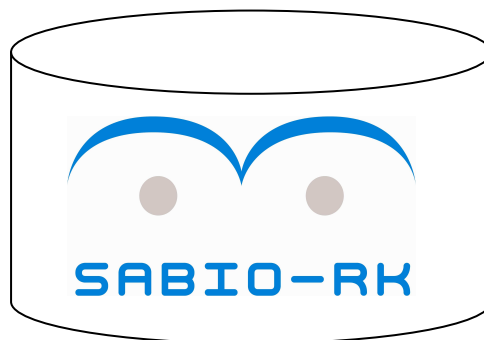


SABIO-RK: Curated Kinetic Data of Biochemical Reactions

Ulrike Wittig
Scientific Databases and Visualization Group
EML Research, Heidelberg, Germany

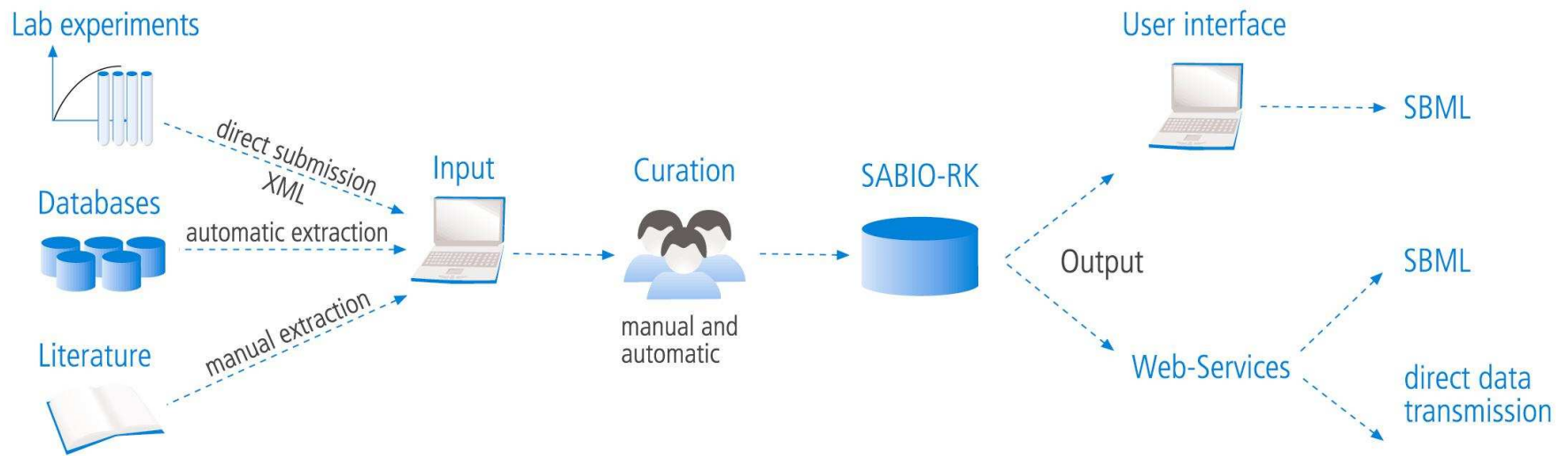


SABIO-RK Database

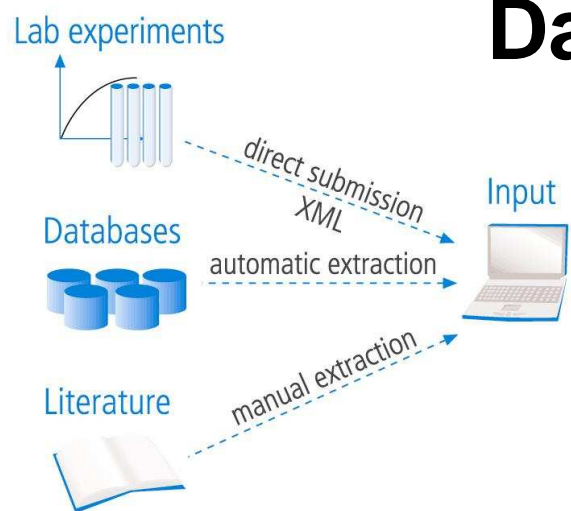


- general information (***from other databases + literature***)
 - reaction (substrate, product, modifier), pathway
 - enzyme, protein information (wildtype, mutant etc.)
 - organism, tissue, cell location
 - information source
- kinetic information (***from literature***)
 - kinetic law, formula
 - parameter (K_m , V_{max} , concentration etc.)
 - experimental condition (pH, temperature, buffer)

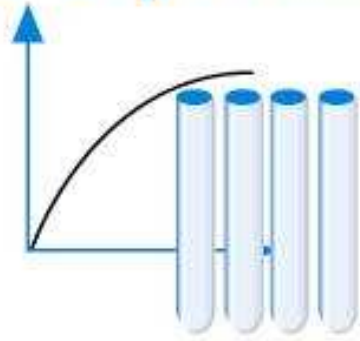
Overview



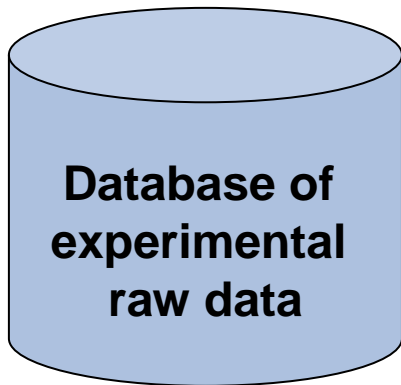
Data Input



- Automatic extraction of information from other databases (e.g. KEGG)
→ *pathways, reactions, enzymes, compounds*
- Data manually extracted from literature
→ *reactions, protein details, kinetic parameter, environmental conditions, mechanism etc.*
- Data directly obtained from laboratory experiments
→ *kinetic parameter, environmental conditions etc.*



↓
Generation of
experimental data



Storage of kinetic data
(e.g. K_m , V_{max})

→

←

Link to original data



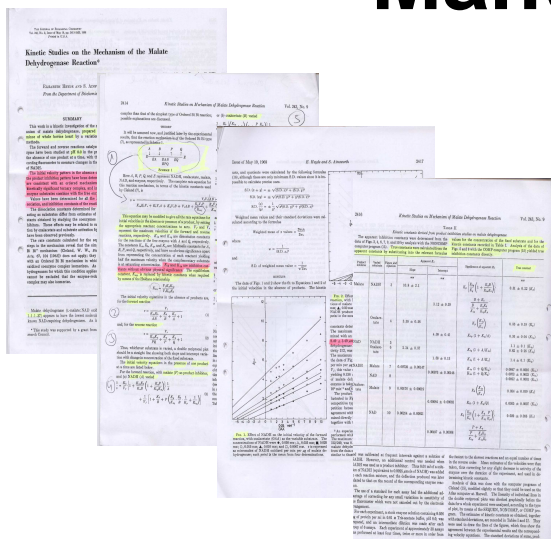
↓
Data access



Automatic Input (XML based)

**Collaboration with Douglas Kell, Neil Swainston
(Manchester Center for Integrative Systems Biology)**

Manual Data Extraction



- Data stored in publications (tables, formulas, graphs etc.)
- Some information is only noted as reference (e.g. environmental conditions)
- No controlled vocabulary in the literature (different names for compounds, kinetic laws etc.)
- Missing information



Input Interface

- Web interface
- Structuring the data from literature

Input Interface – Single Entry

experimental conditions

| pH | | temperature (°C) | | buffer |
|-------|-----|------------------|-----|----------------------------------|
| start | end | start | end | composition |
| 7.4 | | 25 | | 10 mM Tris/Cl, 150 mM NaCl, 5 mM |

| other condition | | | | |
|-----------------|-----|------|------|-----------------------------------|
| start | end | unit | name | comment |
| | | | | experimental conditions are taken |

| | | | |
|-----------------|---|--------|---------|
| organism | Homo sapiens | strain | 5 |
| mechanism | unknown | | unknown |
| tissue/celltype | muscle | | 1016 |
| info source | Human cytosolic adenylate kinase allelozymes; purification and characterization; Luz CM, König I, Schirme | | |
| info type | Journal | | |
| comment | comment | | |

choose organism:

choose tissue:

choose info source:

Input Interface - Summary

Enzyme classification

| Entry # | Complex information | EC number | Wildtype | Recombinant | Expressed in | edit |
|---------|---------------------|-----------|---------------------------|-------------|--------------|----------------------|
| 21630 | P00568 | 2.7.4.3 | wildtype allelozyme AK1*2 | . | . | edit |
| 21631 | P00568 | 2.7.4.3 | wildtype allelozyme AK1*2 | . | . | edit |
| 21632 | P00568 | 2.7.4.3 | wildtype allelozyme AK1*1 | . | . | edit |
| 21633 | P00568 | 2.7.4.3 | wildtype allelozyme AK1*1 | . | . | edit |

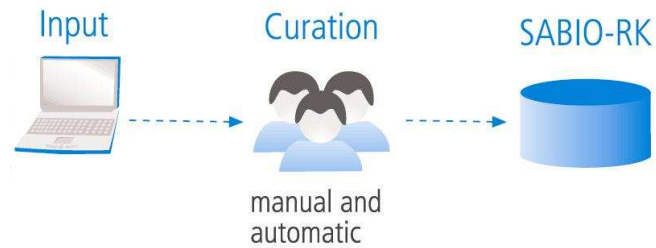
Enzyme description

| Entry # | Stoe | Name | UniProt ID | MW (kDa) | Deviation (kDa) | edit |
|---------|------|--------|------------|----------|-----------------|----------------------|
| 21630 | 1 | native | complex | 21.7 | . | edit |
| 21631 | 1 | native | complex | 21.7 | . | edit |
| 21632 | 1 | native | complex | 21.7 | . | edit |
| 21633 | 1 | native | complex | 21.7 | . | edit |

Environment conditions

| Entry # | pH Start | pH End | Temp Start | Temp End | Other Start | Other End | Other Unit | Other Types | Buffer | Comment | edit |
|---------|----------|--------|------------|----------|-------------|-----------|------------|-------------|---|---|----------------------|
| 21630 | 7.4 | . | 25 | . | . | . | . | . | 10 mM Tris/Cl, 150 mM NaCl, 5 mM dithioerythritol, 0.1 mM EDTA, 4 mM phosphoenolpyruvate, 20 mM KCl, 0.5 mg/ml bovine serum albumin, 1 mM MgCl ₂ , 0.2 mM NADH, 20 U/ml lactate dehydrogenase, 10 U/ml pyruvate kinase | experimental conditions are taken from: PubMed ID 214039 | edit |
| 21631 | 8.1 | . | 30 | . | . | . | . | . | 50 mM Tris/OAc, 2.1 mM Mg(OAc) ₂ , 6.7 mM glucose, 0.67 mM NADP, 2.67 U/ml hexokinase, 2.33 U/ml glucose 6-phosphate dehydrogenase | experimental conditions are taken from: PubMed ID 6269633 | edit |
| 21632 | 7.4 | . | 25 | . | . | . | . | . | 10 mM Tris/Cl, 150 mM NaCl, 5 mM dithioerythritol, 0.1 mM EDTA, 4 mM phosphoenolpyruvate, 20 mM KCl, 0.5 mg/ml bovine serum albumin, 1 mM MgCl ₂ , 0.2 mM NADH, 20 U/ml lactate dehydrogenase, 10 U/ml pyruvate kinase | experimental conditions are taken from: PubMed ID 214039 | edit |
| 21633 | 8.1 | . | 30 | . | . | . | . | . | 50 mM Tris/OAc, 2.1 mM Mg(OAc) ₂ , 6.7 mM glucose, 0.67 mM NADP, 2.67 U/ml hexokinase, 2.33 U/ml glucose 6-phosphate dehydrogenase | experimental conditions are taken from: PubMed ID 6269633 | edit |

Curation



- Data first inserted in an intermediate database
- Curation process
 - *Manually by biological experts*
 - *Semi-automatically by consistency checks*
 - *Standardization*
 - *Unification*
 - *Annotation to controlled vocabularies and external databases*
- Transfer data from intermediate to public SABIO-RK database

Curation Problems

Missing or only partial information in the data source:

- *Incomplete reactions (e.g. products not mentioned)*
- *Organism specification is missing*
- *Assay conditions or methods description missing or reference to another paper (no temperature or room temperature etc.)*
- *Kinetic law equation (or fitting equation) not described or parameters incomplete*
- *Isoenzyme not specified (old papers)*

Identification of compounds, reactions and enzymes:

- *Ambiguous descriptions of chemical compounds or enzymes*

Automatic Consistency Checks

- Check if all parameters in a kinetic law formula are in the parameters list
- Check if all reaction participants are written and have a defined role in the reaction equation
- Check if parameter type and its role (variable or constant) is defined
- Check if compound-dependent parameter types have a defined species

Identification of Identical Chemical Compounds

Methods developed to support curation:

- Normalization of compound names
- Analysis of compound names and generation of SMILES string
- Generation of chemical structure based on SMILES string
- Classification of chemical compounds

Normalization of Compounds

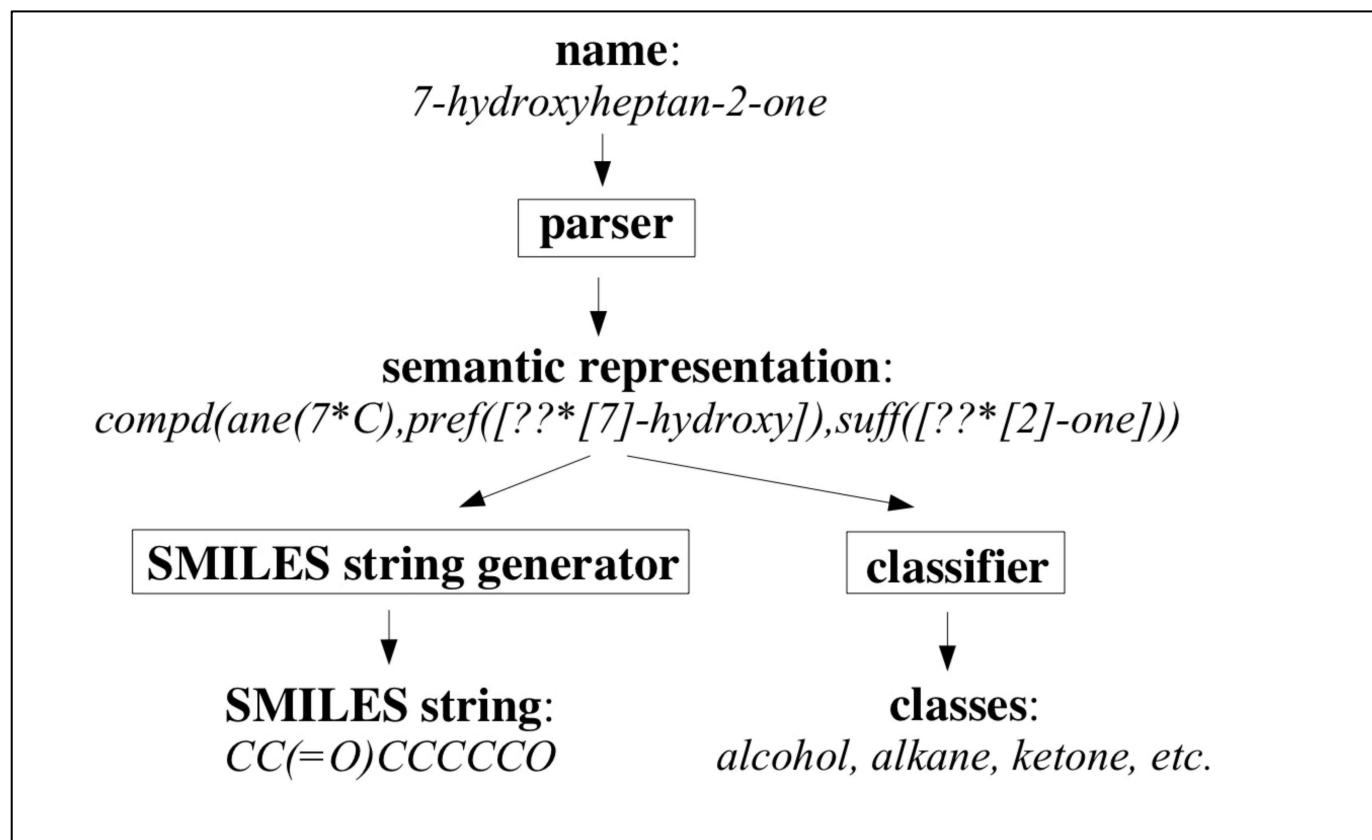
Matching names with different databases (SABIO-RK, ChEBI, PubChem) to find synonyms of chemical compounds

Example rules:

- Lowercase letters only
- Normalise different types of brackets to one type
- Remove spaces
- Replace '-p' at end of name by '-phosphate'
- Replace all suffixes '-phosphate' by prefixes 'phospho-'
- Replace 'ate' followed by a delimiting character by 'ic acid'

<http://sabiork.villa-bosch.de/normaWeb>

Analysis of Compound Names



Classification of Compounds

Functional groups of compounds

All groups

Select compound in DB: D-Glucose

Smiles representation of compound: OCC(O)C(O)C(O)C(=O)O

Classify compound

Enter new Smiles:

Molecule formula: $C_6H_{12}O_6$

Molecular weight: 180.156

Functional Group

- secondary alcohol
- short chain alcohol
- saturated alcohol
- aliphatic alcohol
- aldehyde
- short chain aldehyde
- saturated aldehyde
- aliphatic aldehyde
- carbohydrate
- aldose
- hexose

Integrate new compound into DB

Compound Classification: Glucose

File

Select Compound Delete Selection Zoom Out Zoom In Zoom Selected Fit Content Layout

Aldose Hexose

Aldohexose

Glucose

D-Glucose

alpha-D-Glucose beta-D-Glucose

Level Up 2 Level Down 2 Edit

- Generation of structural formula, totals formula and molecular weight based on SMILES string

- Rules for compound classifications

- Graph and sub-graph search for functional groups

- Classification using different criteria, for example D-Glucose is a:

-Aldose (functional group aldehyde)

-Hexose (number of C-Atoms = 6)

→ **SABIO-RK search for general compounds and all sub-classes**

Ontologies used in SABIO-RK

- **ChEBI**: database and ontology for chemical compounds
- **NCBI taxonomy**: classification of organisms
- **Gene Ontology**: ontology for molecular functions, biological processes and cellular components
- **Systems Biology Ontology**: ontology for systems biology

Annotations/links to ontologies and external databases in SABIO-RK user interface and SBML export

Controlled Vocabularies in SABIO-RK

- Chemical compounds names
- Role of reaction participants (*substrate, product, modifier*)
- Defined reactions and pathways
- Organisms, tissues and cellular locations
- Kinetic law types (*Michaelis-Menten, Ordered Bi Bi*)
- Parameter types (*K_m, k_{cat}*) and units (*mM, 1/sec*)
- Protein details (*wildtype, mutant, isoenzyme; complex composition; information about recombinant enzymes*)

To avoid redundancies and typing errors by defined notations

Controlled Vocabularies in SABIO-RK

Edit entry

Infosource ID: 550
Entry ID: 5742

List of values

pathway

reaction

SwissProt protein ID

EC-number

species

| stoe | name | role |
|------|--------------------------------|-------------|
| 1 | dTMP | Product |
| 1 | 5,10-Methylenetetrahydrofolate | Substrate |
| 1 | dUMP | Substrate |
| 1 | Dihydrofolate | Product |
| 1 | Enzyme | Modifier-C |
| 1 | E-5-(2-Bromovinyl) | Modifier-In |
| 1 | | unknown |

- D-Dopaquinone
- D-Epifucose
- D-Erythritol 4-phosphate
- D-erythro-1-(imidazol-4-yl)glycerol 3-phosphate
- D-Erythro-2-pentulose
- D-erythro-2-Pentulose
- D-erythro-3-Methylmalate
- D-erythro-Ascorbate
- D-erythro-Hexulose
- D-Erythro-hexulose
- D-erythro-Imidazole-glycerol 3-phosphate
- D-erythro-Imidazole-glycerol phosphate
- D-erythro-Isocitric acid
- D-erythro-Neopterin
- D-Erythrol
- D-Erythrose
- D-Erythrose 4-phosphate
- D-Erythrulose
- D-Erythrulose 4-phosphate
- D-Fructofuranose 1,2':2,3'-dianhydride
- D-Fructofuranose 2-phosphate
- D-Fructose
- D-Fructose 1,6-bisphosphate**
- D-Fructose 1-phosphate
- D-Fructose 2,6-bisphosphate
- D-Fructose 2-phosphate
- D-Fructose 6-phosphate
- D-Fructose 6-phosphate-gamma-S
- D-Fructose 6-phosphoric acid
- D-Fructose, 6-(dihydrogen phosphate)

choose species: D 788-1

enter species: deoxyuridine

choose location: acrosome

choose pathway: 1,1,1-Trichloro-2,2-bis(4-chlorophenyl)ethane (DDT) degradation

clear reaction fields

missing

88

wildtype

| unit def. | comment | SpecID |
|--------------------------------------|---------------|--------|
| % | | 65 |
| % | | 1308 |
| s ⁽⁻¹⁾ | | 1334 |
| % | | 1336 |
| mM ⁽⁻¹⁾ s ⁽⁻¹⁾ | | miss |
| % | active specie | miss |
| % | | |

add this species

search reactions

add this location

add this pathway

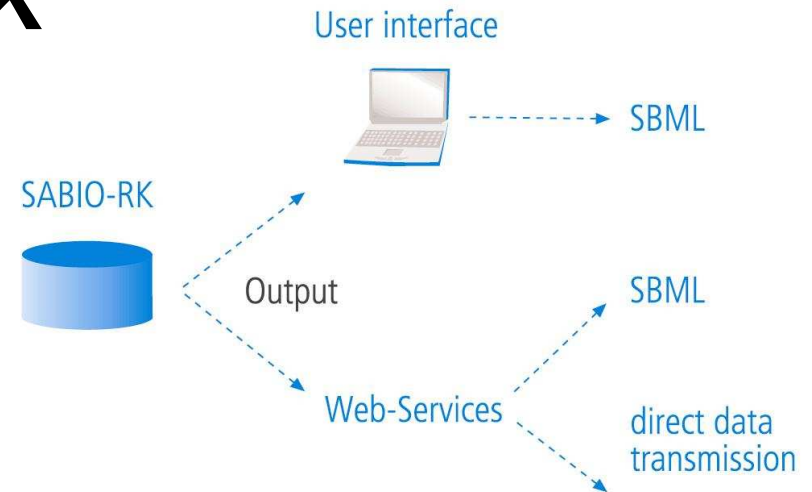
Protein Details

→ Structured information about proteins based on the literature

- *Complex composition (e.g. homotetramer)*
- *Information: recombinant; expressed in ...*
- *wildtype, mutant, isozyme*
- *Molecular weights of complex and subunits*

| | | | | |
|---|-------------------------------|-------------------|-------------------|----------------------------|
| Tissue: | liver | | | |
| EC Class: 4.2.1.22 | wildtype | | | |
| Recombinant | Expressed in Escherichia coli | | | |
| Substrates | | | | |
| name | location | comment | | |
| L-Homocysteine | - | - | | |
| L-Serine | - | - | | |
| Products | | | | |
| name | location | comment | | |
| H2O | - | - | | |
| L-Cystathionine | - | - | | |
| Modifiers | | | | |
| name | location | effect | comment | protein complex |
| Cystathionine beta-synthase(Enzyme) | - | Modifier-Catalyst | - | P35520 *4; |
| Enzyme (protein data) | | | | |
| | UniProt-ID | name | mol. weight (kDa) | deviation (kDa) |
| subunit | - | - | - | - |
| complex | - | - | 252.0 | - |

Access to SABIO-RK



➤ **Web-based user interface**

for browsing and searching the data manually

➤ **Web Services (API access)**

can be automatically called by external tools, e.g. by other databases or simulation programs for biochemical network models

Both interfaces support the export of the data in SBML

SABIO-RK Queries

Search for

- reactions by defining participants (reactants, enzymes, proteins)
- publications
- pathways, organisms, tissues etc.
- reactions containing defined kinetic parameters or laws
- reactions under defined experimental conditions

Definition of queries by the combination of all the search criteria

SABIO-RK Database

<http://sabio.villa-bosch.de/>



[CONTACT](#) | [HELP](#) | [IMPRINT](#)

Reaction Search

Return only reactions having kinetic data matching all criteria (blue and grey)

Search Reaction

SBML Model Setup

- Search criteria in blue are used to define the search conditions for reactions, independently if there is or not kinetic data for these reactions.

Specify Search Criteria:

Submit Search

Reset Form

with **Reactants(s)** [+] [-]

in **Pathway(s)** [+] [-]

having **Enzyme(s)** [+] [-]

4.2.1.22:Cystathionine beta-synthase

Join entries with
 AND or OR



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in **Publication** [+] [-]

related to **Protein** (UniProtID) [+] [-]

in **Organism(s)** [+] [-]

SABIO-RK Database

<http://sabio.villa-bosch.de/>



[CONTACT](#) | [HELP](#) | [IMPRINT](#)

Search Results

Total number of reactions found for specified search criteria: **6**

[Click here to view your search criteria](#)

[Modify Search](#)

Kinetic Data Availability:

- [view](#) Kinetic data available matching the search criteria
- [view](#) Kinetic data available, but not matching all search criteria
- [No](#) No kinetic data available

Search Reaction

SBML Model Setup

Number of results per page:

[Display](#)

Show only reactions having kinetic data matching the search criteria

[Send Selected Reactions to SBML File](#)

| Reactions | Select Reaction(s) (De)Select All | Kinetic Data for this reaction (Click to View) | Enzyme EC# | Kinetic data for enzymes (Click to View) |
|---|--------------------------------------|---|--|--|
| L-Homocysteine + L-Serine <-> H2O + L-Cystathionine | <input type="checkbox"/> | view | 4.2.1.22 | view |
| L-Cysteine + L-Homocysteine <-> Hydrogen sulfide + L-Cystathionine | <input type="checkbox"/> | view | 4.2.1.22 | view |
| Acetate + Sulfide <-> L-Cysteine + O-Acetyl-L-serine | <input type="checkbox"/> | view | 2.5.1.47 4.2.1.22 | view view |
| L-Cysteine + 2-Mercaptoethanol <-> Hydrogen sulfide + S-(2-Hydroxyethyl)-L- | <input type="checkbox"/> | view | 4.2.1.22 | view |



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SABIO-RK Database

<http://sabio.villa-bosch.de/>



Reaction Details

Stoichiometric Equation [L-Homocysteine + L-Serine <-> H2O + L-Cystathionine](#)

Substrates [L-Homocysteine](#)
[L-Serine](#)

Products [H2O](#)
[L-Cystathionine](#)

| EC Number | in Organism | SWP/UnitProt Link | PubMedID |
|--------------------------|-------------------|-----------------------------|--------------------------|
| 4.2.1.22 | Homo sapiens | SWP/UnitPro | 9675031 |
| 4.2.1.22 | Homo sapiens | SWP/UnitPro | 681363 |
| 4.2.1.22 | Homo sapiens | SWP/UnitPro | 15520012 |
| 4.2.1.22 | Homo sapiens | SWP/UnitPro | 15581573 |
| 4.2.1.22 | Aeropyrum pernix | SWP/UnitPro | 12644499 |
| 4.2.1.22 | Rattus norvegicus | SWP/UnitPro | 5456996 |

Enzymes known to catalyse this reaction (curated information)

Pathways [Glycine, Serine and Threonine metabolism](#)
[Methionine metabolism](#)

Enzyme Details

| | |
|----------------------------------|---|
| Enzyme (recommended) name | Cystathionine beta-synthase |
| Alternative names | L-serine hydro-lyase (adding homocysteine) Serine sulfhydrase beta-thionase Methylcysteine synthase Cysteine synthase Serine sulfhydrilase |
| EC Classification | 4.2.1.22 |
| Classification | Lyases Carbon-oxygen lyases Hydro-lyases |
| Catalyses reactions | L-Serine + Sulfide <-> L-Cysteine + H2O L-Homocysteine + L-Serine <-> H2O + Cystathionine L-Homocysteine + L-Serine <-> H2O + L-Cystathionine Selenohomocysteine + L-Serine <-> Selenocystathionine + H2O L-Cysteine + L-Homocysteine <-> Hydrogen sulfide + L-Cystathionine Acetate + Sulfide <-> L-Cysteine + O-Acetyl-L-serine L-Cysteine + 2-Mercaptoethanol <-> Hydrogen sulfide + S-(2-Hydroxyethyl)-L-cysteine |
| External links | Expasy KEGG IntEnz (EBI) IUBMB Reactome HepatoSys (Only accessible for HepatoSys project members) |

Compound Details

[Back](#)

[List of Reactions](#)

| | |
|--------------------------|--|
| Common Name | L-Homocysteine |
| Synonyms | L-2-Amino-4-mercaptobutyric acid |
| SABIO-Compound-ID | 1950 |
| External Links | |
| CAS-ID | 6027-13-0 |
| KEGG-ID | C00155 |
| PUBCHEM-ID | 3455 |
| CHEBI-ID | 17588 |
| HepatoSys-ID | C00155 (Only accessible for HepatoSys project members) |



SABIO-RK Database

<http://sabio.villa-bosch.de/>

| | |
|---|-------------------------------|
| Tissue: | liver |
| EC Class: 4.2.1.22 | wildtype |
| Recombinant | Expressed in Escherichia coli |

Kinetic I
L-Homocysteine +

Expai

| Substrates | | |
|--------------------------------|----------|---------|
| name | location | comment |
| L-Homocysteine | - | - |
| L-Serine | - | - |

| Products | | |
|---------------------------------|----------|---------|
| name | location | comment |
| H2O | - | - |
| L-Cystathionine | - | - |

| Modifiers | | | | | |
|-------------------------------------|----------|-------------------|---------|-------------------------------|--|
| name | location | effect | comment | protein complex | |
| Cystathionine beta-synthase(Enzyme) | - | Modifier-Catalyst | - | (P35520)*4; | |

| Enzyme (protein data) | | | | |
|-----------------------|------------|------|-------------------|-----------------|
| | UniProt-ID | name | mol. weight (kDa) | deviation (kDa) |
| subunit | - | - | - | - |
| complex | - | - | 252.0 | - |

| Kinetic Law | |
|------------------|-------------------------------|
| type | formula |
| Michaelis-Menten | $E * k_{cat} * S / (K_m + S)$ |

| Parameters | | | | | | | |
|------------|----------------|---------------|-------------|-----------|-----------|---------------------------------------|---------|
| name | species | type | start value | end value | deviation | unit | comment |
| E | Enzyme | concentration | - | - | - | - | - |
| S | L-Serine | concentration | 0.005 | 6.4 | - | mM | - |
| A | L-Homocysteine | concentration | 5 | - | - | mM | - |
| Km | L-Serine | Km | 3 | - | - | mM | - |
| kcat_Km | L-Serine | kcat/Km | 2 | - | - | mM ⁽⁻¹⁾ *s ⁽⁻¹⁾ | - |
| kcat | - | kcat | 6 | - | - | s ⁽⁻¹⁾ | - |

| Experimental conditions | | | |
|-------------------------|----------------|-----------|------|
| | start value | end value | unit |
| pH | 8.6 | - | - |
| temperature | 37 | - | °C |
| buffer: | 10 mM Tris/HCl | | |

General comment: -

PUBMEDID: [9675031](#)

Entry Nr. 3101

| | |
|---|---------------------|
| Organism: | Homo sapiens |
| Tissue: | unknown |
| EC Class: 4.2.1.22 | wildtype |

Entry Nr. 3102

| | |
|---|---------------------|
| Organism: | Homo sapiens |
| Tissue: | unknown |
| EC Class: 4.2.1.22 | mutant delta411-551 |

Entry Nr. 3103

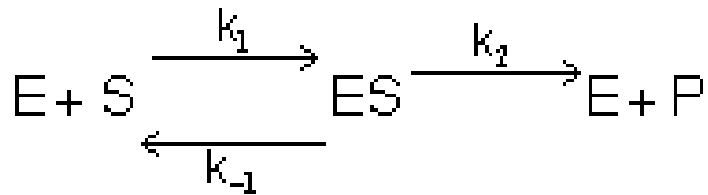
| | |
|---|---------------------|
| Organism: | Homo sapiens |
| Tissue: | unknown |
| EC Class: 4.2.1.22 | wildtype |

Entry Nr. 5535

| | |
|---|---------------------|
| Organism: | Homo sapiens |
| Tissue: | unknown |
| EC Class: 4.2.1.22 | wildtype |

Entry Nr. 8224

Reaction Mechanism



$$\text{Velocity} = V = \frac{V_{\max}[S]}{[S] + K_M}$$

V_{\max} = maximal enzyme velocity

K_M = Michaelis-Menten constant $(k_2 + k_{-1})/k_1$

- Simulation experiments need detailed information about the reaction mechanism and kinetic parameters for the steps
- No quantitative data for mechanism steps available in structured format (*no database contains such data at the moment*)

User Interface – Mechanism

Mechanism for Reaction:

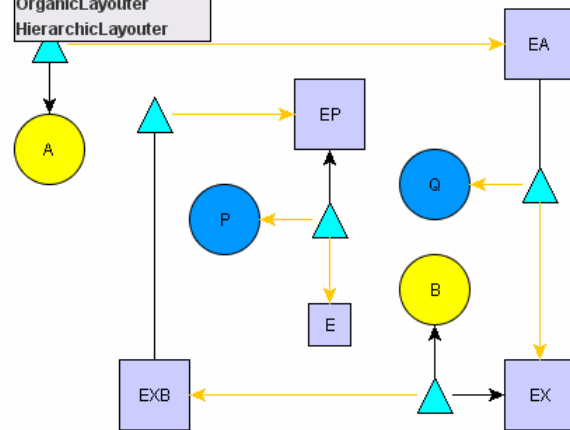
L-Homocysteine + L-Serine = H₂O + Cystathionine

EntriesID: 20619



■ Substrate ■ Product ■ Activator ■ Inhibitor □ Enzyme/Enzyme-Complex ○ Molecule ▲ Reaction Details

- OrthogonalLayouter
- OrthogonalLayouter
- CircularLayouter
- OrganicLayouter
- HierarchicLayouter



Legend

| Name | Description |
|------|-----------------------------------|
| A | L-Serine |
| B | L-Homocysteine |
| E | Enzyme |
| EA | Enzyme-Serine |
| EP | Enzyme-Cystathionine |
| EX | Enzyme-Aminoacrylate |
| EXB | Enzyme-Aminoacrylate-Homocysteine |
| P | Cystathionine |
| Q | H ₂ O |

Mechanism step details

Expand All

Close All

1 A+E-->EA

2 EA-->A+E

3 EA-->EX+Q

4 B+EX-->EXB

5 EXB-->B+EX

6 EXB-->EP

7 EP-->E+P

8 E+P-->EP

User Interface – Mechanism

Mechanism for Reaction:

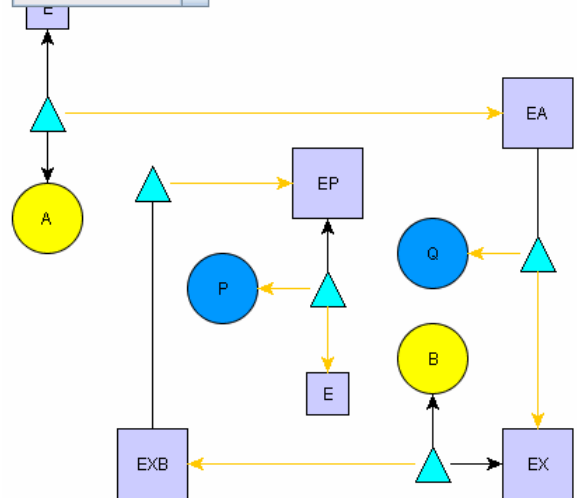


EntriesID: 20619



■ Substrate
 ■ Product
 ■ Activator
 ■ Inhibitor
 Enzyme/Enzyme-Complex
 Molecule
 ▲ Reaction Details

OrthogonalLayouter



Legend

| Name | Description |
|------|-----------------------------------|
| A | L-Serine |
| B | L-Homocysteine |
| E | Enzyme |
| EA | Enzyme-Serine |
| EP | Enzyme-Cystathionine |
| EX | Enzyme-Aminoacrylate |
| EXB | Enzyme-Aminoacrylate-Homocysteine |
| P | Cystathionine |
| Q | H ₂ O |

Mechanism step details

Expand All

Close All

1 A+E-->EA

| Substrates | |
|------------|-------------|
| name | description |
| E | Enzyme |
| A | L-Serine |

| Products | |
|----------|---------------|
| name | description |
| EA | Enzyme-Serine |

| Kinetic law | |
|-------------|---------|
| type | formula |
| - | - |

| Parameter | | | | | | |
|-----------|----------|---------------|-------------|-----------|------|--------------------------------------|
| name | species | type | start value | end value | dev. | unit |
| A | L-Serine | concentration | 0.0 | 20.0 | - | mM |
| E | Enzyme | concentration | 18.0 | - | - | μM |
| k1 | | rate const. | 14.0 | - | - | mM ⁽⁻¹⁾ s ⁽⁻¹⁾ |

| Experimental conditions | | | |
|-------------------------|-------------|-----------|------|
| | start value | end value | unit |
| temperature | 14 | 16 | °C |
| pH | 8 | - | |
| buffer | 0.2 mM Tris | | |

General comment: -

2 EA-->A+E

SABIO-RK Summary

- curated database for biochemical reactions and their kinetics
- platform for kinetic data storage and exchange
- free available for academic use
- use of standard data formats, controlled vocabularies and ontologies
- links to original data sources (literature, databases etc.)

SABIO-RK Statistics

| | |
|------------------------|-------|
| Publications (curated) | 2208 |
| Entries (curated) | 30710 |
| Reactions | 9596 |

with kinetic data:

| | |
|-----------|------|
| Reactions | 4924 |
| Enzymes | 779 |
| Organisms | 504 |
| Tissues | 175 |

as of April 2009

Future Perspectives

- SABIO-RK as platform for experimental kinetic data
 - *Scientists producing the data can directly enter it into SABIO-RK*
- Input interface as storage and exchange tool for authors of publications and journal editors
- Kinetic data for signaling reactions
- Information about in vivo metabolite concentrations
- Development and implementation of tools for information extraction and supporting data curation



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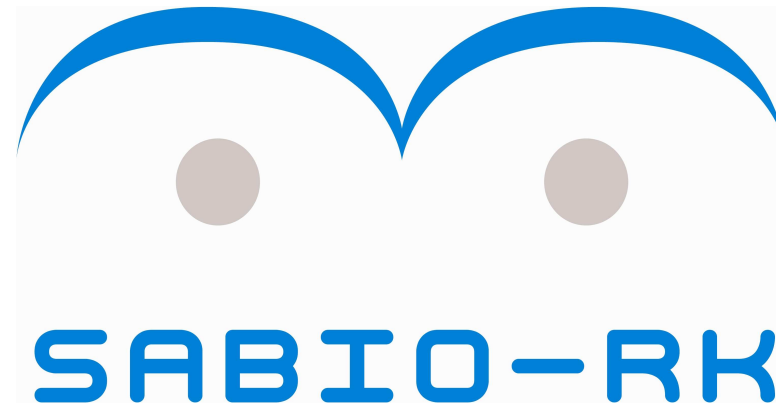


SABIO-RK is member of:



SABIO-RK User Meeting

***June 15-16, 2009
Heidelberg, Germany***



<http://sabio.villa-bosch.de/>