species	Species desired (either "Rat" or default "Human").
clearance.assay.conc	Concentration of chemical used in measuring intrinsic clearance data, 1 or 10 uM.
output.units	Returned units for function, defaults to mg/L but can also be uM (specify units = "uM").
suppress.messages	Whether or not the output message is suppressed.

Author(s)

John Wambaugh

References

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Sochaski, M.A., Rotroff, D.M., Freeman, K., Clewell, H.J., Dix, D.H., Andersen, M.E., Houck, K.A., Allen, B., Judson, R.S., Sing, R., Kavlock, R.J., Richard, A.M., and Thomas, R.S., "Integration of Dosimetry, Exposure and High-Throughput Screening Data in Chemical Toxicity Assessment," *Toxicological Sciences* 125 157-174 (2012)

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Li, L., Clewell, H.J. III, Judson, R.S., Freeman, K., Bao, W., Sochaski, M.A., Chu T.-M., Black, M.B., Healy, E., Allen, B., Andersen M.E., Wolfinger, R.D., and Thomas R.S., "The Relative Impact of Incorporating Pharmacokinetics on Predicting in vivo Hazard and Mode-of-Action from High-Throughput in vitro Toxicity Assays" *Toxicological Sciences*, 132:327-346 (2013).

Wetmore, B. A., Wambaugh, J. F., Allen, B., Ferguson, S. S., Sochaski, M. A., Setzer, R. W., Houck, K. A., Strope, C. L., Cantwell, K., Judson, R. S., LeCluyse, E., Clewell, H.J. III, Thomas, R.S., and Andersen, M. E. (2015). "Incorporating High-Throughput Exposure Predictions with Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing" *Toxicological Sciences*, kfv171.

Examples

```
get_lit_css(chem.cas="34256-82-1")
```

```
get_lit_css(chem.cas="34256-82-1", species="Rat", which.quantile=0.5)
```

```
get_lit_css(chem.cas="80-05-7", daily.dose = 1, which.quantile = 0.5, output.units = "uM")
```

get_lit_oral_equiv *Get Literature Oral Equivalent Dose*

Description

This function converts a chemical plasma concentration to an oral equivalent dose using the values from the Wetmore et al. (2012) and (2013) publications and other literature.

Usage

```
get_lit_oral_equiv(
  conc,
  chem.name = NULL,
  chem.cas = NULL,
  suppress.messages = F,
  which.quantile = 0.95,
  species = "Human",
  input.units = "uM",
  output.units = "mg",
  clearance.assay.conc = NULL,
  ...
)
```

Arguments

conc	Bioactive in vitro concentration in units of specified input.units, default of uM.
chem.name	Either the chemical name or the CAS number must be specified.
chem.cas	Either the CAS number or the chemical name must be specified.
suppress.messages	Suppress output messages.
which.quantile	Which quantile from the SimCYP Monte Carlo simulation is requested. Can be a vector. Papers include 0.05, 0.5, and 0.95 for humans and 0.5 for rats.
species	Species desired (either "Rat" or default "Human").
input.units	Units of given concentration, default of uM but can also be mg/L.
output.units	Units of dose, default of 'mg' for mg/kg BW/ day or 'mol' for mol/ kg BW/ day.
clearance.assay.conc	Concentration of chemical used in measuring intrinsic clearance data, 1 or 10 uM.
...	Additional parameters passed to get_lit_css.

Value

Equivalent dose in specified units, default of mg/kg BW/day.

Author(s)

John Wambaugh

References

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Sochaski, M.A., Rotroff, D.M., Freeman, K., Clewell, H.J., Dix, D.H., Andersen, M.E., Houck, K.A., Allen, B., Judson, R.S., Sing, R., Kavlock, R.J., Richard, A.M., and Thomas, R.S., "Integration of Dosimetry, Exposure and High-Throughput Screening Data in Chemical Toxicity Assessment," Toxicological Sciences 125 157-174 (2012)

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Li, L., Clewell, H.J. III, Judson, R.S., Freeman, K., Bao, W., Sochaski, M.A., Chu T.-M., Black, M.B., Healy, E., Allen, B., Andersen M.E., Wolfinger, R.D., and Thomas R.S., "The Relative Impact of Incorporating Pharmacokinetics on Predicting in vivo Hazard and Mode-of-Action from High-Throughput in vitro Toxicity Assays" Toxicological Sciences, 132:327-346 (2013).

Wetmore, B. A., Wambaugh, J. F., Allen, B., Ferguson, S. S., Sochaski, M. A., Setzer, R. W., Houck, K. A., Strope, C. L., Cantwell, K., Judson, R. S., LeCluyse, E., Clewell, H.J. III, Thomas, R.S., and Andersen, M. E. (2015). "Incorporating High-Throughput Exposure Predictions with Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing" Toxicological Sciences, kfv171.

Examples

```
table <- NULL
for(this.cas in sample(get_lit_cheminfo(),50)) table <- rbind(table,cbind(
as.data.frame(this.cas),as.data.frame(get_lit_oral_equiv(conc=1,chem.cas=this.cas))))
```

```
get_lit_oral_equiv(0.1,chem.cas="34256-82-1")
```

```
get_lit_oral_equiv(0.1,chem.cas="34256-82-1",which.quantile=c(0.05,0.5,0.95))
```

get_physchem_param	<i>Get physico-chemical parameters from chem.physical_and_invitro.data</i>
--------------------	--

Description

This function retrieves physico-chemical properties ("param") for the chemical specified by chem.name or chem.cas from the vLiver tables.

Usage

```
get_physchem_param(param, chem.name = NULL, chem.cas = NULL, dtxsid = NULL)
```

Arguments

param	The desired parameters, a vector or single value.
chem.name	The chemical names that you want parameters for, a vector or single value
chem.cas	The chemical CAS numbers that you want parameters for, a vector or single value
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs

Value

The paramters, either a single value, a named list for a single chemical, or a list of lists

Author(s)

John Wambaugh and Robert Pearce

Examples

```
get_physchem_param(param = 'logP', chem.cas = '80-05-7')
get_physchem_param(param = c('logP', 'MW'), chem.cas = c('80-05-7', '81-81-2'))
```

get_rblood2plasma	<i>Get ratio of the blood concentration to the plasma concentration.</i>
-------------------	--

Description

This function attempts to retrieve a measured species- and chemical-specific blood:plasma concentration ratio.

Usage

```
get_rblood2plasma(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  species = "Human",
  default.to.human = F
)
```

Arguments

chem.name	Either the chemical name or the CAS number must be specified.
chem.cas	Either the CAS number or the chemical name must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing animal values with human values if true.

Details

A value of NA is returned when the requested value is unavailable. Values are retrieved from chem.physical_and_invitro.data. details than the description above ~~

Author(s)

Robert Pearce

Examples

```
get_rblood2plasma(chem.name="Bisphenol A")  
get_rblood2plasma(chem.name="Bisphenol A",species="Rat")
```

get_weight_class	<i>Given vectors of age, BMI, recumbent length, weight, and gender, categorizes weight classes using CDC and WHO categories.</i>
------------------	--

Description

Given vectors of age, BMI, recumbent length, weight, and gender, categorizes weight classes using CDC and WHO categories.

Usage

```
get_weight_class(age_years, age_months, bmi, recumlen, weight, gender)
```

Arguments

age_years	A vector of ages in years.
age_months	A vector of ages in months.
bmi	A vector of BMIs.
recumlen	A vector of heights or recumbent lengths in cm.
weight	A vector of body weights in kg.
gender	A vector of genders (as 'Male' or 'Female').

Value

A character vector of weight classes. Each element will be one of 'Underweight', 'Normal', 'Overweight', or 'Obese'.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

hematocrit_infants	<i>Predict hematocrit in infants under 1 year old.</i>
--------------------	--

Description

For infants under 1 year, hematocrit was not measured in NHANES. Assume a log-normal distribution where plus/minus 1 standard deviation of the underlying normal distribution is given by the reference range. Draw hematocrit values from these distributions by age.

Usage

```
hematocrit_infants(age_months)
```

Arguments

age_months	Vector of ages in months; all must be <= 12.
------------	--

Details

Age	Reference range
<1 month	31-49
1-6 months	29-42
7-12 months	33-38

Value

Vector of hematocrit percentages corresponding to the input vector of ages.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

honda.ivive	<i>Return the assumptions used in Honda et al. 2019</i>
-------------	---

Description

This function returns four of the better performing sets of assumptions evaluated in Honda et al. 2019 (<https://doi.org/10.1371/journal.pone.0217564>). These include four different combinations of hepatic clearance assumption, in vivo bioactivity assumption, and relevant tissue assumption. Generally, this function is not called directly by the user, but instead called by setting the IVIVE option in `calc_mc_oral_equiv`, `calc_mc_css`, and `calc_analytic` functions. Currently, these IVIVE option is not implemented the `solve_1comp` etc. functions.

Usage

```
honda.ivive(method = "Honda1", tissue = "liver")
```

Arguments

method	This is set to one of "Honda1", "Honda2", "Honda3", or "Honda4".
tissue	This is only relevant to "Honda4" and indicates the relevant tissue compartment.

Details

"Honda1" - tissue = NULL, restrictive.clearance = TRUE, bioactive.free.invivo = TRUE This assumption assumes restrictive hepatic clearance, and treats the free concentration in plasma as the bioactive concentration in vivo. This option must be used in combination with the concentration in vitro predicted by `armitage_eval()`, otherwise the result will be the same as "Honda2". This option corresponds to the result in Figure 8 panel c) restrictive, mean free plasma conc., Armitage in Honda et al. 2019. "Honda2" - tissue = NULL, restrictive.clearance = TRUE, bioactive.free.invivo = TRUE This assumption assumes restrictive hepatic clearance, and treats the free concentration in plasma as the bioactive concentration in vivo. This option corresponds to the result in Figure 8 panel b) restrictive, mean free plasma conc. in Honda et al. 2019. "Honda3" - tissue = NULL, restrictive.clearance = TRUE, bioactive.free.invivo = TRUE This assumption assumes restrictive hepatic clearance, and treats the free concentration in plasma as the bioactive concentration in vivo. This option corresponds to the result in Figure 8 panel a) restrictive, mean total plasma conc. in Honda et al. 2019. "Honda4" - tissue = tissue, restrictive.clearance = FALSE, bioactive.free.invivo = TRUE This assumption assumes restrictive hepatic clearance, and treats the free concentration in plasma as the bioactive concentration in vivo. The input tissue should be relevant to the in vitro assay endpoint used as input or that the result is being compared to. This option corresponds to the result in Figure 8 panel d) nonrestrictive, mean tissue conc. in Honda et al. 2019.

Value

A list of tissue, bioactive.free.invivo, and restrictive.clearance assumptions.

Author(s)

Greg Honda and John Wambaugh

References

Honda, Gregory S., et al. "Using the Concordance of In Vitro and In Vivo Data to Evaluate Extrapolation Assumptions." 2019. PLoS ONE 14(5): e0217564.

Examples

```
honda.ivive(method = "Honda1", tissue = NULL)
```

howgate

Howgate 2006

Description

This data set is only used in Vignette 5.

Usage

howgate

Format

A data.table containing 24 rows and 11 columns.

Author(s)

Caroline Ring

References

Howgate, E. M., et al. "Prediction of in vivo drug clearance from in vitro data. I: impact of inter-individual variability." *Xenobiotica* 36.6 (2006): 473-497.

httkpop

httkpop: Virtual population generator for HTTK.

Description

The httkpop package generates virtual population physiologies for use in population TK.

Main function to generate a population

If you just want to generate a table of (chemical-independent) population physiology parameters, use [httkpop_generate](#).

Using HTTK-Pop with HTTK

To generate a population and then run an HTTK model for that population, the workflow is as follows:

1. Generate a population using [httkpop_generate](#).
2. For a given HTTK chemical and general model, convert the population data to corresponding sets of HTTK model parameters using [httkpop_mc](#).

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

httkpop_biotophys_default

Convert HTTK-Pop-generated parameters to HTTK physiological parameters

Description

Convert HTTK-Pop-generated parameters to HTTK physiological parameters

Usage

```
httkpop_biotophys_default(indiv_dt)
```

Arguments

indiv_dt The data.table object returned by httkpop_generate()

Value

A data.table with the physiological parameters expected by any HTTK model, including body weight (BW), hematocrit, tissue volumes per kg body weight, tissue flows as fraction of CO, CO per (kg BW)^{3/4}, GFR per (kg BW)^{3/4}, portal vein flow per (kg BW)^{3/4}, and liver density.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

httkpop_direct_resample

Generate a virtual population by directly resampling the NHANES data.

Description

Generate a virtual population by directly resampling the NHANES data.

Usage

```
httkpop_direct_resample(
  nsamp = NULL,
  gendernum = NULL,
  agelim_years = NULL,
  agelim_months = NULL,
  weight_category = c("Underweight", "Normal", "Overweight", "Obese"),
  gfr_category = c("Normal", "Kidney Disease", "Kidney Failure"),
```

```

reths = c("Mexican American", "Other Hispanic", "Non-Hispanic White",
          "Non-Hispanic Black", "Other")
)

```

Arguments

nsamp	The desired number of individuals in the virtual population. nsamp need not be provided if gendernum is provided.
gendernum	Optional: A named list giving the numbers of male and female individuals to include in the population, e.g. <code>list(Male=100,Female=100)</code> . Default is NULL, meaning both males and females are included, in their proportions in the NHANES data. If both nsamp and gendernum are provided, they must agree (i.e., nsamp must be the sum of gendernum).
agelim_years	Optional: A two-element numeric vector giving the minimum and maximum ages (in years) to include in the population. Default is <code>c(0,79)</code> . If agelim_years is provided and agelim_months is not, agelim_years will override the default value of agelim_months.
agelim_months	Optional: A two-element numeric vector giving the minimum and maximum ages (in months) to include in the population. Default is <code>c(0, 959)</code> , equivalent to the default agelim_years. If agelim_months is provided and agelim_years is not, agelim_months will override the default values of agelim_years.
weight_category	Optional: The weight categories to include in the population. Default is <code>c('Underweight', 'Normal')</code> . User-supplied vector must contain one or more of these strings.
gfr_category	The kidney function categories to include in the population. Default is <code>c('Normal', 'Kidney Disease', 'Kidney Failure')</code> to include all kidney function levels.
reths	Optional: a character vector giving the races/ethnicities to include in the population. Default is <code>c('Mexican American', 'Other Hispanic', 'Non-Hispanic White', 'Non-Hispanic Black', 'Other')</code> , to include all races and ethnicities in their proportions in the NHANES data. User-supplied vector must contain one or more of these strings.

Value

A data.table where each row represents an individual, and each column represents a demographic, anthropometric, or physiological parameter.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

httkpop_direct_resample_inner

Inner loop function called by httkpop_direct_resample.

Description

Inner loop function called by httkpop_direct_resample.

Usage

```
httkpop_direct_resample_inner(
  nsamp,
  gendernum,
  agelim_months,
  agelim_years,
  reths,
  weight_category
)
```

Arguments

- | | |
|-----------------|---|
| nsamp | The desired number of individuals in the virtual population. nsamp need not be provided if gendernum is provided. |
| gendernum | Optional: A named list giving the numbers of male and female individuals to include in the population, e.g. <code>list(Male=100,Female=100)</code> . Default is NULL, meaning both males and females are included, in their proportions in the NHANES data. If both nsamp and gendernum are provided, they must agree (i.e., nsamp must be the sum of gendernum). |
| agelim_months | Optional: A two-element numeric vector giving the minimum and maximum ages (in months) to include in the population. Default is <code>c(0, 959)</code> , equivalent to the default agelim_years. If agelim_months is provided and agelim_years is not, agelim_months will override the default values of agelim_years. |
| agelim_years | Optional: A two-element numeric vector giving the minimum and maximum ages (in years) to include in the population. Default is <code>c(0,79)</code> . If agelim_years is provided and agelim_months is not, agelim_years will override the default value of agelim_months. |
| reths | Optional: a character vector giving the races/ethnicities to include in the population. Default is <code>c('Mexican American', 'Other Hispanic', 'Non-Hispanic White', 'Non-Hispanic Black', 'Other')</code> , to include all races and ethnicities in their proportions in the NHANES data. User-supplied vector must contain one or more of these strings. |
| weight_category | Optional: The weight categories to include in the population. Default is <code>c('Underweight', 'Normal')</code> . User-supplied vector must contain one or more of these strings. |

Value

A data.table where each row represents an individual, and each column represents a demographic, anthropometric, or physiological parameter.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

httkpop_generate	<i>Generate a virtual population</i>
------------------	--------------------------------------

Description

Generate a virtual population

Usage

```
httkpop_generate(
  method,
  nsamp = NULL,
  gendernum = NULL,
  agelim_years = NULL,
  agelim_months = NULL,
  weight_category = c("Underweight", "Normal", "Overweight", "Obese"),
  gfr_category = c("Normal", "Kidney Disease", "Kidney Failure"),
  reths = c("Mexican American", "Other Hispanic", "Non-Hispanic White",
            "Non-Hispanic Black", "Other")
)
```

Arguments

method	The population-generation method to use. Either "virtual individuals" or "direct resampling." Short names may be used: "d" or "dr" for "direct resampling", and "v" or "vi" for "virtual individuals".
nsamp	The desired number of individuals in the virtual population. nsamp need not be provided if gendernum is provided.
gendernum	Optional: A named list giving the numbers of male and female individuals to include in the population, e.g. <code>list(Male=100,Female=100)</code> . Default is NULL, meaning both males and females are included, in their proportions in the NHANES data. If both nsamp and gendernum are provided, they must agree (i.e., nsamp must be the sum of gendernum).
agelim_years	Optional: A two-element numeric vector giving the minimum and maximum ages (in years) to include in the population. Default is <code>c(0,79)</code> . If only a single value is provided, both minimum and maximum ages will be set to that value; e.g. <code>agelim_years=3</code> is equivalent to <code>agelim_years=c(3,3)</code> . If <code>agelim_years</code> is provided and <code>agelim_months</code> is not, <code>agelim_years</code> will override the default value of <code>agelim_months</code> .

agelim_months	Optional: A two-element numeric vector giving the minimum and maximum ages (in months) to include in the population. Default is c(0, 959), equivalent to the default agelim_years. If only a single value is provided, both minimum and maximum ages will be set to that value; e.g. agelim_months=36 is equivalent to agelim_months=c(36, 36). If agelim_months is provided and agelim_years is not, agelim_months will override the default values of agelim_years.
weight_category	Optional: The weight categories to include in the population. Default is c('Underweight', 'Normal'). User-supplied vector must contain one or more of these strings.
gfr_category	The kidney function categories to include in the population. Default is c('Normal', 'Kidney Disease', 'Kidney Failure') to include all kidney function levels.
reths	Optional: a character vector giving the races/ethnicities to include in the population. Default is c('Mexican American', 'Other Hispanic', 'Non-Hispanic White', 'Non-Hispanic Black', 'Other'), to include all races and ethnicities in their proportions in the NHANES data. User-supplied vector must contain one or more of these strings.

Value

A data.table where each row represents an individual, and each column represents a demographic, anthropometric, or physiological parameter.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

Examples

```
## Not run:
##Simply generate a virtual population of 100 individuals,
##using the direct-resampling method
set.seed(42)
httkpop_generate(method='direct resampling', nsamp=100)
#Generate a population using the virtual-individuals method,
#include 80 females and 20 males,
#include only ages 20-65,
#include only Mexican American and
#Non-Hispanic Black individuals,
#include only non-obese individuals
httkpop_generate(method = 'virtual individuals',
gendernum=list(Female=80,
Male=20),
agelim_years=c(20,65),
reths=c('Mexican American',
'Non-Hispanic Black'),
weight_category=c('Underweight',
'Normal',
'Overweight'))
```

```
## End(Not run)
```

httkpop_mc	<i>Converts the HTTK-Pop population data table to a table of the parameters needed by HTTK, for a specific chemical.</i>
------------	--

Description

Takes the data table generated by [httkpop_generate](#), and converts it to the corresponding table of HTTK model parameters for a specified chemical and HTTK model.

Usage

```
httkpop_mc(model, samples = 1000, httkpop.dt = NULL, ...)
```

Arguments

model	One of the HTTK models: "1compartment", "3compartmentss", "3compartment", or "pbtk".
samples	The number of Monte Carlo samples to use (can often think of these as separate individuals)
httkpop.dt	A data table generated by httkpop_generate . This defaults to NULL, in which case httkpop_generate is called to generate this table.
...	Additional arguments passed on to httkpop_generate .

Author(s)

Caroline Ring and John Wambaugh

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

Rowland, Malcolm, Leslie Z. Benet, and Garry G. Graham. "Clearance concepts in pharmacokinetics." *Journal of Pharmacokinetics and Biopharmaceutics* 1.2 (1973): 123-136.

Examples

```
set.seed(42)
indiv_examp <- httkpop_generate(method="d", nsamp=100)
httk_param <- httkpop_mc(httkpop.dt=indiv_examp,
model="1compartment")
```

httkpop_virtual_indiv *Generate a virtual population by the virtual individuals method.*

Description

Generate a virtual population by the virtual individuals method.

Usage

```
httkpop_virtual_indiv(
  nsamp = NULL,
  gendernum = NULL,
  agelim_years = NULL,
  agelim_months = NULL,
  weight_category = c("Underweight", "Normal", "Overweight", "Obese"),
  gfr_category = c("Normal", "Kidney Disease", "Kidney Failure"),
  reths = c("Mexican American", "Other Hispanic", "Non-Hispanic White",
            "Non-Hispanic Black", "Other")
)
```

Arguments

nsamp	The desired number of individuals in the virtual population. nsamp need not be provided if gendernum is provided.
gendernum	Optional: A named list giving the numbers of male and female individuals to include in the population, e.g. <code>list(Male=100,Female=100)</code> . Default is NULL, meaning both males and females are included, in their proportions in the NHANES data. If both nsamp and gendernum are provided, they must agree (i.e., nsamp must be the sum of gendernum).
agelim_years	Optional: A two-element numeric vector giving the minimum and maximum ages (in years) to include in the population. Default is <code>c(0,79)</code> . If agelim_years is provided and agelim_months is not, agelim_years will override the default value of agelim_months.
agelim_months	Optional: A two-element numeric vector giving the minimum and maximum ages (in months) to include in the population. Default is <code>c(0, 959)</code> , equivalent to the default agelim_years. If agelim_months is provided and agelim_years is not, agelim_months will override the default values of agelim_years.
weight_category	Optional: The weight categories to include in the population. Default is <code>c('Underweight', 'Normal')</code> . User-supplied vector must contain one or more of these strings.
gfr_category	The kidney function categories to include in the population. Default is <code>c('Normal', 'Kidney Disease', 'Kidney Failure')</code> to include all kidney function levels.
reths	Optional: a character vector giving the races/ethnicities to include in the population. Default is <code>c('Mexican American', 'Other Hispanic', 'Non-Hispanic White', 'Non-Hispanic Black', 'Other')</code> , to include all races and ethnicities in their proportions in the NHANES data. User-supplied vector must contain one or more of these strings.

Value

A data.table where each row represents an individual, and each column represents a demographic, anthropometric, or physiological parameter.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

in.list	<i>Convenience Boolean (yes/no) functions to identify chemical membership in several key lists.</i>
---------	---

Description

These functions allow easy identification of whether or not a chemical CAS is included in various research projects. While it is our intent to keep these lists up-to-date, the information here is only for convenience and should not be considered to be definitive.

Usage

```
in.list(chem.cas = NULL, which.list = "ToxCast")
```

Arguments

chem.cas	The Chemical Abstracts Service Registry Number (CAS-RN) corresponding to the chemical of interest.
which.list	A character string that can take the following values: "ToxCast", "Tox21", "ExpoCast", "NHANES", ""NHANES.serum.parent", "NHANES.serum.analyte", "NHANES.blood.parent", "NHANES.urine.parent", "NHANES.urine.analyte"

Details

Tox21: Toxicology in the 21st Century (Tox21) is a U.S. federal High Throughput Screening (HTS) collaboration among EPA, NIH, including National Center for Advancing Translational Sciences and the National Toxicology Program at the National Institute of Environmental Health Sciences, and the Food and Drug Administration. (Bucher et al., 2008)

ToxCast: The Toxicity Forecaster (ToxCast) is a HTS screening project led by the U.S. EPA to perform additional testing of a subset of Tox21 chemicals. (Judson et al. 2010)

ExpoCast: ExpoCast (Exposure Forecaster) is an U.S. EPA research project to generate tentative exposure estimates (e.g., mg/kg BW/day) for thousands of chemicals that have little other information using models and informatics. (Wambaugh et al. 2014)

NHANES: The U.S. Centers for Disease Control (CDC) National Health and Nutrition Examination Survey (NHANES) is an on-going survey to characterize the health and biometrics (e.g., weight, height) of the U.S. population. One set of measurements includes the quantification of xenobiotic chemicals in various samples (blood, serum, urine) of the thousands of surveyed individuals. (CDC, 2014)

Value

logical A Boolean (1/0) value that is TRUE if the chemical is in the list.

Author(s)

John Wambaugh

References

Bucher, J. R. (2008). Guest Editorial: NTP: New Initiatives, New Alignment. *Environ Health Perspect* 116(1).

Judson, R. S., Houck, K. A., Kavlock, R. J., Knudsen, T. B., Martin, M. T., Mortensen, H. M., Reif, D. M., Rotroff, D. M., Shah, I., Richard, A. M. and Dix, D. J. (2010). In Vitro Screening of Environmental Chemicals for Targeted Testing Prioritization: The ToxCast Project. *Environmental Health Perspectives* 118(4), 485-492.

Wambaugh, J. F., Wang, A., Dionisio, K. L., Frame, A., Egeghy, P., Judson, R. and Setzer, R. W. (2014). High Throughput Heuristics for Prioritizing Human Exposure to Environmental Chemicals. *Environmental Science & Technology*, 10.1021/es503583j.

CDC (2014). National Health and Nutrition Examination Survey. Available at: <http://www.cdc.gov/nchs/nhanes.htm>.

See Also

[is.httk](#) for determining inclusion in httk project

Examples

```
httk.table <- get_cheminfo(info=c("CAS","Compound"))
httk.table[, "Rat"] <- ""
httk.table[, "NHANES"] <- ""
httk.table[, "Tox21"] <- ""
httk.table[, "ToxCast"] <- ""
httk.table[, "ExpoCast"] <- ""
httk.table[, "PBTk"] <- ""
# To make this example run quickly, this loop is only over the first ten
# chemicals. To build a table with all available chemicals use:
# for (this.cas in httk.table$CAS)
for (this.cas in httk.table$CAS[1:10])
{
  this.index <- httk.table$CAS==this.cas
  if (is.nhanes(this.cas)) httk.table[this.index, "NHANES"] <- "Y"
  if (is.tox21(this.cas)) httk.table[this.index, "Tox21"] <- "Y"
  if (is.toxcast(this.cas)) httk.table[this.index, "ToxCast"] <- "Y"
  if (is.expcast(this.cas)) httk.table[this.index, "ExpoCast"] <- "Y"
  if (is.httk(this.cas, model="PBTk")) httk.table[this.index, "PBTk"] <- "Y"
  if (is.httk(this.cas, species="rat")) httk.table[this.index, "Rat"] <- "Y"
}
```

 invitro_mc

Draw in vitro TK parameters including uncertainty and variability.

Description

Given a CAS in the HHTK data set, a virtual population from HHTK-Pop, some user specifications on the assumed distributions of Funbound.plasma and Clint, draw "individual" values of Funbound.plasma and Clint from those distributions.

Usage

```
invitro_mc(
  parameters.dt = NULL,
  samples,
  fup.meas.cv = 0.4,
  clint.meas.cv = 0.3,
  fup.pop.cv = 0.3,
  clint.pop.cv = 0.3,
  poormetab = TRUE,
  fup.lod = 0.01,
  fup.censored.dist = FALSE,
  adjusted.Funbound.plasma = T,
  clint.pvalue.threshold = 0.05,
  minimum.Funbound.plasma = 1e-04
)
```

Arguments

parameters.dt	A data table of physiological parameters
samples	The number of samples to draw.
fup.meas.cv	Coefficient of variation of distribution of measured Funbound.plasma values.
clint.meas.cv	Coefficient of variation of distribution of measured Clint values.
fup.pop.cv	Coefficient of variation of distribution of population Funbound.plasma values.
clint.pop.cv	Coefficient of variation of distribution of population Clint values.
poormetab	Logical. Whether to include poor metabolizers in the Clint distribution or not.
fup.lod	The average limit of detection for Funbound.plasma, below which distribution will be censored if fup.censored.dist is TRUE. Default 0.01.
fup.censored.dist	Logical. Whether to draw Funbound.plasma from a censored distribution or not.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE.
clint.pvalue.threshold	Hepatic clearance for chemicals where the in vitro clearance assay result has a p-values greater than the threshold are set to zero.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).
parameters	A list of chemical-specific model parameters containing at least Funbound.plasma, Clint, and Fhep.assay.correction.

Value

A data.table with three columns: `Funbound.plasma` and `Clint`, containing the sampled values, and `Fhep.assay.correction`, containing the value for fraction unbound in hepatocyte assay.

Author(s)

Caroline Ring and John Wambaugh

References

Wambaugh, John F., et al. "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization." *Toxicological Sciences* (2019).

is.httk

Convenience Boolean (yes/no) function to identify chemical membership and treatment within the httk project.

Description

Allows easy identification of whether or not a chemical CAS is included in various aspects of the httk research project (by model type and species of interest). While it is our intent to keep these lists up-to-date, the information here is only for convenience and should not be considered definitive.

Usage

```
is.httk(chem.cas, species = "Human", model = "3compartmentss")
```

Arguments

<code>chem.cas</code>	The Chemical Abstracts Service Registry Number (CAS-RN) corresponding to the chemical of interest.
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
<code>model</code>	Model used in calculation, 'pbtk' for the multiple compartment model, '1compartment' for the one compartment model, '3compartment' for three compartment model, '3compartmentss' for the three compartment model without partition coefficients, or 'schmitt' for chemicals with logP and fraction unbound (used in <code>predict_partitioning_schmitt</code>).

Details

Tox21: Toxicology in the 21st Century (Tox21) is a U.S. federal High Throughput Screening (HTS) collaboration among EPA, NIH, including National Center for Advancing Translational Sciences and the National Toxicology Program at the National Institute of Environmental Health Sciences, and the Food and Drug Administration. (Bucher et al., 2008)

ToxCast: The Toxicity Forecaster (ToxCast) is a HTS screening project led by the U.S. EPA to perform additional testing of a subset of Tox21 chemicals. (Judson et al. 2010)

ExpoCast: ExpoCast (Exposure Forecaster) is an U.S. EPA research project to generate tentative exposure estimates (e.g., mg/kg BW/day) for thousands of chemicals that have little other information using models and informatics. (Wambaugh et al. 2014)

NHANES: The U.S. Centers for Disease Control (CDC) National Health and Nutrition Examination Survey (NHANES) is an on-going survey to characterize the health and biometrics (e.g., weight, height) of the U.S. population. One set of measurements includes the quantification of xenobiotic chemicals in various samples (blood, serum, urine) of the thousands of surveyed individuals. (CDC, 2014)

Value

logical A Boolean (1/0) value that is TRUE if the chemical is included in the httk project with a given modeling scheme (PBTk) and a given species

Author(s)

John Wambaugh

References

Bucher, J. R. (2008). Guest Editorial: NTP: New Initiatives, New Alignment. Environ Health Perspect 116(1).

Judson, R. S., Houck, K. A., Kavlock, R. J., Knudsen, T. B., Martin, M. T., Mortensen, H. M., Reif, D. M., Rotroff, D. M., Shah, I., Richard, A. M. and Dix, D. J. (2010). In Vitro Screening of Environmental Chemicals for Targeted Testing Prioritization: The ToxCast Project. Environmental Health Perspectives 118(4), 485-492.

Wambaugh, J. F., Wang, A., Dionisio, K. L., Frame, A., Egeghy, P., Judson, R. and Setzer, R. W. (2014). High Throughput Heuristics for Prioritizing Human Exposure to Environmental Chemicals. Environmental Science & Technology, 10.1021/es503583j.

CDC (2014). National Health and Nutrition Examination Survey. Available at: <http://www.cdc.gov/nchs/nhanes.htm>.

See Also

[in.list](#) for determining chemical membership in several other key lists

Examples

```
httk.table <- get_cheminfo(info=c("CAS", "Compound"))
httk.table[, "Rat"] <- ""
httk.table[, "NHANES"] <- ""
httk.table[, "Tox21"] <- ""
httk.table[, "ToxCast"] <- ""
httk.table[, "ExpoCast"] <- ""
httk.table[, "PBTk"] <- ""
# To make this example run quickly, this loop is only over the first ten
# chemicals. To build a table with all available chemicals use:
# for (this.cas in httk.table$CAS)
for (this.cas in httk.table$CAS[1:10])
{
  this.index <- httk.table$CAS==this.cas
  if (is.nhanes(this.cas)) httk.table[this.index, "NHANES"] <- "Y"
  if (is.tox21(this.cas)) httk.table[this.index, "Tox21"] <- "Y"
  if (is.toxcast(this.cas)) httk.table[this.index, "ToxCast"] <- "Y"
  if (is.expocast(this.cas)) httk.table[this.index, "ExpoCast"] <- "Y"
  if (is.httk(this.cas, model="PBTk")) httk.table[this.index, "PBTk"] <- "Y"
  if (is.httk(this.cas, species="rat")) httk.table[this.index, "Rat"] <- "Y"
}
```

is_in_inclusive	<i>Checks whether a value, or all values in a vector, is within inclusive limits</i>
-----------------	--

Description

Checks whether a value, or all values in a vector, is within inclusive limits

Usage

```
is_in_inclusive(x, lims)
```

Arguments

x	A numeric value, or vector of values.
lims	A two-element vector of (min, max) values for the inclusive limits. If x is a vector, lims may also be a two-column matrix with nrow=length(x) where the first column is lower limits and the second column is upper limits. If x is a vector and lims is a two-element vector, then each element of x will be checked against the same limits. If x is a vector and lims is a matrix, then each element of x will be checked against the limits given by the corresponding row of lims.

Value

A logical vector the same length as x, indicating whether each element of x is within the inclusive limits given by lims.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

johnson	<i>Johnson 2006</i>
---------	---------------------

Description

This data set is only used in Vignette 5.

Usage

```
johnson
```

Format

A data.table containing 60 rows and 11 columns.

Author(s)

Caroline Ring

References

Johnson, Trevor N., Amin Rostami-Hodjegan, and Geoffrey T. Tucker. "Prediction of the clearance of eleven drugs and associated variability in neonates, infants and children." *Clinical pharmacokinetics* 45.9 (2006): 931-956.

kidney_mass_children *Predict kidney mass for children*

Description

For individuals under age 18, predict kidney mass from weight, height, and gender. using equations from Ogiu et al. 1997

Usage

```
kidney_mass_children(weight, height, gender)
```

Arguments

weight	Vector of weights in kg.
height	Vector of heights in cm.
gender	Vector of genders (either 'Male' or 'Female').

Value

A vector of kidney masses in kg.

Author(s)

Caroline Ring

References

Ogiu, Nobuko, et al. "A statistical analysis of the internal organ weights of normal Japanese people." *Health physics* 72.3 (1997): 368-383.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

liver_mass_children	<i>Predict liver mass for children</i>
---------------------	--

Description

For individuals under 18, predict the liver mass from height, weight, and gender, using equations from Ogiu et al. 1997

Usage

```
liver_mass_children(height, weight, gender)
```

Arguments

height	Vector of heights in cm.
weight	Vector of weights in kg.
gender	Vector of genders (either 'Male' or 'Female').

Value

A vector of liver masses in kg.

Author(s)

Caroline Ring

References

Ogiu, Nobuko, et al. "A statistical analysis of the internal organ weights of normal Japanese people." Health physics 72.3 (1997): 368-383.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

load_sipes2017	<i>Load data from Sipes et al 2017.</i>
----------------	---

Description

This function returns an updated version of chem.physical_and_invitro.data that includes data predicted with Simulations Plus' ADMET predictor that was used in Sipes et al. 2017, included in admet.data.

Usage

```
load_sipes2017(overwrite = F, target.env = .GlobalEnv)
```

Arguments

<code>overwrite</code>	Only matters if <code>load.image=FALSE</code> . If <code>overwrite=TRUE</code> then existing data in <code>chem.physical_and_invitro.data</code> will be replaced by any data/predictions in Sipes et al. (2017) that is for the same chemical and property. If <code>overwrite=FALSE</code> (DEFAULT) then new data for the same chemical and property are ignored. Funbound.plasma values of 0 (below limit of detection) are overwritten either way.
<code>target.env</code>	The environment where the new <code>chem.physical_and_invitro.data</code> is loaded. Defaults to global environment.

Value

<code>data.frame</code>	An updated version of <code>chem.physical_and_invitro.data</code> .
-------------------------	---

Author(s)

Robert Pearce and John Wambaugh

References

Sipes, Nisha S., et al. "An intuitive approach for predicting potential human health risk with the Tox21 10k library." *Environmental Science & Technology* 51.18 (2017): 10786-10796.

Examples

```
## Not run:
chem.physical_and_invitro.data <- load_sipes2017()
chem.physical_and_invitro.data <- load_sipes2017(overwrite=T)

## End(Not run)
```

<code>lump_tissues</code>	<i>Lump tissue parameters</i>
---------------------------	-------------------------------

Description

This function takes the parameters from `predict_partitioning_schmitt` and lumps the partition coefficients along with the volumes and flows based on the given tissue list. It is useful in Monte Carlo simulation of individual partition coefficients when calculating the rest of body partition coefficient.

Usage

```
lump_tissues(
  Ktissue2pu.in,
  parameters = NULL,
  tissuelist = NULL,
  species = "Human",
  tissue.vols = NULL,
  tissue.flows = NULL
)
```

Arguments

<code>Ktissue2pu.in</code>	List of partition coefficients from <code>predict_partitioning_schmitt</code> .
<code>parameters</code>	A list of physiological parameters including flows and volumes for tissues in <code>tissuelist</code>
<code>tissuelist</code>	Specifies compartment names and tissues groupings. Remaining tissues in <code>tissue.data</code> are lumped in the rest of the body.
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
<code>tissue.vols</code>	A list of volumes for tissues in <code>tissuelist</code>
<code>tissue.flows</code>	A list of flows for tissues in <code>tissuelist</code>

Details

This function returns the flows, volumes, and partition coefficients for the lumped tissues specified in tissue list `Ktissue2plasma` – tissue to free plasma concentration partition coefficients for every tissue specified by Schmitt (2008) (the `tissue.data` table) `tissuelist` – a list of character vectors, the name of each entry in the list is a lumped tissue, the words in the vector are the Schmitt (2008) tissues that are to be lumped, for example: `tissuelist<-list(Rapid=c("Brain","Kidney"))` `species` specifies the `flow.col` and `vol.col` in the `tissuedata.table`

Value

<code>Krbc2pu</code>	Ratio of concentration of chemical in red blood cells to unbound concentration in plasma.
<code>Krest2pu</code>	Ratio of concentration of chemical in rest of body tissue to unbound concentration in plasma.
<code>Vrestc</code>	Volume of the rest of the body per kg body weight, L/kg BW.
<code>Vliverc</code>	Volume of the liver per kg body weight, L/kg BW.
<code>Qtotall.liverf</code>	Fraction of cardiac output flowing to the gut and liver, i.e. out of the liver.
<code>Qgutf</code>	Fraction of cardiac output flowing to the gut.
<code>Qkidneyf</code>	Fraction of cardiac output flowing to the kidneys.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Examples

```
pcs <- predict_partitioning_schmitt(chem.name='bisphenola')
tissuelist <- list(liver=c("liver"),kidney=c("kidney"),lung=c("lung"),gut=c("gut"),
,muscle.bone=c('muscle','bone'))
lump_tissues(pcs,tissuelist=tissuelist)
```

lung_mass_children	<i>Predict lung mass for children</i>
--------------------	---------------------------------------

Description

For individuals under 18, predict the liver mass from height, weight, and gender, using equations from Ogiu et al. 1997

Usage

```
lung_mass_children(height, weight, gender)
```

Arguments

height	Vector of heights in cm.
weight	Vector of weights in kg.
gender	Vector of genders (either 'Male' or 'Female').

Value

A vector of lung masses in kg.

Author(s)

Caroline Ring

References

Ogiu, Nobuko, et al. "A statistical analysis of the internal organ weights of normal Japanese people." *Health physics* 72.3 (1997): 368-383.

Price, Paul S., et al. "Modeling interindividual variation in physiological factors used in PBPK models of humans." *Critical reviews in toxicology* 33.5 (2003): 469-503.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

mcnally_dt	<i>Reference tissue masses and flows from tables in McNally et al. 2014.</i>
------------	--

Description

Reference tissue masses, flows, and marginal distributions from McNally et al. 2014.

Usage

```
mcnally_dt
```


Format

A data.table with variables:

tissue Body tissue

gender Gender: Male or Female

mass_ref Reference mass in kg, from Reference Man

mass_cv Coefficient of variation for mass

mass_dist Distribution for mass: Normal or Log-normal

flow_ref Reference flow in L/h, from Reference Man

flow_cv Coefficient of variation for flow (all normally distributed)

height_ref Reference heights (by gender)

CO_ref Reference cardiac output by gender

flow_frac Fraction of CO flowing to each tissue: flow_ref/CO_ref

Author(s)

Caroline Ring

Source

McNally K, Cotton R, Hogg A, Loizou G. "PopGen: A virtual human population generator." Toxicology 315, 70-85, 2004.

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

metabolism_data_Linakis2020

Metabolism data involved in Linakis 2020 vignette analysis.

Description

Metabolism data involved in Linakis 2020 vignette analysis.

Usage

metabolism_data_Linakis2020

Format

A data.frame containing x rows and y columns.

Author(s)

Matt Linakis

Source

Matt Linakis

References

DSStox database ([http:// www.epa.gov/ncct/dsstox](http://www.epa.gov/ncct/dsstox))

monte_carlo

Monte Carlo for pharmacokinetic models

Description

This function performs Monte Carlo to assess uncertainty and variability for toxicokinetic models.

Usage

```
monte_carlo(
  parameters,
  cv.params = NULL,
  censored.params = NULL,
  samples = 1000
)
```

Arguments

- | | |
|-----------------|---|
| parameters | These parameters that are also listed in either cv.params or censored.params are sampled using Monte Carlo. |
| cv.params | The parameters listed in cv.params are sampled from a normal distribution that is truncated at zero. This argument should be a list of coefficients of variation (cv) for the normal distribution. Each entry in the list is named for a parameter in "parameters". New values are sampled with mean equal to the value in "parameters" and standard deviation equal to the mean times the cv. |
| censored.params | The parameters listed in censored.params are sampled from a normal distribution that is censored for values less than the limit of detection (specified separately for each parameter). This argument should be a list of sub-lists. Each sublist is named for a parameter in "params" and contains two elements: "cv" (coefficient of variation) and "LOD" (limit of detection), below which parameter values are censored. New values are sampled with mean equal to the value in "params" and standard deviation equal to the mean times the cv. Censored values are sampled on a uniform distribution between 0 and the limit of detection. |
| samples | This argument is the number of samples to be generated for calculating quantiles. |

Author(s)

John Wambaugh

References

- Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* 147.1 (2015): 55-67.
- Pearce, Robert G., et al. "Httk: R package for high-throughput toxicokinetics." *Journal of statistical software* 79.4 (2017): 1.

Examples

```
#Example from Pearce et al. (2017):
## Not run:
library(ggplot2)
library(scales)
vary.params <- NULL
parameters <- parameterize_pbt(chem.name = "Zoxamide")
for(this.param in names(subset(parameters,
names(parameters) != "Funbound.plasma"))){ vary.parameters[this.param] <- .2
censored.params <- list(Funbound.plasma = list(cv = 0.2, lod = 0.01))
set.seed(1)
out <- monte_carlo(parameters, cv.params = vary.params,
censored.params = censored.params, model = "pbt", suppress.messages = T)
zoxamide <- ggplot(as.data.frame(out), aes(out)) +
geom_histogram(fill="blue", binwidth=1/6) + scale_x_log10() +
ylab("Number of Samples") + xlab("Steady State Concentration (uM)") +
theme(axis.text = element_text(size = 16),
axis.title = element_text(size = 16))
print(zoxamide)

# Fig 1 in Wambaugh et al. (2015) SimCYP vs. our predictions:

vary.params <- list(BW=0.3)
vary.parameters[["Vliverc"]]<-0.3
vary.parameters[["Qgfrc"]]<-0.3
vary.parameters[["Qtotall.liverc"]]<-0.3
vary.parameters[["million.cells.per.g liver"]]<-0.3
vary.parameters[["Clint"]]<-0.3
censored.params<-list(Funbound.plasma=list(cv=0.3,lod=0.01))

pValues <- get_cheminfo(c("Compound","CAS","Clint.pValue"))
pValues.rat <- get_cheminfo(c("Compound","CAS","Clint.pValue"),species="Rat")

Wetmore.table <- NULL
for (this.CAS in get_cheminfo(model="3compartmentss")){
  if (this.CAS %in% get_wetmore_cheminfo()){
    print(this.CAS)
    these.params <- parameterize_steadystate(chem.cas=this.CAS)
    if (these.parameters[["Funbound.plasma"]] == 0.0)
    {
      these.parameters[["Funbound.plasma"]] <- 0.005
    }
    these.parameters[["Fhep.assay.correction"]] <- 1
    vLiver.human.values <- monte_carlo(these.params,
cv.params=vary.params,
```

```

                                censored.params=censored.params,
                                output.units="mg/L",
                                model='3compartmentss',
                                suppress.messages=T,
                                well.stirred.correction=F,
                                Funbound.plasma.correction=F)

percentiles <- c("5","50","95")
for (this.index in 1:3)
{
  this.row <- as.data.frame(get_wetmore_css(chem.cas=this.CAS))
  this.row <- cbind(this.row, as.data.frame(vLiver.human.values[this.index]))
  this.row <- cbind(this.row, as.data.frame(percentiles[this.index]))
  this.row <- cbind(this.row, as.data.frame("Human"))
  this.row <- cbind(this.row, as.data.frame(this.CAS))
  this.row <- cbind(this.row, as.data.frame(pValues[pValues$CAS==this.CAS,
                                                "Human.Clint.pValue"]<0.05))
  colnames(this.row) <- c("Wetmore", "Predicted", "Percentile", "Species",
                          "CAS", "Systematic")
  if (is.na(this.row["Systematic"])) this.row["Systematic"] <- F
  Wetmore.table <- rbind(Wetmore.table, this.row)
}
}

scientific_10 <- function(x) {
  out <- gsub("1e", "10^", scientific_format()(x))
  out <- gsub("\\+", "", out)
  out <- gsub("10^01", "10", out)
  out <- parse(text=gsub("10^00", "1", out))
}

Fig1 <- ggplot(Wetmore.table, aes(Predicted, Wetmore, group = CAS)) +
  geom_line() +
  geom_point(aes(colour=factor(Percentile), shape=factor(Percentile))) +
  scale_colour_discrete(name="Percentile") +
  scale_shape_manual(name="Percentile", values=c("5"=21, "50"=22, "95"=24)) +
  scale_x_log10(expression(paste(C[ss], " Predicted (mg/L) with Refined Assumptions")),
                 label=scientific_10) +
  scale_y_log10(expression(paste(C[ss], " Wetmore ", italic("et al."), " (2012) (mg/L)")),
                 label=scientific_10) +
  geom_abline(intercept = 0, slope = 1, linetype="dashed")+
  theme_bw()+
  theme(legend.position="bottom", text = element_text(size=18))

print(Fig1)

Fig1a.fit <- lm(log(Wetmore) ~ log(Predicted)*Percentile, Wetmore.table)
## End(**Not run**)

## End(Not run)

```

Description

NHANES data on demographics, anthropometrics, and some laboratory measures, cleaned and combined into a single data set.

Usage

```
nhanes_mec_svy
```

Format

A `survey.design2` object, including masked cluster and strata. Variables are available as a `data.table` by `nhanes_mec_svy$variables`. Variables are as described in NHANES Demographics and Examination documentation, with the exception of:

`wtmec6yr` 6-year sample weights for combining 3 cycles, computed by dividing 2-year sample weights by 3.

`bmhtlenavg` Average of height and recumbent length if both were measured; if only one was measured, takes value of the one that was measured.

`logbmwt` Natural log of measured body weight.

`logbmhtlenavg` Natural log of `bmhtlenavg`.

`weight_class` One of Underweight, Normal, Overweight, or Obese. Assigned using methods in `get_weight_class`.

Author(s)

Caroline Ring

Source

http://www.cdc.gov/nhanes/nhanes_questionnaires.htm

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

Obach2008

Published Pharmacokinetic Parameters from Obach et al. 2008

Description

This data set is used in Vignette 4 for steady state concentration.

Usage

```
Obach2008
```

Format

A `data.frame` containing 670 rows and 8 columns.

References

Obach, R. Scott, Franco Lombardo, and Nigel J. Waters. "Trend analysis of a database of intravenous pharmacokinetic parameters in humans for 670 drug compounds." *Drug Metabolism and Disposition* 36.7 (2008): 1385-1405.

onlyp	<i>NHANES Exposure Data</i>
-------	-----------------------------

Description

This data set is only used in Vignette 6.

Usage

onlyp

Format

A data.table containing 1060 rows and 5 columns.

Author(s)

Caroline Ring

References

Wambaugh, John F., et al. "High throughput heuristics for prioritizing human exposure to environmental chemicals." *Environmental science & technology* 48.21 (2014): 12760-12767.

pancreas_mass_children	<i>Predict pancreas mass for children</i>
------------------------	---

Description

For individuals under 18, predict the pancreas mass from height, weight, and gender, using equations from Ogiu et al.

Usage

```
pancreas_mass_children(height, weight, gender)
```

Arguments

height	Vector of heights in cm.
weight	Vector of weights in kg.
gender	Vector of genders (either 'Male' or 'Female').

Value

A vector of pancreas masses in kg.

Author(s)

Caroline Ring

References

Ogiu, Nobuko, et al. "A statistical analysis of the internal organ weights of normal Japanese people." Health physics 72.3 (1997): 368-383.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." Environment International 106 (2017): 105-118

parameterize_1comp	<i>Parameterize_1comp</i>
--------------------	---------------------------

Description

This function initializes the parameters needed in the function solve_1comp.

Usage

```
parameterize_1comp(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  species = "Human",  
  default.to.human = F,  
  adjusted.funbound.plasma = T,  
  regression = T,  
  restrictive.clearance = T,  
  well.stirred.correction = T,  
  suppress.messages = F,  
  clint.pvalue.threshold = 0.05,  
  minimum.funbound.plasma = 1e-04  
)
```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) – the chemical must be identified by either CAS, name, or DTXISDs
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing rat values with human values if true.

<code>adjusted.funbound.plasma</code>	Uses <code>adjusted.funbound.plasma</code> when set to TRUE along with volume of distribution calculated with this value.
<code>regression</code>	Whether or not to use the regressions in calculating partition coefficients in volume of distribution calculation.
<code>restrictive.clearance</code>	In calculating elimination rate and hepatic bioavailability, protein binding is not taken into account (set to 1) in liver clearance if FALSE.
<code>well.stirred.correction</code>	Uses correction in calculation of hepatic clearance for well-stirred model if TRUE. This assumes clearance relative to amount unbound in whole blood instead of plasma, but converted to use with plasma concentration.
<code>suppress.messages</code>	Whether or not to suppress messages.
<code>clint.pvalue.threshold</code>	Hepatic clearance for chemicals where the in vitro clearance assay result has a p-value greater than the threshold are set to zero.
<code>minimum.funbound.plasma</code>	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured F_{up} in our dataset).

Value

<code>Vdist</code>	Volume of distribution, units of L/kg BW.
<code>Fgutabs</code>	Fraction of the oral dose absorbed, i.e. the fraction of the dose that enters the gutlumen.
<code>Fhep.assay.correction</code>	The fraction of chemical unbound in hepatocyte assay using the method of Kilford et al. (2008)
<code>kelim</code>	Elimination rate, units of 1/h.
<code>hematocrit</code>	Percent volume of red blood cells in the blood.
<code>kgutabs</code>	Rate chemical is absorbed, 1/h.
<code>million.cells.per.gliver</code>	Millions cells per gram of liver tissue.
<code>MW</code>	Molecular Weight, g/mol.
<code>Rblood2plasma</code>	The ratio of the concentration of the chemical in the blood to the concentration in the plasma. Not used in calculations but included for the conversion of plasma outputs.
<code>hepatic.bioavailability</code>	Fraction of dose remaining after first pass clearance, calculated from the corrected well-stirred model.
<code>BW</code>	Body Weight, kg.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Kilford, P. J., Gertz, M., Houston, J. B. and Galetin, A. (2008). Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data. Drug Metabolism and Disposition 36(7), 1194-7, 10.1124/dmd.108.020834.

Examples

```
parameters <- parameterize_1comp(chem.name='Bisphenol-A',species='Rat')
parameters <- parameterize_1comp(chem.cas='80-05-7',
                                restrictive.clearance=FALSE,
                                species='rabbit',
                                default.to.human=TRUE)
out <- solve_1comp(parameters=parameters)
```

parameterize_3comp	<i>Parameterize_3comp</i>
--------------------	---------------------------

Description

This function initializes the parameters needed in the function solve_3comp.

Usage

```
parameterize_3comp(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  species = "Human",
  default.to.human = F,
  force.human.clint.fup = F,
  clint.pvalue.threshold = 0.05,
  adjusted.funbound.plasma = T,
  regression = T,
  suppress.messages = F,
  restrictive.clearance = T,
  minimum.funbound.plasma = 1e-04
)
```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) – the chemical must be identified by either CAS, name, or DTXISDs

species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing animal values with human values if true.
force.human.clint.fup	Forces use of human values for hepatic intrinsic clearance and fraction of unbound plasma if true.
clint.pvalue.threshold	Hepatic clearances with clearance assays having p-values greater than the threshold are set to zero.
adjusted.Funbound.plasma	Returns adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
suppress.messages	Whether or not the output message is suppressed.
restrictive.clearance	In calculating hepatic.bioavailability, protein binding is not taken into account (set to 1) in liver clearance if FALSE.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Value

BW	Body Weight, kg.
Clmetabolismc	Hepatic Clearance, L/h/kg BW.
Fgutabs	Fraction of the oral dose absorbed, i.e. the fraction of the dose that enters the gutlumen.
Funbound.plasma	Fraction of plasma that is not bound.
Fhep.assay.correction	The fraction of chemical unbound in hepatocyte assay using the method of Kilford et al. (2008)
hematocrit	Percent volume of red blood cells in the blood.
Kgut2pu	Ratio of concentration of chemical in gut tissue to unbound concentration in plasma.
Kliver2pu	Ratio of concentration of chemical in liver tissue to unbound concentration in plasma.
Krbc2pu	Ratio of concentration of chemical in red blood cells to unbound concentration in plasma.
Krest2pu	Ratio of concentration of chemical in rest of body tissue to unbound concentration in plasma.
million.cells.per.gliver	Millions cells per gram of liver tissue.
MW	Molecular Weight, g/mol.
Qcardiac	Cardiac Output, L/h/kg BW ^{3/4} .
Qgfr	Glomerular Filtration Rate, L/h/kg BW ^{3/4} , volume of fluid filtered from kidney and excreted.

Qgut	Fraction of cardiac output flowing to the gut.
Qliver	Fraction of cardiac output flowing to the liver.
Rblood2plasma	The ratio of the concentration of the chemical in the blood to the concentration in the plasma.
Vgut	Volume of the gut per kg body weight, L/kg BW.
Vliver	Volume of the liver per kg body weight, L/kg BW.
Vrest	Volume of the rest of the body per kg body weight, L/kg BW.

Author(s)

Robert Pearce and John Wambaugh

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Kilford, P. J., Gertz, M., Houston, J. B. and Galetin, A. (2008). Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data. Drug Metabolism and Disposition 36(7), 1194-7, 10.1124/dmd.108.020834.

Examples

```
parameters <- parameterize_3comp(chem.name='Bisphenol-A',species='Rat')
parameters <- parameterize_3comp(chem.cas='80-05-7',
                                species='rabbit',default.to.human=TRUE)
out <- solve_3comp(parameters=parameters,plots=TRUE)
```

parameterize_gas_pbt *Parameterize_gas_pbt*

Description

This function initializes the parameters needed in the function solve_gas_pbt

Usage

```
parameterize_gas_pbt(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  species = "Human",
  default.to.human = F,
  tissuelist = list(liver = c("liver"), kidney = c("kidney"), lung = c("lung"), gut =
    c("gut")),
  force.human.clint.fup = F,
  clint.pvalue.threshold = 0.05,
  adjusted.funbound.plasma = T,
  regression = T,
```

```

vmax = 0,
km = 1,
exercise = F,
fR = 12,
VT = 0.75,
VD = 0.15,
suppress.messages = F,
minimum.funbound.plasma = 1e-04,
...
)

```

Arguments

chem.cas	Either the chemical name or the CAS number must be specified.
chem.name	Either the chemical name or the CAS number must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
tissuelist	Specifies compartment names and tissues groupings. Remaining tissues in tissue.data are lumped in the rest of the body. However, solve_pbt only works with the default parameters.
force.human.clint.fup	Forces use of human values for hepatic intrinsic clearance and fraction of unbound plasma if true.
clint.pvalue.threshold	Hepatic clearance for chemicals where the in vitro clearance assay result has a p-values greater than the threshold are set to zero.
adjusted.funbound.plasma	Returns adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
vmax	Michaelis-Menten vmax value in reactions/min
km	Michaelis-Menten concentration of half-maximal reaction velocity in desired output concentration units.
exercise	Logical indicator of whether to simulate an exercise-induced heightened respiration rate
fR	Respiratory frequency (breaths/minute), used especially to adjust breathing rate in the case of exercise. This parameter, along with VT and VD (below) gives another option for calculating Q _{alv} (Alveolar ventilation) in case pulmonary ventilation rate is not known
VT	Tidal volume (L), to be modulated especially as part of simulating the state of exercise
VD	Anatomical dead space (L), to be modulated especially as part of simulating the state of exercise
suppress.messages	Whether or not the output message is suppressed.

minimum.Funbound.plasma Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

... Other parameters

Value

BW Body Weight, kg.

Clint Hepatic intrinsic clearance, uL/min/10⁶ cells

Clint.dist Distribution of hepatic intrinsic clearance values (median, lower 95th, upper 95th, p value)

Clmetabolismc Hepatic Clearance, L/h/kg BW.

Fgutabs Fraction of the oral dose absorbed, i.e. the fraction of the dose that enters the gut lumen.

Fhep.assay.correction The fraction of chemical unbound in hepatocyte assay using the method of Kilford et al. (2008)

Funbound.plasma Fraction of chemical unbound to plasma.

Funbound.plasma.adjustment Fraction unbound to plasma adjusted as described in Pearce et al. 2017

Funbound.plasma.dist Distribution of fraction unbound to plasma (median, lower 95th, upper 95th)

hematocrit Percent volume of red blood cells in the blood.

Kblood2air Ratio of concentration of chemical in blood to air

Kgut2pu Ratio of concentration of chemical in gut tissue to unbound concentration in plasma.

kgutabs Rate that chemical enters the gut from gutlumen, 1/h.

Kkidney2pu Ratio of concentration of chemical in kidney tissue to unbound concentration in plasma.

Kliver2pu Ratio of concentration of chemical in liver tissue to unbound concentration in plasma.

Klung2pu Ratio of concentration of chemical in lung tissue to unbound concentration in plasma.

km Michaelis-Menten concentration of half-maximal activity

Kmuc2air Mucus to air partition coefficient

Krbc2pu Ratio of concentration of chemical in red blood cells to unbound concentration in plasma.

Krest2pu Ratio of concentration of chemical in rest of body tissue to unbound concentration in plasma.

kUrtc Unscaled upper respiratory tract uptake parameter (L/h/kg^{0.75})

liver.density Density of liver in g/mL

MA phospholipid:water distribution coefficient, membrane affinity

million.cells.per.gliver Millions cells per gram of liver tissue.

MW Molecular Weight, g/mol.

pKa_Accept	compound H association equilibrium constant(s)
pKa_Donor	compound H dissociation equilibrium constant(s)
Pow	octanol:water partition coefficient (not log transformed)
Qalvc	Unscaled alveolar ventilation rate (L/h/kg BW ^{0.75})
Qcardiac	Cardiac Output, L/h/kg BW ^{3/4} .
Qgfr	Glomerular Filtration Rate, L/h/kg BW ^{0.75} , volume of fluid filtered from kidney and excreted.
Qgut	Fraction of cardiac output flowing to the gut.
Qkidney	Fraction of cardiac output flowing to the kidneys.
Qliver	Fraction of cardiac output flowing to the liver.
Qlung	Fraction of cardiac output flowing to lung tissue.
Qrest	Fraction of blood flow to rest of body
Rblood2plasma	The ratio of the concentration of the chemical in the blood to the concentration in the plasma from available_rblood2plasma.
Vartc	Volume of the arteries per kg body weight, L/kg BW.
Vgut	Volume of the gut per kg body weight, L/kg BW.
Vkidney	Volume of the kidneys per kg body weight, L/kg BW.
Vliver	Volume of the liver per kg body weight, L/kg BW.
Vlung	Volume of the lungs per kg body weight, L/kg BW.
vmax	Michaelis-Menten maximum reaction velocity (1/min)
Vmuc	Unscaled mucosal volume (L/kg BW ^{0.75})
Vrest	Volume of the rest of the body per kg body weight, L/kg BW.
Vven	Volume of the veins per kg body weight, L/kg BW.

Author(s)

Matt Linakis, Robert Pearce, John Wambaugh

References

Linakis, Matthew W., et al. "Development and Evaluation of a High Throughput Inhalation Model for Organic Chemicals", submitted

Kilford, P. J., Gertz, M., Houston, J. B. and Galetin, A. (2008). Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data. *Drug Metabolism and Disposition* 36(7), 1194-7, 10.1124/dmd.108.020834.

Examples

```
parameters <- parameterize_gas_pbt(chem.cas='129-00-0')

parameters <- parameterize_gas_pbt(chem.name='pyrene', species='Rat')

# Change the tissue lumping:
compartments <- list(liver=c("liver"), fast=c("heart", "brain", "muscle", "kidney"),
                    lung=c("lung"), gut=c("gut"), slow=c("bone"))
parameterize_gas_pbt(chem.name="Bisphenol a", species="Rat", default.to.human=TRUE,
                    tissuelist=compartments)
```

parameterize_pbtck	<i>Parameterize_PBTk</i>
--------------------	--------------------------

Description

This function initializes the parameters needed in the functions `solve_pbtck`, `calc_css`, and others using the multiple compartment model.

Usage

```
parameterize_pbtck(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  species = "Human",
  default.to.human = F,
  tissuelist = list(liver = c("liver"), kidney = c("kidney"), lung = c("lung"), gut =
    c("gut")),
  force.human.clint.fup = F,
  clint.pvalue.threshold = 0.05,
  adjusted.Funbound.plasma = T,
  regression = T,
  suppress.messages = F,
  restrictive.clearance = T,
  minimum.Funbound.plasma = 1e-04
)
```

Arguments

<code>chem.cas</code>	Chemical Abstract Services Registry Number (CAS-RN) – the chemical must be identified by either CAS, name, or DTXISD
<code>chem.name</code>	Chemical name (spaces and capitalization ignored) – the chemical must be identified by either CAS, name, or DTXISD
<code>dtxsid</code>	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) – the chemical must be identified by either CAS, name, or DTXSIDs
<code>species</code>	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
<code>default.to.human</code>	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
<code>tissuelist</code>	Specifies compartment names and tissues groupings. Remaining tissues in <code>tissue.data</code> are lumped in the rest of the body. However, <code>solve_pbtck</code> only works with the default parameters.
<code>force.human.clint.fup</code>	Forces use of human values for hepatic intrinsic clearance and fraction of unbound plasma if true.
<code>clint.pvalue.threshold</code>	Hepatic clearance for chemicals where the in vitro clearance assay result has a p-values greater than the threshold are set to zero.

adjusted.funbound.plasma	Returns adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
suppress.messages	Whether or not the output message is suppressed.
restrictive.clearance	In calculating hepatic.bioavailability, protein binding is not taken into account (set to 1) in liver clearance if FALSE.
minimum.funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Value

BW	Body Weight, kg.
Clmetabolismc	Hepatic Clearance, L/h/kg BW.
Fgutabs	Fraction of the oral dose absorbed, i.e. the fraction of the dose that enters the gutlumen.
Funbound.plasma	Fraction of plasma that is not bound.
Fhep.assay.correction	The fraction of chemical unbound in hepatocyte assay using the method of Kilford et al. (2008)
hematocrit	Percent volume of red blood cells in the blood.
Kgut2pu	Ratio of concentration of chemical in gut tissue to unbound concentration in plasma.
kgutabs	Rate that chemical enters the gut from gutlumen, 1/h.
Kkidney2pu	Ratio of concentration of chemical in kidney tissue to unbound concentration in plasma.
Kliver2pu	Ratio of concentration of chemical in liver tissue to unbound concentration in plasma.
Klung2pu	Ratio of concentration of chemical in lung tissue to unbound concentration in plasma.
Krbc2pu	Ratio of concentration of chemical in red blood cells to unbound concentration in plasma.
Krest2pu	Ratio of concentration of chemical in rest of body tissue to unbound concentration in plasma.
million.cells.per.gliver	Millions cells per gram of liver tissue.
MW	Molecular Weight, g/mol.
Qcardiac	Cardiac Output, L/h/kg BW ^{3/4} .
Qgfr	Glomerular Filtration Rate, L/h/kg BW ^{3/4} , volume of fluid filtered from kidney and excreted.
Qgutf	Fraction of cardiac output flowing to the gut.
Qkidneyf	Fraction of cardiac output flowing to the kidneys.
Qliverf	Fraction of cardiac output flowing to the liver.

Rblood2plasma	The ratio of the concentration of the chemical in the blood to the concentration in the plasma from available_rblood2plasma.
Vartc	Volume of the arteries per kg body weight, L/kg BW.
Vgutc	Volume of the gut per kg body weight, L/kg BW.
Vkidneyc	Volume of the kidneys per kg body weight, L/kg BW.
Vliverc	Volume of the liver per kg body weight, L/kg BW.
Vlungc	Volume of the lungs per kg body weight, L/kg BW.
Vrestc	Volume of the rest of the body per kg body weight, L/kg BW.
Vvenc	Volume of the veins per kg body weight, L/kg BW.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Httk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Kilford, P. J., Gertz, M., Houston, J. B. and Galetin, A. (2008). Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data. Drug Metabolism and Disposition 36(7), 1194-7, 10.1124/dmd.108.020834.

Examples

```
parameters <- parameterize_pbt(chem.cas='80-05-7')

parameters <- parameterize_pbt(chem.name='Bisphenol-A',species='Rat')

# Change the tissue lumping (note, these model parameters will not work with our current solver):
compartments <- list(liver=c("liver"),fast=c("heart","brain","muscle","kidney"),
                    lung=c("lung"),gut=c("gut"),slow=c("bone"))
parameterize_pbt(chem.name="Bisphenol a",species="Rat",default.to.human=TRUE,
                 tissuelist=compartments)
```

parameterize_schmitt *Get the Parameters for Schmitt's Tissue Partition Coefficient Method*

Description

This function provides the necessary parameters to run predict_partitioning_schmitt, excluding the data in tissue.data.

Usage

```
parameterize_schmitt(
  chem.cas = NULL,
  chem.name = NULL,
  dtxsid = NULL,
  parameters = NULL,
  species = "Human",
  default.to.human = F,
  force.human.fup = F,
  suppress.messages = F,
  minimum.funbound.plasma = 1e-04
)
```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) – if parameters is not specified then the chemical must be identified by either CAS, name, or DTXISDs
parameters	Chemical and physiological description parameters needed to run the Schmitt et al. (2008) model
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing fraction of unbound plasma with human values if true.
force.human.fup	Returns human fraction of unbound plasma in calculation for rats if true. When species is specified as rabbit, dog, or mouse, the human unbound fraction is substituted.
suppress.messages	Whether or not the output message is suppressed.
minimum.funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Value

Funbound.plasma	corrected unbound fraction in plasma
unadjusted.funbound.plasma	measured unbound fraction in plasma (0.005 if below limit of detection)
Pow	octanol:water partition coefficient (not log transformed)
pKa_Donor	compound H dissociation equilibrium constant(s)
pKa_Accept	compound H association equilibrium constant(s)
MA	phospholipid:water distribution coefficient, membrane affinity
Fprotein.plasma	protein fraction in plasma
plasma.pH	pH of the plasma

Author(s)

Robert Pearce and John Wambaugh

References

Schmitt, Walter. "General approach for the calculation of tissue to plasma partition coefficients." *Toxicology in Vitro* 22.2 (2008): 457-467.

Schmitt, Walter. "Corrigendum to: General approach for the calculation of tissue to plasma partition coefficients" *Toxicology in Vitro* 22.6 (2008): 1666.

Peyret, Thomas, Patrick Poulin, and Kannan Krishnan. "A unified algorithm for predicting partition coefficients for PBPK modeling of drugs and environmental chemicals." *Toxicology and applied pharmacology* 249.3 (2010): 197-207.

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Examples

```
parameterize_schmitt(chem.name='bisphenola')
```

```
parameterize_steadystate
```

Parameterize_SteadyState

Description

This function initializes the parameters needed in the functions `calc_mc_css`, `calc_mc_oral_equiv`, and `calc_analytic_css` for the three compartment steady state model ('3compartmentss').

Usage

```
parameterize_steadystate(  
  chem.cas = NULL,  
  chem.name = NULL,  
  dtxsid = NULL,  
  species = "Human",  
  clint.pvalue.threshold = 0.05,  
  default.to.human = F,  
  human.clint.fup = F,  
  adjusted.funbound.plasma = T,  
  restrictive.clearance = T,  
  fup.lod.default = 0.005,  
  suppress.messages = F,  
  minimum.funbound.plasma = 1e-04  
)
```

Arguments

chem.cas	Chemical Abstract Services Registry Number (CAS-RN) – the chemical must be identified by either CAS, name, or DTXISD
chem.name	Chemical name (spaces and capitalization ignored) – the chemical must be identified by either CAS, name, or DTXISD
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) – the chemical must be identified by either CAS, name, or DTXSIDs
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
clint.pvalue.threshold	Hepatic clearances with clearance assays having p-values greater than the threshold are set to zero.
default.to.human	Substitutes missing rat values with human values if true.
human.clint.fup	Uses human hepatic intrinsic clearance and fraction of unbound plasma in calculation of partition coefficients for rats if true.
adjusted.funbound.plasma	Returns adjusted Funbound.plasma when set to TRUE.
restrictive.clearance	In calculating hepatic.bioavailability, protein binding is not taken into account (set to 1) in liver clearance if FALSE.
fup.lod.default	Default value used for fraction of unbound plasma for chemicals where measured value was below the limit of detection. Default value is 0.0005.
suppress.messages	Whether or not the output message is suppressed.
minimum.funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

Value

Clint	Hepatic Intrinsic Clearance, uL/min/10 ⁶ cells.
Fgutabs	Fraction of the oral dose absorbed, i.e. the fraction of the dose that enters the gutlumen.
Funbound.plasma	Fraction of plasma that is not bound.
Qtotal.liverc	Flow rate of blood exiting the liver, L/h/kg BW ^{3/4} .
Qgfrc	Glomerular Filtration Rate, L/h/kg BW ^{3/4} , volume of fluid filtered from kidney and excreted.
BW	Body Weight, kg
MW	Molecular Weight, g/mol
million.cells.per.gliver	Millions cells per gram of liver tissue.
Vliverc	Volume of the liver per kg body weight, L/kg BW.
liver.density	Liver tissue density, kg/L.

Fhep.assay.correction

The fraction of chemical unbound in hepatocyte assay using the method of Kilford et al. (2008)

hepatic.bioavailability

Fraction of dose remaining after first pass clearance, calculated from the corrected well-stirred model.

Author(s)

John Wambaugh

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Kilford, P. J., Gertz, M., Houston, J. B. and Galetin, A. (2008). Hepatocellular binding of drugs: correction for unbound fraction in hepatocyte incubations using microsomal binding or drug lipophilicity data. Drug Metabolism and Disposition 36(7), 1194-7, 10.1124/dmd.108.020834.

Examples

```
parameters <- parameterize_steadystate(chem.name='Bisphenol-A',species='Rat')
parameters <- parameterize_steadystate(chem.cas='80-05-7')
```

pc.data

Partition Coefficient Data

Description

Measured rat in vivo partition coefficients and data for predicting them.

Usage

pc.data

Format

A data.frame.

Author(s)

Jimena Davis and Robert Pearce

References

- Schmitt, W., General approach for the calculation of tissue to plasma partition coefficients. *Toxicology in Vitro*, 2008. 22(2): p. 457-467.
- Schmitt, W., Corrigendum to: "General approach for the calculation of tissue to plasma partition coefficients" [*Toxicology in Vitro* 22 (2008) 457-467]. *Toxicology in Vitro*, 2008. 22(6): p. 1666.
- Poulin, P. and F.P. Theil, A priori prediction of tissue: plasma partition coefficients of drugs to facilitate the use of physiologically based pharmacokinetic models in drug discovery. *Journal of pharmaceutical sciences*, 2000. 89(1): p. 16-35.
- Rodgers, T. and M. Rowland, Physiologically based pharmacokinetic modelling 2: predicting the tissue distribution of acids, very weak bases, neutrals and zwitterions. *Journal of pharmaceutical sciences*, 2006. 95(6): p. 1238-1257.
- Rodgers, T., D. Leahy, and M. Rowland, Physiologically based pharmacokinetic modeling 1: predicting the tissue distribution of moderate-to-strong bases. *Journal of pharmaceutical sciences*, 2005. 94(6): p. 1259-1276.
- Rodgers, T., D. Leahy, and M. Rowland, Tissue distribution of basic drugs: Accounting for enantiomeric, compound and regional differences amongst beta-blocking drugs in rat. *Journal of pharmaceutical sciences*, 2005. 94(6): p. 1237-1248.
- Gueorguieva, I., et al., Development of a whole body physiologically based model to characterise the pharmacokinetics of benzodiazepines. 1: Estimation of rat tissue-plasma partition ratios. *Journal of pharmacokinetics and pharmacodynamics*, 2004. 31(4): p. 269-298.
- Poulin, P., K. Schoenlein, and F.P. Theil, Prediction of adipose tissue: plasma partition coefficients for structurally unrelated drugs. *Journal of pharmaceutical sciences*, 2001. 90(4): p. 436-447.
- Bjorkman, S., Prediction of the volume of distribution of a drug: which tissue-plasma partition coefficients are needed? *Journal of pharmacy and pharmacology*, 2002. 54(9): p. 1237-1245.
- Yun, Y. and A. Edginton, Correlation-based prediction of tissue-to-plasma partition coefficients using readily available input parameters. *Xenobiotica*, 2013. 43(10): p. 839-852.
- Uchimura, T., et al., Prediction of human blood-to-plasma drug concentration ratio. *Biopharmaceutics & drug disposition*, 2010. 31(5-6): p. 286-297.

pharma

DRUGS\NORMAN: Pharmaceutical List with EU, Swiss, US Consumption Data

Description

SWISSPHARMA is a list of pharmaceuticals with consumption data from Switzerland, France, Germany and the USA, used for a suspect screening/exposure modelling approach described in Singer et al 2016, DOI: 10.1021/acs.est.5b03332. The original data is available on the NORMAN Suspect List Exchange.

Usage

pharma

Format

An object of class `data.frame` with 954 rows and 14 columns.

Source

https://comptox.epa.gov/dashboard/chemical_lists/swisspharma

References

Wambaugh et al. (2019) "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization", Toxicological Sciences, 172(2), 235-251.

physiology.data	<i>Species-specific physiology parameters</i>
-----------------	---

Description

This data set contains values from Davies and Morris (1993) necessary to parameterize a toxicokinetic model for human, mouse, rat, dog, or rabbit. The temperature for each species are taken from Robertshaw et al. (2004), Gordon (1993), and Stammers(1926).

Usage

physiology.data

Format

A data.frame containing 11 rows and 7 columns.

Author(s)

John Wambaugh and Nisha Sipes

Source

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." Toxicological Sciences (2015): 228-237.

References

Davies, B. and Morris, T. (1993). Physiological Parameters in Laboratory Animals and Humans. Pharmaceutical Research 10(7), 1093-1095, 10.1023/a:1018943613122.

Environment, in Dukes' Physiology of Domestic Animals, 12th ed., Reece W.O., Ed. Copyright 2004 by Cornell University. Stammers (1926) The blood count and body temperature in normal rats
Gordon (1993) Temperature Regulation in Laboratory Rodents

predict_partitioning_schmitt

Predict partition coefficients using the method from Schmitt (2008).

Description

This function implements the method from Schmitt (2008) in predicting the tissue to unbound plasma partition coefficients for the tissues contained in the tissue.data table.

Usage

```
predict_partitioning_schmitt(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  species = "Human",
  default.to.human = F,
  parameters = NULL,
  alpha = 0.001,
  adjusted.funbound.plasma = T,
  regression = T,
  regression.list = c("brain", "adipose", "gut", "heart", "kidney", "liver", "lung",
    "muscle", "skin", "spleen", "bone"),
  tissues = NULL,
  minimum.funbound.plasma = 1e-04,
  suppress.messages = F
)
```

Arguments

chem.name	Either the chemical name or the CAS number must be specified.
chem.cas	Either the chemical name or the CAS number must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
parameters	Chemical parameters from parameterize_schmitt overrides chem.name, dtxsid, and chem.cas.
alpha	Ratio of Distribution coefficient D of totally charged species and that of the neutral form
adjusted.funbound.plasma	Whether or not to use Funbound.plasma adjustment.
regression	Whether or not to use the regressions. Regressions are used by default.
regression.list	Tissues to use regressions on.
tissues	Vector of desired partition coefficients. Returns all by default.

minimum.Funbound.plasma

Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

suppress.messages

Whether or not the output message is suppressed.

Details

A separate regression is used when adjusted.Funbound.plasma is FALSE.

A regression is used for membrane affinity when not provided. The regressions for correcting each tissue are performed on tissue plasma partition coefficients ($K_{\text{tissue2pu}} * \text{Funbound.plasma}$) calculated with the corrected Funbound.plasma value and divided by this value to get $K_{\text{tissue2pu}}$. Thus the regressions should be used with the corrected Funbound.plasma.

The red blood cell regression can be used but is not by default because of the span of the data used, reducing confidence in the regression for higher and lower predicted values.

Human tissue volumes are used for species other than Rat.

Value

Returns tissue to unbound plasma partition coefficients for each tissue.

Author(s)

Robert Pearce

References

Schmitt, Walter. "General approach for the calculation of tissue to plasma partition coefficients." *Toxicology in Vitro* 22.2 (2008): 457-467.

Birnbaum, L., et al. "Physiological parameter values for PBPK models." International Life Sciences Institute, Risk Science Institute, Washington, DC (1994).

Pearce, Robert G., et al. "Evaluation and calibration of high-throughput predictions of chemical distribution to tissues." *Journal of pharmacokinetics and pharmacodynamics* 44.6 (2017): 549-565.

Yun, Y. E., and A. N. Edginton. "Correlation-based prediction of tissue-to-plasma partition coefficients using readily available input parameters." *Xenobiotica* 43.10 (2013): 839-852.

Examples

```
predict_partitioning_schmitt(chem.name='ibuprofen', regression=FALSE)
```

propagate_invitrouv_1comp

Propagates uncertainty and variability in in vitro HTTK data into one compartment model parameters

Description

Propagates uncertainty and variability in in vitro HTTK data into one compartment model parameters

Usage

```
propagate_invitrouv_1comp(parameters.dt, ...)
```

Arguments

`parameters.dt` The data table of parameters being used by the Monte Carlo sampler
`...` Additional arguments passed to [calc_elimination_rate](#)

Value

A data.table whose columns are the parameters of the HTTK model specified in model1.

Author(s)

John Wambaugh

propagate_invitrouv_3comp

Propagates uncertainty and variability in in vitro HTTK data into three compartment model parameters

Description

Propagates uncertainty and variability in in vitro HTTK data into three compartment model parameters

Usage

```
propagate_invitrouv_3comp(parameters.dt, ...)
```

Arguments

`parameters.dt` The data table of parameters being used by the Monte Carlo sampler
`...` Additional arguments passed to [calc_hep_clearance](#)

Value

A data.table whose columns are the parameters of the HTTK model specified in model1.

Author(s)

John Wambaugh

propagate_invitrouv_pbt*Propagates uncertainty and variability in in vitro HTTK data into PBPK model parameters*

Description

Propagates uncertainty and variability in in vitro HTTK data into PBPK model parameters

Usage

propagate_invitrouv_pbt(parameters.dt, ...)

Arguments

parameters.dt The data table of parameters being used by the Monte Carlo sampler
... Additional arguments passed to [calc_hep_clearance](#)

Value

A data.table whose columns are the parameters of the HTTK model specified in model.

Author(s)

John Wambaugh

reset_httk*Reset HTTK to Default Data Tables*

Description

This function returns an updated version of chem.physical_and_invitro.data that includes data predicted with Simulations Plus' ADMET predictor that was used in Sipes et al. 2017, included in admet.data.

Usage

reset_httk(target.env = .GlobalEnv)

Arguments

target.env The environment where the new chem.physical_and_invitro.data is loaded. Defaults to global environment.

Value

data.frame The package default version of chem.physical_and_invitro.data.

Author(s)

John Wambaugh

Examples

```
## Not run:  
chem.physical_and_invitro.data <- load_sipes2017()  
reset_httk()  
  
## End(Not run)
```

rfun

Randomly draws from a one-dimensional KDE

Description

Randomly draws from a one-dimensional KDE

Usage

```
rfun(n, fhat)
```

Arguments

n	Number of samples to draw
fhat	A list with elements x, w, and h (h is the KDE bandwidth).

Value

A vector of n samples from the KDE fhat

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

r_left_censored_norm	<i>Returns draws from a normal distribution with a lower censoring limit of lod (limit of detection)</i>
----------------------	--

Description

Returns draws from a normal distribution with a lower censoring limit of lod (limit of detection)

Usage

```
r_left_censored_norm(n, mean = 0, sd = 1, lod = 0.005, lower = 0, upper = 1)
```

Arguments

n	Number of samples to take
mean	Mean of censored distribution. Default 0.
sd	Standard deviation of censored distribution. Default 1.
lod	Bound below which to censor. Default 0.005.
lower	Lower bound on censored distribution. Default 0.
upper	Upper bound on censored distribution. Default 1.

Value

A vector of samples from the specified censored distribution.

scale_dosing	<i>Scale mg/kg body weight doses according to body weight and units</i>
--------------	---

Description

This function transforms the dose (in mg/kg) into the appropriate units. It handles single doses, matrices of doses, or daily repeated doses (at varying intervals. Gut absorption is also factored in through the parameter Fgutabs, and scaling is currently avoided in the inhalation exposure case with a scale factor of 1

Usage

```
scale_dosing(dosing, parameters, route, output.units = "uM")
```

Arguments

dosing	List of dosing metrics used in simulation, which must include the general entries with names "initial.dose", "doses.per.day", "daily.dose", and "dosing.matrix". The "dosing.matrix" is used for more precise dose regimen specification, and is either a vector of dosing times or a matrix consisting of two columns or rows named "time" and "dose" containing the time and amount, in mg/kg BW, of each dose. Minimal usage case of all entries but "initial.dose" set to NULL in value.
--------	--

parameters	Chemical parameters from parameterize_pbt function, overrides chem.name and chem.cas.
route	String specification of route of exposure for simulation: "oral", "iv", "inhalation", ...
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").

Author(s)

John Wambaugh

sipes2017	<i>Sipes et al. 2017 data</i>
-----------	-------------------------------

Description

This table includes in silico predicted chemical-specific plasma protein unbound fraction (fup) and intrinsic hepatic clearance values for the entire Tox21 library (see <https://www.epa.gov/chemical-research/toxicology-testing-21st-century-tox21>). Predictions were made with Simulations Plus ADMET predictor, as reported in Sipes et al. (2017).

Usage

sipes2017

Format

data.frame

Author(s)

Nisha Sipes

Source

ADMET, Simulations Plus

References

Sipes, Nisha S., et al. "An Intuitive Approach for Predicting Potential Human Health Risk with the Tox21 10k Library." *Environmental Science & Technology* 51.18 (2017): 10786-10796.

skeletal_muscle_mass *Predict skeletal muscle mass*

Description

Predict skeletal muscle mass from age, height, and gender.

Usage

```
skeletal_muscle_mass(smm, age_years, height, gender)
```

Arguments

smm	Vector of allometrically-scaled skeletal muscle masses.
age_years	Vector of ages in years.
height	Vector of heights in cm.
gender	Vector of genders, either 'Male' or 'Female.'

Details

For individuals over age 18, use allometrically-scaled muscle mass with an age-based scaling factor, to account for loss of muscle mass with age (Janssen et al. 2000). For individuals under age 18, use [skeletal_muscle_mass_children](#).

Value

Vector of skeletal muscle masses in kg.

Author(s)

Caroline Ring

References

Janssen, Ian, et al. "Skeletal muscle mass and distribution in 468 men and women aged 18-88 yer." *Journal of Applied Physiology* 89.1 (2000): 81-88

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

See Also

[skeletal_muscle_mass_children](#)

skeletal_muscle_mass_children

Predict skeletal muscle mass for children

Description

For individuals under age 18, predict skeletal muscle mass from gender and age, using a nonlinear equation from Webber and Barr (2012)

Usage

```
skeletal_muscle_mass_children(gender, age_years)
```

Arguments

gender	Vector of genders (either 'Male' or 'Female').
age_years	Vector of ages in years.

Value

Vector of skeletal muscle masses in kg.

Author(s)

Caroline Ring

References

Webber, Colin E., and Ronald D. Barr. "Age-and gender-dependent values of skeletal muscle mass in healthy children and adolescents." *Journal of cachexia, sarcopenia and muscle* 3.1 (2012): 25-29.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

skin_mass_bosgra

Predict skin mass

Description

Using equation from Bosgra et al. 2012, predict skin mass from body surface area.

Usage

```
skin_mass_bosgra(BSA)
```

Arguments

BSA	Vector of body surface areas in cm ² .
-----	---

Value

Vector of skin masses in kg.

Author(s)

Caroline Ring

References

Bosgra, Sieto, et al. "An improved model to predict physiologically based model parameters and their inter-individual variability from anthropometry." *Critical reviews in toxicology* 42.9 (2012): 751-767.

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

solve_1comp

Solve one compartment TK model

Description

This function solves for the amount or concentration of a chemical in plasma for a one compartment model as a function of time based on the dose and dosing frequency.

Usage

```
solve_1comp(  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL,  
  times = NULL,  
  parameters = NULL,  
  days = 10,  
  tsteps = 4,  
  daily.dose = NULL,  
  dose = 1,  
  doses.per.day = NULL,  
  initial.values = NULL,  
  plots = F,  
  suppress.messages = F,  
  species = "Human",  
  iv.dose = F,  
  output.units = "uM",  
  method = "lsoda",  
  rtol = 1e-08,  
  atol = 1e-12,  
  default.to.human = F,  
  recalc.blood2plasma = F,  
  recalc.clearance = F,  
  dosing.matrix = NULL,  
  adjusted.funbound.plasma = T,
```

```

    regression = T,
    restrictive.clearance = T,
    minimum.Funbound.plasma = 1e-04,
    monitor.vars = NULL,
    ...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
times	Optional time sequence for specified number of days.
parameters	Chemical parameters from parameterize_1comp function, overrides chem.name and chem.cas.
days	Length of the simulation.
tsteps	The number time steps per hour.
daily.dose	Total daily dose, mg/kg BW.
dose	Amount of a single dose, mg/kg BW. Overwrites daily.dose.
doses.per.day	Number of doses per day.
initial.values	Vector containing the initial concentrations or amounts of the chemical in specified tissues with units corresponding to output.units. Defaults are zero.
plots	Plots all outputs if true.
suppress.messages	Whether or not the output message is suppressed.
species	Species desired (either "Rat", "Rabbit", "Dog", or default "Human").
iv.dose	Simulates a single i.v. dose if true.
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
method	Method used by integrator (deSolve).
rtol	Argument passed to integrator (deSolve).
atol	Argument passed to integrator (deSolve).
default.to.human	Substitutes missing rat values with human values if true.
recalc.blood2plasma	Whether or not to recalculate the blood:plasma chemical concentration ratio
recalc.clearance	Whether or not to recalculate the elimination rate.
dosing.matrix	Vector of dosing times or a matrix consisting of two columns or rows named "dose" and "time" containing the time and amount, in mg/kg BW, of each dose.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with volume of distribution calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients in volume of distribution calculation.

`restrictive.clearance`

In calculating elimination rate, protein binding is not taken into account (set to 1) in liver clearance if FALSE.

`minimum.Funbound.plasma`

Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).

`monitor.vars`

Which variables are returned as a function of time. Defaults value of NULL provides "Agutlumen", "Ccompartment", "Ametabolized", "AUC"

`...`

Additional arguments passed to the integrator.

Details

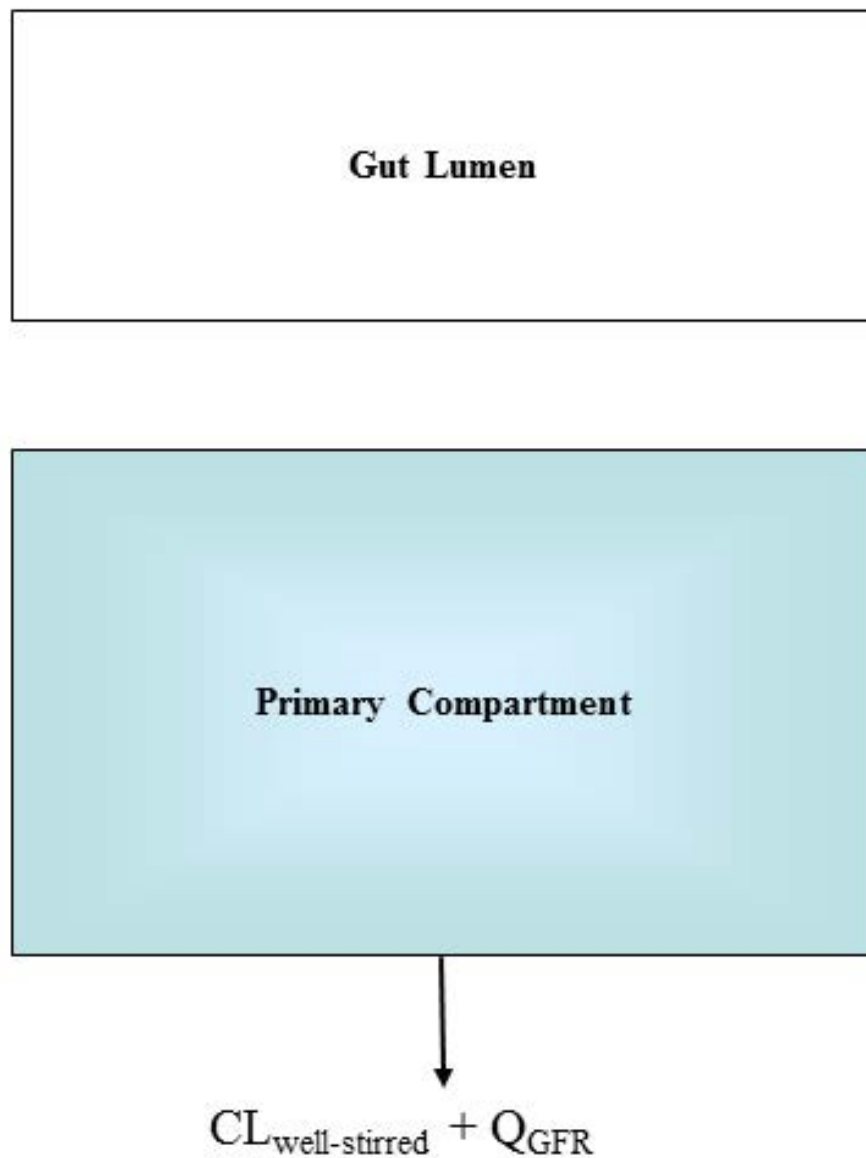
Note that the model parameters have units of hours while the model output is in days.

Default value of NULL for `doses.per.day` solves for a single dose.

When `species` is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

AUC is area under plasma concentration curve.

Model Figure



altalt

Value

A matrix with a column for time(in days) and a column for the compartment and the area under the curve (concentration only).

Author(s)

Robert Pearce

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Examples

```
solve_1comp(chem.name='Bisphenol-A',days=1)
params <- parameterize_1comp(chem.cas="80-05-7")
solve_1comp(parameters=params)
```

solve_3comp

Solve_3comp

Description

This function solves for the amounts or concentrations of a chemical in different tissues as functions of time based on the dose and dosing frequency. It uses a three compartment model with partition coefficients. function does. ~~

Usage

```
solve_3comp(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  times = NULL,
  parameters = NULL,
  days = 10,
  tsteps = 4,
  daily.dose = NULL,
  dose = 1,
  doses.per.day = NULL,
  initial.values = NULL,
  plots = F,
  suppress.messages = F,
  species = "Human",
  iv.dose = F,
  output.units = "uM",
  method = "lsoda",
  rtol = 1e-08,
  atol = 1e-12,
  default.to.human = F,
  recalc.blood2plasma = F,
  recalc.clearance = F,
  dosing.matrix = NULL,
  adjusted.Funbound.plasma = T,
  regression = T,
  restrictive.clearance = T,
  minimum.Funbound.plasma = 1e-04,
  monitor.vars = NULL,
  ...
)
```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's 'DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXIDs
times	Optional time sequence for specified number of days. The dosing sequence begins at the beginning of times.
parameters	Chemical parameters from parameterize_3comp function, overrides chem.name and chem.cas.
days	Length of the simulation.
tsteps	The number time steps per hour.
daily.dose	Total daily dose, mg/kg BW.
dose	Amount of a single dose, mg/kg BW. Overwrites daily.dose.
doses.per.day	Number of doses per day.
initial.values	Vector containing the initial concentrations or amounts of the chemical in specified tissues with units corresponding to output.units. Defaults are zero.
plots	Plots all outputs if true.
suppress.messages	Whether or not the output message is suppressed.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
iv.dose	Simulates a single i.v. dose if true.
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
method	Method used by integrator (deSolve).
rtol	Argument passed to integrator (deSolve).
atol	Argument passed to integrator (deSolve).
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters, calculated with hematocrit, Funbound.plasma, and Krbc2pu.
recalc.clearance	Recalculates the the hepatic clearance (Clmetabolism) with new million.cells.per.g liver parameter.
dosing.matrix	Vector of dosing times or a matrix consisting of two columns or rows named "dose" and "time" containing the time and amount, in mg/kg BW, of each dose.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).
monitor.vars	Which variables are returned as a function of time. Defaults value of NULL provides "Cliver", "Csyscomp", "Atubules", "Ametabolized", "AUC"
...	Additional arguments passed to the integrator.

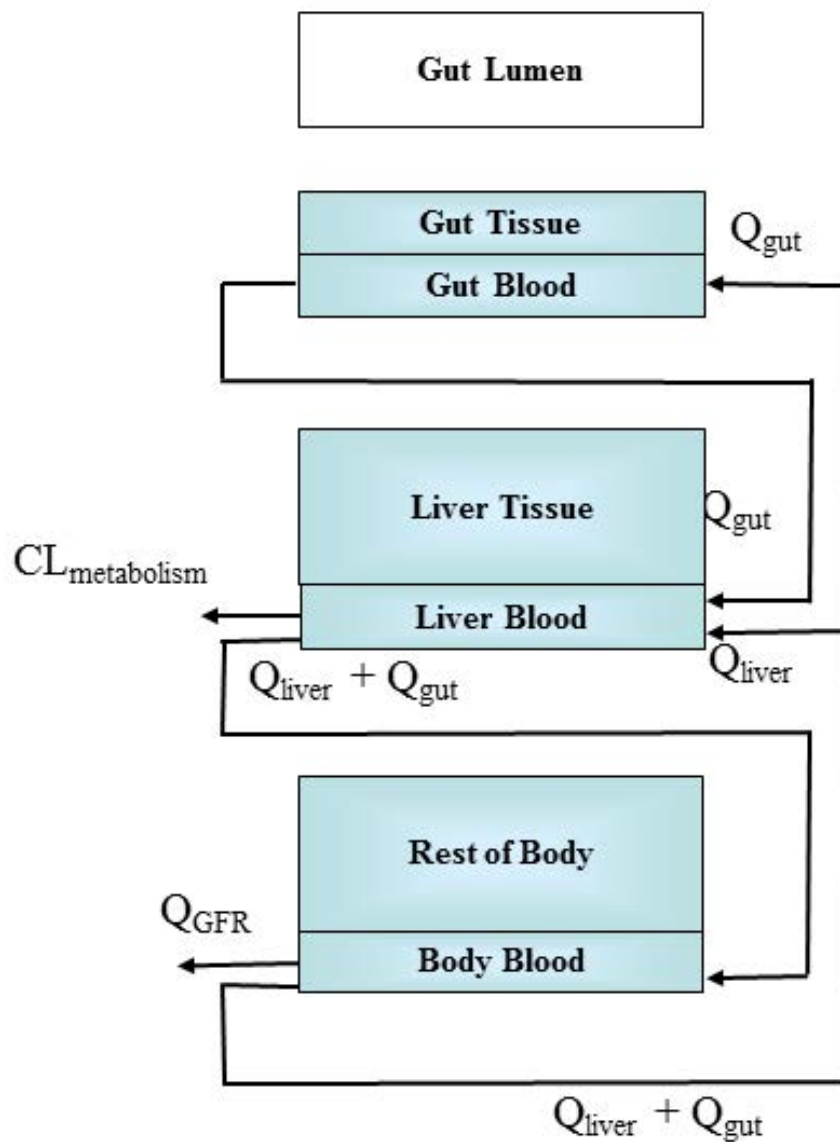
Details

Note that the model parameters have units of hours while the model output is in days.

Default of NULL for doses.per.day solves for a single dose.

The compartments used in this model are the gutlumen, gut, liver, and rest-of-body, with the plasma equivalent to the liver plasma.

Model Figure



altalt

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

A matrix of class `deSolve` with a column for time(in days) and each compartment, the plasma concentration, area under the curve, and a row for each time point.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." *Journal of statistical software* 79.4 (2017): 1.

Examples

```
solve_3comp(chem.name='Bisphenol-A',doses.per.day=2,daily.dose=.5,days=1,tsteps=2)

params <-parameterize_3comp(chem.cas="80-05-7")
solve_3comp(parameters=params)
```

`solve_gas_pbt``solve_gas_pbt`

Description

This function solves for the amounts or concentrations of a chemical in different tissues as functions of time as a result of inhalation exposure.

Usage

```
solve_gas_pbt(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  parameters = NULL,
  times = NULL,
  days = 10,
  tsteps = 4,
  daily.dose = NULL,
  doses.per.day = NULL,
  dose = NULL,
  dosing.matrix = NULL,
  forcings = NULL,
  exp.start.time = 0,
  exp.conc = 1,
  period = 24,
  exp.duration = 12,
  fcontrol = list(method = "constant", rule = 2, f = 0),
  initial.values = NULL,
```



```

plots = F,
suppress.messages = F,
species = "Human",
output.units = "uM",
method = "lsoda",
rtol = 1e-08,
atol = 1e-12,
default.to.human = F,
recalc.blood2plasma = F,
recalc.clearance = F,
adjusted.funbound.plasma = T,
regression = T,
restrictive.clearance = T,
minimum.funbound.plasma = 1e-04,
monitor.vars = NULL,
vmax = 0,
km = 1,
exercise = F,
fR = 12,
VT = 0.75,
VD = 0.15,
...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXIDs
parameters	Chemical parameters from parameterize_pbtok function, overrides chem.name and chem.cas.
times	Optional time sequence for specified number of days. Dosing sequence begins at the beginning of times.
days	Length of the simulation.
tsteps	The number of time steps per hour.
daily.dose	Total daily dose, mg/kg BW.
doses.per.day	Number of doses per day.
dose	Amount of a single dose, mg/kg BW. Overwrites daily.dose.
dosing.matrix	Vector of dosing times or a matrix consisting of two columns or rows named "dose" and "time" containing the time and amount, in mg/kg BW, of each dose. With the gas pbtok model, dosing.matrix is set to specify forcing concentrations to the integrator, either in combination with eventdata or on its own.
forcings	Manual input of 'forcings' data series argument for ode integrator, defaults to NULL
exp.start.time	Start time in specifying forcing exposure series, default 0.
exp.conc	Specified inhalation exposure concentration for use in assembling 'forcings' data series argument for integrator. Defaults to uM/L

period	For use in assembling forcing function data series 'forcings' argument, specified in hours
exp.duration	For use in assembling forcing function data series 'forcings' argument, specified in hours
fcontrol	List of arguments for finetuning inhalation forcing function in conjunction with existing ode integrator methods
initial.values	Vector containing the initial concentrations or amounts of the chemical in specified tissues with units corresponding to output.units. Defaults are zero.
plots	Plots all outputs if true.
suppress.messages	Whether or not the output message is suppressed.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
method	Method used by integrator (deSolve).
rtol	Argument passed to integrator (deSolve).
atol	Argument passed to integrator (deSolve).
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters, calculated with hematocrit, Funbound.plasma, and Krbc2pu.
recalc.clearance	Recalculates the the hepatic clearance (Clmetabolism) with new million.cells.per.gLiver parameter.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).
monitor.vars	Which variables are returned as a function of time. Defaults value of NULL provides "Cgut", "Cliver", "Cven", "Clung", "Cart", "Crest", "Ckidney", "Cplasma", "Calv", "Cendexh", "Cmixexh", "Cmuc", "Atubules", "Ametabolized", "AUC"
vmax	Michaelis-Menten vmax value in reactions/min
km	Michaelis-Menten concentration of half-maximal reaction velocity in desired output concentration units.
exercise	Logical indicator of whether to simulate an exercise-induced heightened respiration rate
fR	Respiratory frequency (breaths/minute), used especially to adjust breathing rate in the case of exercise. This parameter, along with VT and VD (below) gives another option for calculating Qalv (Alveolar ventilation) in case pulmonary ventilation rate is not known

VT	Tidal volume (L), to be modulated especially as part of simulating the state of exercise
VD	Anatomical dead space (L), to be modulated especially as part of simulating the state of exercise
...	Additional arguments passed to the integrator.

Details

The default dosing scheme involves specifying the start time of exposure, the concentration of gas inhaled, the period of a given assumed cycle of exposure, and the duration of the exposure during that period. Together, these arguments determine the forcings passed to the ODE integrator. Forcings can also be specified manually, or effectively turned off by setting exposure concentration to zero, if the user prefers to simulate dosing by other means.

This function solves for the amounts or concentrations in uM of a chemical in different tissues as functions of time based on the dose and dosing frequency.

Note that the model parameters have units of hours while the model output is in days.

Default NULL value for doses.per.day solves for a single dose.

The compartments used in this model are the gut lumen, gut, liver, kidneys, veins, arteries, lungs, and the rest of the body.

The extra compartments include the amounts or concentrations metabolized by the liver and excreted by the kidneys through the tubules.

AUC is the area under the curve of the plasma concentration.

Model parameters are named according to the following convention:

prefix	suffic	Meaning	units
K		Partition coefficient for tissue to free plasma \ tab	unitless
V		Volume	L
Q		Flow	L/h
k		Rate	1/h
	c	Parameter is proportional to body weight	1 / kg for volumes and 1/kg^(3/4) for flows

When species is specified but chemical-specific in vitro data are not available, the function uses the appropriate physiological data (volumes and flows) but default.to.human = TRUE must be used to substitute human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

A matrix of class deSolve with a column for time(in days), each compartment, the area under the curve, and plasma concentration and a row for each time point.

Author(s)

Matt Linakis, John Wambaugh, and Mark Sfeir

References

Linakis, Matthew W., et al. "Development and Evaluation of a High Throughput Inhalation Model for Organic Chemicals", submitted

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Examples

```
solve_gas_pbt(k(chem.name='Pyrene',dose=.5,days = 3,tsteps=2))

out <- solve_gas_pbt(k(chem.name='pyrene',exp.conc = 0, doses.per.day = 2,
daily.dose = 3, plots=TRUE,initial.values=c(Aven=20))

out <- solve_gas_pbt(k(chem.name = 'pyrene',exp.conc = 3, period = 24,
exp.duration = 6, exercise = TRUE))

params <- parameterize_gas_pbt(k(chem.cas="80-05-7")
solve_gas_pbt(k(parameters=params))
```

solve_model

Solve_model

Description

solve_model's arguments prepare an ode system for numerical solution over time of the amounts or concentrations (uM) of chemical in the different bodily compartments of a given available species (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").

Usage

```
solve_model(
  chem.name = NULL,
  chem.cas = NULL,
  dtxsid = NULL,
  times = NULL,
  parameters = NULL,
  model = NULL,
  route = "oral",
  dosing = NULL,
  days = 10,
  tsteps = 4,
  initial.values = NULL,
  plots = F,
  monitor.vars = NULL,
  suppress.messages = F,
  species = "Human",
  output.units = "uM",
  method = "lsoda",
  rtol = 1e-08,
  atol = 1e-12,
  recalc.blood2plasma = F,
  recalc.clearance = F,
  adjusted.funbound.plasma = T,
```

```

    minimum.Funbound.plasma = 1e-04,
    parameterize.arg.list = list(default.to.human = F, Clint.pvalue.threshold = 0.05,
    restrictive.clearance = T, regression = T),
    ...
)

```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.
dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
times	Optional time sequence for specified number of days. Dosing sequence begins at the beginning of times.
parameters	List of chemical parameters, as output by parameterize_pbt function. Overrides chem.name and chem.cas.
model	Specified model to use in simulation: "pbt", "3compartment", "3compartmentss", "1compartment", "schmitt", ...
route	String specification of route of exposure for simulation: "oral", "iv", "inhalation", ...
dosing	List of dosing metrics used in simulation, which must include the general entries with names "initial.dose", "doses.per.day", "daily.dose", and "dosing.matrix". The "dosing.matrix" is used for more precise dose regimen specification, and is either a vector of dosing times or a matrix consisting of two columns or rows named "time" and "dose" containing the time and amount, in mg/kg BW, of each dose. Minimal usage case of all entries but "initial.dose" set to NULL in value.
days	Simulated period. Default 10 days.
tsteps	The number of time steps per hour. Default of 4.
initial.values	Vector containing the initial concentrations or amounts of the chemical in specified tissues with units corresponding to output.units. Defaults are zero.
plots	Plots all outputs if true.
monitor.vars	Which variables are returned as a function of time. Default values of NULL looks up variables specified in modelinfo_MODEL.R
suppress.messages	Whether or not the output message is suppressed.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
method	Method used by integrator (deSolve).
rtol	Argument passed to integrator (deSolve).
atol	Argument passed to integrator (deSolve).
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters, calculated with hematocrit, Funbound.plasma, and Krbc2pu.
recalc.clearance	Recalculates the the hepatic clearance (Clmetabolism) with new million.cells.per.g liver parameter.

`adjusted.funbound.plasma` Uses `adjusted.funbound.plasma` when set to `TRUE` along with partition coefficients calculated with this value.

`minimum.funbound.plasma` Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured `Fup` in our dataset)

`parameterize.arg.list` Additional parameterized passed to the model parameterization function.

`...` Additional arguments passed to the integrator.

`default.to.human` Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).

`regression` Whether or not to use the regressions in calculating partition coefficients.

`restrictive.clearance` Protein binding not taken into account (set to 1) in liver clearance if `FALSE`.

Details

At a minimum, a chemical identifier (whether name, CAS number, or other chemical parameterization), model system of interest ("pbt", "3compartment", "3compartmentss", "1compartment", "schmitt", ...), and dosing regimen must be provided for `solve_model` to run its toxicokinetic simulations. See 'dosing' argument listing below for breakdown of how to specify dose (in terms of route of administration, frequency, and quantity)

Note that the model parameters have units of hours while the model output is in days.

The compartments used in the "pbt" model are the gutlumen, gut, liver, kidneys, veins, arteries, lungs, and the rest of the body. The extra compartments include the amounts or concentrations metabolized by the liver and excreted by the kidneys through the tubules.

AUC is the area under the curve of the plasma concentration.

Model parameters are named according to the following convention:

prefix	suffix	Meaning	units
K		Partition coefficient for tissue to free plasma \ tab	unitless
V		Volume	L
Q		Flow	L/h
k		Rate	1/h
	c	Parameter is proportional to body weight	1 / kg for volumes and 1/kg^(3/4) for flows

When species is specified but chemical-specific in vitro data are not available, the function uses the appropriate physiological data (volumes and flows) but `default.to.human = TRUE` must be used to substitute human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

A matrix of class `deSolve` with a column for time(in days), each compartment, the area under the curve, and plasma concentration and a row for each time point.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

solve_pbt

Solve_PBT

Description

This function solves for the amounts or concentrations in uM of a chemical in different tissues as functions of time based on the dose and dosing frequency.

Usage

```
solve_pbt(  
  chem.name = NULL,  
  chem.cas = NULL,  
  dtxsid = NULL,  
  times = NULL,  
  parameters = NULL,  
  days = 10,  
  tsteps = 4,  
  daily.dose = NULL,  
  dose = 1,  
  doses.per.day = NULL,  
  initial.values = NULL,  
  plots = F,  
  suppress.messages = F,  
  species = "Human",  
  iv.dose = F,  
  output.units = "uM",  
  method = "lsoda",  
  rtol = 1e-08,  
  atol = 1e-12,  
  default.to.human = F,  
  recalc.blood2plasma = F,  
  recalc.clearance = F,  
  dosing.matrix = NULL,  
  adjusted.funbound.plasma = T,  
  regression = T,  
  restrictive.clearance = T,  
  minimum.funbound.plasma = 1e-04,  
  monitor.vars = NULL,  
  ...  
)
```

Arguments

chem.name	Either the chemical name, CAS number, or the parameters must be specified.
chem.cas	Either the chemical name, CAS number, or the parameters must be specified.

dtxsid	EPA's DSSTox Structure ID (http://comptox.epa.gov/dashboard) the chemical must be identified by either CAS, name, or DTXSIDs
times	Optional time sequence for specified number of days. Dosing sequence begins at the beginning of times.
parameters	Chemical parameters from parameterize_pbt function, overrides chem.name and chem.cas.
days	Length of the simulation.
tsteps	The number of time steps per hour.
daily.dose	Total daily dose, mg/kg BW.
dose	Amount of a single dose, mg/kg BW. Overwrites daily.dose.
doses.per.day	Number of doses per day.
initial.values	Vector containing the initial concentrations or amounts of the chemical in specified tissues with units corresponding to output.units. Defaults are zero.
plots	Plots all outputs if true.
suppress.messages	Whether or not the output message is suppressed.
species	Species desired (either "Rat", "Rabbit", "Dog", "Mouse", or default "Human").
iv.dose	Simulates a single i.v. dose if true.
output.units	Desired units (either "mg/L", "mg", "umol", or default "uM").
method	Method used by integrator (deSolve).
rtol	Argument passed to integrator (deSolve).
atol	Argument passed to integrator (deSolve).
default.to.human	Substitutes missing animal values with human values if true (hepatic intrinsic clearance or fraction of unbound plasma).
recalc.blood2plasma	Recalculates the ratio of the amount of chemical in the blood to plasma using the input parameters, calculated with hematocrit, Funbound.plasma, and Krbc2pu.
recalc.clearance	Recalculates the the hepatic clearance (Clmetabolism) with new million.cells.per.g liver parameter.
dosing.matrix	Vector of dosing times or a matrix consisting of two columns or rows named "dose" and "time" containing the time and amount, in mg/kg BW, of each dose.
adjusted.Funbound.plasma	Uses adjusted Funbound.plasma when set to TRUE along with partition coefficients calculated with this value.
regression	Whether or not to use the regressions in calculating partition coefficients.
restrictive.clearance	Protein binding not taken into account (set to 1) in liver clearance if FALSE.
minimum.Funbound.plasma	Monte Carlo draws less than this value are set equal to this value (default is 0.0001 – half the lowest measured Fup in our dataset).
monitor.vars	Which variables are returned as a function of time. Defaults value of NULL provides "Cgut", "Cliver", "Cven", "Clung", "Cart", "Crest", "Ckidney", "Cplasma", "Atubules", "Ametabolized", and "AUC"
...	Additional arguments passed to the integrator.

Details

Note that the model parameters have units of hours while the model output is in days.

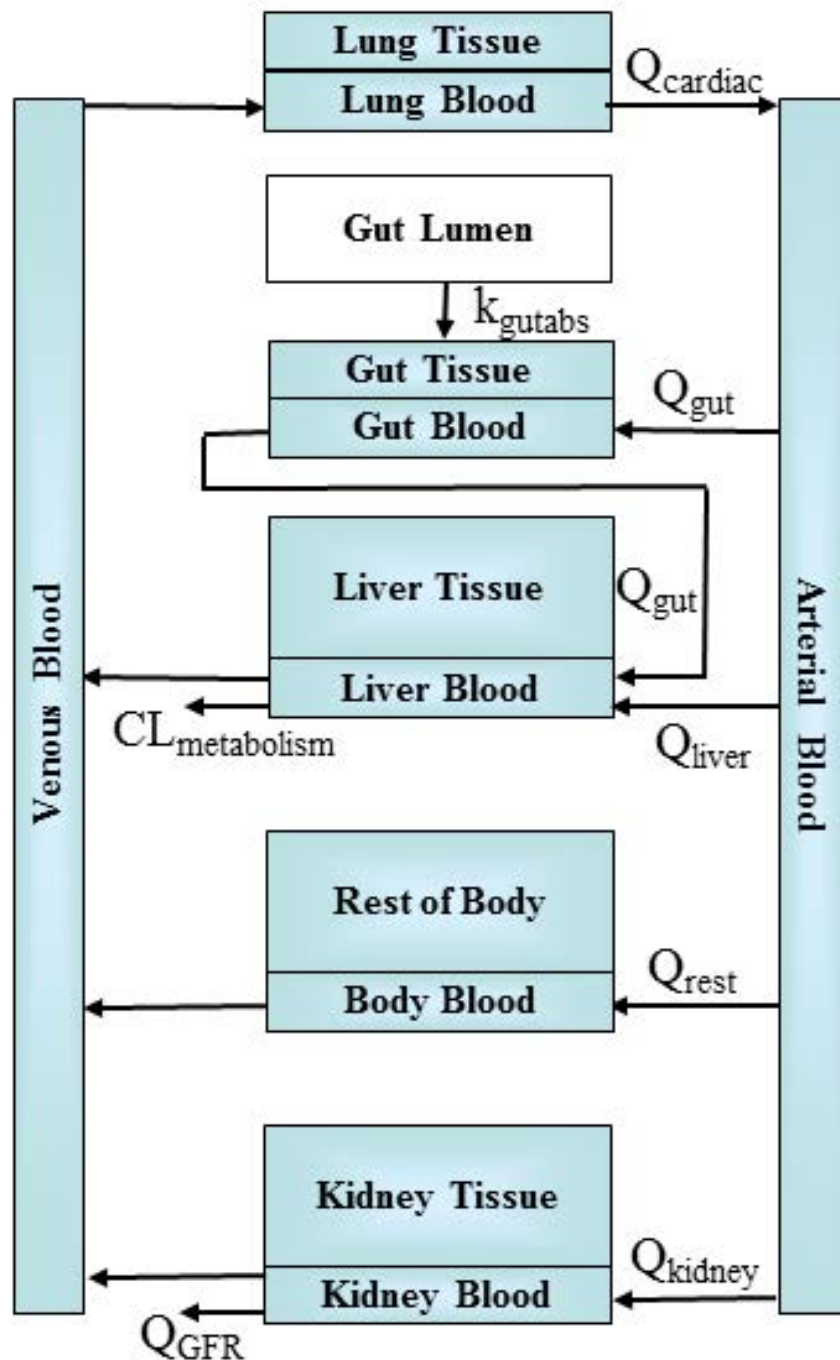
Default NULL value for doses.per.day solves for a single dose.

The compartments used in this model are the gutlumen, gut, liver, kidneys, veins, arteries, lungs, and the rest of the body.

The extra compartments include the amounts or concentrations metabolized by the liver and excreted by the kidneys through the tubules.

AUC is the area under the curve of the plasma concentration.

Model Figure



altalt

When species is specified as rabbit, dog, or mouse, the function uses the appropriate physiological data(volumes and flows) but substitutes human fraction unbound, partition coefficients, and intrinsic hepatic clearance.

Value

A matrix of class `deSolve` with a column for time(in days), each compartment, the area under the curve, and plasma concentration and a row for each time point.

Author(s)

John Wambaugh and Robert Pearce

References

Pearce, Robert G., et al. "Htk: R package for high-throughput toxicokinetics." Journal of statistical software 79.4 (2017): 1.

Examples

```
solve_pbtok(chem.name='Bisphenol-A',daily.dose=.5,days=1,doses.per.day=2,tsteps=2)

out <- solve_pbtok(chem.name='bisphenola',dose=0,output.units="mg/L",
  initial.values=c(Agut=200))

params <- parameterize_pbtok(chem.cas="80-05-7")
solve_pbtok(parameters=params)

## Not run:
parameters <- parameterize_pbtok(chem.name = "triclosan", species = "rat")
parameters["Funbound.plasma"] <- 0.1
out <- solve_pbtok(parameters=parameters)

library("ggplot2")
out <- solve_pbtok(chem.name = "Bisphenol A", days = 50, doses.per.day = 3)
plot.data <- as.data.frame(out)
css <- calc_analytic_css(chem.name = "Bisphenol A")
c.vs.t <- ggplot(plot.data,aes(time, Cplasma)) + geom_line() +
  geom_hline(yintercept = css) + ylab("Plasma Concentration (uM)") +
  xlab("Day") + theme(axis.text = element_text(size = 16), axis.title =
  element_text(size = 16), plot.title = element_text(size = 17)) +
  ggtitle("Bisphenol A")
print(c.vs.t)

## End(Not run)
```

spleen_mass_children *Predict spleen mass for children*

Description

For individuals under 18, predict the spleen mass from height, weight, and gender, using equations from Ogiu et al. (1997)

Usage

```
spleen_mass_children(height, weight, gender)
```

Arguments

height	Vector of heights in cm.
weight	Vector of weights in kg.
gender	Vector of genders (either 'Male' or 'Female').

Value

A vector of spleen masses in kg.

Author(s)

Caroline Ring

References

- Ogiu, Nobuko, et al. "A statistical analysis of the internal organ weights of normal Japanese people." *Health physics* 72.3 (1997): 368-383.
- Price, Paul S., et al. "Modeling interindividual variation in physiological factors used in PBPK models of humans." *Critical reviews in toxicology* 33.5 (2003): 469-503.
- Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

spline_heightweight	<i>Smoothing splines for log height vs. age and log body weight vs. age, along with 2-D KDE residuals, by race and gender.</i>
---------------------	--

Description

#'Smoothing splines and KDE fits to joint distribution of height and weight residuals pre-calculated from NHANES height, weight, and age data by race/ethnicity and gender.

Usage

```
spline_heightweight
```

Format

A data.table with 6 variables:

g Gender: Male or Female

r Race/ethnicity: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other

height_spline A list of smooth.spline objects, each giving a smoothed relationship between log height in cm and age in months

weight_spline A list of smooth.spline objects, each giving a smoothed relationship between log body weight in kg and age in months

hw_kde A list of kde objects; each is a 2-D KDE of the distribution of log height and log body weight residuals about the smoothing splines.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

spline_hematocrit	<i>Smoothing splines for log hematocrit vs. age in months, and KDE residuals, by race and gender.</i>
-------------------	---

Description

Smoothing splines and KDE residuals pre-calculated from NHANES hematocrit and age data by race/ethnicity and gender.

Usage

spline_hematocrit

Format

- A data.table with 6 variables:
- gender Gender: Male or Female
 - reth Race/ethnicity: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other
 - hct_spline A list of smooth.spline objects, each giving a smoothed relationship between log hematocrit and age in months
 - hct_kde A list of kde objects; each is a KDE of the distribution of residuals about the smoothing spline.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

spline_serumcreat	<i>Smoothing splines for log serum creatinine vs. age in months, along with KDE residuals, by race and gender.</i>
-------------------	--

Description

#'Smoothing splines and KDE residuals pre-calculated from NHANES serum creatinine and age data by race/ethnicity and gender.

Usage

```
spline_serumcreat
```

Format

A data.table with 6 variables:

gender Gender: Male or Female

reth Race/ethnicity: Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Other

sc_spline A list of smooth.spline objects, each giving a smoothed relationship between log serum creatinine and age in months

sc_kde A list of kde objects; each is a KDE of the distribution of residuals about the smoothing spline.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

supptab1_Linakis2020	<i>Supplementary output from Linakis 2020 vignette analysis.</i>
----------------------	--

Description

Supplementary output from Linakis 2020 vignette analysis.

Usage

```
supptab1_Linakis2020
```

Format

A data.frame containing x rows and y columns.

Author(s)

Matt Linakis

Source

Matt Linakis

References

DSStox database ([http:// www.epa.gov/ncct/dsstox](http://www.epa.gov/ncct/dsstox))

supptab2_Linakis2020 *More supplementary output from Linakis 2020 vignette analysis.*

Description

More supplementary output from Linakis 2020 vignette analysis.

Usage

supptab2_Linakis2020

Format

A data.frame containing x rows and y columns.

Author(s)

Matt Linakis

Source

Matt Linakis

References

DSStox database ([http:// www.epa.gov/ncct/dsstox](http://www.epa.gov/ncct/dsstox))

Tables.Rdata.stamp	<i>A timestamp of table creation</i>
--------------------	--------------------------------------

Description

The Tables.RData file is separately created as part of building a new release of HHTK. This time stamp indicates the script used to build the file and when it was run.

Usage

Tables.Rdata.stamp

Format

An object of class character of length 1.

Author(s)

John Wambaugh

tissue.data	<i>Tissue composition and species-specific physiology parameters</i>
-------------	--

Description

This data set contains values from Schmitt (2008) and Ruark et al. (2014) describing the composition of specific tissues and from Birnbaum et al. (1994) describing volumes of and blood flows to those tissues, allowing parameterization of toxicokinetic models for human, mouse, rat, dog, or rabbit. Tissue volumes were calculated by converting the fractional mass of each tissue with its density (both from ICRP), lumping the remaining tissues into the rest-of-body, excluding the mass of the gastrointestinal contents

Usage

tissue.data

Format

A data.frame containing 13 rows and 20 columns.

Author(s)

John Wambaugh, Robert Pearce, and Nisha Sipes

Source

Pearce et al. (2017), in preparation,

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." *Toxicological Sciences* (2015): 228-237.

References

- Birnbaum, L and Brown, R and Bischoff, K and Foran, J and Blancato, J and Clewell, H and Dedrick, R (1994). Physiological parameter values for PBPK model. International Life Sciences Institute, Risk Science Institute, Washington, DC
- Ruark, Christopher D., et al. "Predicting passive and active tissue: plasma partition coefficients: Interindividual and interspecies variability." *Journal of pharmaceutical sciences* 103.7 (2014): 2189-2198.
- Schmitt, W. (2008). General approach for the calculation of tissue to plasma partition coefficients. *Toxicology in vitro : an international journal published in association with BIBRA* 22(2), 457-67, 10.1016/j.tiv.2007.09.010.
- ICRP. Report of the Task Group on Reference Man. ICRP Publication 23 1975

tissue_masses_flows	<i>Given a data.table describing a virtual population by the NHANES quantities, generates HTTK physiological parameters for each individual.</i>
---------------------	--

Description

Given a data.table describing a virtual population by the NHANES quantities, generates HTTK physiological parameters for each individual.

Usage

```
tissue_masses_flows(tmf_dt)
```

Arguments

tmf_dt	A data.table generated by gen_age_height_weight(), containing variables gender, reth, age_months, age_years, weight, and height.
--------	--

Value

The same data.table, with additional variables describing tissue masses and flows.

Author(s)

Caroline Ring

References

- Barter, Zoe E., et al. "Scaling factors for the extrapolation of in vivo metabolic drug clearance from in vitro data: reaching a consensus on values of human micro-somal protein and hepatocellularity per gram of liver." *Current Drug Metabolism* 8.1 (2007): 33-45.
- Birnbaum, L., et al. "Physiological parameter values for PBPK models." International Life Sciences Institute, Risk Science Institute, Washington, DC (1994).
- Geigy Pharmaceuticals, "Scientific Tables", 7th Edition, John Wiley and Sons (1970)
- McNally, Kevin, et al. "PopGen: a virtual human population generator." *Toxicology* 315 (2014): 70-85.
- Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

tissue_scale	<i>Allometric scaling.</i>
--------------	----------------------------

Description

Allometrically scale a tissue mass or flow based on $\text{height}^{3/4}$.

Usage

```
tissue_scale(height_ref, height_indiv, tissue_mean_ref)
```

Arguments

height_ref	Reference height in cm.
height_indiv	Individual height in cm.
tissue_mean_ref	Reference tissue mass or flow.

Value

Allometrically scaled tissue mass or flow, in the same units as `tissue_mean_ref`.

Author(s)

Caroline Ring

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

wambaugh2019	<i>in vitro Toxicokinetic Data from Wambaugh et al. (2019)</i>
--------------	--

Description

These data are the new HTTK in vitro data for chemicals reported in Wambaugh et al. (2019). They are the processed values used to make the figures in that manuscript. These data summarize the results of Bayesian analysis of the in vitro toxicokinetic experiments conducted by Cyprotex to characterize fraction unbound in the presence of pooled human plasma protein and the intrinsic hepatic clearance of the chemical by pooled human hepatocytes.

Usage

```
wambaugh2019
```

Format

A data frame with 496 rows and 17 variables:

Compound The name of the chemical

CAS The Chemical Abstracts Service Registry Number

Human.Clint Median of Bayesian credible interval for intrinsic hepatic clearance (uL/min/million hepatocytes)]

Human.Clint.pValue Probability that there is no clearance

Human.Funbound.plasma Median of Bayesian credible interval for fraction of chemical free in the presence of plasma

pKa_Accept pH(s) at which hydrogen acceptor sites (if any) are at equilibrium

pKa_Donor pH(s) at which hydrogen donor sites (if any) are at equilibrium

DSTox_Substance_Id Identifier for CompTox Chemical Dashboard

SMILES Simplified Molecular-Input Line-Entry System structure description

Human.Clint.Low95 Lower 95th percentile of Bayesian credible interval for intrinsic hepatic clearance (uL/min/million hepatocytes)

Human.Clint.High95 Upper 95th percentile of Bayesian credible interval for intrinsic hepatic clearance (uL/min/million hepatocytes)

Human.Clint.Point Point estimate of intrinsic hepatic clearance (uL/min/million hepatocytes)

Human.Funbound.plasma.Low95 Lower 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma

Human.Funbound.plasma.High95 Upper 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma

Human.Funbound.plasma.Point Point estimate of the fraction of chemical free in the presence of plasma

MW Molecular weight (Daltons)

logP log base ten of octanol:water partition coefficient

Author(s)

John Wambaugh

Source

Wambaugh et al. (2019)

References

Wambaugh et al. (2019) "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization", *Toxicological Sciences*, 172(2), 235-251.

wambaugh2019.nhanes	<i>NHANES Chemical Intake Rates for chemicals in Wambaugh et al. (2019)</i>
---------------------	---

Description

These data are a subset of the Bayesian inferences reported by Ring et al. (2017) from the U.S. Centers for Disease Control and Prevention (CDC) National Health and Nutrition Examination Survey (NHANES). They reflect the population median intake rate (mg/kg body weight/day), with uncertainty.

Usage

wambaugh2019.nhanes

Format

A data frame with 20 rows and 4 variables:

IP The median of the Bayesian credible interval for median population intake rate (mg/kg body-weight/day)

IP.min The lower 95th percentile of the Bayesian credible interval for median population intake rate (mg/kg bodyweight/day)

IP.max The upper 95th percentile of the Bayesian credible interval for median population intake rate (mg/kg bodyweight/day)

CASRN The Chemical Abstracts Service Registry Number

Author(s)

John Wambaugh

Source

Wambaugh et al. (2019)

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment international* 106 (2017): 105-118

Wambaugh et al. (2019) "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization", *Toxicological Sciences*, 172(2), 235-251.

wambaugh2019.raw*Raw Bayesian in vitro Toxicokinetic Data Analysis from Wambaugh et al. (2019)*

Description

These data are the new HTTK in vitro data for chemicals reported in Wambaugh et al. (2019). They are the output of different Bayesian models evaluated to compare using a single protein concentration vs. the new three concentration titration protocol. These data summarize the results of Bayesian analysis of the in vitro toxicokinetic experiments conducted by Cyprotex to characterize fraction unbound in the presence of pooled human plasma protein and the intrinsic hepatic clearance of the chemical by pooled human hepatocytes. This file includes replicates (different Compound-Name id's but same chemical')

Usage

wambaugh2019.raw

Format

A data frame with 530 rows and 28 variables:

DTXSID Identifier for CompTox Chemical Dashboard

Name The name of the chemical

CAS The Chemical Abstracts Service Registry Number

CompoundName Sample name provided by EPA to Cyprotex

Fup.point Point estimate of the fraction of chemical free in the presence of plasma

Base.Fup.Med Median of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of 100 physiological plasma protein data only (base model)

Base.Fup.Low Lower 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of 100 physiological plasma protein data only (base model)

Base.Fup.High Upper 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of 100 physiological plasma protein data only (base model)

Affinity.Fup.Med Median of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of protein titration protocol data (affinity model)

Affinity.Fup.Low Lower 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of protein titration protocol data (affinity model)

Affinity.Fup.High Upper 95th percentile of Bayesian credible interval for fraction of chemical free in the presence of plasma for analysis of protein titration protocol data (affinity model)

Affinity.Kd.Med Median of Bayesian credible interval for protein binding affinity from analysis of protein titration protocol data (affinity model)

Affinity.Kd.Low Lower 95th percentile of Bayesian credible interval for protein binding affinity from analysis of protein titration protocol data (affinity model)

Affinity.Kd.High Upper 95th percentile of Bayesian credible interval for protein binding affinity from analysis of protein titration protocol data (affinity model)

Decreases.Prob Probability that the chemical concentration decreased systematically during hepatic clearance assay.

Saturates.Prob Probability that the rate of chemical concentration decrease varied between the 1 and 10 uM hepatic clearance experiments.

Slope.1uM.Median Estimated slope for chemical concentration decrease in the 1 uM hepatic clearance assay.

Slope.10uM.Median Estimated slope for chemical concentration decrease in the 10 uM hepatic clearance assay.

CLint.1uM.Median Median of Bayesian credible interval for intrinsic hepatic clearance at 1 uM initial chemical concentration (uL/min/million hepatocytes)]

CLint.1uM.Low95th Lower 95th percentile of Bayesian credible interval for intrinsic hepatic clearance at 1 uM initial chemical concentration (uL/min/million hepatocytes)

CLint.1uM.High95th Upper 95th percentile of Bayesian credible interval for intrinsic hepatic clearance at 1 uM initial chemical concentration (uL/min/million hepatocytes)

CLint.10uM.Median Median of Bayesian credible interval for intrinsic hepatic clearance at 10 uM initial chemical concentration (uL/min/million hepatocytes)]

CLint.10uM.Low95th Lower 95th percentile of Bayesian credible interval for intrinsic hepatic clearance at 10 uM initial chemical concentration (uL/min/million hepatocytes)

CLint.10uM.High95th Upper 95th percentile of Bayesian credible interval for intrinsic hepatic clearance at 10 uM initial chemical concentration (uL/min/million hepatocytes)

CLint.1uM.Point Point estimate of intrinsic hepatic clearance (uL/min/million hepatocytes) for 1 uM initial chemical concentration

CLint.10uM.Point Point estimate of intrinsic hepatic clearance (uL/min/million hepatocytes) for 10 uM initial chemical concentration

Fit Classification of clearance observed

SMILES Simplified Molecular-Input Line-Entry System structure description

Author(s)

John Wambaugh

Source

Wambaugh et al. (2019)

References

Wambaugh et al. (2019) "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization", *Toxicological Sciences*, 172(2), 235-251.

wambaugh2019.seem3	<i>ExpoCast SEEM3 Consensus Exposure Model Predictions for Chemical Intake Rates</i>
--------------------	--

Description

These data are a subset of the Bayesian inferences reported by Ring et al. (2019) for a consensus model of twelve exposure predictors. The predictors were calibrated based upon their ability to predict intake rates inferred National Health and Nutrition Examination Survey (NHANES). They reflect the population median intake rate (mg/kg body weight/day), with uncertainty.

Usage

wambaugh2019.seem3

Format

A data frame with 385 rows and 38 variables:

Author(s)

John Wambaugh

Source

Wambaugh et al. (2019)

References

Ring, Caroline L., et al. "Consensus modeling of median chemical intake for the US population based on predictions of exposure pathways." *Environmental science & technology* 53.2 (2018): 719-732.

Wambaugh et al. (2019) "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization", *Toxicological Sciences*, 172(2), 235-251.

wambaugh2019.tox21	<i>Tox21 2015 Active Hit Calls (EPA)</i>
--------------------	--

Description

The ToxCast and Tox21 research programs employ batteries of high throughput assays to assess chemical bioactivity in vitro. Not every chemical is tested through every assay. Most assays are conducted in concentration response, and each corresponding assay endpoint is analyzed statistically to determine if there is a concentration-dependent response or "hit" using the ToxCast Pipeline. Most assay endpoint-chemical combinations are non-responsive. Here, only the hits are treated as potential indicators of bioactivity. This bioactivity does not have a direct toxicological interpretation. The October 2015 release (invitrodb_v2) of the ToxCast and Tox21 data were used for this analysis. This object contains just the chemicals in Wambaugh et al. (2019) and only the quantiles across all assays for the ACC.

Usage

wambaugh2019.tox21

Format

A data.table with 401 rows and 6 columns

Author(s)

John Wambaugh

Source

ftp://newftp.epa.gov/COMPTOX/High_Throughput_Screening_Data/Previous_Data/ToxCast_Data_Release_Oct_2015/

References

Kavlock, Robert, et al. "Update on EPA's ToxCast program: providing high throughput decision support tools for chemical risk management." *Chemical research in toxicology* 25.7 (2012): 1287-1302.

Tice, Raymond R., et al. "Improving the human hazard characterization of chemicals: a Tox21 update." *Environmental health perspectives* 121.7 (2013): 756-765.

Richard, Ann M., et al. "ToxCast chemical landscape: paving the road to 21st century toxicology." *Chemical research in toxicology* 29.8 (2016): 1225-1251.

Filer, Dayne L., et al. "tcpl: the ToxCast pipeline for high-throughput screening data." *Bioinformatics* 33.4 (2016): 618-620.

Wambaugh, John F., et al. "Assessing Toxicokinetic Uncertainty and Variability in Risk Prioritization." *Toxicological Sciences* 172.2 (2019): 235-251.

well_param

Microtiter Plate Well Descriptions for Armitage et al. (2014) Model

Description

Microtiter Plate Well Descriptions for Armitage et al. (2014) model from Honda et al. (2019)

Usage

well_param

Format

A data frame with 53940 rows and 10 variables:

area_bottom

cell_yield

diam

sysID

v_total
v_working
well_desc
well_number

Author(s)

Greg Honda

Source

<http://www.diamondse.info/>

References

Armitage, J. M.; Wania, F.; Arnot, J. A. Environ. Sci. Technol. 2014, 48, 9770-9779. dx.doi.org/10.1021/es501955g
Honda, Gregory S., et al. "Using the Concordance of In Vitro and In Vivo Data to Evaluate Extrapolation Assumptions", PloS ONE 14.5 (2019): e0217564.

Wetmore.data

Published toxicokinetic predictions based on in vitro data

Description

This data set gives the chemical specific predictions for serum concentration at steady state resulting from constant infusion exposure, as published in a series of papers from Barbara Wetmore's group at the Hamner Institutes for Life Sciences. Predictions include the median and 90% interval in uM and mg/L. Calculations were made using the 1 and 10 uM in vitro measured clearances.

Usage

Wetmore.data

Format

A data.frame containing 577 rows and 20 columns.

Source

Wambaugh, John F., et al. "Toxicokinetic triage for environmental chemicals." Toxicological Sciences (2015): 228-237.

References

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Sochaski, M.A., Rotroff, D.M., Freeman, K., Clewell, H.J., Dix, D.H., Andersen, M.E., Houck, K.A., Allen, B., Judson, R.S., Sing, R., Kavlock, R.J., Richard, A.M., and Thomas, R.S., "Integration of Dosimetry, Exposure and High-Throughput Screening Data in Chemical Toxicity Assessment," Toxicological Sciences 125 157-174 (2012)
Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Li, L., Clewell, H.J. III, Judson, R.S., Freeman, K., Bao, W., Sochaski, M.A., Chu T.-M., Black, M.B., Healy, E., Allen, B., Andersen M.E., Wolfinger, R.D., and Thomas R.S., "The Relative Impact of Incorporating Pharmacokinetics on Predicting in

vivo Hazard and Mode-of-Action from High-Throughput in vitro Toxicity Assays" Toxicological Sciences, 132:327-346 (2013).

Wetmore, B. A., Wambaugh, J. F., Allen, B., Ferguson, S. S., Sochaski, M. A., Setzer, R. W., Houck, K. A., Strope, C. L., Cantwell, K., Judson, R. S., LeCluyse, E., Clewell, H.J. III, Thomas, R.S., and Andersen, M. E. (2015). "Incorporating High-Throughput Exposure Predictions with Dosimetry-Adjusted In Vitro Bioactivity to Inform Chemical Toxicity Testing" Toxicological Sciences, kfv171.

Wetmore2012

Published toxicokinetic predictions based on in vitro data from Wetmore et al. 2012.

Description

This data set overlaps with Wetmore.data and is used only in Vignette 4 for steady state concentration.

Usage

Wetmore2012

Format

A data.frame containing 13 rows and 15 columns.

References

Wetmore, B.A., Wambaugh, J.F., Ferguson, S.S., Sochaski, M.A., Rotroff, D.M., Freeman, K., Clewell, H.J., Dix, D.H., Andersen, M.E., Houck, K.A., Allen, B., Judson, R.S., Sing, R., Kavlock, R.J., Richard, A.M., and Thomas, R.S., "Integration of Dosimetry, Exposure and High-Throughput Screening Data in Chemical Toxicity Assessment," Toxicological Sciences 125 157-174 (2012)

wfl

WHO weight-for-length charts

Description

Charts giving weight-for-length percentiles for boys and girls under age 2.

Usage

wfl

Format

A data.table object with variables

Sex 'Male' or 'Female'

Length length in cm

L, M, S LMS parameters; see http://www.cdc.gov/growthcharts/percentile_data_files.htm

P2.3, P5, P10, P25, P50, P75, P90, P95, and P97.7 weight percentiles

Details

For infants under age 2, weight class depends on weight for length percentile. #'

Underweight <2.3rd percentile

Normal weight 2.3rd-97.7th percentile

Obese >=97.7th percentile

Author(s)

Caroline Ring

Source

http://www.cdc.gov/growthcharts/who/girls_weight_head_circumference.htm and http://www.cdc.gov/growthcharts/who/boys_weight_head_circumference.htm

References

Ring, Caroline L., et al. "Identifying populations sensitive to environmental chemicals by simulating toxicokinetic variability." *Environment International* 106 (2017): 105-118

Index

*Topic **1compartment**

calc_analytic_css_1comp, [21](#)
calc_elimination_rate, [29](#)
calc_total_clearance, [49](#)
calc_vdist, [51](#)
convert_httkpop_1comp, [63](#)
parameterize_1comp, [111](#)
propagate_invitrouv_1comp, [130](#)
solve_1comp, [137](#)

*Topic **3compartment**

calc_analytic_css_3comp, [22](#)
parameterize_3comp, [113](#)
propagate_invitrouv_3comp, [130](#)
solve_3comp, [141](#)

*Topic **3compss**

calc_analytic_css_3compss, [23](#)
parameterize_steadystate, [123](#)

*Topic **Dynamic**

scale_dosing, [133](#)

*Topic **Export**

export_pbt_k_jarnac, [69](#)
export_pbt_k_sbml, [70](#)

*Topic **Literature**

get_lit_cheminfo, [77](#)
get_lit_css, [78](#)
get_lit_oral_equiv, [80](#)

*Topic **Monte-Carlo**

calc_mc_css, [36](#)
calc_mc_oral_equiv, [40](#)
calc_mc_tk, [43](#)
create_mc_samples, [63](#)
get_lit_css, [78](#)
get_lit_oral_equiv, [80](#)
monte_carlo, [106](#)

*Topic **Parameter**

available_rblood2plasma, [13](#)
calc_elimination_rate, [29](#)
calc_hep_clearance, [31](#)
calc_ionization, [34](#)
calc_krbc2pu, [35](#)
calc_rblood2plasma, [46](#)
calc_total_clearance, [49](#)
calc_vdist, [51](#)

get_rblood2plasma, [82](#)
lump_tissues, [102](#)
parameterize_1comp, [111](#)
parameterize_3comp, [113](#)
parameterize_gas_pbt_k, [115](#)
parameterize_pbt_k, [119](#)
parameterize_schmitt, [121](#)
parameterize_steadystate, [123](#)
predict_partitioning_schmitt, [128](#)

*Topic **Retrieval**

get_cheminfo, [73](#)
get_lit_cheminfo, [77](#)

*Topic **Solve**

calc_analytic_css, [18](#)
calc_stats, [47](#)
honda.ivive, [84](#)
solve_1comp, [137](#)
solve_3comp, [141](#)
solve_gas_pbt_k, [144](#)
solve_model, [148](#)
solve_pbt_k, [151](#)

*Topic **Statistics**

calc_stats, [47](#)

*Topic **Steady-State**

calc_css, [26](#)
calc_mc_css, [36](#)
calc_mc_oral_equiv, [40](#)

*Topic **cheminformatics**

get_chem_id, [75](#)

*Topic **datasets**

EPA.ref, [66](#)
Tables.Rdata.stamp, [160](#)

*Topic **data**

age_dist_smooth, [7](#)
armitage_input, [12](#)
bmiage, [15](#)
chem.invivo.PK.aggregate.data, [52](#)
chem.invivo.PK.data, [53](#)
chem.invivo.PK.summary.data, [56](#)
chem.lists, [59](#)
chem.physical_and_invitro.data, [60](#)
concentration_data_Linakis2020, [62](#)
Frank2018invivo, [71](#)

- howgate, 86
- johnson, 99
- mcnally_dt, 104
- metabolism_data_Linakis2020, 105
- nhanes_mec_svy, 108
- Obach2008, 109
- onlyp, 110
- pc.data, 125
- pharma, 126
- physiology.data, 127
- sipes2017, 134
- spline_heightweight, 156
- spline_hematocrit, 157
- spline_serumcreat, 158
- supptab1_Linakis2020, 158
- supptab2_Linakis2020, 159
- tissue.data, 160
- wambaugh2019, 162
- wambaugh2019.nhanes, 164
- wambaugh2019.raw, 165
- wambaugh2019.seem3, 167
- wambaugh2019.tox21, 167
- well_param, 168
- Wetmore.data, 169
- Wetmore2012, 170
- wfl, 170
- *Topic **dynamic**
 - calc_mc_tk, 43
- *Topic **httk-pop**
 - age_dist_smooth, 7
 - age_draw_smooth, 8
 - blood_mass_correct, 14
 - blood_weight, 15
 - bmiage, 15
 - body_surface_area, 16
 - bone_mass_age, 17
 - brain_mass, 18
 - ckd_epi_eq, 61
 - convert_httkpop_1comp, 63
 - estimate_gfr, 67
 - estimate_gfr_ped, 67
 - estimate_hematocrit, 68
 - gen_age_height_weight, 71
 - gen_height_weight, 73
 - get_gfr_category, 75
 - get_weight_class, 83
 - hematocrit_infants, 84
 - httkpop, 86
 - httkpop_biotophys_default, 87
 - httkpop_direct_resample, 87
 - httkpop_direct_resample_inner, 89
 - httkpop_generate, 90
 - httkpop_mc, 92
 - httkpop_virtual_indiv, 93
 - is_in_inclusive, 99
 - kidney_mass_children, 100
 - liver_mass_children, 101
 - lung_mass_children, 104
 - mcnally_dt, 104
 - nhanes_mec_svy, 108
 - pancreas_mass_children, 110
 - rfunc, 132
 - skeletal_muscle_mass, 135
 - skeletal_muscle_mass_children, 136
 - skin_mass_bosgra, 136
 - spleen_mass_children, 155
 - spline_heightweight, 156
 - spline_hematocrit, 157
 - spline_serumcreat, 158
 - tissue_masses_flows, 161
 - tissue_scale, 162
 - well_param, 168
 - wfl, 170
- *Topic **in-vitro**
 - calc_hep_fu, 33
 - invitro_mc, 96
- *Topic **monte-carlo**
 - httkpop_biotophys_default, 87
 - httkpop_direct_resample, 87
 - httkpop_direct_resample_inner, 89
 - httkpop_generate, 90
 - httkpop_mc, 92
 - httkpop_virtual_indiv, 93
 - invitro_mc, 96
 - propagate_invitrouv_1comp, 130
 - propagate_invitrouv_3comp, 130
 - propagate_invitrouv_pbtk, 131
- *Topic **package**
 - httk-package, 5
- *Topic **pbtk**
 - calc_analytic_css_pbtk, 25
 - parameterize_pbtk, 119
 - propagate_invitrouv_pbtk, 131
 - solve_pbtk, 151
- *Topic **physiology**
 - calc_hep_bioavailability, 30
- *Topic **schmitt**
 - parameterize_schmitt, 121
- *Topic **simulation**
 - calc_mc_tk, 43
- add_chemtable, 6
- age_dist_smooth, 7
- age_draw_smooth, 8
- armitage_estimate_sarea, 9

- armitage_eval, 10
- armitage_input, 12
- available_rblood2plasma, 13

- blood_mass_correct, 14
- blood_weight, 14, 15
- bmiage, 15
- body_surface_area, 16
- bone_mass_age, 17
- brain_mass, 18

- calc_analytic_css, 18, 38
- calc_analytic_css_1comp, 21
- calc_analytic_css_3comp, 22
- calc_analytic_css_3compss, 23
- calc_analytic_css_pbtck, 25
- calc_css, 26
- calc_elimination_rate, 29, 130
- calc_hep_bioavailability, 30
- calc_hep_clearance, 31, 130, 131
- calc_hep_fu, 33
- calc_ionization, 34
- calc_krbc2pu, 35
- calc_mc_css, 36
- calc_mc_oral_equiv, 40
- calc_mc_tk, 43
- calc_rblood2plasma, 46
- calc_stats, 47
- calc_total_clearance, 49
- calc_vdist, 51
- chem.invivo.PK.aggregate.data, 52
- chem.invivo.PK.data, 53
- chem.invivo.PK.summary.data, 56
- chem.lists, 59
- chem.physical_and_invitro.data, 60
- ckd_epi_eq, 61
- concentration_data_Linakis2020, 62
- convert_httkpop_1comp, 63
- create_mc_samples, 63, 63

- EPA.ref, 66
- estimate_gfr, 67
- estimate_gfr_ped, 67
- estimate_hematocrit, 68
- export_pbtck_jarnac, 69
- export_pbtck_sbml, 70

- Frank2018invivo, 71

- gen_age_height_weight, 71
- gen_height_weight, 73
- get_chem_id, 75
- get_cheminfo, 73

- get_gfr_category, 75
- get_invitroPK_param, 76
- get_lit_cheminfo, 77
- get_lit_css, 78
- get_lit_oral_equiv, 80
- get_physchem_param, 81
- get_rblood2plasma, 82
- get_weight_class, 83

- hematocrit_infants, 84
- honda.ivive, 84
- howgate, 86
- httk (httk-package), 5
- httk-package, 5
- httkpop, 86
- httkpop-package (httkpop), 86
- httkpop_biotophys_default, 87
- httkpop_direct_resample, 87
- httkpop_direct_resample_inner, 89
- httkpop_generate, 38, 44, 63, 65, 86, 90, 92
- httkpop_mc, 86, 92
- httkpop_virtual_indiv, 93

- in.list, 94, 98
- invitro_mc, 38, 44, 65, 96
- is.expocast (in.list), 94
- is.httk, 95, 97
- is.nhanes (in.list), 94
- is.pharma (in.list), 94
- is.tox21 (in.list), 94
- is.toxcast (in.list), 94
- is_in_inclusive, 99

- johnson, 99

- kidney_mass_children, 100

- liver_mass_children, 101
- load_sipes2017, 101
- lump_tissues, 102
- lung_mass_children, 104

- mcnally_dt, 104
- metabolism_data_Linakis2020, 105
- monte_carlo, 106

- nhanes_mec_svy, 108

- Obach2008, 109
- onlyp, 110

- pancreas_mass_children, 110
- parameterize_1comp, 111
- parameterize_3comp, 113

parameterize_gas_pbtck, 115
parameterize_pbtck, 119
parameterize_schmitt, 46, 121, 128
parameterize_steadystate, 123
pc.data, 125
pharma, 126
physiology.data, 127
predict_partitioning_schmitt, 46, 128
propagate_invitrouv_1comp, 63, 130
propagate_invitrouv_3comp, 130
propagate_invitrouv_pbtck, 131

r_left_censored_norm, 133
reset_httk, 131
rfun, 132

scale_dosing, 133
Sipes2017 (sipes2017), 134
sipes2017, 134
skeletal_muscle_mass, 135
skeletal_muscle_mass_children, 135, 136
skin_mass_bosgra, 136
solve_1comp, 137
solve_3comp, 141
solve_gas_pbtck, 144
solve_model, 44, 148
solve_pbtck, 27, 151
spleen_mass_children, 155
spline_heightweight, 156
spline_hematocrit, 157
spline_serumcreat, 158
supptab1_Linakis2020, 158
supptab2_Linakis2020, 159

Tables.Rdata.stamp, 160
tissue.data, 160
tissue_masses_flows, 161
tissue_scale, 162

wambaugh2019, 162
wambaugh2019.nhanes, 164
wambaugh2019.raw, 165
wambaugh2019.seem3, 167
wambaugh2019.tox21, 167
well_param, 168
Wetmore.data, 169
Wetmore2012, 170
wfl, 170