

	QMRP identifier (JRC Inventory): To be entered by JRC
	QMRP Title: GT3_MNT_MOUSE, Micronucleus test, in vivo, Mouse, version 1.9.0.8.1284.350
	Printing Date: Apr 3, 2024

1. QSAR identifier

1.1. QSAR identifier (title):

GT3_MNT_MOUSE, Micronucleus test, in vivo, Mouse, version
1.9.0.8.1284.350

1.2. Other related models:

This model is part of the set of CASE Ultra Genotoxicity models:

GT2_CHROM_CHL(Chromosomal aberration in CHL cell line), GT2_CHROM_CHO(Chromosomal aberration in CHO cell line), GT4_ML_ACT (Mouse Lymphoma activated),
GT4_ML_UNACT (Mouse Lymphoma unactivated)

1.3. Software coding the model:

CASE Ultra Version 1.9.0.8

QSAR based bioactivity and toxicity prediction software

sales@multicase.com, MultiCASE Inc, 5885 Landerbrook Dr. #210 Mayfield Heights, OH 44124
USA www.multicase.com

<http://www.multicase.com/case-ultra>

2. General information

2.1. Date of QMRP:

July 2nd, 2019

2.2. QMRP author(s) and contact details:

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[2]Mounika Girireddy MultiCASE Inc +1-440-565-7221 girireddy@multicase.com
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2.3. Date of QMRP update(s):

March 27, 2024

2.4. QMRP update(s):

- Added data from FDA drug labels and echemportal (ECHA)
- Rebuild and revalidated the models

2.5. Model developer(s) and contact details:

Models were constructed under a Research Collaboration Agreement between the US Food and Drug Administration's Center for Drug Evaluation and Research, and MultiCASE Inc. +1-440-565-7221 saiakhov@multicase.com www.multicase.com

2.6. Date of model development and/or publication:

The original MC4PC model was developed in 2005; Published in 2005; Last update in 2014

2.7. Reference(s) to main scientific papers and/or software package:

[1]Edwin J. Matthews, Naomi L. Kruhlak, Michael C. Cimino, R. Daniel Benz, Joseph F. Contrera. An analysis of genetic toxicity, reproductive and developmental toxicity, and carcinogenicity data: I. Identification of carcinogens using surrogate endpoints Regulatory Toxicology and Pharmacology 44 (2006) 83–96

[2]Edwin J. Matthews, Naomi L. Kruhlak, Michael C. Cimino, R. Daniel Benz, Joseph F. Contrera. An analysis of genetic toxicity, reproductive and developmental toxicity, and carcinogenicity data: II. Identification of genotoxicants, reprotoxicants, and carcinogens using in silico methods Regulatory Toxicology and Pharmacology 44 (2006) 97–110

[3]Yoo JW, Minnier BL, Kruhlak NL, Stavitskaya L. Development of improved (Q)SAR models for predicting the outcome of the in vivo micronucleus genetic toxicity assay. Abstracts of Papers, 54th Society of Toxicology Annual meetings, San Diego CA, March 22-26, 2015, poster presentation.

[4]Hewes KP, Stavitskaya L, Minnier BL, Kruhlak NL. Construction and application of (Q)SAR models to predict in vitro chromosome aberrations. Abstracts of Papers, 54th Society of Toxicology Annual meetings, San Diego CA, March 22-26, 2015, poster presentation.

[5]FDA Drug Labels data from: Data provided by the U.S. Food and Drug Administration
<https://open.fda.gov>

[6]European Chemicals Agency <http://echa.europa.eu/>

2.8. Availability of information about the model:

Model is commercial. Although the training set is not publicly available, Information about the non-proprietary training set chemicals, assay conditions and details, information about the alerts are available through CASE Ultra interface. For any other specific details contact: sales@multicase.com, MultiCASE Inc. 5885 Landerbrook Dr. #210 Mayfield Heights, OH 44124 USA.
Phone: +1-440-565-7221.

2.9. Availability of another QMRF for exactly the same model:

None

3. Defining the endpoint - OECD Principle 1

3.1. Species:

In vivo micronucleus, mouse

3.2. Endpoint:

Genotoxicity Micronucleus in vivo

3.3. Comment on endpoint:

The mammalian in vivo micronucleus test is used for the detection of damage induced by the test substance to the chromosomes or the mitotic apparatus of erythroblasts, by analysis of erythrocytes as sampled in bone marrow and/or peripheral blood cells of animals, usually rodents (mice or rats). The purpose of the micronucleus test is to identify substances (liquid or solid) that cause cytogenetic damage which results in the formation of micronuclei containing lagging chromosome fragments or whole chromosomes. An increase in the frequency of micronucleated polychromatic erythrocytes in treated animals is an indication of induced chromosome damage. Animals are exposed to the test substance by an appropriate route (usually by gavage using a stomach tube or a suitable intubation cannula, or by intraperitoneal injection). Bone marrow and/or blood cells are collected, prepared and stained. Preparations are analyzed for the presence of micronuclei. Each treated and control group must include at least 5 analyzable animals per sex. Administration of the treatments consists of a single dose of test substance or two daily doses (or more). The limit dose is 2000

mg/kg/body weight/day for treatment up to 14 days, and 1000 mg/kg/body weight/day for treatment longer than 14 days.

3.4.Endpoint units:

Binary Units

3.5.Dependent variable:

Overall Positive (1) or Negative (0). The final calls were determined as a summary of all the strains used in the test.

3.6.Experimental protocol:

Per OECD Guideline 474

3.7.Endpoint data quality and variability:

High quality curated data. Structures of training chemicals and names were verified. Duplicates were removed. Mixtures components were manually reviewed and used as separate entries if applicable.

4.Defining the algorithm - OECD Principle 2

4.1.Type of model:

Model built using Statistical Machine Learning techniques.

QSAR model with binary classification ability. Consists of a logistic regression model with molecular fragment/substructures as the descriptors. The descriptors cover both potentiating and deactivating/mitigating molecular features for compounds exhibiting or not-exhibiting genotoxic potential. The molecular features related to chromosome damage were identified from training data using various machine learning techniques.

4.2.Explicit algorithm:

Logistic regression QSAR

Training: Multiple Logistic Regression model with occurrence of Alerts and Deactivating Features as independent and overall test outcome as dependent variable. Prediction: Application of the logistic regression model using the identification of alerts and modulators in the query compounds

4.3.Descriptors in the model:

Molecular fragment based descriptors. Occurrence of molecular fragment-based Alerts and modulating features as independent and overall test outcome as dependent variable.

4.4.Descriptor selection:

A descriptor selection process was applied on the initial pool of molecular fragments which picks up the fragments with positive and negative contributions so as to give the best predictive ability to the whole model. The final model contains 165 alerts.

4.5.Algorithm and descriptor generation:

Descriptors for this CASE Ultra model are molecular fragments which are generated from splitting the training set compounds systematically and creating a dictionary of unique fragments. After selecting a few most relevant fragments, a statistical logistic regression data-fitting was applied between the X and Y variables to give the final model.

4.6.Software name and version for descriptor generation:

CASE Ultra V 1.9.0.8

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<http://www.multicase.com/case-ultra>

4.7. Chemicals/Descriptors ratio:

Number of Chemicals = 1284 (384 positives/900 negatives), Number of Descriptors = 165

5. Defining the applicability domain - OECD Principle 3

5.1. Description of the applicability domain of the model:

The applicability domain of the model is defined by fragment based chemical space defined by the training set chemicals and range in the computed prediction probabilities where the model has weakest differentiability.

5.2. Method used to assess the applicability domain:

The CASE Ultra program evaluates automatically whether a tested molecule is within the domain of applicability of the model it is tested with. A combination of two criteria were used:

1. Checking for 3-atom fragments that are not present in the training chemicals, and
2. Calculated prediction probabilities that fall between 0.27 - 0.36 where the model has weakest differentiability

5.3. Software name and version for applicability domain assessment:

CASE Ultra Version 1.9.0.8

QSAR expert system for in-silico prediction of toxicity and bioactivity of chemicals

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5.4. Limits of applicability:

Inorganic compounds, mixtures and large biomolecules are not covered.

In addition,

1. Test chemicals with 3-atom fragments that are not present in the training chemicals potentially are out-of-domain, and
2. Test chemicals with computed prediction probabilities between 0.27 - 0.36 are in grey zone

6. Internal validation - OECD Principle 4

6.1. Availability of the training set:

Yes

6.2. Available information for the training set:

CAS RN: Yes

Chemical Name: Yes

Smiles: Yes

Formula: No

INChI: No

MOL file: Yes

NanoMaterial: null

6.3.Data for each descriptor variable for the training set:

Some

6.4.Data for the dependent variable for the training set:

Some

6.5.Other information about the training set:

Within CASE Ultra interface, all the fragment descriptors are supported by the training chemicals. Every descriptor is supported by relevant statistics, e.g. number of positive and negative training chemicals that contain the fragment. Training set chemicals are explained with assay type, assay conditions, scientific publications etc.

6.6.Pre-processing of data before modelling:

1. Extracted new data from FDA drug safety labels and ECHA, also included data from existing models (data obtained through research collaboration with FDA)
2. Verification of chemical structures, registry numbers, CID and names.
3. Duplicates were removed.
4. Mixture components were treated on case by case basis, components if necessary were separated and assigned activity if possible.

6.7.Statistics for goodness-of-fit:**6.8.Robustness - Statistics obtained by leave-one-out cross-validation:**

not performed

6.9.Robustness - Statistics obtained by leave-many-out cross-validation:

Sensitivity 66.6%; Specificity 86.6% Positive predictivity 65.9%
Negative predictivity 87.1%, Coverage 64.6% AUC 0.889, 10 iterations,
10% off Classification cut-off 0.35

6.10.Robustness - Statistics obtained by Y-scrambling:

Sensitivity 22.8%; Specificity 72.9% Positive predictivity 32.0%
Negative predictivity 62.9%, Coverage 23.0% AUC 0.503, 10 iterations,
10% off Classification cut-off 0.35

6.11.Robustness - Statistics obtained by bootstrap:

Sensitivity 67.7%; Specificity 85.6% Positive predictivity 67.7%
Negative predictivity 85.6%, Coverage 64% AUC 0.879, 10 iterations, 10%
off Classification cut-off 0.35

6.12.Robustness - Statistics obtained by other methods:

Self Validation - Sensitivity 65.5%; Specificity 93.0% Positive
predictivity 78.5% Negative predictivity 87.3%, Coverage 80% AUC 0.945,
Classification cut-off 0.35

7.External validation - OECD Principle 4**7.1.Availability of the external validation set:**

Yes

7.2.Available information for the external validation set:

CAS RN: Yes

Chemical Name: Yes

Smiles: Yes

Formula: No

INChI: No

MOL file: Yes

NanoMaterial: null

7.3.Data for each descriptor variable for the external validation set:

Some

7.4.Data for the dependent variable for the external validation set:

Some

7.5.Other information about the external validation set:

7.6.Experimental design of test set:

The external set was composed of 75 compounds, 30 positive and 45 negatives. The external compounds were randomly selected from complete dataset (before splitting into training and test sets). Experimental protocol of the external compounds are same as the training set compounds.

7.7.Predictivity - Statistics obtained by external validation:

Sensitivity 46.43%; Specificity 55.56% Positive predictivity 44.83%
Negative predictivity 57.14%, Coverage 85.33%, Classification cut-off
0.35

7.8.Predictivity - Assessment of the external validation set:

7.9.Comments on the external validation of the model:

8.Providing a mechanistic interpretation - OECD Principle 5

8.1.Mechanistic basis of the model:

CASE Ultra models do not have any predefined knowledge of molecular mechanism that explains the activity of a molecule. However, the way the modules were built, splitting the entire learning set into clusters of molecules with a dedicated QSAR in every cluster, suggests very close links with a mechanistic explanations of activity. Indeed many of the resulting biophores have modes of action that are obvious to persons with expert knowledge for the endpoint in question. For example, the presence of an alert containing N-nitroso fragment in bacterial mutagenicity model will undoubtedly suggest potential mutagenicity activity. Other fragments, which do not have such a clear mechanism of action assigned to them, can support an intelligent guess about possible sets of events causing activity. Either way, it is certain that the results of a MultiCASE analysis can serve as a mechanistic research tool as well as a QSAR builder.

8.2.A priori or a posteriori mechanistic interpretation:

The mechanistic basis of the model was neither determined a priori nor a posteriori. The selected features were mined completely automatically from the training data during the model building process and they agree very well with the known chemical mechanisms of genotoxicity. The training structures were also not selected with any specific mechanism in mind.

8.3.Other information about the mechanistic interpretation:

None

9. Miscellaneous information

9.1. Comments:

This model should be useful in the risk assessment of identifying compounds causing genotoxicity. It will also be helpful in understanding various known and unknown mechanisms of compounds causing genotoxicity. It will be particularly helpful in regulatory submission. When a prediction is made using this model in CASE Ultra program, the identified alerts (if any) are highlighted in the query chemical which is helpful in interpreting the results.

9.2. Bibliography:

- [1] Optimizing predictive performance of CASE Ultra expert system models using the applicability domains of individual toxicity alerts; Chakravarti, S.K., Saiakhov, R.D. and Klopman, G., Journal of Chemical Information and Modeling, 2012, 52, 2609-2618. DOI: 10.1021/ci300111r
- [2] Effectiveness of CASE Ultra Expert System in Evaluating Adverse Effects of Drugs; Saiakhov, R.D., Chakravarti, S.K. and Klopman, G.; Molecular Informatics, 2012, 32, 87-97.
- [3] Computing similarity between structural environments of mutagenicity alerts, Chakravarti, S.K., Saiakhov, R. D.; Mutagenesis, October 20, 2018,

9.3. Supporting information:

Training set(s) Test set(s) Supporting information

10. Summary (JRC QSAR Model Database)

10.1. QMRF number:

To be entered by JRC

10.2. Publication date:

To be entered by JRC

10.3. Keywords:

To be entered by JRC

10.4. Comments:

To be entered by JRC