

# Building and Refining AraCyc: Data Content, Sources, and Methodologies

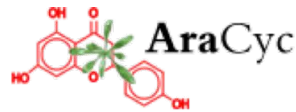


Kate Dreher

TAIR, AraCyc, PMN  
Carnegie Institution for Science

# AraCyc

- AraCyc – **Ara**bidopsis Metabolic En**Cyc**lopedia
  - Database of metabolic pathways found in Arabidopsis



- Accessible from:

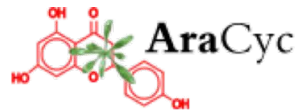


- TAIR – The Arabidopsis Information Resource
  - [www.arabidopsis.org](http://www.arabidopsis.org)



# AraCyc

- AraCyc – **Ara**bidopsis Metabolic En**Cyc**lopedia
  - Database of metabolic pathways found in Arabidopsis



- Accessible from:



- PMN – Plant Metabolic Network
  - **www.plantcyc.org**



**AraCyc Pathway: choline biosynthesis III**



# AraCyc Pathway pages

Superclasses: [Biosynthesis](#) → [Fatty Acids and Lipids](#) → [Choline Biosynthesis](#)

## Classification

### Summary:

**General information:** Choline is a fundamental metabolite in plants because of its contribution to the synthesis of the membrane phospholipid phosphatidylcholine, which accounts for 40 to 60% of lipids in non-plasmid plant membranes [ [Mio02](#) ]. Choline is also a precursor for the formation of glycine betaine ( [glycine betaine biosynthesis II \(plants\)](#) ) in certain plants such as spinach, where this osmoprotectant is accumulated and confers also tolerance to salinity, drought, and other environmental stresses. In addition choline has been recognized as an essential nutrient for humans [ [McNeil01](#) ].

The choline biosynthetic pathway enables plants to decouple choline synthesis from lipid metabolism (Kennedy pathway - [triacylglycerol biosynthesis](#) ) and provides them with the metabolic flexibility to adapt to environmental conditions where large and variable amounts of choline are beneficial for survival [ [Boutant03](#) ].

**Pathway information:** The first step in choline biosynthesis is the direct decarboxylation of serine to ethanolamine [ [Boutant04](#) ], which is catalyzed by a serine decarboxylase unique to plants [ [Boutant03](#) ]. Ethanolamine is widely recognized as the entrance compound to choline biosynthesis.

The pathway variant displayed (nucleotide pathway) represents the biosynthetic route as found in diverse plant families. The synthesis of choline from ethanolamine may take place at three parallel pathways, where three consecutive N-methylation steps are carried out either on free-bases [ [Phytohorm02](#) ], phospho-bases [ [Nuccio00](#) ], phosphatidyl-bases [ [McNeil01](#) ] or a mixture of the latter [ [Duckworth](#) ] [ [Duckworth](#) ] [ [Hill01](#) ].

The synthesis of intermediates on both the phospho-base and phosphatidyl-base level includes the nucleotide pathway via CDP-phosphoaminoalcohol and the methylation pathway. However, it has been pointed out that the synthesis of phosphatidylethanolamine and phosphatidylcholine is characterized by a high degree of interaction and ligation on the various levels of arising intermediates. Consequently, it has been assumed that the reactions embedded in the nucleotide and methylation pathways may be two characteristics of one overall phosphoaminoalcohol pathway for the formation of phosphatidylcholine in plants [ [Kinney03](#) ].

The release of choline from the different pathway levels is also species-specific. Phosphocholine can either be directly dephosphorylated to release choline as observed in spinach [ [Summers03](#) ] or incorporated into phosphatidylcholine with the subsequent release of choline, as in tobacco [ [McNeil00](#) ]. The latter reaction has been shown to be specifically catalyzed by phospholipase D ( [phospholipases](#) ) in cyster bean [ [Wang04](#) ]. Although a well-defined physiological role of phospholipase D (PLD) still await further research, progress has been made to assign some members of the heterogeneous family of PLDs to distinct cellular functions [ [Hill00](#) ]. The remaining enzymes involved in this pathway, phosphoaminoalcohol cytidyltransferase and CDP-aminoalcohol phosphotransferase, cover a broader spectrum of substrates. This may be beneficial to process the heterogeneous mixture of possible substrates but it also indicates that the pathway flux is probably controlled more upstream [ [Kinney03](#) ].

Superpathways: [superpathway of choline biosynthesis](#)

## Superpathways

Variants: [choline biosynthesis I - choline biosynthesis](#)

## Summary

Unification Link: [MetaCyc:PWY3681](#)

## Pathway variants

### Legend for Pathway Diagram

If an enzyme name is shown in bold, there is experimental evidence for this enzymatic activity.

### References

[Duckworth](#), Curtis AH, Mudd SH. (1988) "Enzymes of phosphatidylcholine synthesis in *Lemna*, *soybean*, and *corn*." *Plant Physiol.* (1988), 88, 1330-1340.

[Duckworth](#), Curtis AH, Mudd SH. (1988) "Phosphatidylcholine synthesis. Differing patterns in *soybean* and *corn*." *Plant Physiol.* (1988), 88, 954-961.

[Hill](#), Hill WD, Rhodes D, Hanson AD. (1985) "Radioactive evidence implicating phosphoryl and phosphatidyl bases as intermediates in betaine synthesis by water-stressed barley leaves." *Plant Physiol.* (1985), 80, 914-922.

## References

# AraCyc Pathway pages

The screenshot displays the AraCyc Pathway page. On the left, a chemical reaction is shown with a chemical structure of a phosphorylated compound and a list of enzymes: *cholesterol-phosphate synthase*, *cholesterol-phosphate synthase*, and *cholesterol-phosphate synthase*. A box labeled "Compound" points to the chemical structure, and a box labeled "Enzyme" points to the enzyme list. On the right, a "Evidence" panel shows three entries, each with an "Evidence code: EV-EXP-IDA", a "Source" (e.g., [Wang94](#)), a "Definition" (IDA inferred from direct assay), and a list of experimental methods: Enzyme assays, In vitro reconstitution (e.g. transcription), Immunofluorescence, and Cell fractionation. A box labeled "Evidence Code" points to the "Evidence code" field, and a box labeled "Pathway" points to the "Pathway" field.

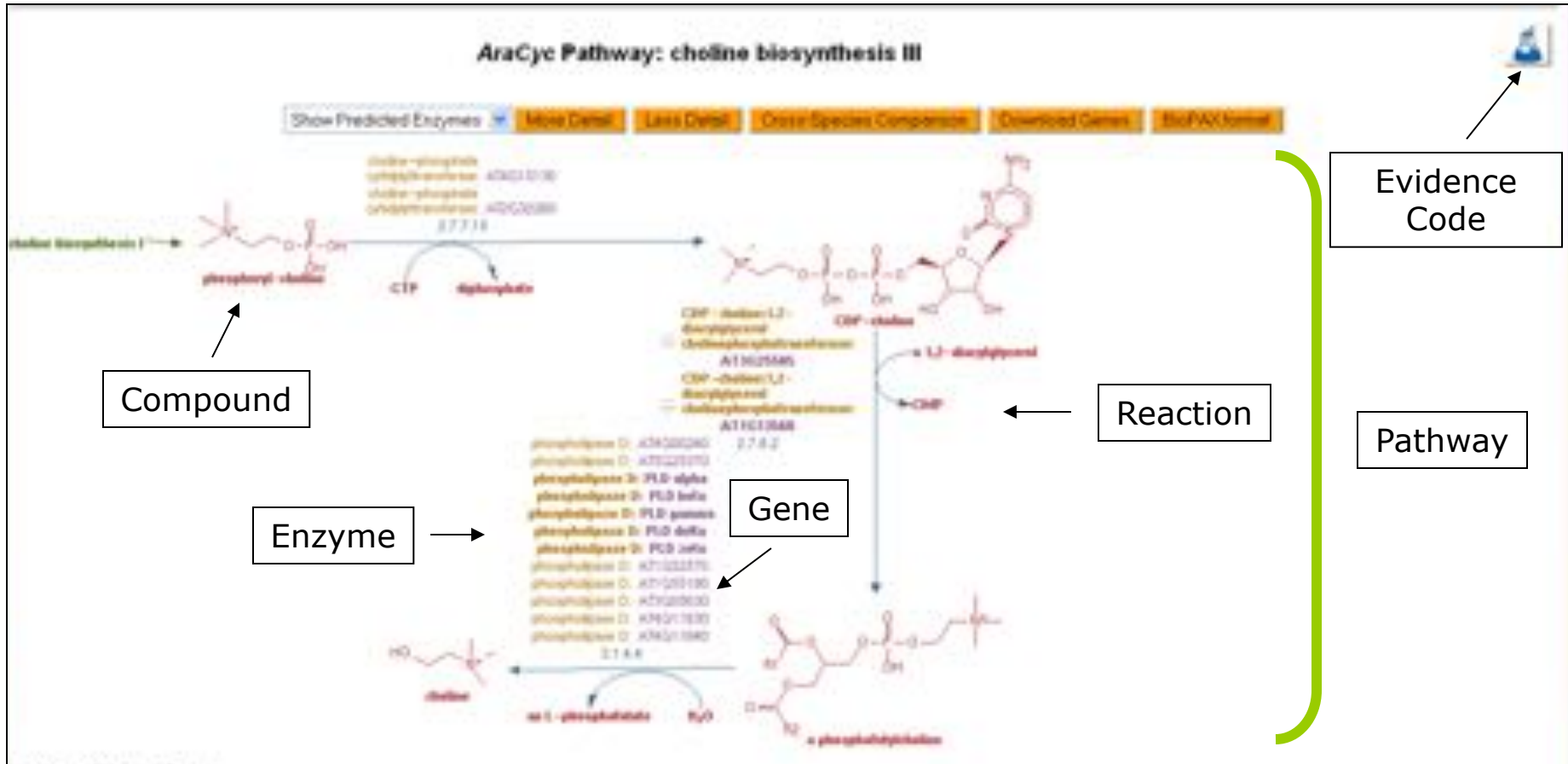
Compound

Enzyme

Evidence Code

Pathway

# AraCyc Pathway pages





# AraCyc Compound pages

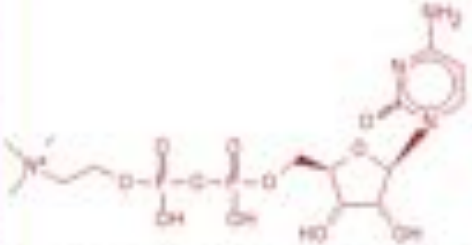
## AraCyc Compound: CDP-choline

Synonyms: citicoline , citicholine , citilles , cyticholine , cytidine 5'-diphosphocholine , cytidine diphosphate choline

Superclasses: [a nucleic acid component](#) -> [a base derivative](#)  
[a nucleic acid component](#) -> [a pyrimidine-related compound](#)

Empirical Formula: C<sub>14</sub>H<sub>27</sub>N<sub>4</sub>O<sub>13</sub>P<sub>2</sub>

Molecular Weight: 489.34 daltons

Chemical Structure: 

SMILES: C(=O)OP(=O)(=O)OP(=O)(=O)OCCN+([C@H](C)C)C1=OC(=O)C(=O)N2C(=O)NC(=O)N2

Unification Links: CAS:987-78-0

Gibbs Energy of Formation (kcal/mol, estimated): -116.7

In Pathway Reactions as a Reactant:

[phospholipid biosynthesis](#): [a 1,2-diacylglycerol](#) + **CDP-choline** -> [a phosphatidylcholine](#) + [CMP](#)

[choline biosynthesis III](#): [a 1,2-diacylglycerol](#) + **CDP-choline** -> [a phosphatidylcholine](#) + [CMP](#)

In Pathway Reactions as a Product:

[phospholipid biosynthesis](#): [phosphorylcholine](#) + [CTP](#) -> **CDP-choline** + [diphosphate](#)

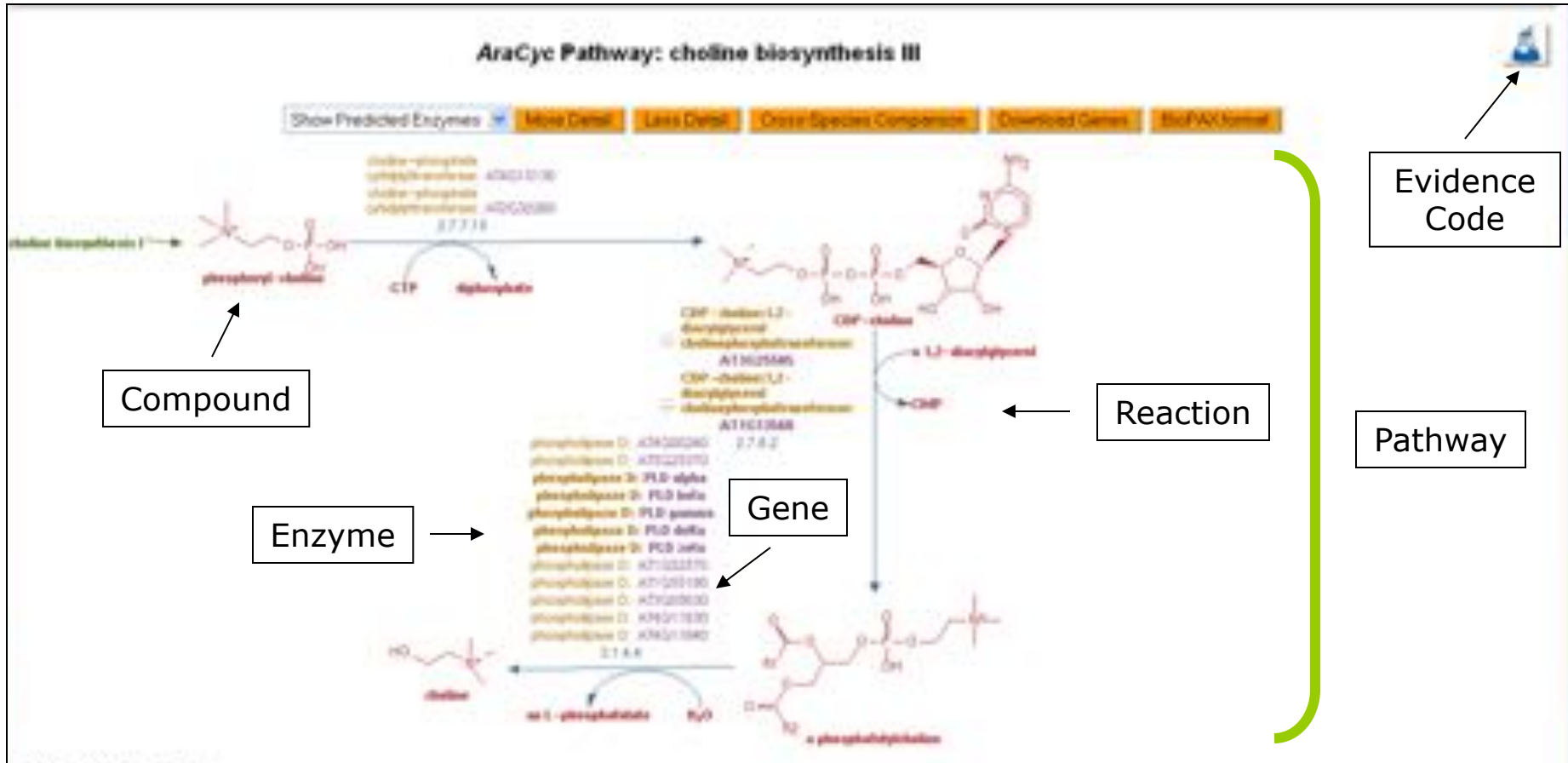
[choline biosynthesis III](#): [phosphorylcholine](#) + [CTP](#) -> **CDP-choline** + [diphosphate](#)

Annotations:

- Synonyms (points to the synonyms list)
- Classification(s) (points to the superclasses)
- Molecular Weight / Formula (points to the empirical formula and molecular weight)
- Appears as Reactant (points to the CDP-choline in the reactant roles)
- Appears as Product (points to the CDP-choline in the product roles)



# AraCyc Pathway pages



# AraCyc Enzyme detail pages

## AraCyc Enzyme: phosphatidyltransferase

Synonyms: aminolipophosphotransferase

Gene: [AT1G13680](#)

Sequence Length: 1196 AAs

Unification Links: [Entrez AAC61794](#)

Gene-Reaction Schematic: 



Multifunctional  
protein

\*

\*

Enzymatic reaction of: cholinephosphotransferase (phosphatidyltran

[1,3-diacylglycerol + CDP-choline <=> 1-phosphatidylcholine + CMP](#)

Enzymatic reaction of: ethanolaminephosphotransferase (phosphatidyltransferase)

[1,3-diacylglycerol + CDP-ethanolamine <=> sn-1-phosphatidyl-ethanolamine + CMP](#)

Pathway Tools evidence ontology click on:  
<http://bioinformatics.wri.com/evidence-ontology/>

 **Experimental Evidence:**

Evidence code: EV-EXP-IDA-UNPURIFIED-PROTEIN  
Source: [Goad99](#)  
Definition: Direct assay of unpurified protein. Presence of a protein activity is indicated by an assay. However, the precise identity of the protein with that activity is not established by this experiment (protein has not been purified).

**References**

[Goad99](#): Goad JH, Dewey RE, (1999) "Characterization of aminolipophosphotransferases from Arabidopsis thaliana and soybean." *Plant Physiol. Biochem.* (1999), 37(5), 485-490

Home Help Contact [CMA/PMI](#) [EPR](#) 

# AraCyc Enzyme detail pages

## AraCyc Enzyme: phosphatidyltransferase

### Enzymatic reaction of: cholinephosphotransferase (phosphatidyltransferase)

[1,3-diacylglycerol](#) + [CDP-choline](#)  $\rightleftharpoons$  [a phosphatidylcholine](#) + [CMP](#)

Reaction

The reaction direction shown, that is,  $A + B \rightleftharpoons C + D$  versus  $C + D \rightleftharpoons A + B$ , is in accordance with the Enzyme Commission system.

Reversibility of this reaction is unspecified.

In Pathways: [choline biosynthesis II](#), [phospholipid biosynthesis](#)

Pathway(s)

#### Summary:

Two cDNAs from *Arabidopsis thaliana* (AtAAP1, AtAAP2) have been isolated from an *Arabidopsis* cDNA library using the AAP cDNA from soybean as a heterologous hybridization probe. Both cDNAs encode aminoalcoholphosphotransferases involved in the nucleotide pathway of the biosynthesis of phosphatidylethanolamine (PE) and phosphatidylcholine (PC) as demonstrated by gene expression in yeast mutants lacking these enzyme activities. It has been demonstrated that both AtAAP1 and AtAAP2 convert CDP-ethanolamine and CDP-choline into the corresponding phosphatidylalcohols although with slight differences regarding the substrate preference. AtAAP2 showed a higher preference for CDP-choline over CDP-ethanolamine in comparison to AtAAP1 and was also inhibited to a lesser degree by  $\text{Ca}^{2+}$  and Cytidine monophosphate (CMP) than AtAAP1 [ [Goode99](#) ]. Both enzymes (AtAAP1, AtAAP2) were able to catalyze the reverse reaction supporting the proposal that diacylglycerol, involved as substrate in both PC and triacylglycerol biosynthesis [ [triacylglycerol biosynthesis](#) ], is in equilibrium with PC and maintains this equilibrium via the reversibility of the cholinephosphotransferase reaction [ [Stack85](#) ]. AtAAP1 and AtAAP2 seem to represent the only aminoalcoholphosphotransferases in *Arabidopsis* as concluded from the Southern blotting patterns. Both polypeptides contain seven membrane spanning regions as shown by their hydropathy files. This finding is in agreement with other AAPs isolated so far and confirms their localization in membranes [ [Goode99](#) ].

Inhibitors (Allosteric): [CMP](#) [ [Goode99](#) ]

Inhibitors (Unknown): [Ca<sup>2+</sup>](#) [ [Goode99](#) ]

Primary Physiological Regulators of Enzyme Activity: [CMP](#)

Inhibitors, Kinetic Parameters, etc.

Summary

#### References

[Goode99](#), Goode JH, Dewey FE, (1999) "Characterization of aminoalcoholphosphotransferases from *Arabidopsis thaliana* and soybean." *Plant Physiol. Biochem.* (1999), 37(5), 445-457.

[Stack85](#), Stack CR, Roughan PG, Browne JA, Gardiner SE, (1985) "Some properties of cholinephosphotransferase from developing safflower cotyledons." *Biochim. Biophys. Acta* (1985), 833, 439-449.

References

# AraCyc Pathway pages

## AraCyc Pathway: choline biosynthesis III

Show Predicted Enzymes

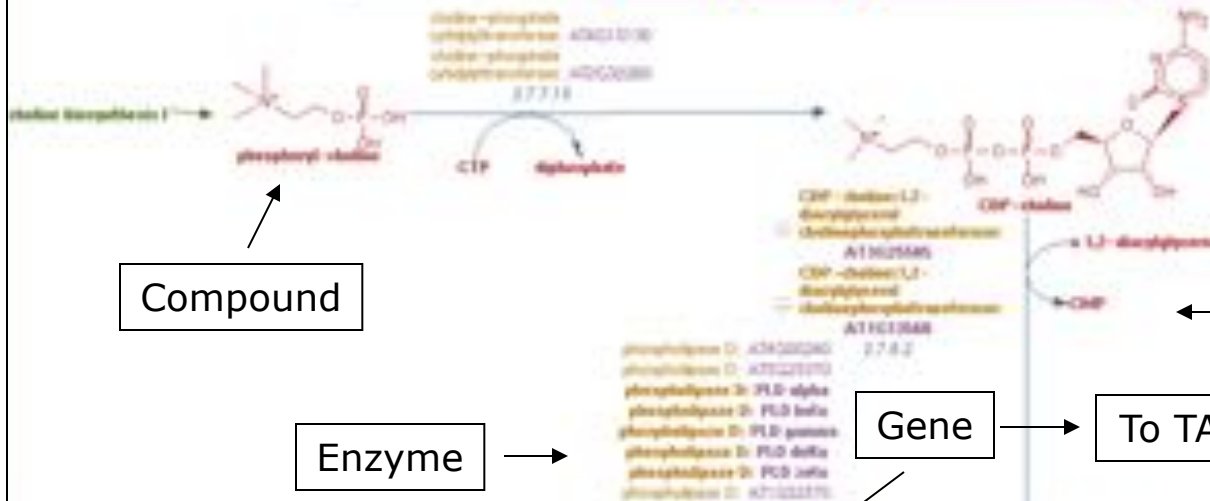
More Detail

Less Detail

Other Species Comparisons

Download Genes

BioPAX Format



Compound

Enzyme

Gene

To TAIR . . .

Reaction

Evidence Code

Pathway

### Locus: AT4G35790

Date last modified: 2003-05-03

TAIR Accession: Locus 3126318

Representation: AT4G35790.1

Gene Model:

Other names: ATPADIPORIN THALIANA PHOSPHOLIPASE D DELTA, ATPDDELTA, F4B14.36, F4B14.60, PLDDDELTA

Description: Encodes a protein with phospholipase D activity involved in phospholipase metabolism. Mutants are affected in hydrogen peroxide mediated cell death.

# AraCyc 4.5 (released June 2008)

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Pathways	288
Compounds	1956
Reactions	1723
Citations	2279

- More detailed information available in the Release Notes

# PlantCyc 1.0 (released June 2008)

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Pathways	508
Compounds	2314
Reactions	2277
Citations	4208
<b>Species</b>	<b>292</b>

□ [www.plantcyc.org](http://www.plantcyc.org)



# Putting AraCyc (and PlantCyc) to use

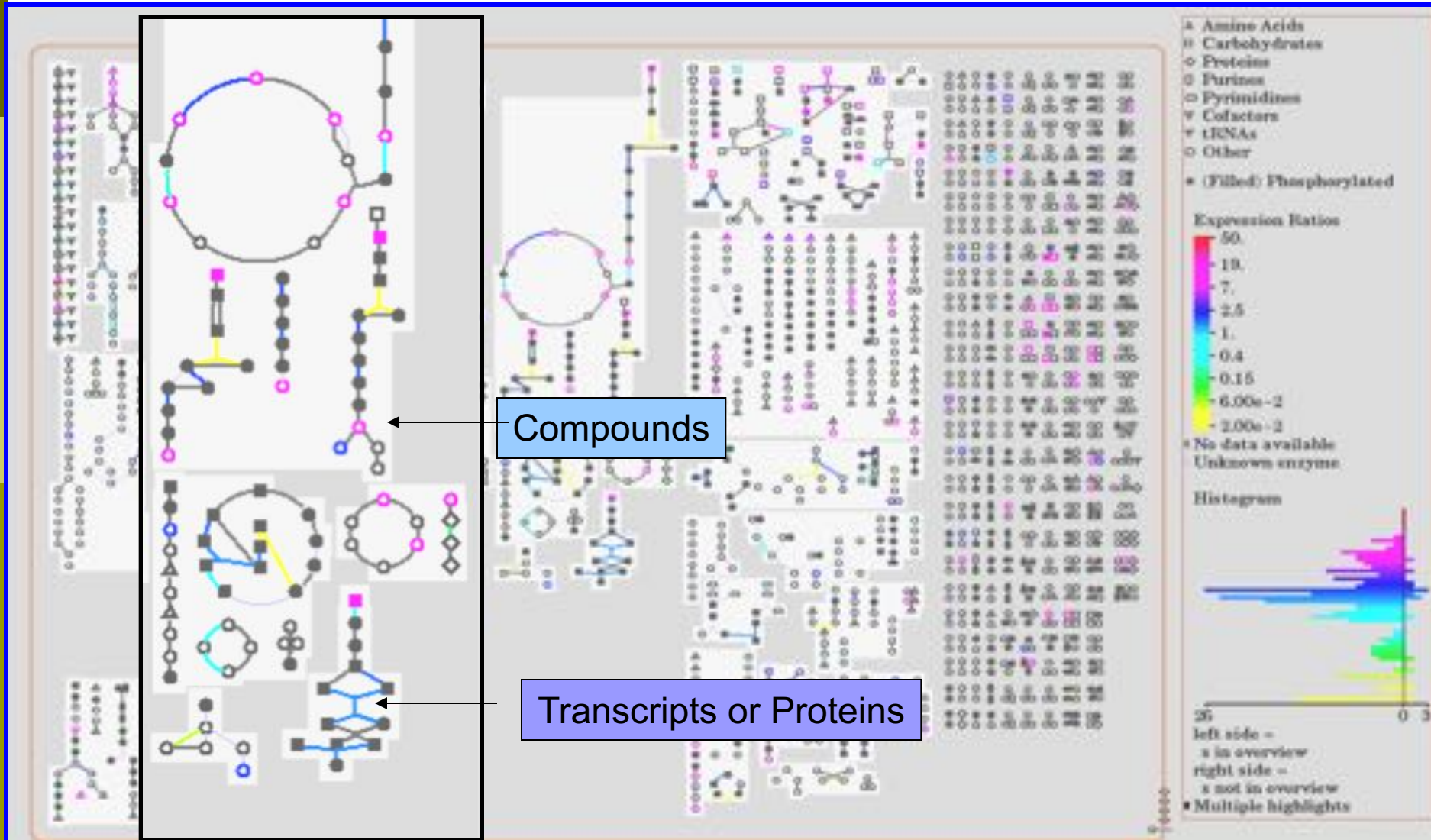
---

- Reference information
  - Pathways, Genes, Enzymes, Reactions, and Metabolites
  
- Data Analysis (AraCyc)
  - Use the OMICS viewer
    - Display the results of experiments on an Arabidopsis metabolic map
    - Study **your data** or **public data sets**



# Putting AraCyc to use

- Display the results of experiments on an Arabidopsis metabolic map



# Putting AraCyc (and PlantCyc) to use

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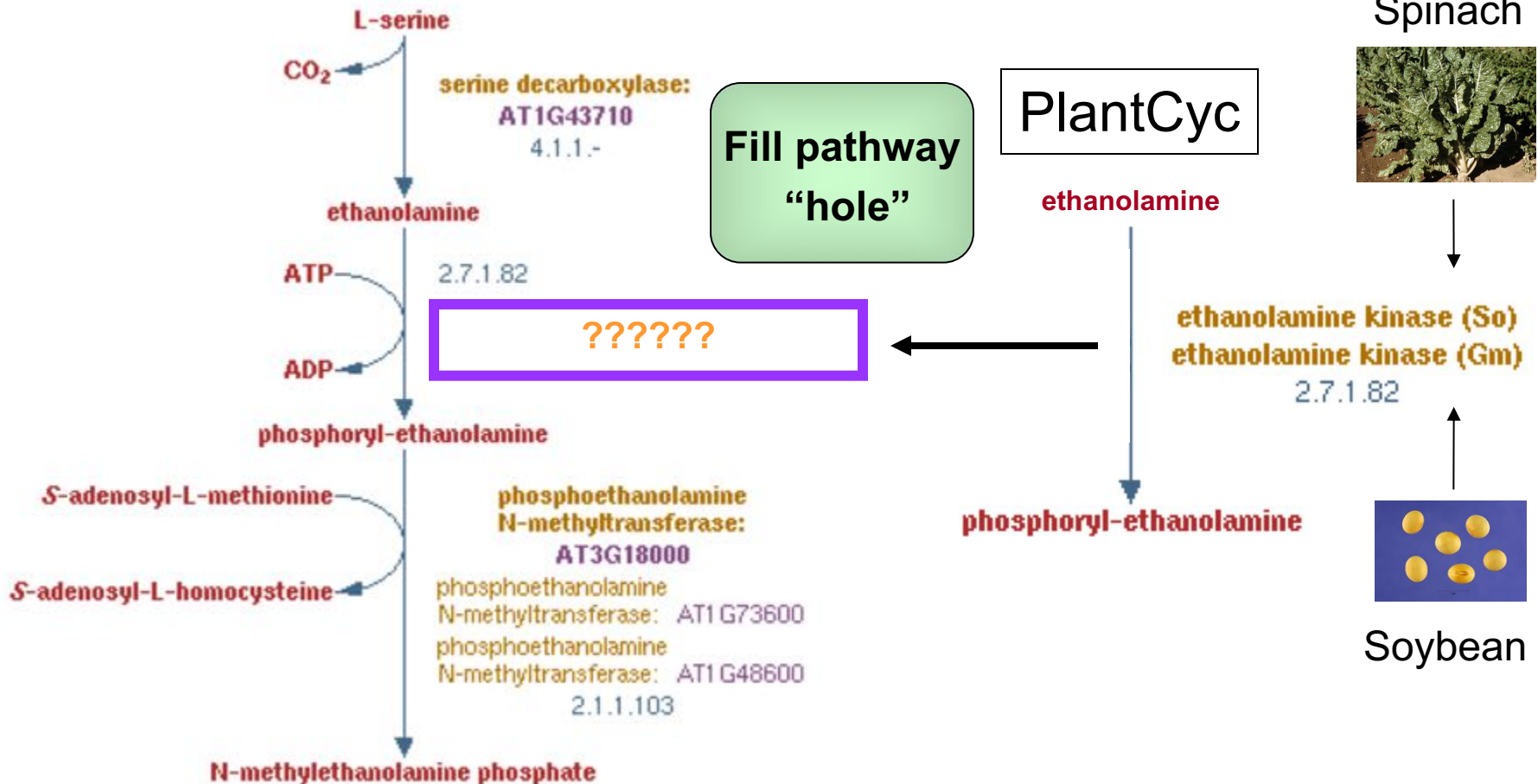
- Reference information
  - Pathways, Genes, Enzymes, Reactions, and Metabolites
  
- Data Analysis (AraCyc)
  - Use the OMICS viewer
    - Display the results of experiments on an Arabidopsis metabolic map
    - Study **your data** or **public data sets**
  - Generate new hypotheses
    - Find metabolic differences in your mutant with “no phenotype”
    - Identify pathways that are related to your favorite biological process
  - See more at “*Advanced Bioinformatic Resources for Arabidopsis*”
    - Thursday, July 24, 7 PM in the Grand Salon
  
- Enzyme discovery
  - Fill “pathway holes” through comparative analyses

# Putting AraCyc (and PlantCyc) to use

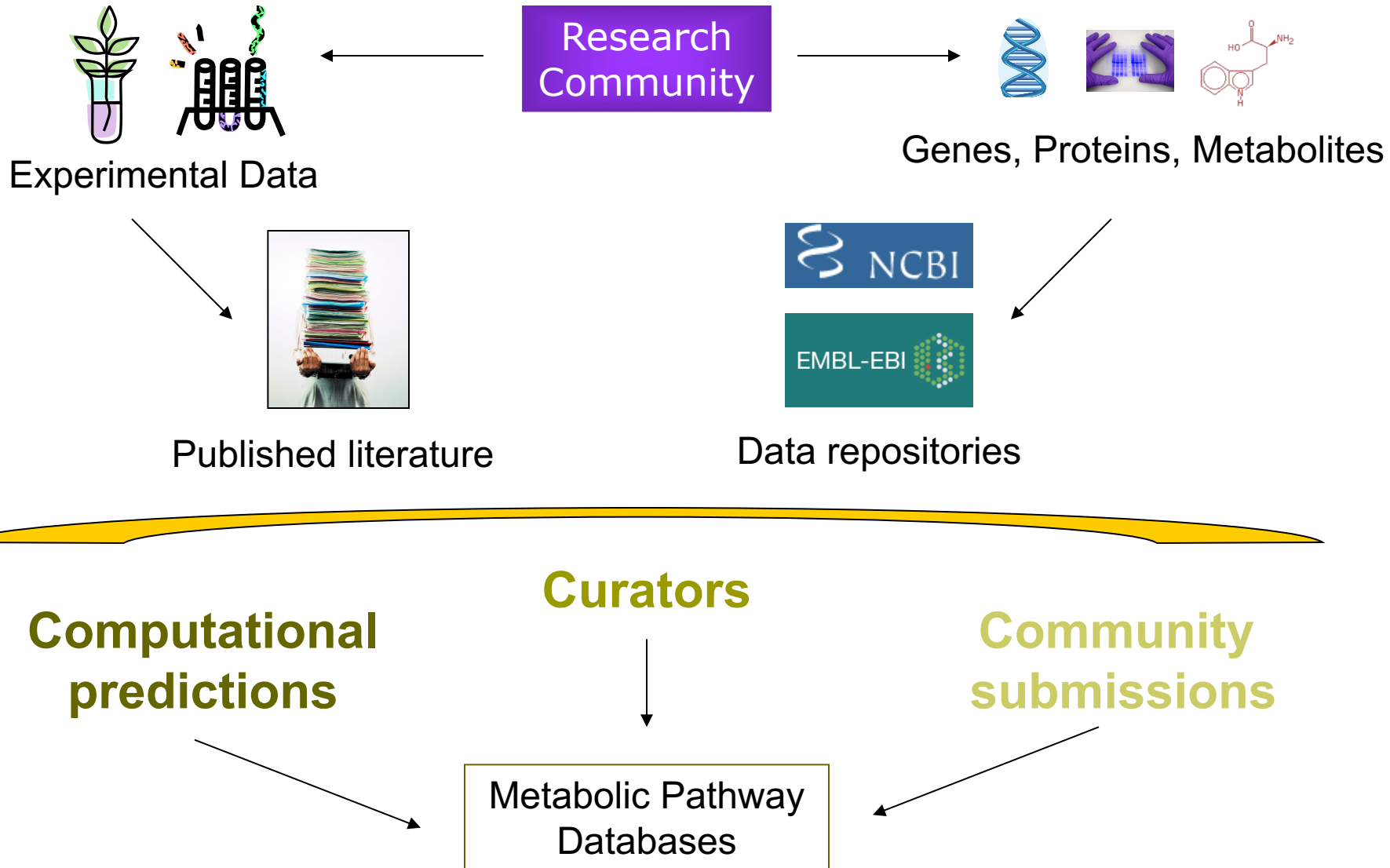
AraCyc

## Pathway “Hole Filling”

### Choline Biosynthesis I



# Data sources and data flow



# Data sources and data flow

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- Information enters metabolic pathway database in two stages
  - **Stage 1:** Initial build
  - **Stage 2:** Updates and improvements
- AraCyc 1.0 – Initial Build - 2002

## Initial AraCyc Build (2002)

---

- 7900 *Arabidopsis* genes annotated to the GO term 'catalytic activity'
- 4900 loci in small molecule metabolism
  - 19% of the total genome
- Goal: Map these loci to metabolic PATHWAYS
- Solution:
  - Use reference database: MetaCyc (460 metabolic pathways)
  - Run PathoLogic program (SRI International)
  - Predict metabolic pathways present in *Arabidopsis*

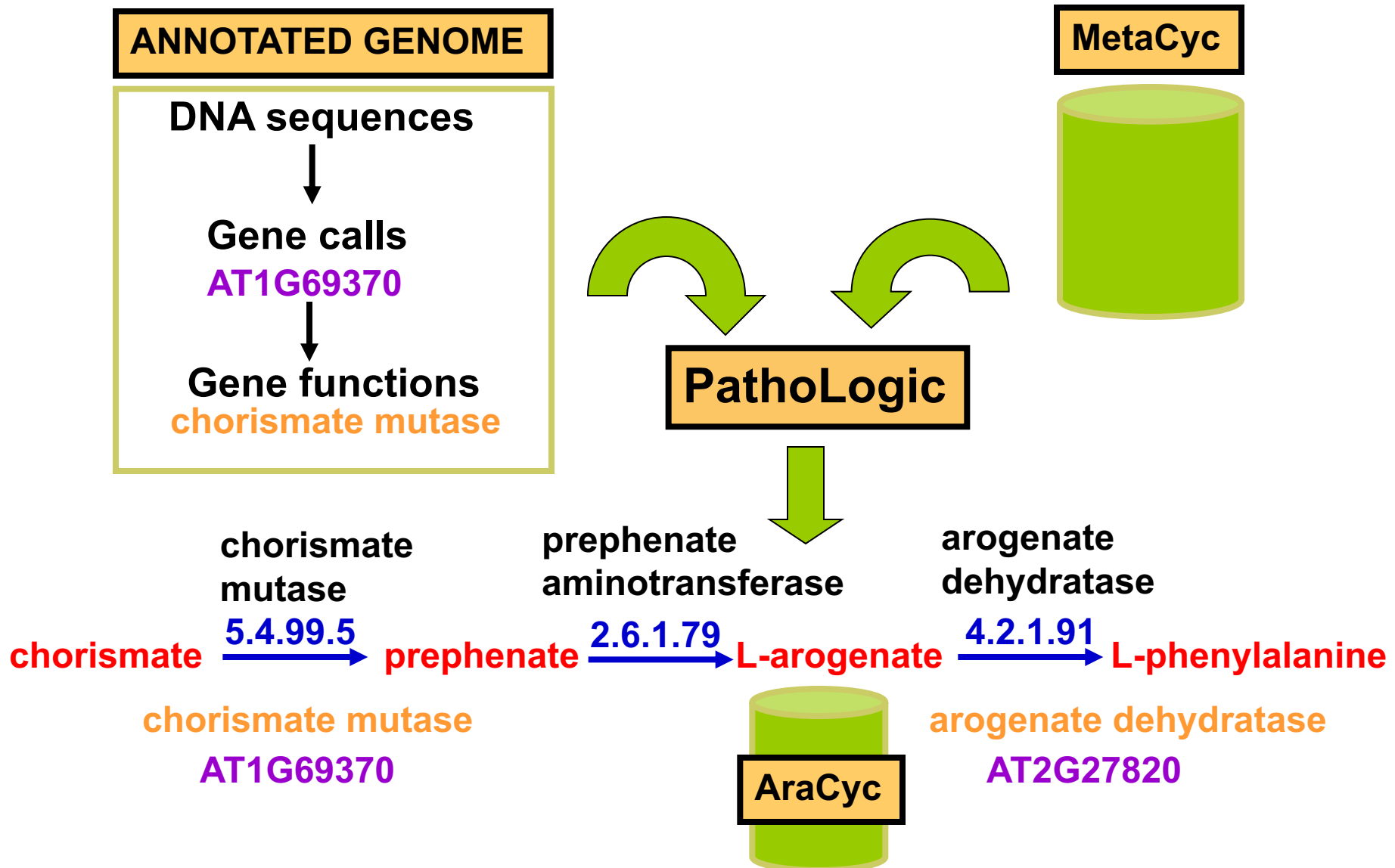
# MetaCyc

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- Multi-kingdom metabolic pathway database
  - **META**bolic En**CYC**lopedia
  - SRI International ([www.metacyc.org](http://www.metacyc.org))
- First released in 1999
- All pathways generated by curators extracting information from the scientific literature
- Only contains pathways with experimental support
- Reference database
  - Used to create SINGLE SPECIES databases
  - . . . including AraCyc in 2002!



# Initial AraCyc Build (2002)



# PathoLogic Program

---

- ❑ Matches input enzymes to reference enzymes
  - Name
  - Enzyme Commission (EC) number
- ❑ Identifies probable pathways
  - Enzyme coverage
  - Predicted species distribution
- ❑ Initial AraCyc 1.0 build (2002)
  - PathoLogic inferred over 200 pathways
  - PathoLogic mapped 940 genes to the pathways

# Validation of a New Database

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- ❑ PathoLogic errs on the side of over-prediction
- ❑ Curators validate pathways . . .

# Validation of a New Database

---

- Curators

- Find support for predicted pathways

- Is the pathway described in *Arabidopsis* literature?
    - Are the crucial metabolites described in *Arabidopsis* literature?
    - Does the pathway include a unique reaction catalyzed by an *Arabidopsis* protein?

# Validation of a New Database

---

- Curators:
  - Remove pathways not found in *Arabidopsis*
    - glycogen biosynthesis
    - C4 photosynthesis
    - caffeine biosynthesis
  - Edit pathways operating via a different route
    - Phenylalanine biosynthesis in bacteria vs. *Arabidopsis*

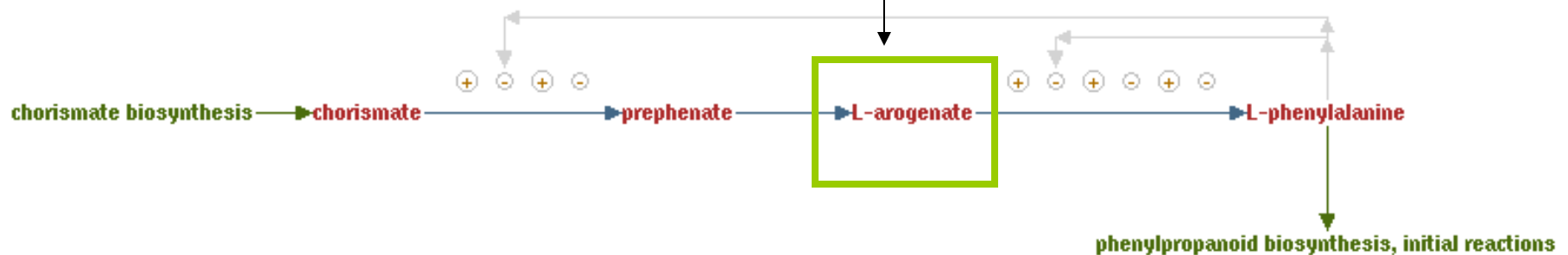
# Validation of a New Database

- Edit pathways operating via a different route

## MetaCyc Pathway: phenylalanine biosynthesis I

[More Detail](#)[Less Detail](#)[Cross-Species Comparison](#)[BioPAX format](#)

## AraCyc Pathway: phenylalanine biosynthesis



# Completion of a New Database

---

## □ Curators

- Add *Arabidopsis* pathways not present in reference database
- Add *Arabidopsis* compounds, reactions, and enzymes not mapped to a pathway
- Assign evidence codes to pathways and enzymes



# Assignment of Evidence Codes

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**AraCyc Pathway: phenylalanine biosynthesis**



**AraCyc Pathway: ribose degradation**



**AraCyc Pathway: arginine biosynthesis III**



# AraCyc 1.0 . . . and beyond

---

- Information enters metabolic pathway database in two stages
  - **Stage 1:** Initial build
  - **Stage 2:** Updates and improvement

# Database updates and improvements

---

Release	AraCyc 1.0	AraCyc 4.5	AraCyc 5.0
Pathways	219	288	even more!

# Database updates and improvements

---

- New rounds of computational pathway prediction
  - New TAIR genome releases
  - New MetaCyc releases
    - New round of PathoLogic prediction

# Database updates and improvements

---

- ❑ New rounds of computational pathway prediction
  - New TAIR genome releases
  - New reference database – **PlantCyc**
    - ❑ Part of the Plant Metabolic Network
    - ❑ Released in June 2008
    - ❑ Contains plant pathways supported by:
      - experimental evidence
      - expert hypothesis \*\*\*
    - ❑ Reviewed by an editorial board of biochemists
    - ❑ Will include enzymes from newly sequenced plant genomes and EST collections

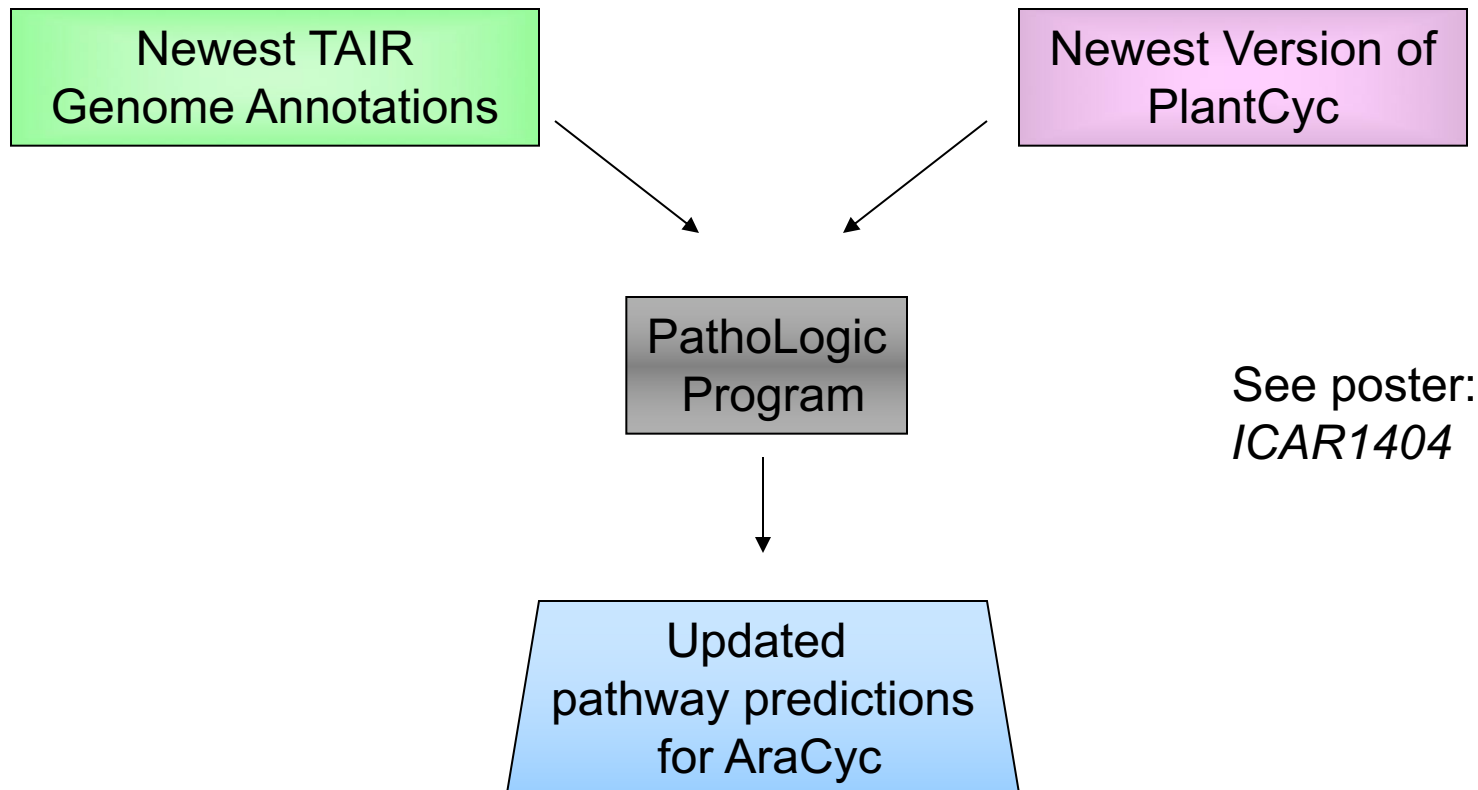


[www.plantcyc.org](http://www.plantcyc.org)

# Database updates and improvements

---

## ■ New rounds of computational pathway prediction



- Newly predicted pathways undergo pathway validation

# Database updates and improvements

---

- New curator entries
  - Curators search for new information in scientific literature
  - TAIR curators
    - Assign new functional annotations to metabolic genes
  - AraCyc curators
    - Manually attach enzymes to pathways
    - Identify new and updated pathways
    - Write or revise summaries



# Database updates and improvements

---

- New community submissions
  - Jamborees
    - Experts meet individually with curators
    - Review pathways in specific metabolic domains
    - Provide useful references and suggest important pathways
  - Curation Booth \*\*\*\*\*
    - Open during all poster sessions – Booth #1
    - Please come (*free candy!*)
  - TAIR or PMN website

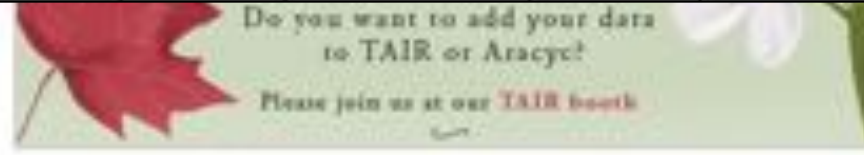
# Community submissions

## TAIR – [www.arabidopsis.org](http://www.arabidopsis.org)



pathway\_form

	A	B	C	D	E	F	G
1	Please <a href="#">SAVE this form</a> and send as an <a href="#">ATTACHMENT</a> to: <a href="mailto:curator@arabidopsis.org">curator@arabidopsis.org</a>	PATHWAY SUBMISSION / CORRECTION FORM			Thank you for sharing your knowledge with us!		
2	Pathway name (required)	Submission or Correction? (required)	Pathway synonym(s)	Organism(s) where the pathway exists (required)	Reaction (required)	Enzyme(s)	Reference(s) / Link(s) to supporting evidence (required)
3					(*Please add more detailed information using an enzyme/ reaction submission form)	(*Please add more detailed information using an enzyme/ reaction submission form)	
4	Example: isoliquiritigenin biosynthesis	submission (new enzyme)	42'-trihydroxychalcone biosynthesis	Arabidopsis thaliana, medicago sativa, sesbania rostrata	coenzyme A + 4-coumarate + ATP = 4-coumaroyl-CoA + PPi + AMP	4CL1, 4CL2, 4CL3, 4CL5 - Arabidopsis thaliana (Phytochemistry)	PMID: 14769935
5	Example: isoliquiritigenin biosynthesis	submission (new enzyme)	same as row 4	same as row 4	4-coumaroyl-CoA + 3 malonyl-CoA + NADPH = isoliquiritigenin + 4 coA + 3CO2 + NADP(+) + H2O	CHR7 (chalcone reductase- Medicago sativa - PMID), SrCHR1 (Sesbania rostrata)	Medicago sativa (Ballance, 1995, Plant Physiol 107(3): 1027-8); srCHR1 (PMID: 10457030)
6	Please begin entering your data below:						
7							
8							
9							
10							



Zeller et al. 2000 PSF's now in TAIR

# Community submissions

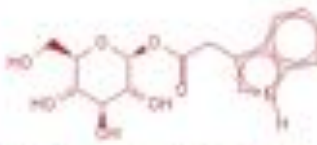
□ TAIR – w

Superclasses: [Reactions-Classified-B](#)  
[Hexosyltransferases](#)  
[Reactions-Classified-B](#)

Enzymes and Genes:  
[glucosyl acid glucosyltransferase](#), [UGT](#)

In Pathway: [IAA conjugate biosynthesis](#)

  
Indole-3-acetate

  
Indole-3-acetyl- $\beta$ -1-D-glucose

  
UDP

**User Feedback Form**

We welcome the comments and suggestions of our user community to help us maintain a high-quality and up-to-date resource. Please use the form below to report any of the following:

- An error or omission in the data
- An error or problem with a generated display page
- A suggestion for improvement
- Other comments or feedback

Alternatively, you may send email to [curator@arabidopsis.org](mailto:curator@arabidopsis.org)

Please fill in the following information:

Your Name:

Your Email:

URL where the problem appears:

Your comments, suggestions, or problem description:

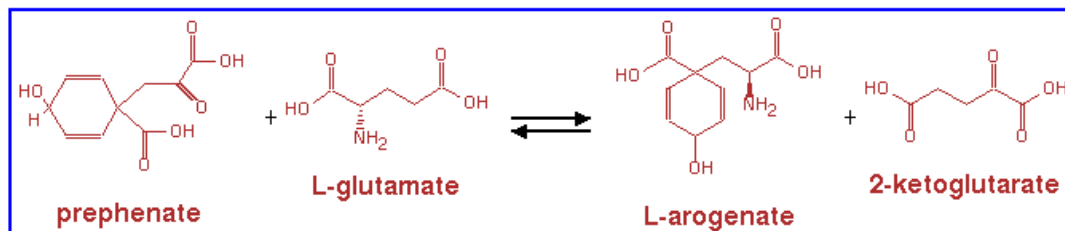
Quick Search

# Community submissions

## PMN – [www.plantcyc.org](http://www.plantcyc.org)

The screenshot shows the PMN website homepage. At the top left is the PMN logo with the text "Plant Metabolic Network". To the right is a search bar with a dropdown menu set to "PlantCyc" and a "search" button. Below the search bar is a navigation menu with links: "About PMN", "Databases", "Downloads", "Tools", "Useful Sites", "Submit Data", "Help", and "Feedback". The "Submit Data" link is highlighted with a yellow box. Below the navigation menu, there is an "Introduction" section on the left and a "Feedback Form" and "Item of the Month" section on the right. The "Item of the Month" section mentions "The PMN launches PlantCyc 1.0" and "On June 17, 2008, PlantCyc made its".

In Pathway: [tyrosine biosynthesis I](#), [phenylalanine biosynthesis](#)



Quick Search

Go

Query Page

Advanced Query Page

Report Errors or Provide Feedback

# Community submissions

- PMN – [www.plantcyc.org](http://www.plantcyc.org)



[curator@plantcyc.org](mailto:curator@plantcyc.org)



**PMN Feedback Form**

To send a message to a helpful PMN curator, please fill in your name and e-mail address, then select a category and add a subject to your message before you submit it.

Name:	<input type="text"/>
E-mail:	<input type="text"/>
Category:	<input type="text" value="Ask a question"/>
Subject:	<input type="text"/>
Referring URL:	<input type="text" value="http://www.plantcyc.org/"/>

Please enter your message here:



# Community submissions = fame!

## □ PMN Contributor page

**PMN Contributors**

PMN contributors from around the world have added to or helped to improve the content of AraCyc, PlantCyc, and the other PlantCyc-derived databases that are part of the PMN.

In addition to the active contributions from the PMN [editorial board](#) and PMN [collaborators](#), the following individuals have contributed significantly in improving the content of PlantCyc, AraCyc and the other PlantCyc-derived databases that are part of the PMN.

- Some contributors have [contacted us](#) with suggestions and requests.
- Some have generously responded to appeals for help from the curators.
- Some have attended curatorial jamborees.

**Contributors to Pathways of [Primary](#) and [Secondary](#) Metabolism**

**Primary Metabolism**

**Amino Acids and Polyamines**

- John Jelenko - Virginia Tech, USA

**Fatty Acids and Lipids**


- Daniel Lynch - Williams College, USA

**General Primary Metabolites**

- Oliver Fiehn - University of California, Davis, USA

**Hormones and Regulators**

- Bonnie Bartel - Rice University, USA
- Hiroshi Moragawa - Kyoto University, Japan



# Acknowledgements

---

## TAIR, AraCyc, and the PMN

Eva Huala (*Director and Co-PI*)

Sue Rhee (*PI and Co-PI*)

### Current Curators:

- Peifen Zhang (*Director and lead curator- metabolism*)
- Tanya Berardini (*lead curator – functional annotation*)
- David Swarbreck (*lead curator – structural annotation*)
- A. S. Karthikeyan (*curator*)
- Donghui Li (*curator*)

### Recent Past Curators:

- Christophe Tissier (*curator*)
- Hartmut Foerster (*curator*)

### Tech Team Members:

- Bob Muller (*Manager*)
- Larry Ploetz (*Sys. Administrator*)
- Raymond Chetty
- Anjo Chi
- Vanessa Kirkup
- Cynthia Lee
- Tom Meyer
- Shanker Singh
- Chris Wilks

### Metabolic Pathway Software:

- Peter Karp and SRI group (**NIH**)

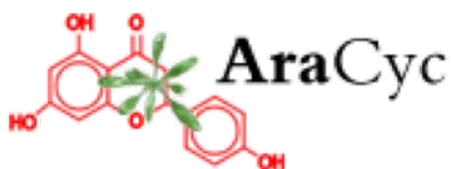
# Thank you . . .

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[www.arabidopsis.org](http://www.arabidopsis.org)

[curator@arabidopsis.org](mailto:curator@arabidopsis.org)



[www.arabidopsis.org/biocyc](http://www.arabidopsis.org/biocyc)

[curator@arabidopsis.org](mailto:curator@arabidopsis.org)



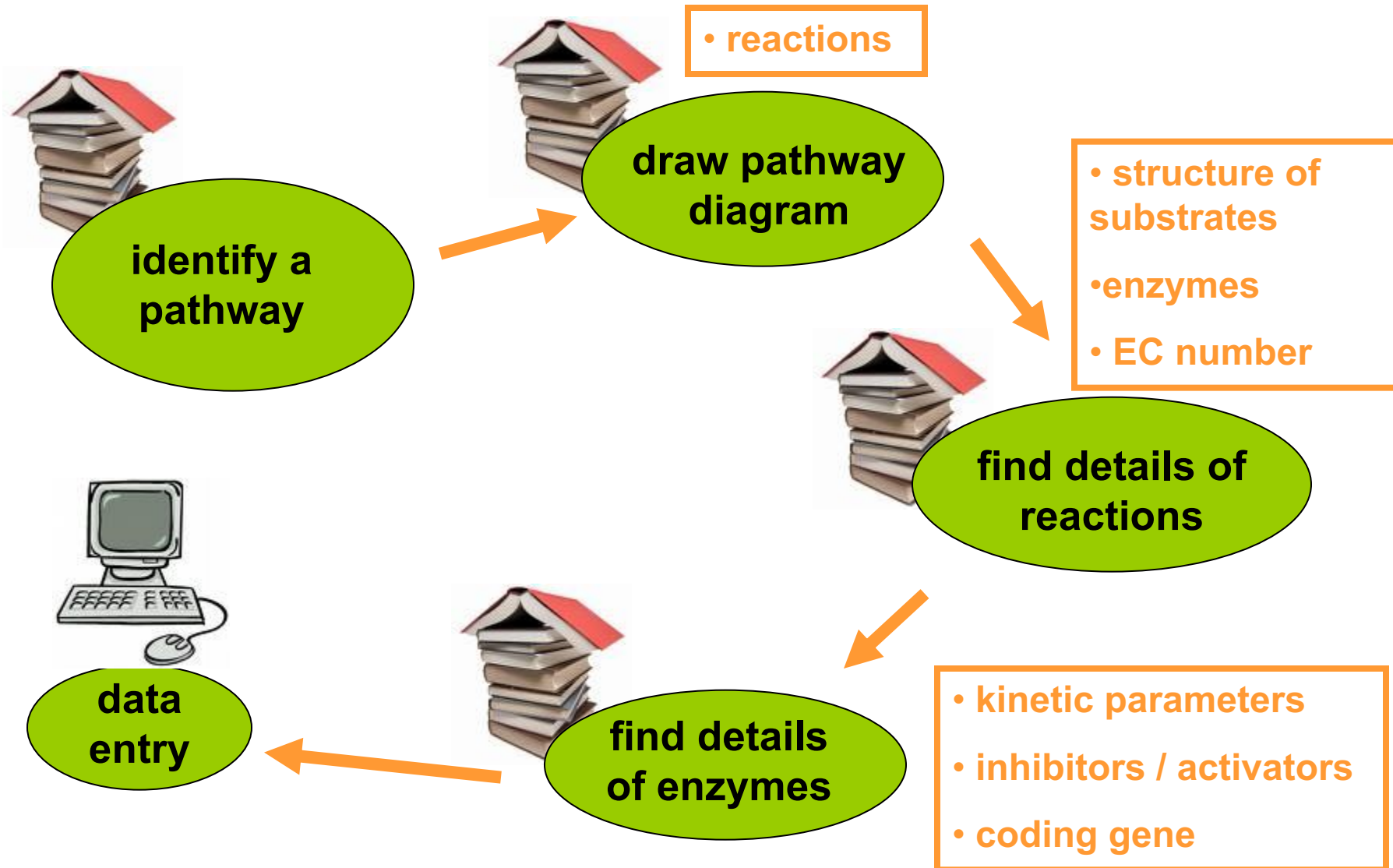
[www.plantcyc.org](http://www.plantcyc.org)

[curator@plantcyc.org](mailto:curator@plantcyc.org)

**Please visit us at the Curation Booth!**



# Curation workflow



# Database maintenance and improvement

Genome Annotation

+

PathoLogic Prediction

+

Manual Pathway Curation

Single Species Databases

**AraCyc 5.0**

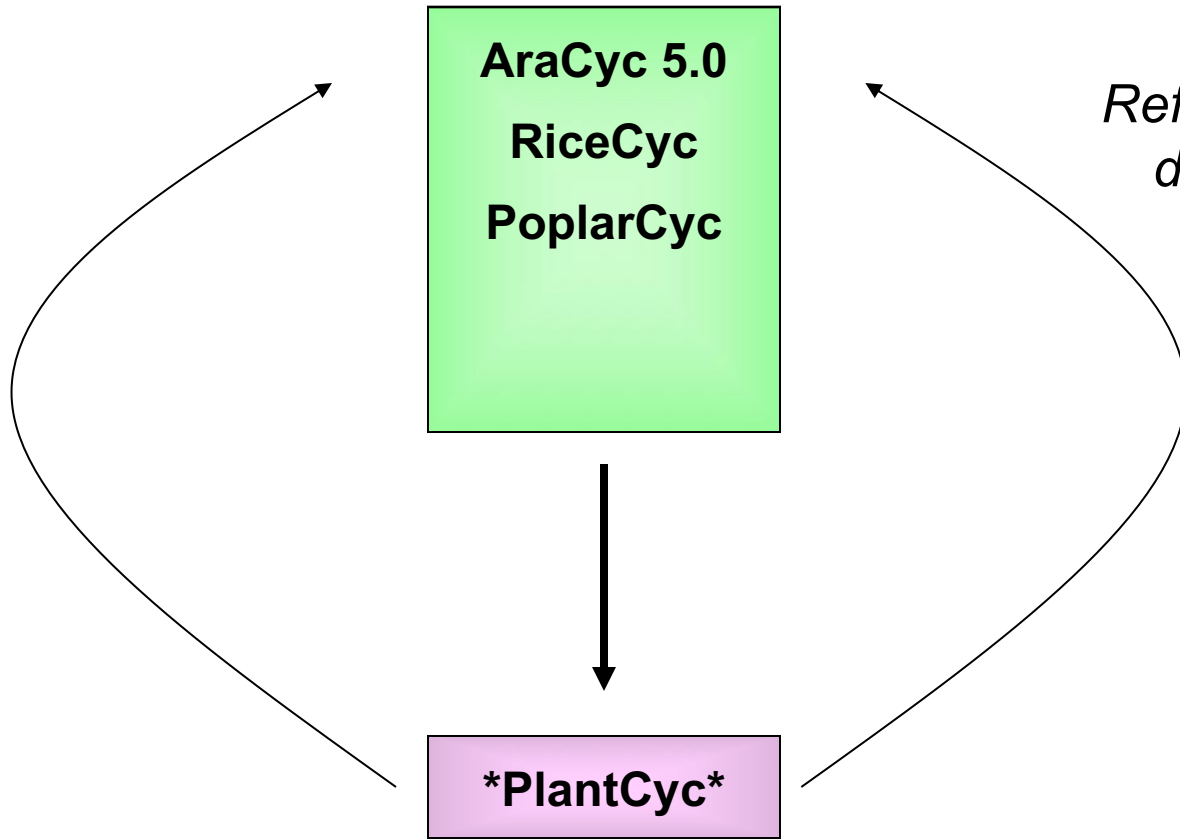
**RiceCyc**

**PoplarCyc**

*Refine existing  
databases*

**\*PlantCyc\***

Multi-species reference database



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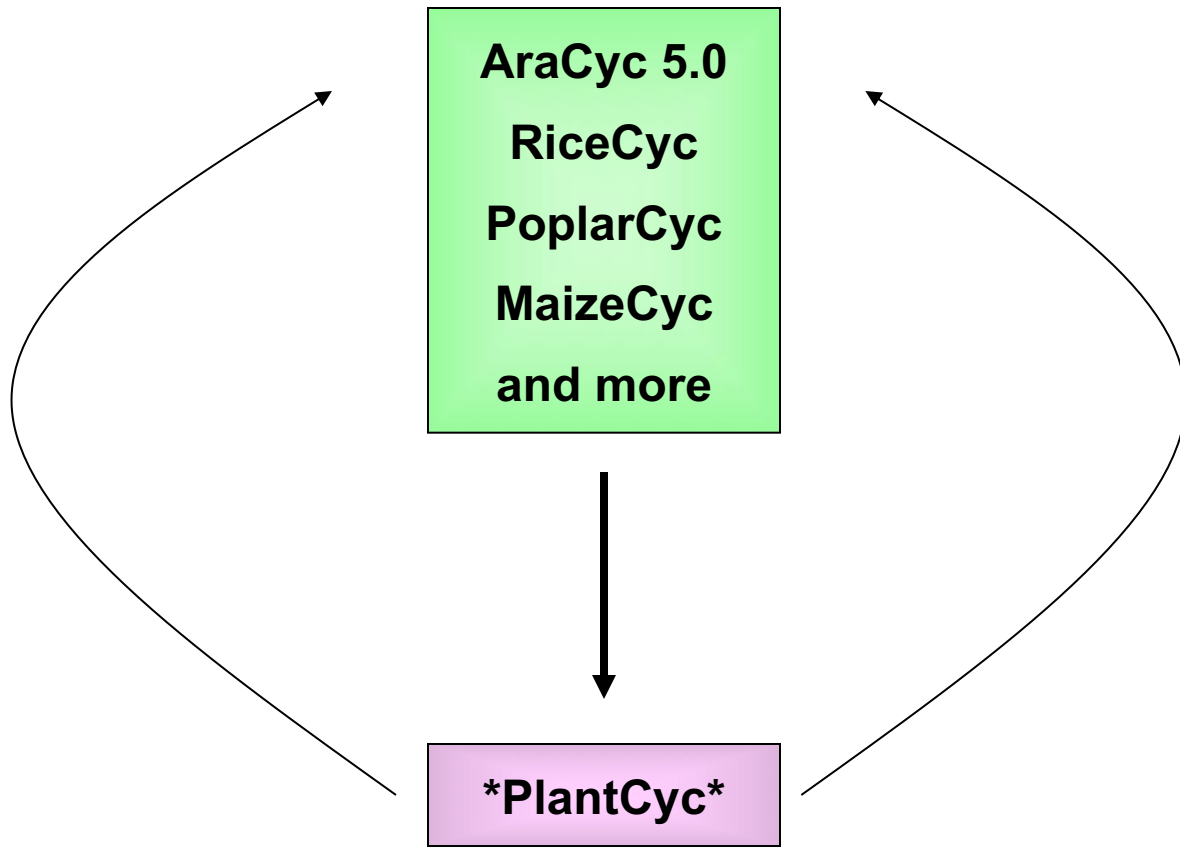
**PoplarCyc**

**MaizeCyc**

**and more**

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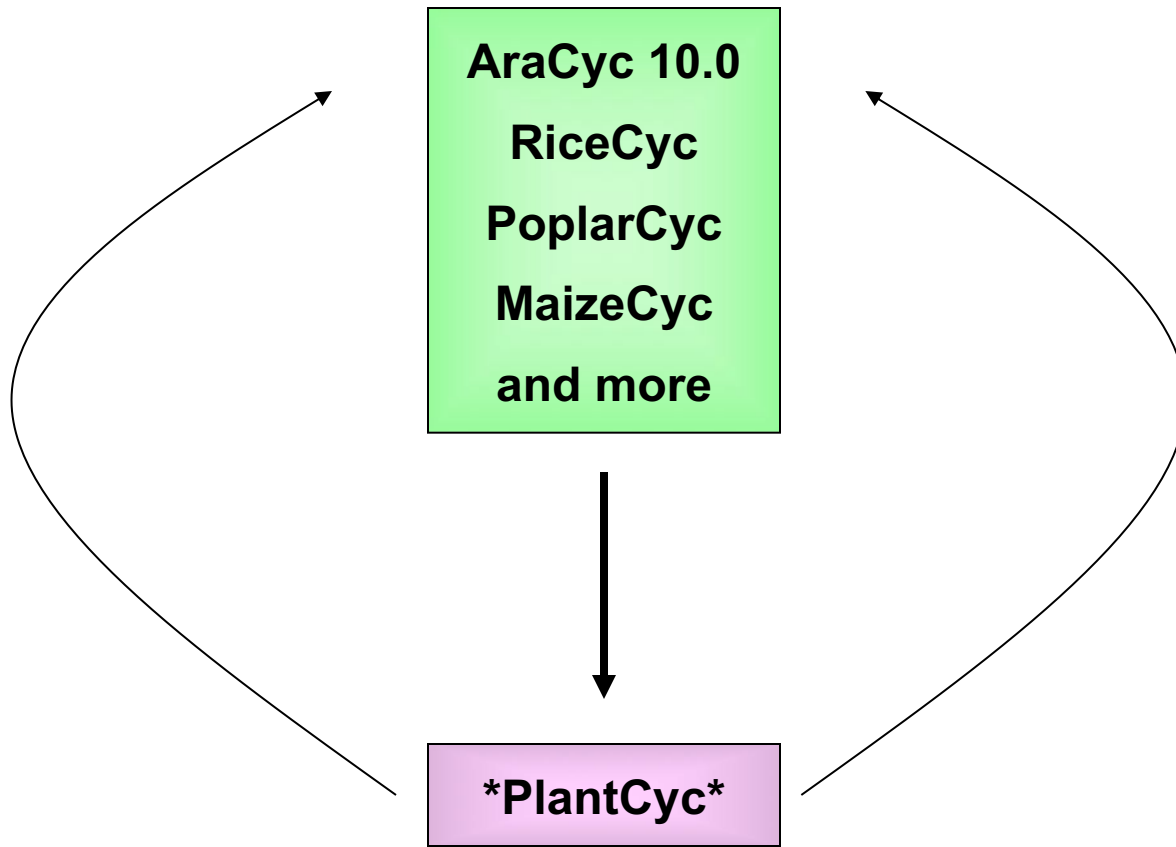
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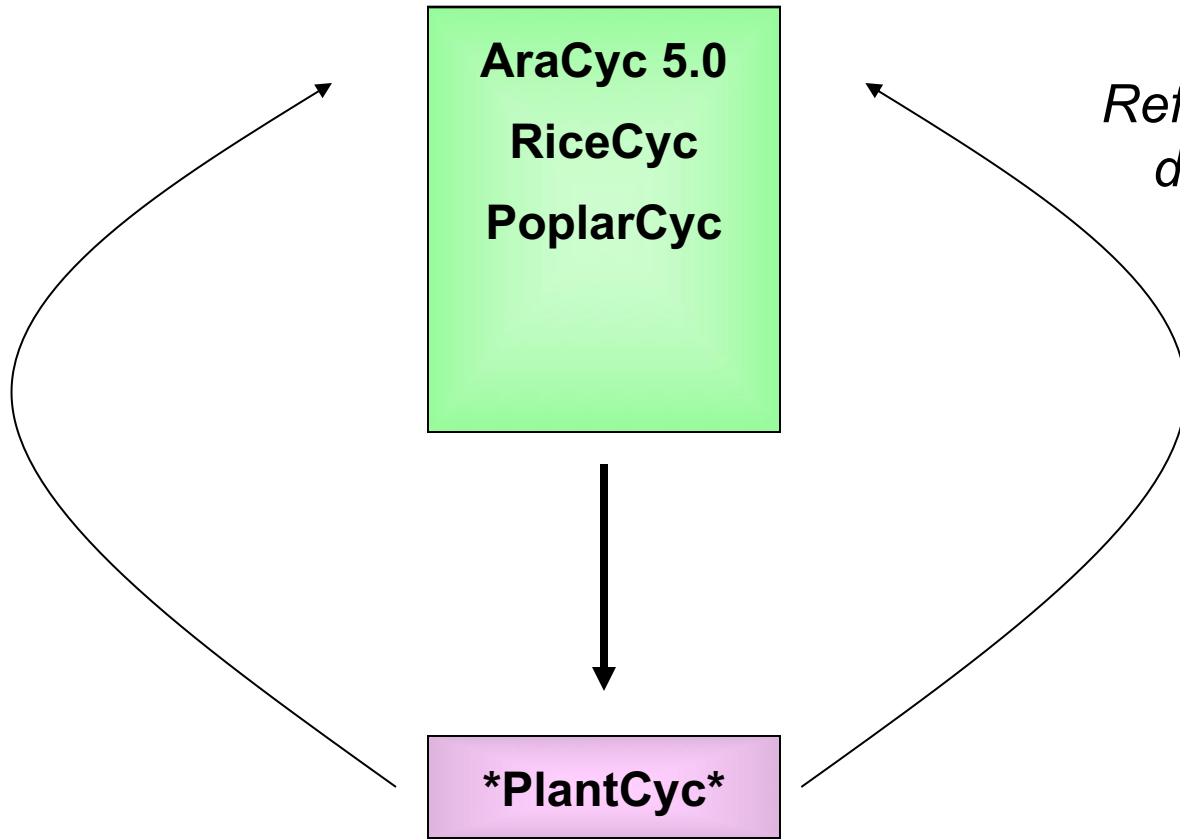
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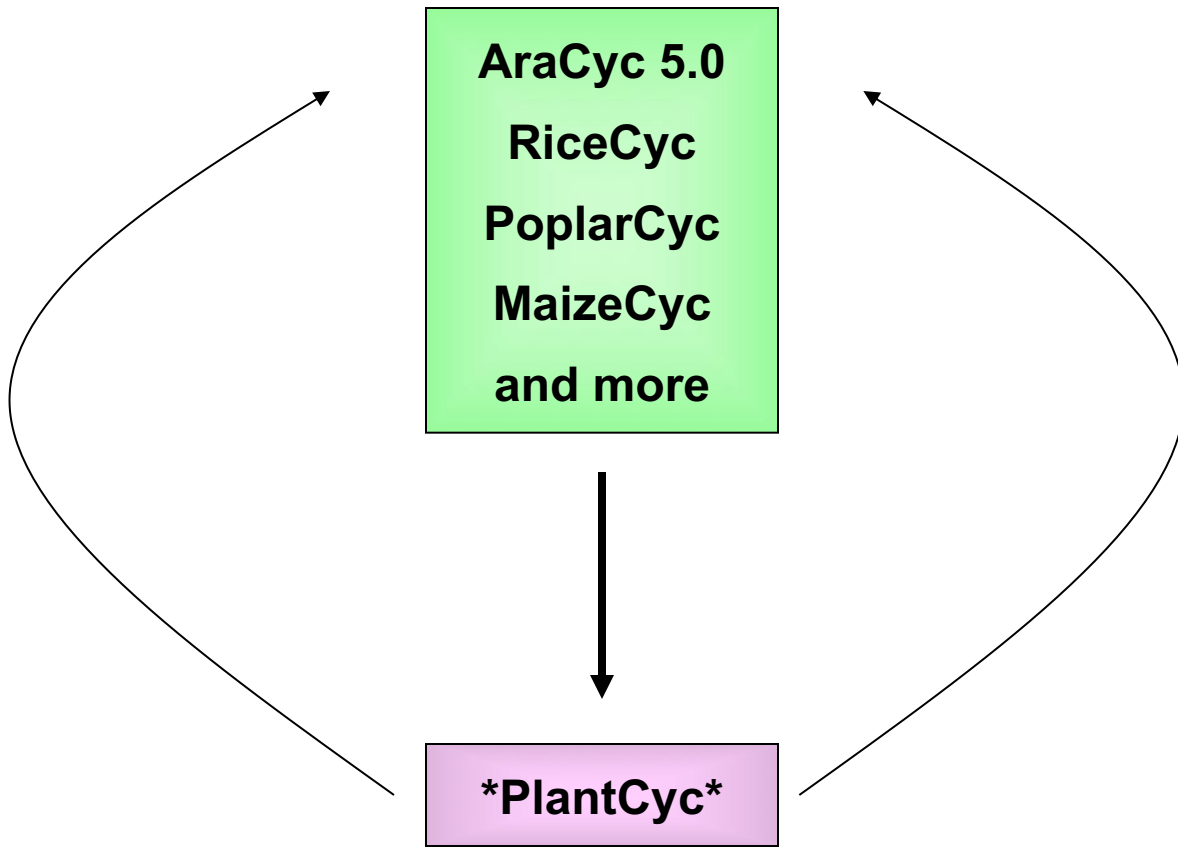
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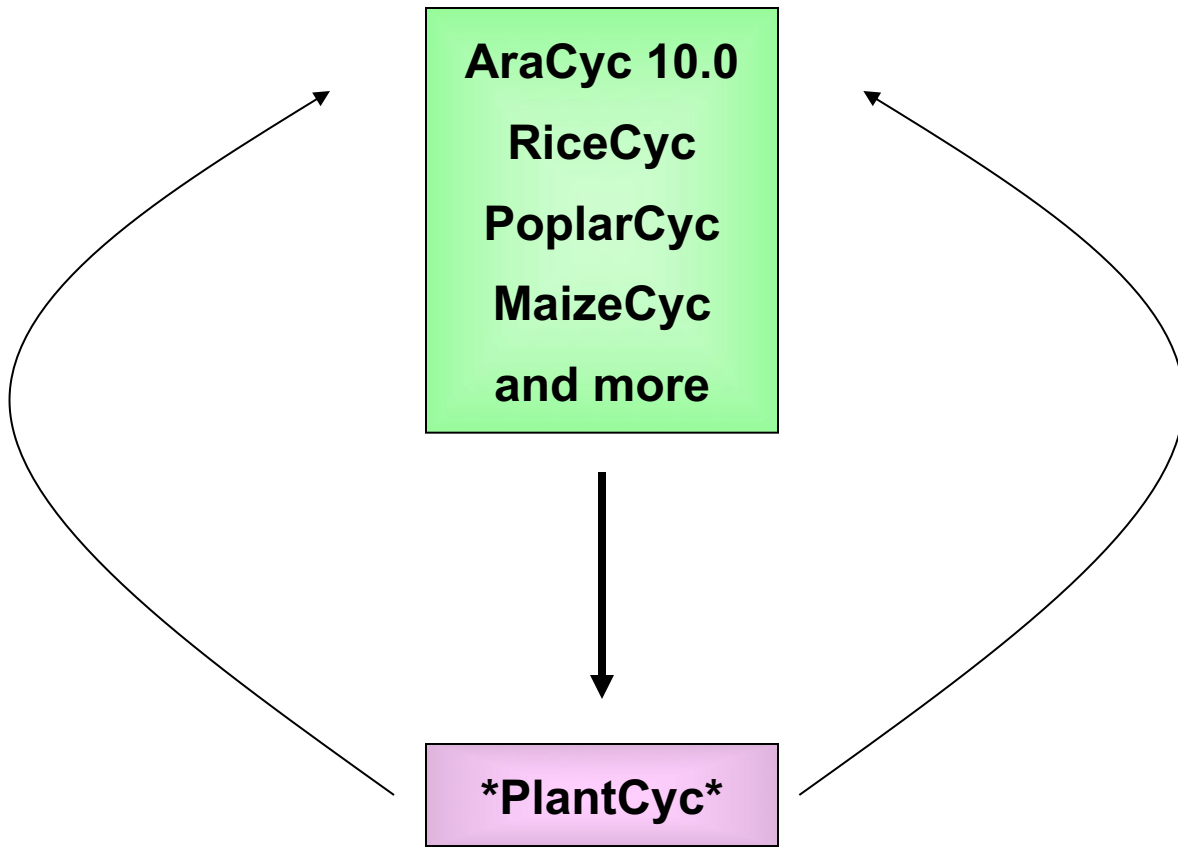
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Single Species Databases

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**RiceCyc**

**PoplarCyc**

**PlantCyc**

*Build  
NEW databases*

Multi-species reference database

