



## GENERAL EXPLANATIONS

- Enzymes with pink background belong to a pre-defined KEGG module.
- Enzymes highlighted with a frame of a non-pink colour (green, purple/violet, blue, orange/brown) belong to a module defined based on Wendisch VF (ed). *Amino acid biosynthesis – Pathways, regulation and metabolic engineering*. Microbiology Monographs. Springer-Verlag: Berlin Heidelberg, Germany, 2007.
- Final product (amino acid) of the route 
- Intermediate metabolite of the route 

ALANINE, ASPARTATE AND GLUTAMATE METABOLISM

**Alanine biosynthesis**

- \* Aspartate -> alanine
- \* Pyruvate -> alanine (3 E.C. can do this conversion)

**Aspartate biosynthesis**

- \* Asparagine -> aspartate (3 E.C. can do this conversion)
- \* Oxaloacetate -> aspartate

**Asparagine biosynthesis**

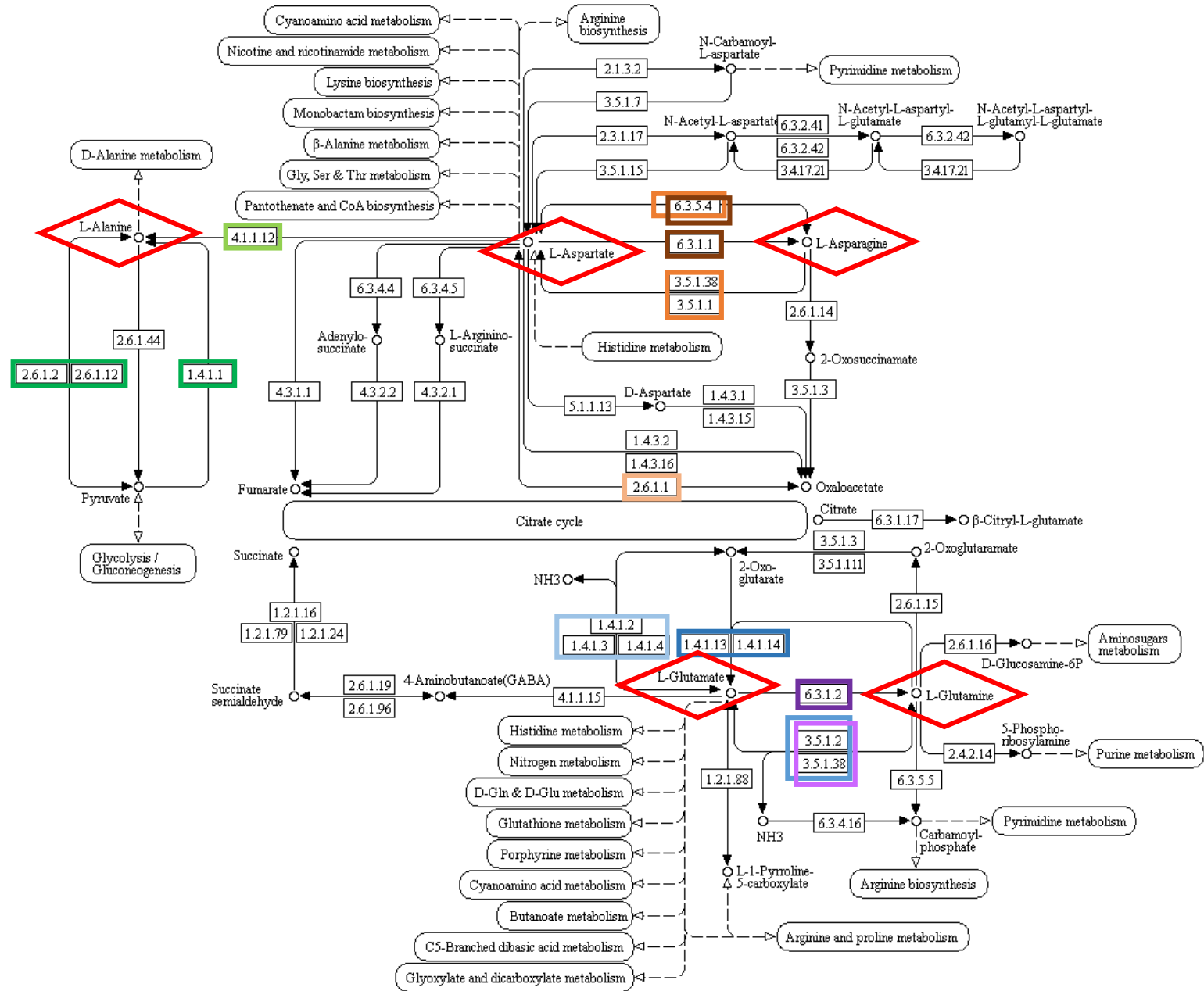
- \* Aspartate -> asparagine (2 E.C. can do this conversion)

**Glutamate biosynthesis**

- \* 2-Oxoglutarate -> glutamate (3 E.C. can do this conversion)
- \* Glutamine -> glutamate (2 E.C. can do this conversion)
- \* 2-Oxoglutarate + glutamine -> Glutamate (2 E.C. can do this conversion)

**Glutamine biosynthesis**

- \* Glutamate -> glutamine
- \* Glutamate + NH<sub>3</sub> -> glutamine (2 E.C. can do this conversion)

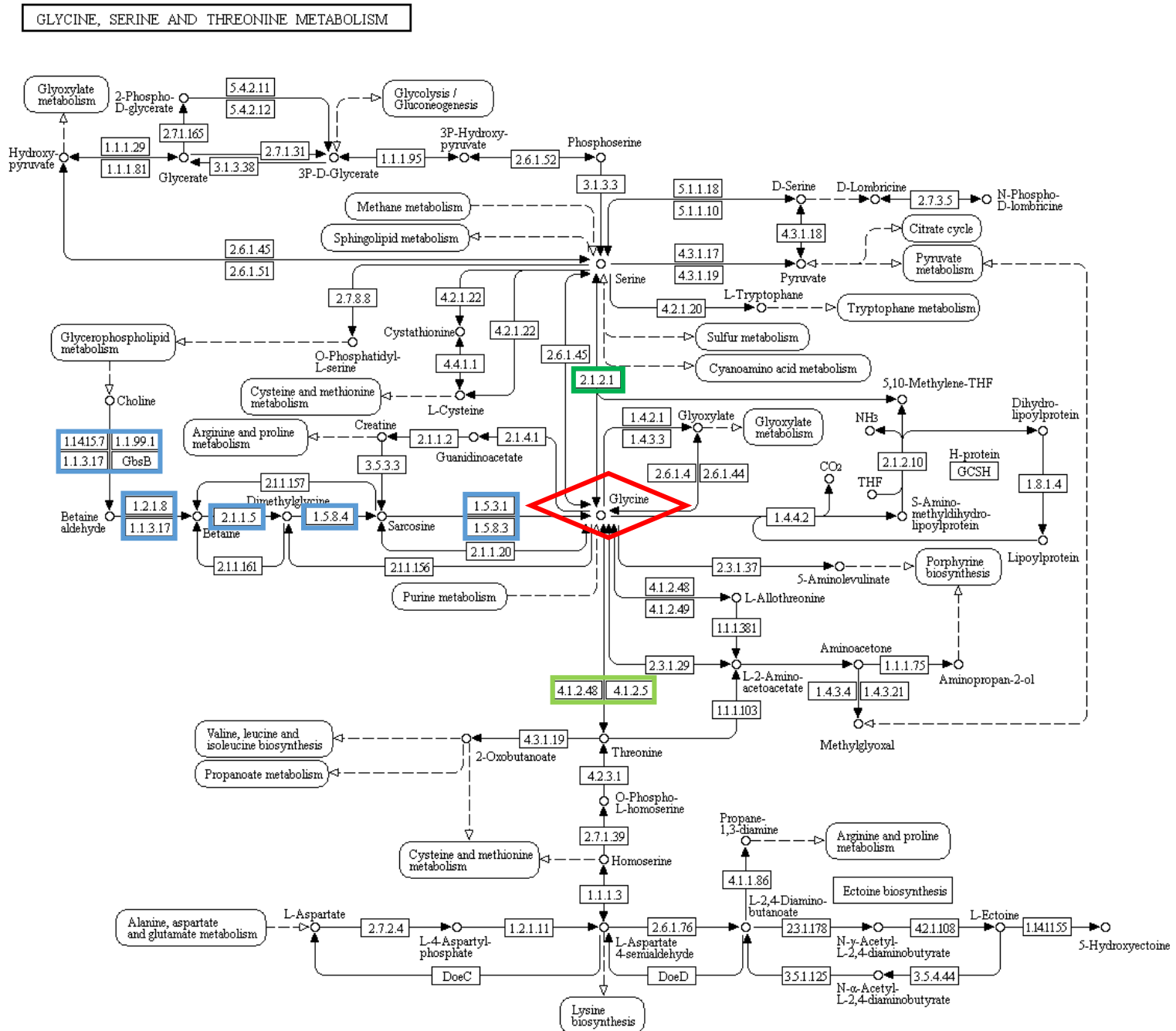


# Glycine biosynthesis – 3 alternative modules:

Serine → glycine

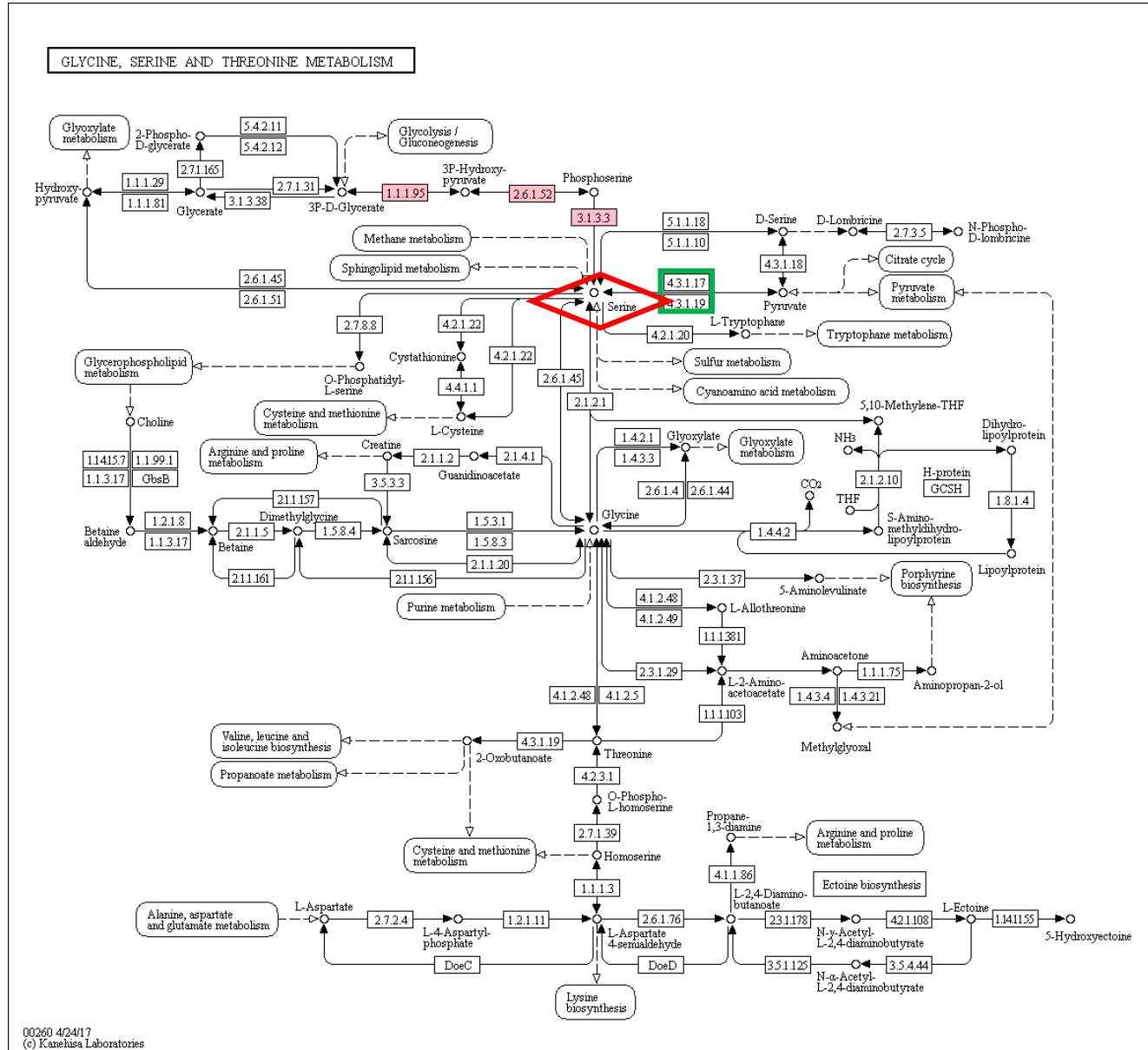
Threonine → glycine

Choline → glycine (unlikely route in bacteria)



# Serine biosynthesis - 2 alternative modules:

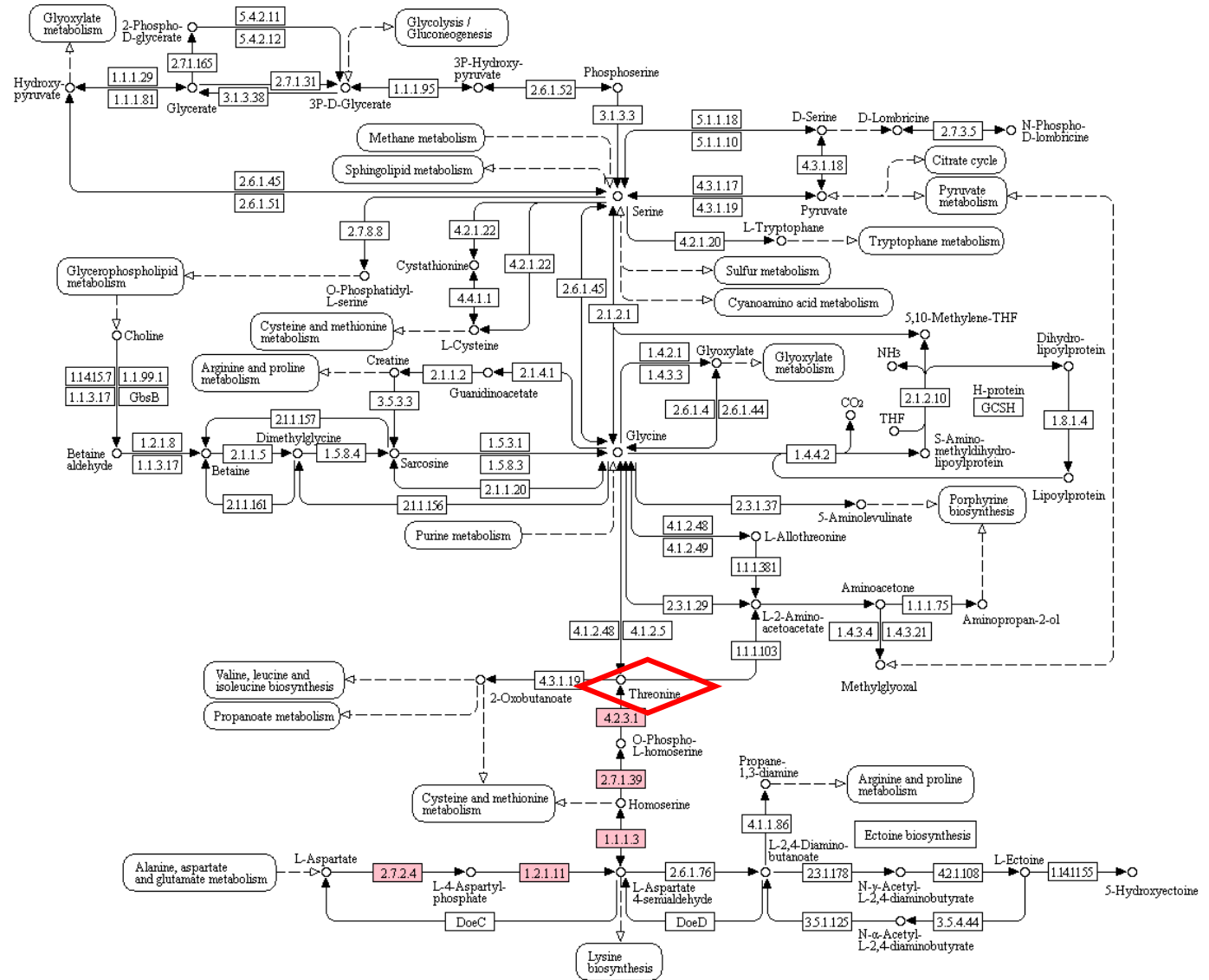
M00020: glycerate-3P => serine  
 pyruvate => serine



# Threonine biosynthesis – 1 KEGG module

M00018: aspartate => homoserine => threonine

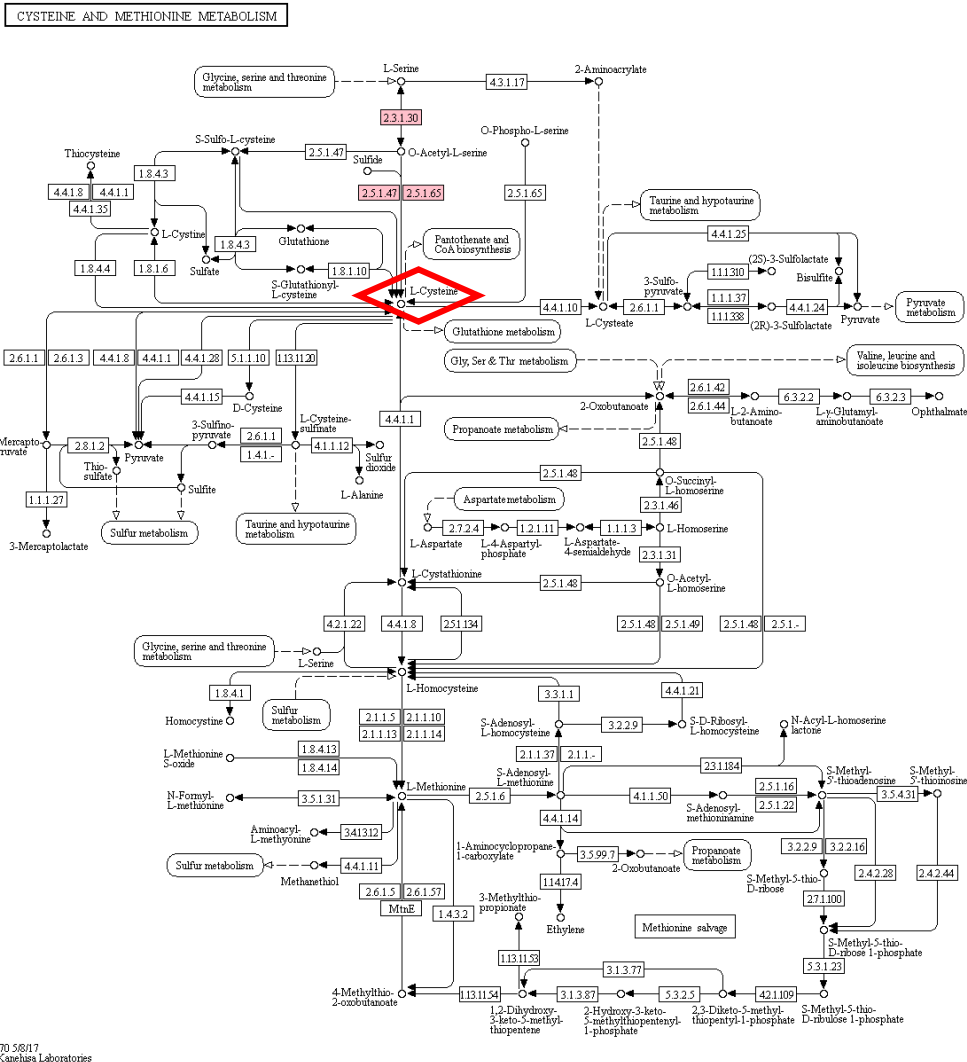
## GLYCINE, SERINE AND THREONINE METABOLISM



# Cysteine biosynthesis – 3 alternative modules defined by KEGG

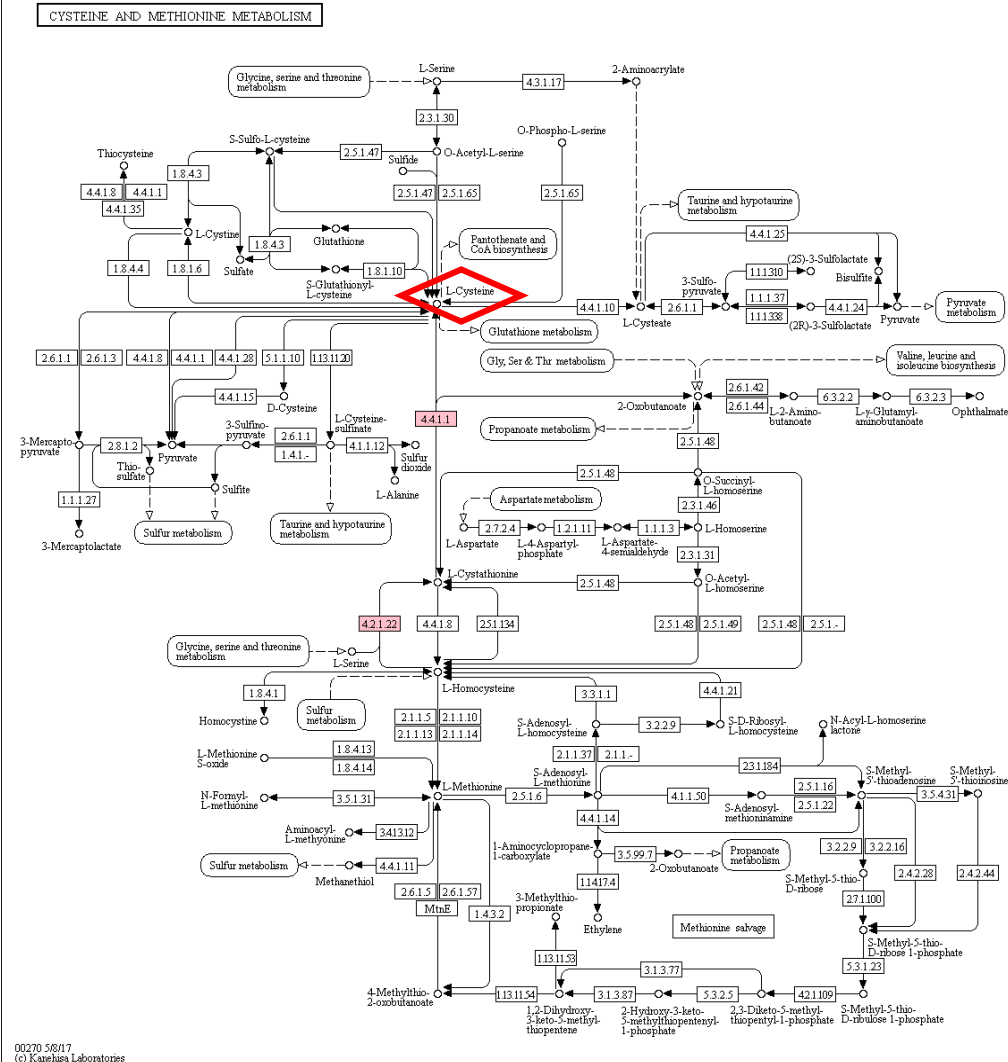
## Module A

M00021: serine => cysteine



## Module B

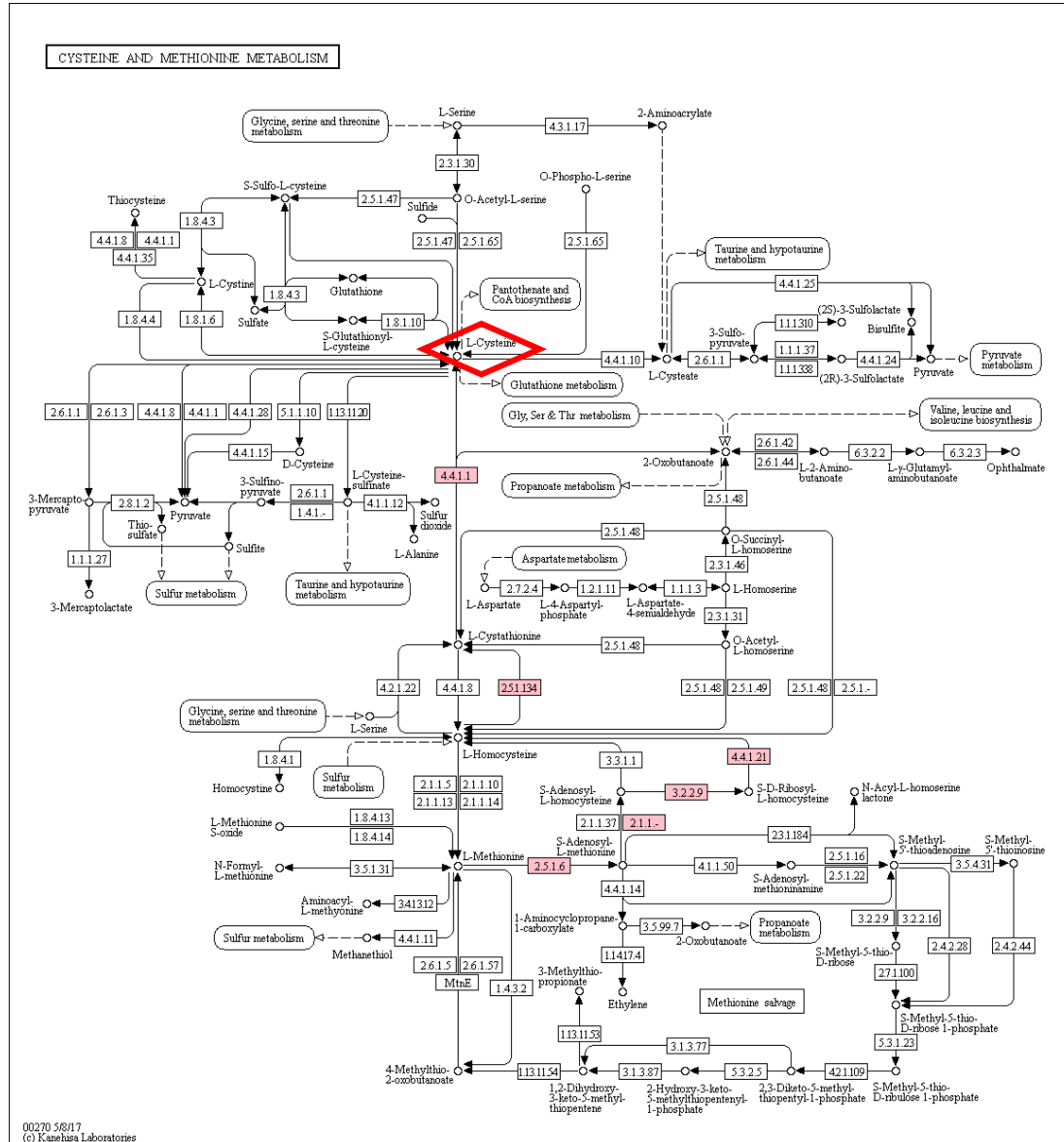
M00338: homocysteine + serine => cysteine



# Cysteine biosynthesis – 3 alternative modules defined by KEGG

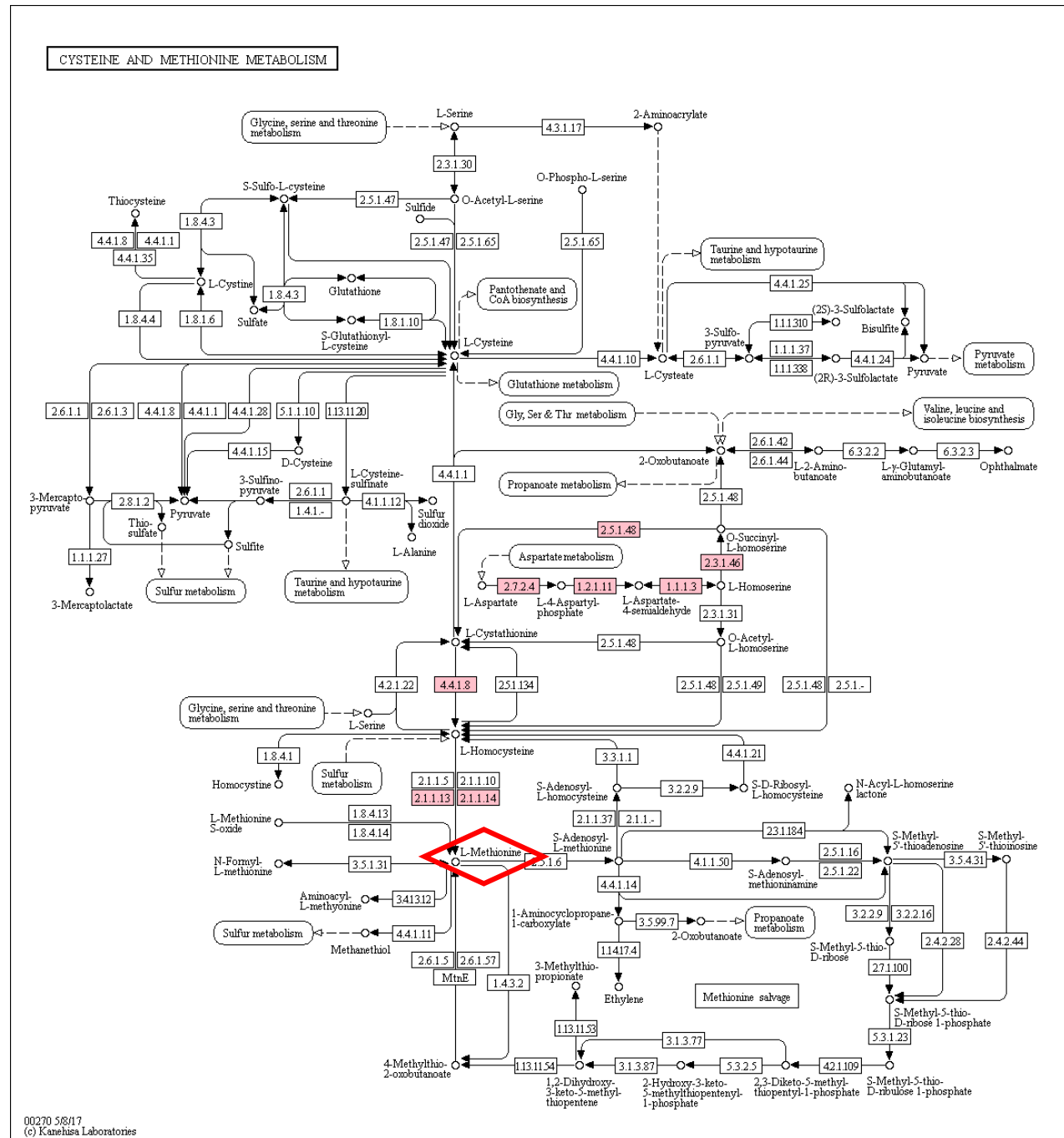
## Module C

M00609: methionine => cysteine



# Methionine biosynthesis – 1 KEGG module

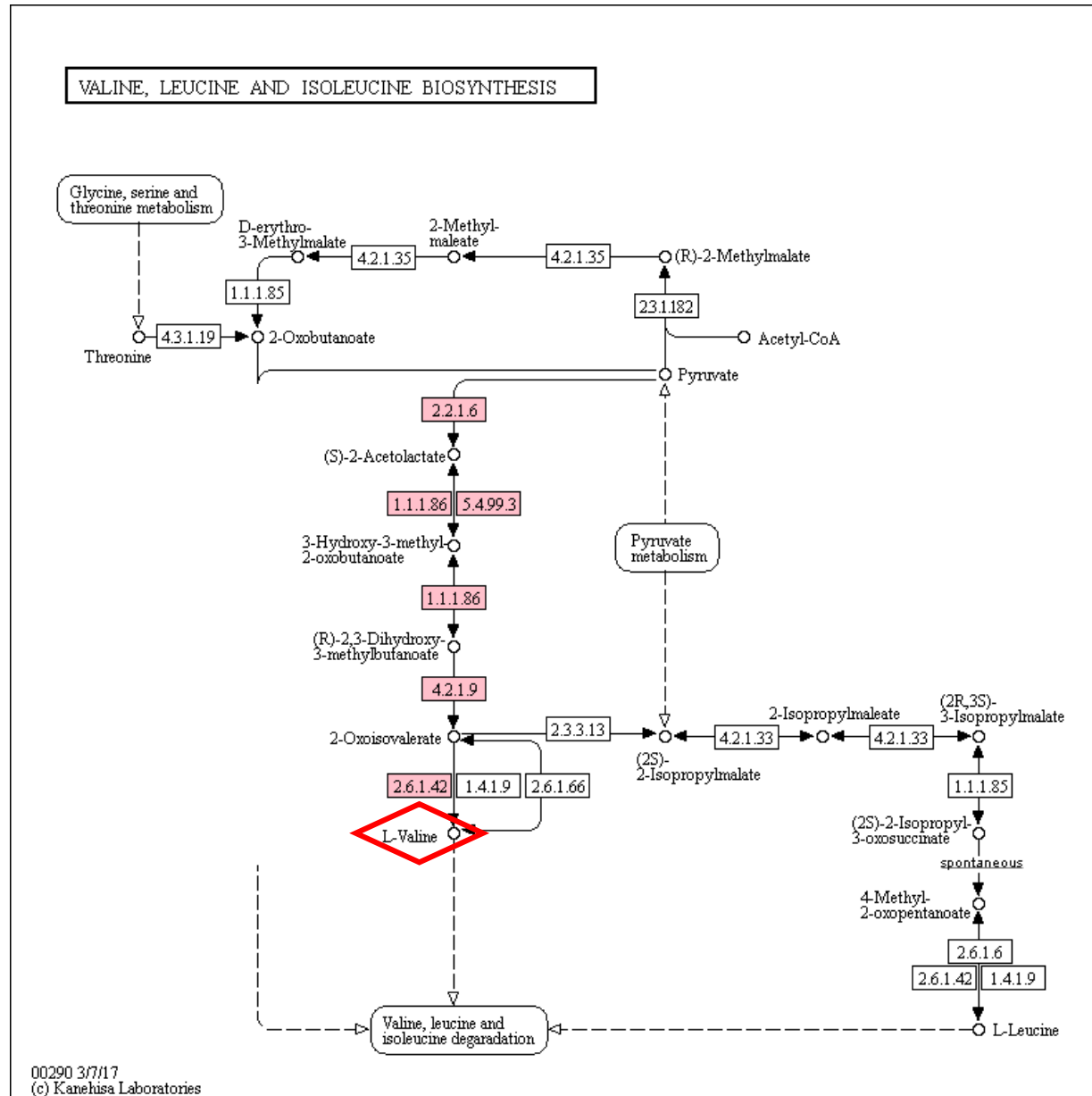
M0017: aspartate => homoserine => methionine





# Valine biosynthesis – 1 KEGG module

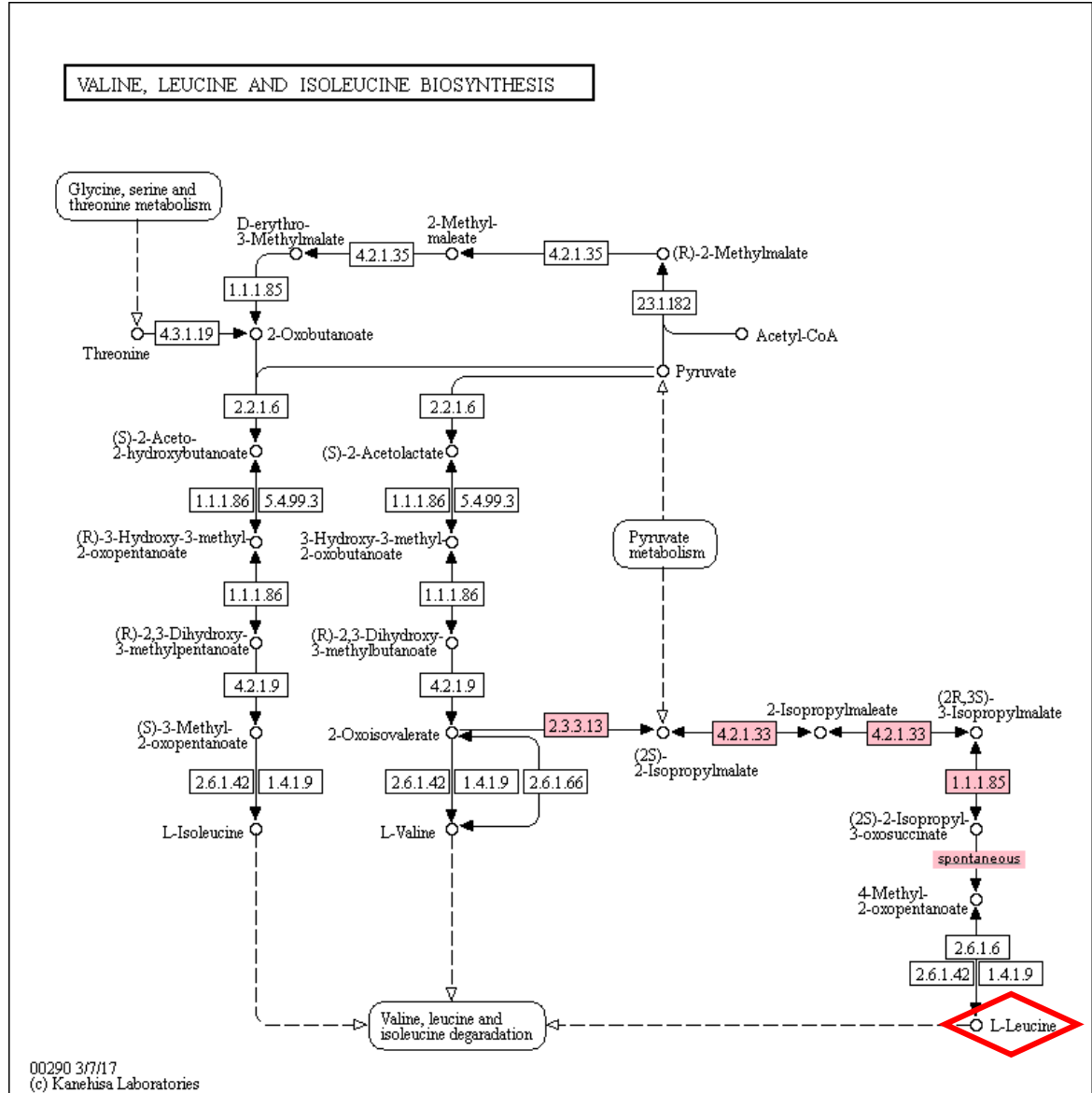
M00019: pyruvate => valine



# Leucine biosynthesis – 1 KEGG module

M00432: 2-oxoisovalerate => 2-oxoisocaproate (4-Methyl-2-oxopentanoate).

2-oxoisocaproate => L-leucine



# Isoleucine biosynthesis – 2 KEGG modules are needed

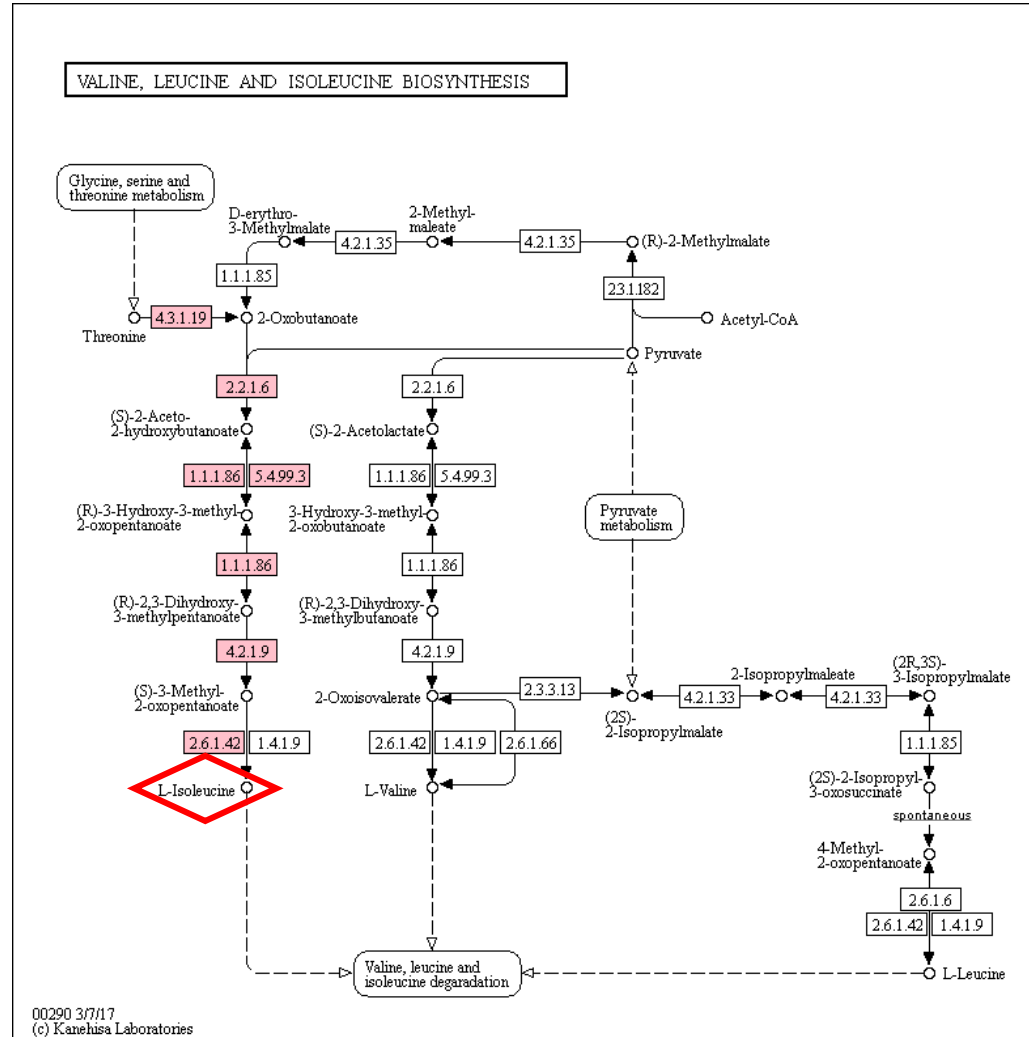
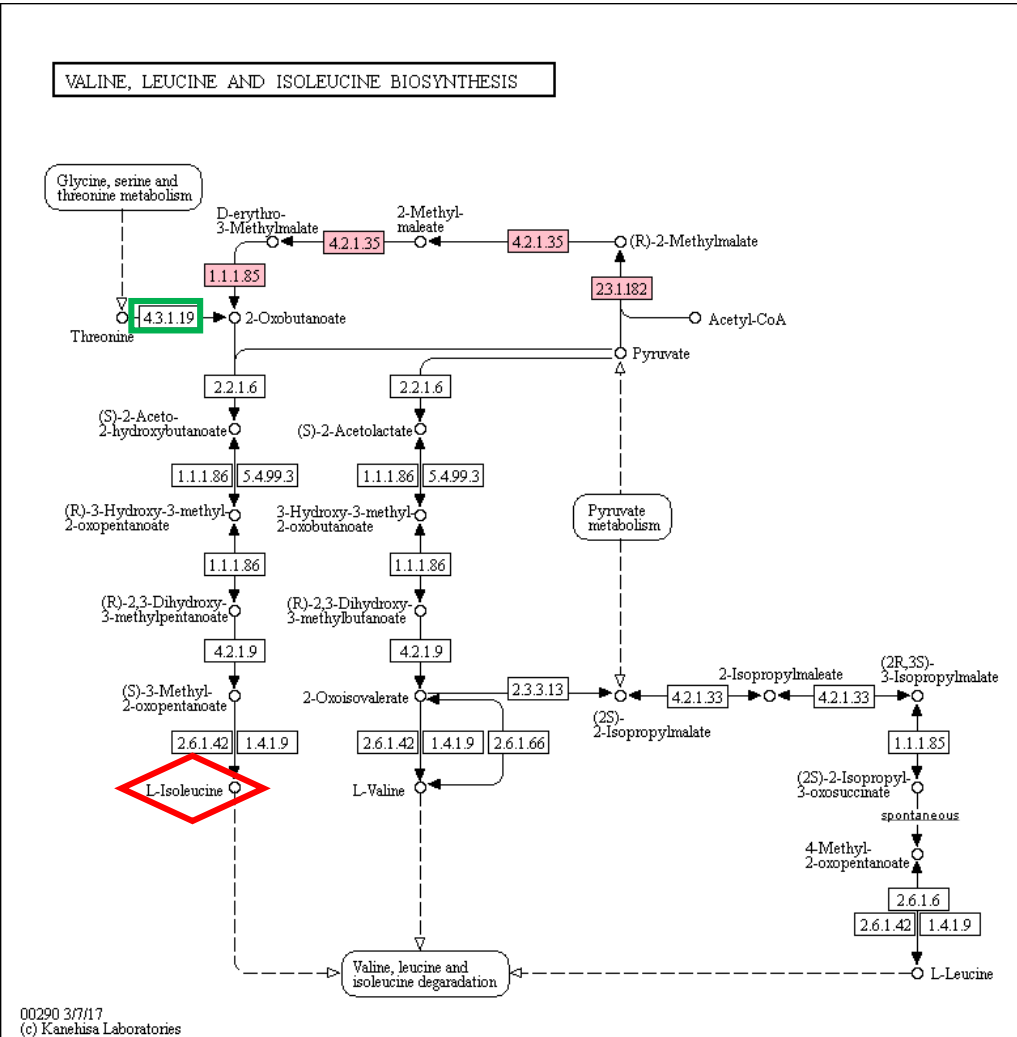
## Module 1: two alternative ways to produce 2-oxobutanoate

**A** M00535: pyruvate => 2-oxobutanoate

**B** threonine => 2-oxobutanoate

## Module 2

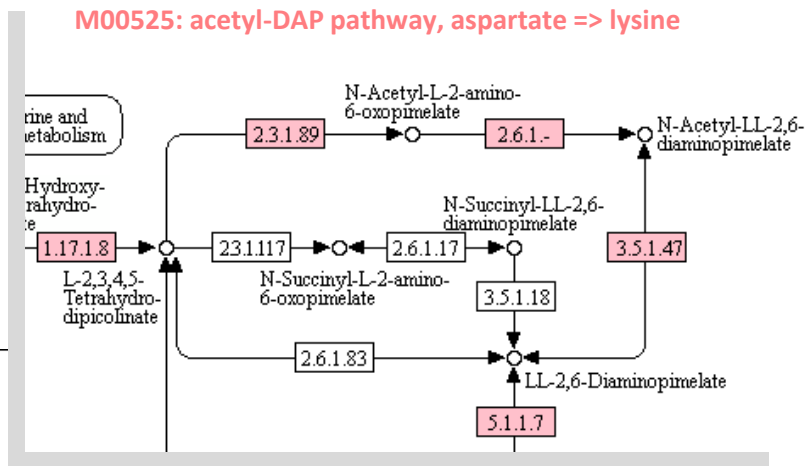
M00570: 2-oxobutanoate => isoleucine



# Lysine biosynthesis – 6 alternative modules defined by KEGG

## Module B

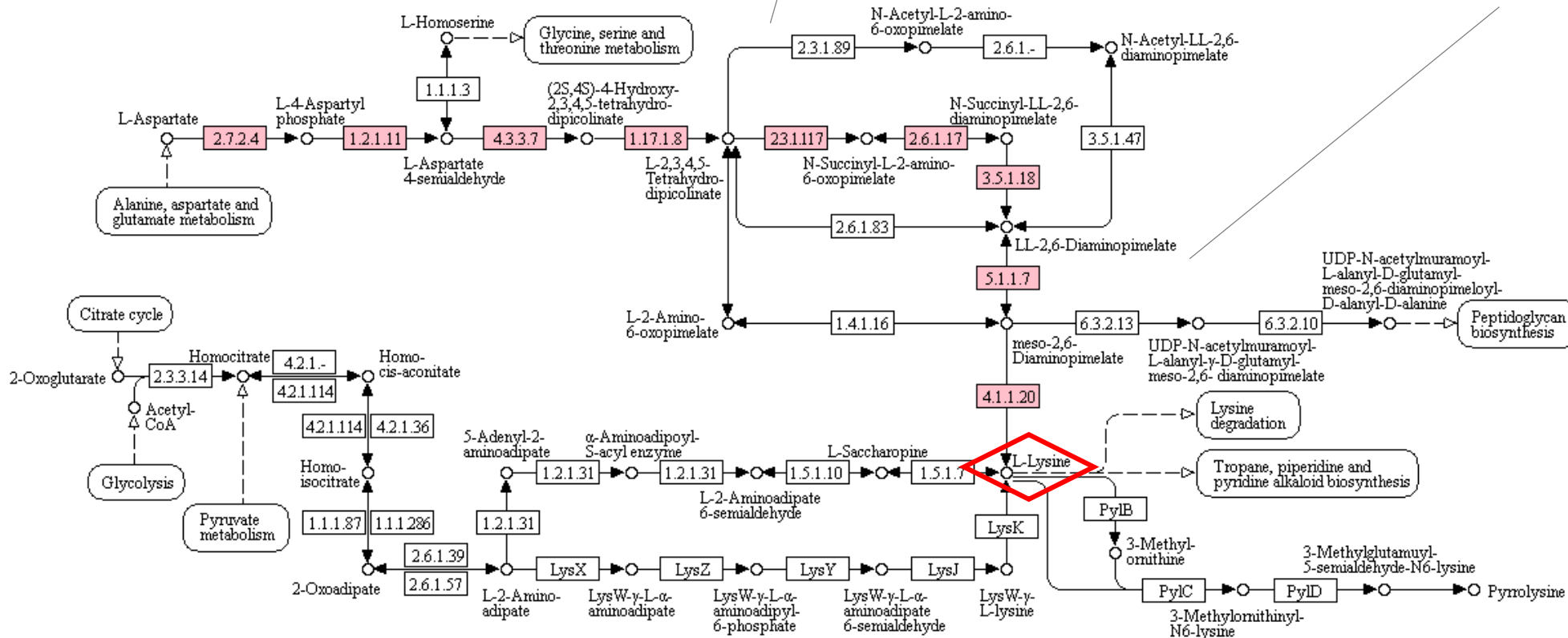
M00525: acetyl-DAP pathway, aspartate => lysine



## Module A

LYSINE BIOSYNTHESIS

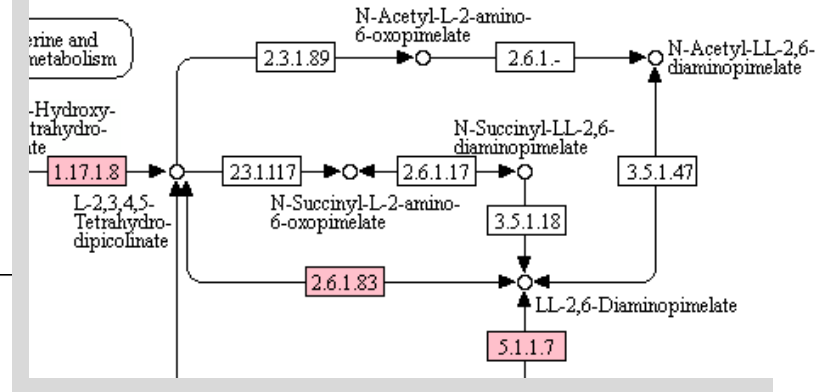
M00016: succinyl-DAP pathway, aspartate => lysine



# Lysine biosynthesis – 6 alternative modules defined by KEGG

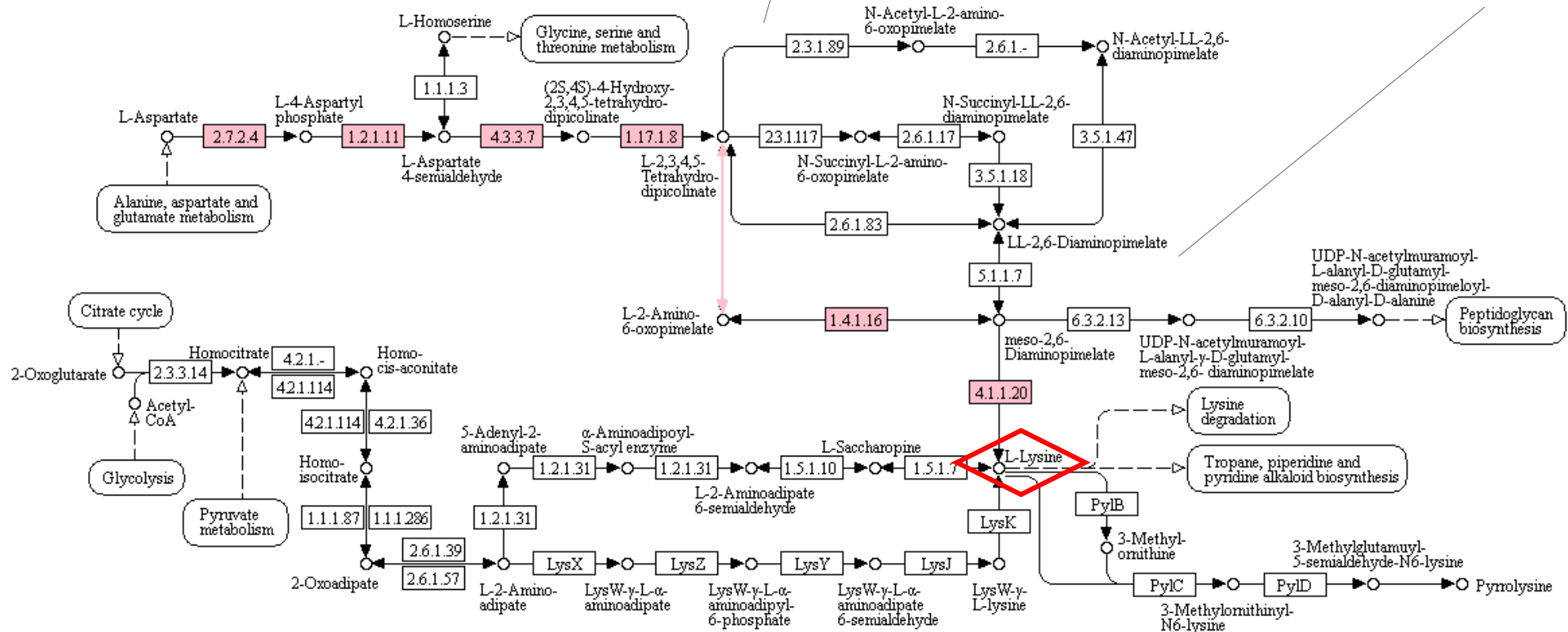
## Module D

### M00527: DAP aminotransferase pathway, aspartate => lysine



## Module C M00526: DAP dehydrogenase pathway, aspartate => lysine

### LYSINE BIOSYNTHESIS

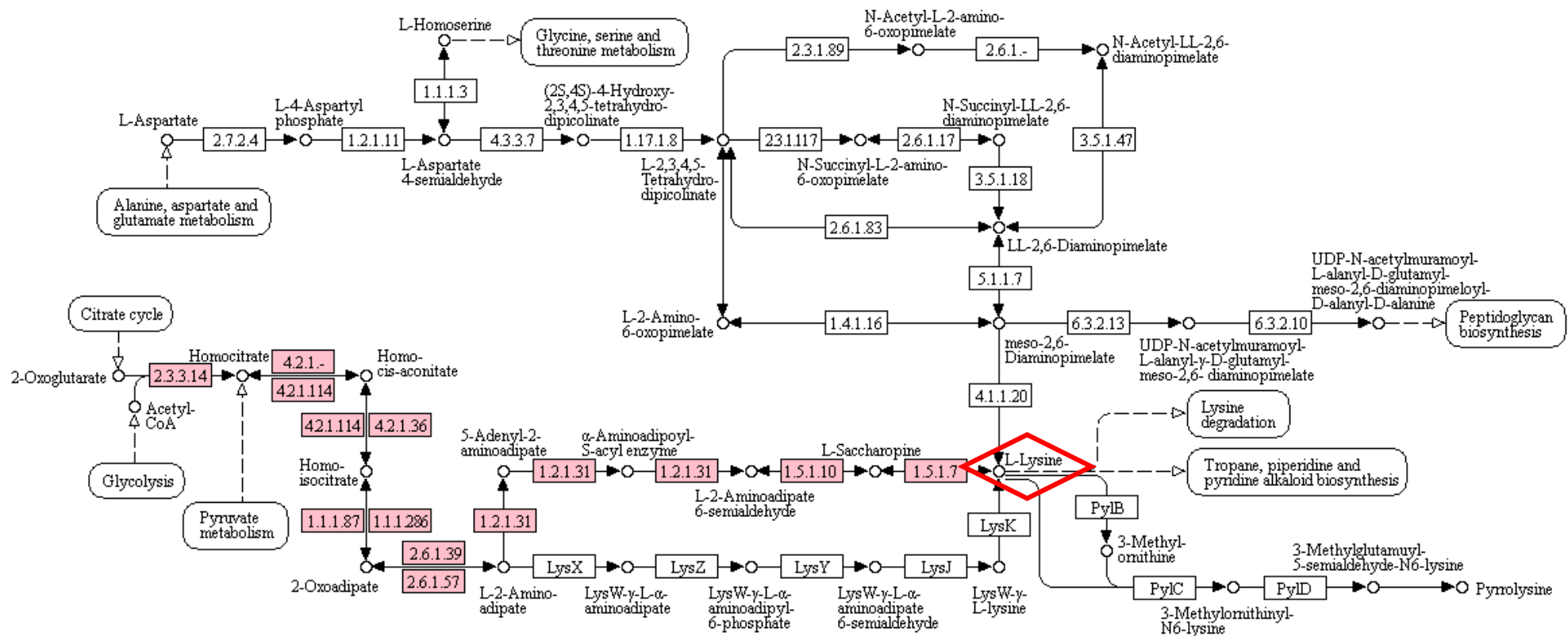


# Lysine biosynthesis – 6 alternative modules defined by KEGG

## Module E

M00030: AAA pathway, 2-oxoglutarate => 2-aminoadipate => lysine

### LYSINE BIOSYNTHESIS

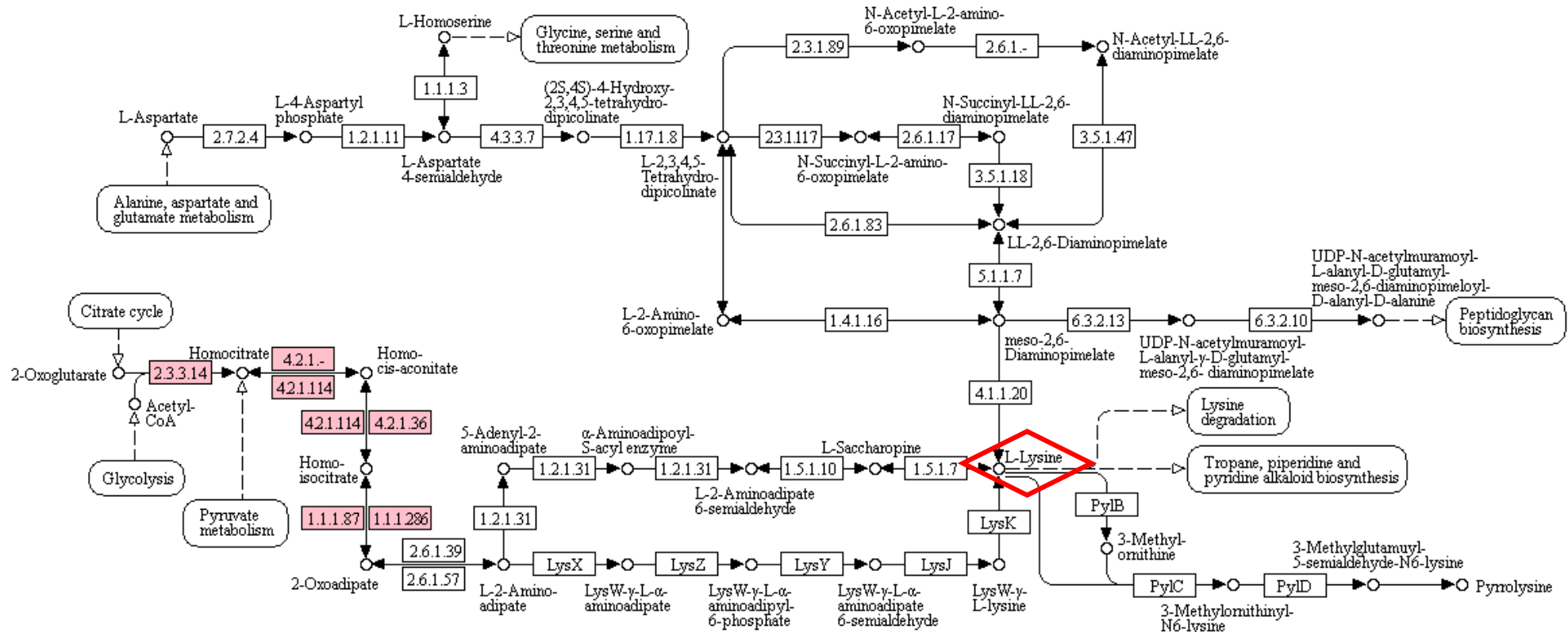


# Lysine biosynthesis – 6 alternative modules defined by KEGG

## Module F, first section

M00433: 2-oxoglutarate => 2-oxoadipate

### LYSINE BIOSYNTHESIS

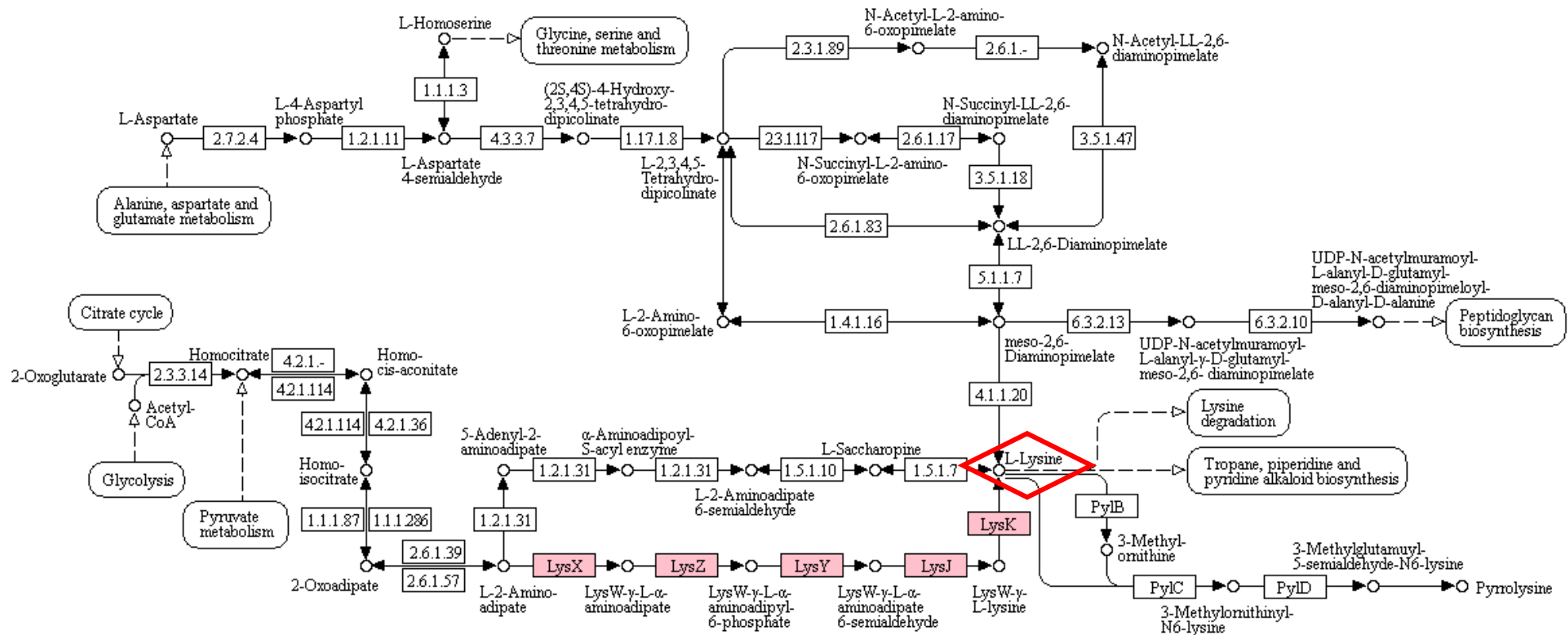


# Lysine biosynthesis – 6 alternative modules defined by KEGG

## Module F, second section

M00031: mediated by LysW, 2-aminoadipate => lysine

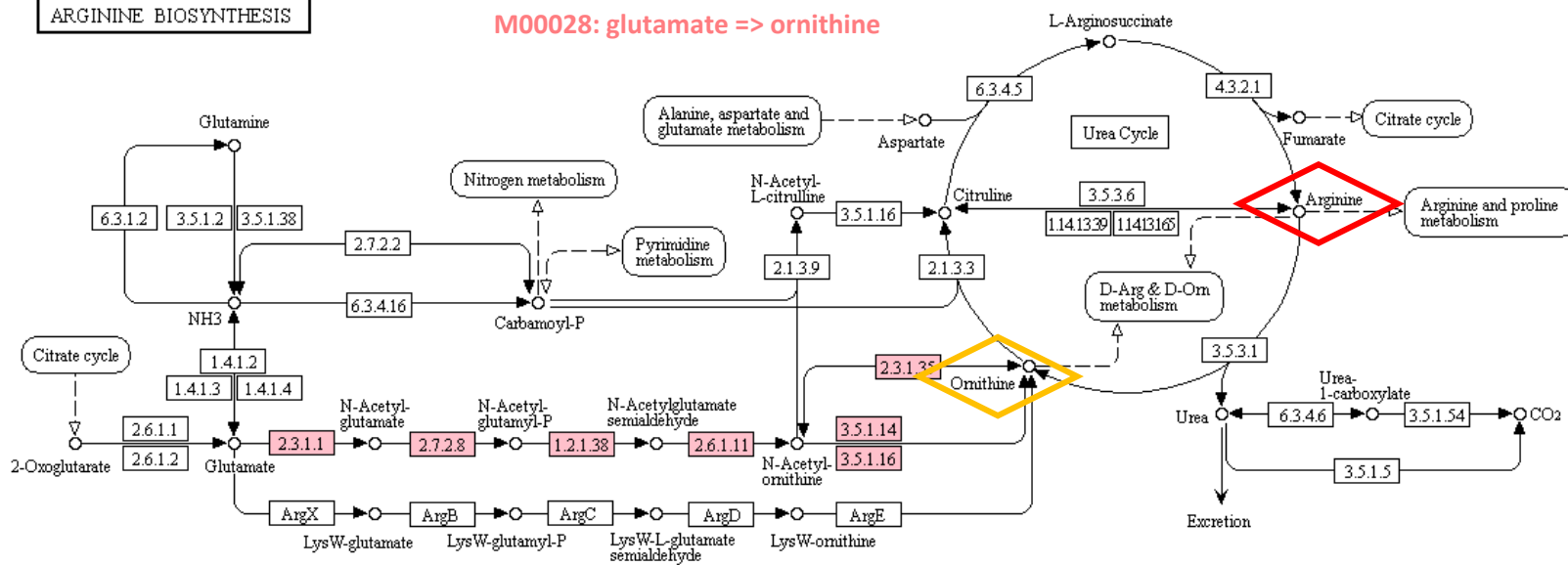
### LYSINE BIOSYNTHESIS





## Arginine biosynthesis – KEGG module of ornithine, alternative A

M00028: glutamate => ornithine

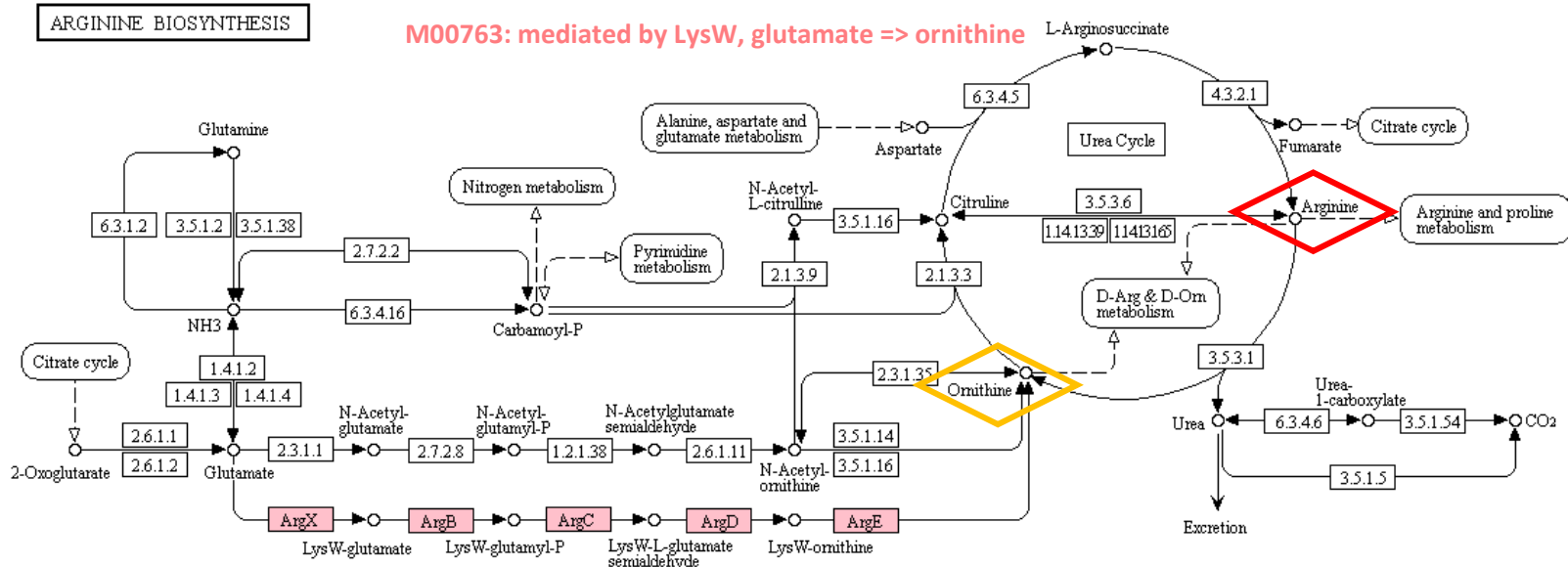


Arginine biosynthesis

Two alternative ways to produce ornithine

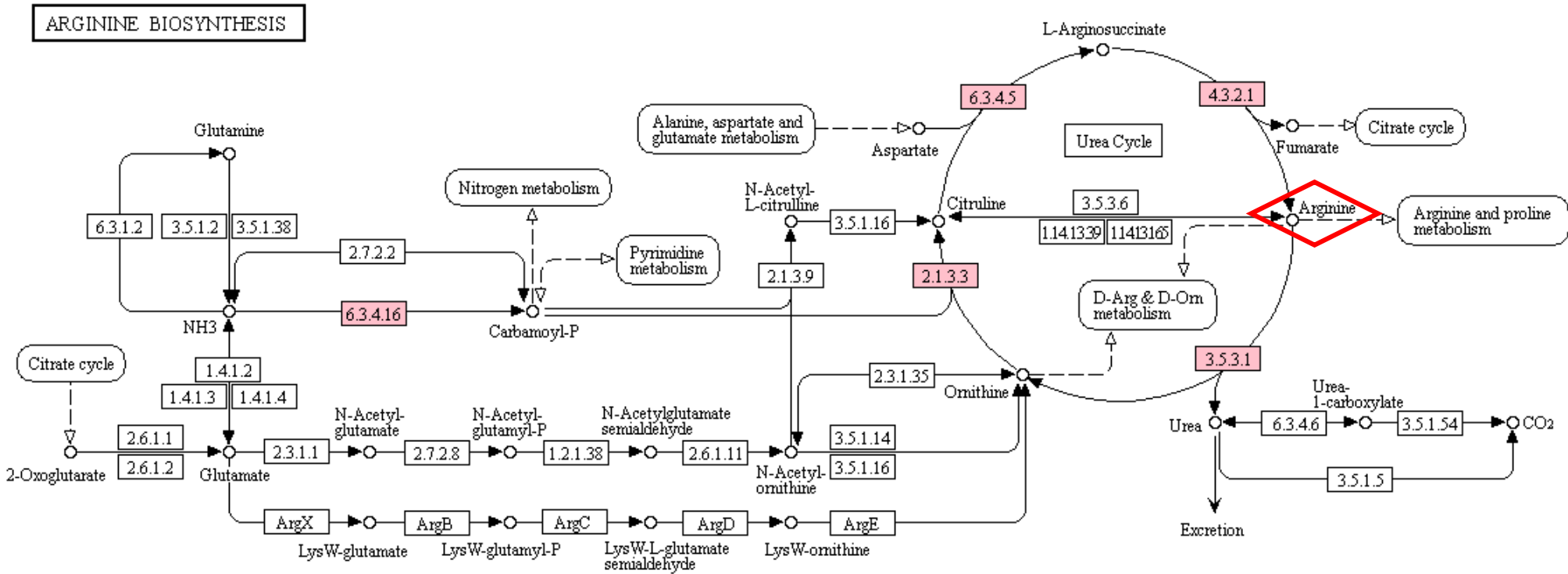
## Arginine biosynthesis – KEGG module of ornithine, alternative B

M00763: mediated by LysW, glutamate => ornithine



# Arginine biosynthesis – KEGG module of urea cycle

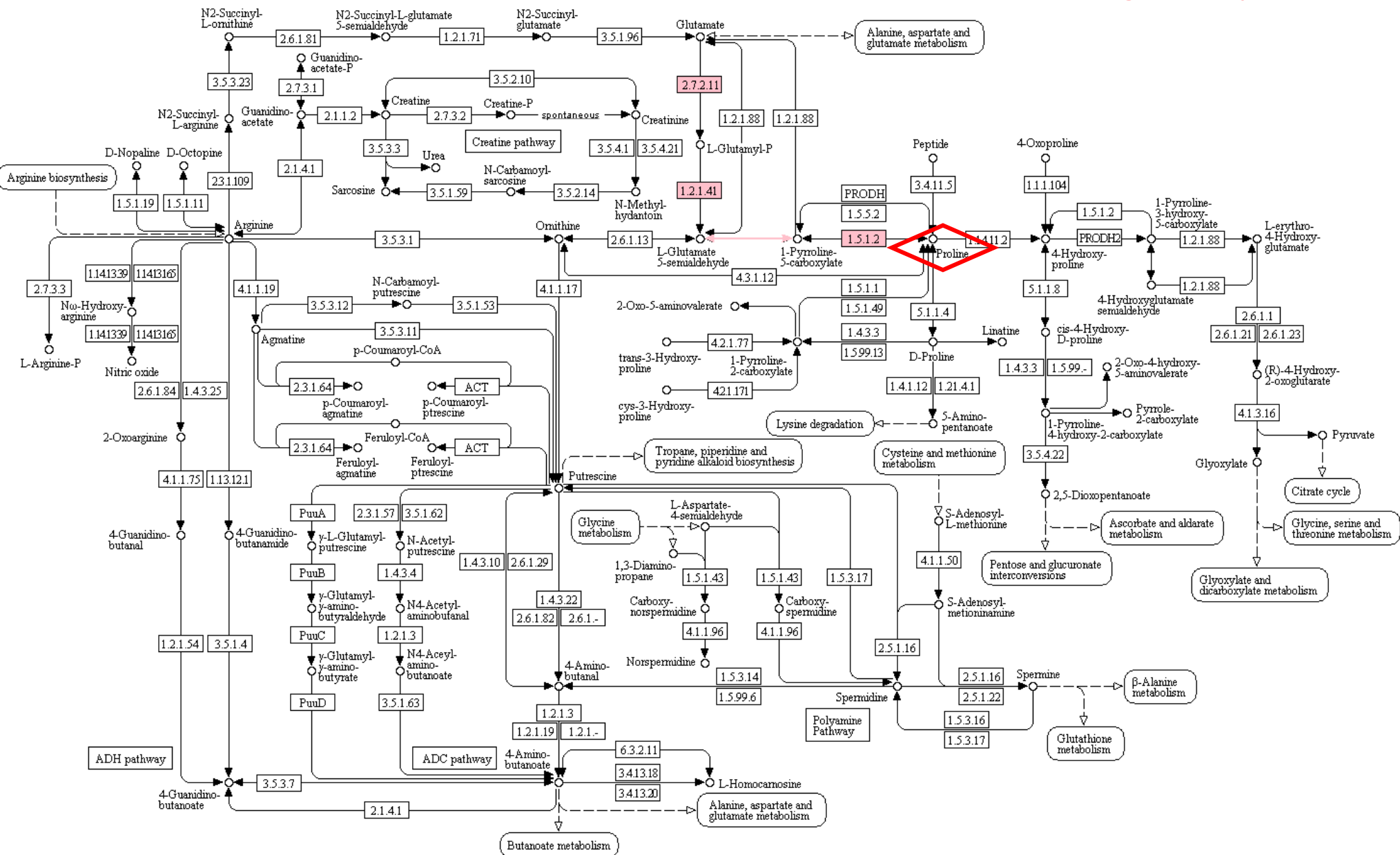
M00029: Urea cycle



# Proline biosynthesis – 1 KEGG module

M00015: glutamate => proline

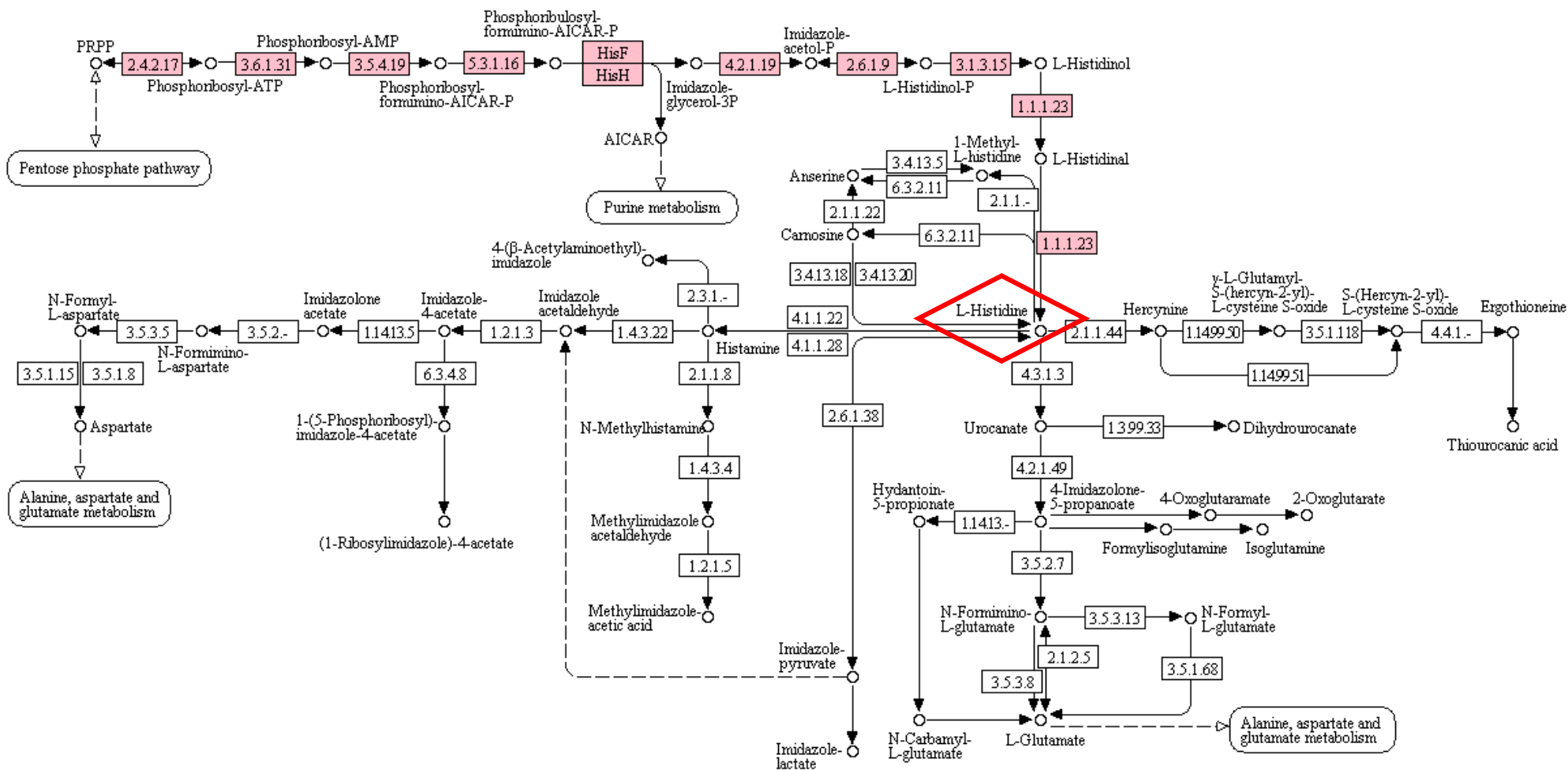
## ARGININE AND PROLINE METABOLISM



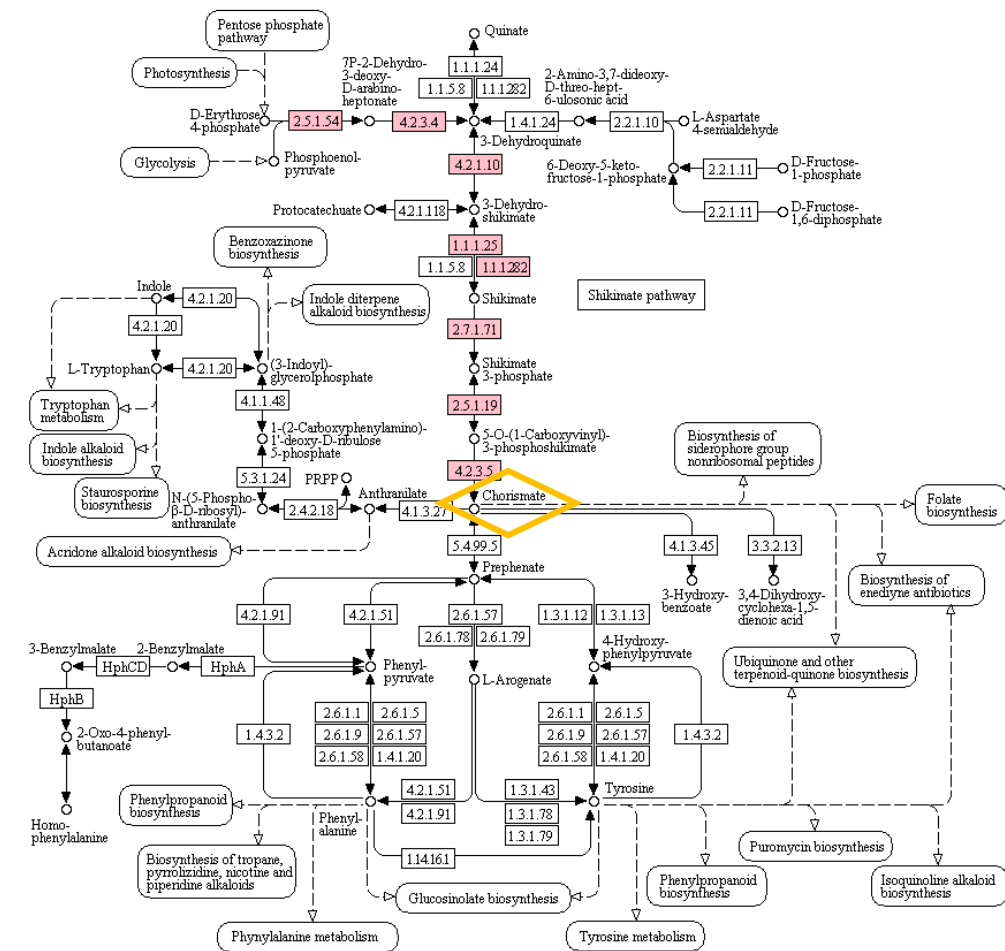
# Histidine biosynthesis – 1 KEGG module

M00026: PRPP => histidine

## HISTIDINE METABOLISM



PHENYLALANINE, TYROSINE AND TRYPTOPHAN BIOSYNTHESIS



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Module 1

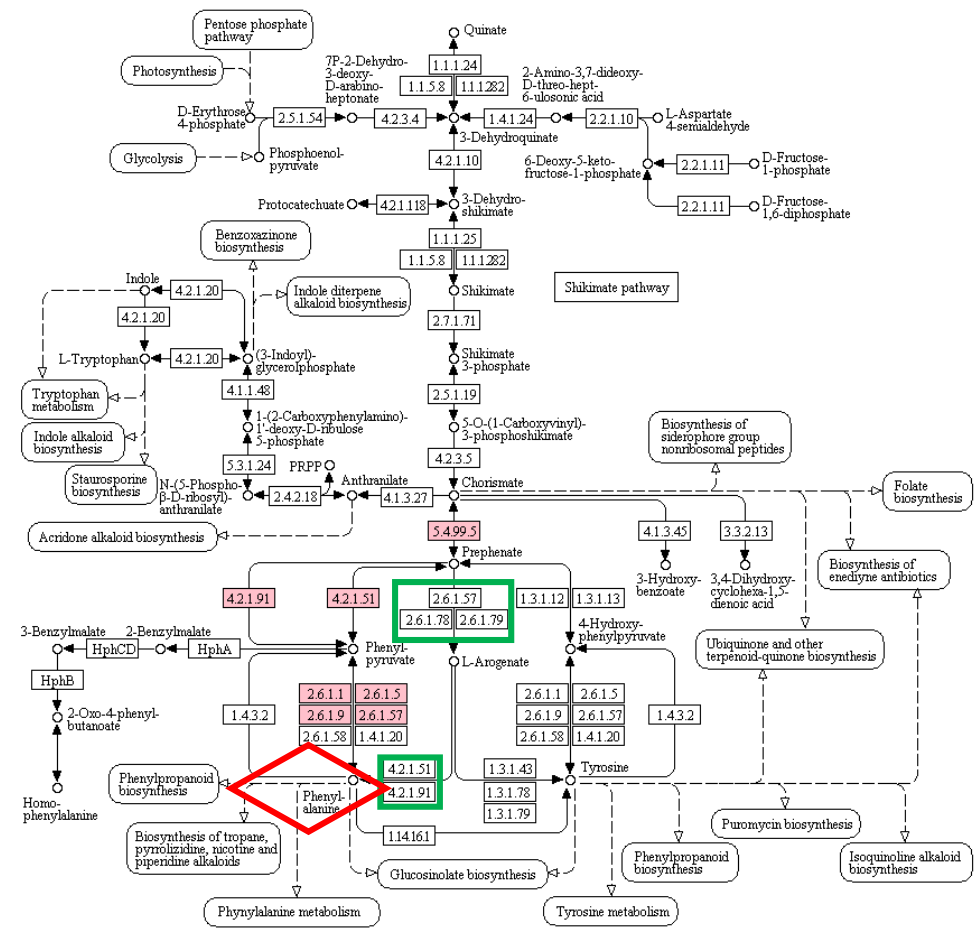
M00022: phosphoenolpyruvate + erythrose-4P => chorismate

Phenylalanine biosynthesis – 2 KEGG modules are needed

Module 2: two alternative ways to produce phenylalanine

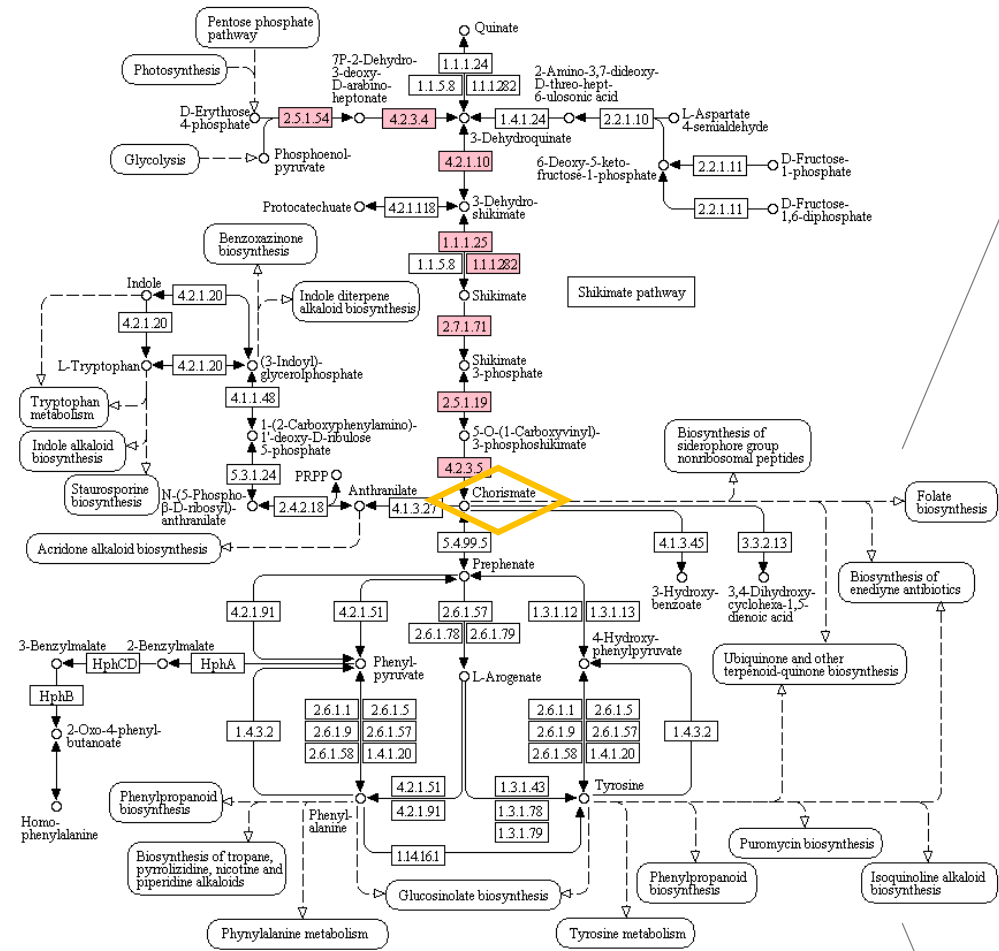
- A M00024: chorismate => phenylalanine (via phenylpyruvate)
- B chorismate => phenylalanine (via L-arogenate). This module is not defined by KEGG

PHENYLALANINE, TYROSINE AND TRYPTOPHAN BIOSYNTHESIS



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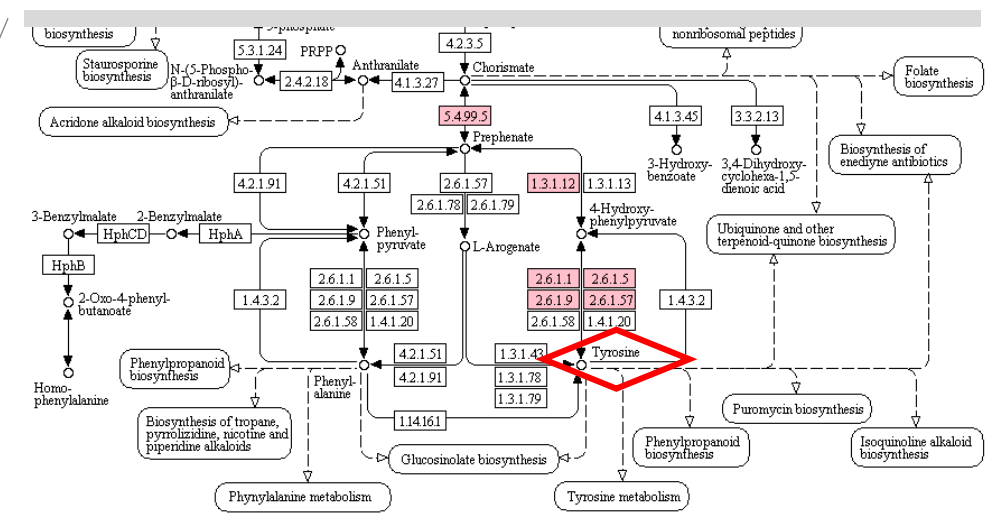
PHENYLALANINE, TYROSINE AND TRYPTOPHAN BIOSYNTHESIS



Tyrosine biosynthesis – 2 KEGG modules are needed

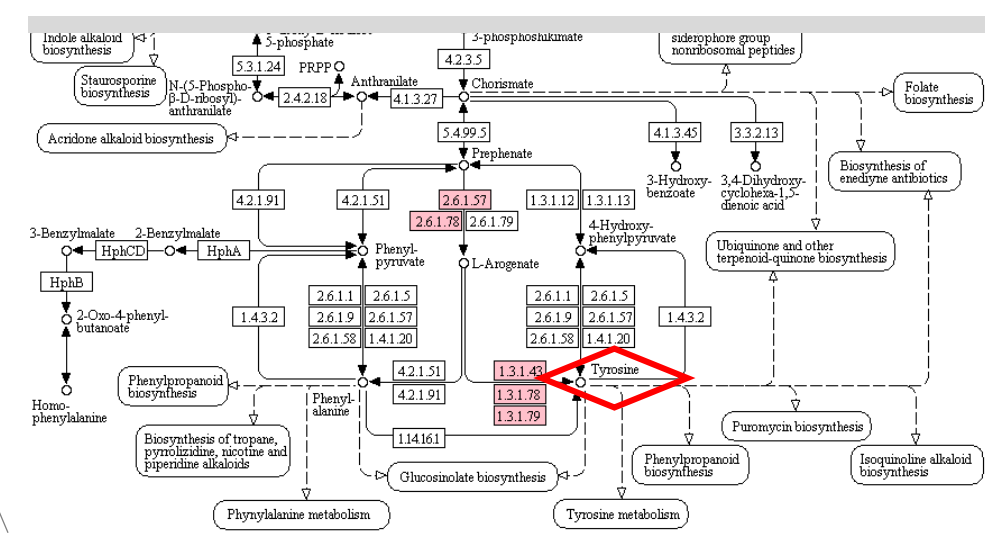
Module 2: two alternative ways to produce tyrosine

A M00025: chorismate => tyrosine



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B M00040: prephenate => pretyrosine (L-arogenate)=> tyrosine

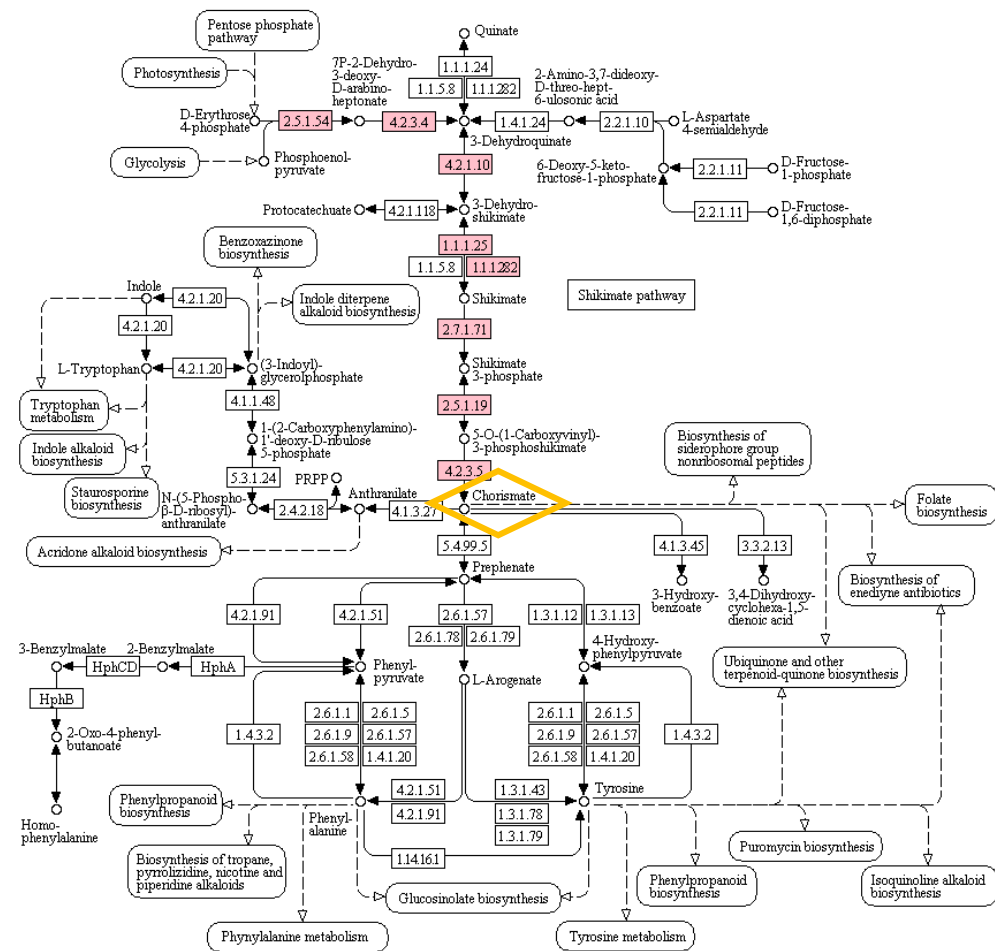


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Module 1

M00022: phosphoenolpyruvate + erythrose-4P => chorismate

PHENYLALANINE, TYROSINE AND TRYPTOPHAN BIOSYNTHESIS



Module 1

M00022: phosphoenolpyruvate + erythrose-4P => chorismate

Tryptophan biosynthesis – 2 KEGG modules are needed

Module 2

M00023: chorismate => tryptophan

PHENYLALANINE, TYROSINE AND TRYPTOPHAN BIOSYNTHESIS

