# Supplementary Material

# Improved Metabolic Pathways of Glycolysis, Glycogen Synthesis, the Urea Cycle, and Cytochrome Peroxidase Oxidative Reabsorption in a Miniature Bioreactor

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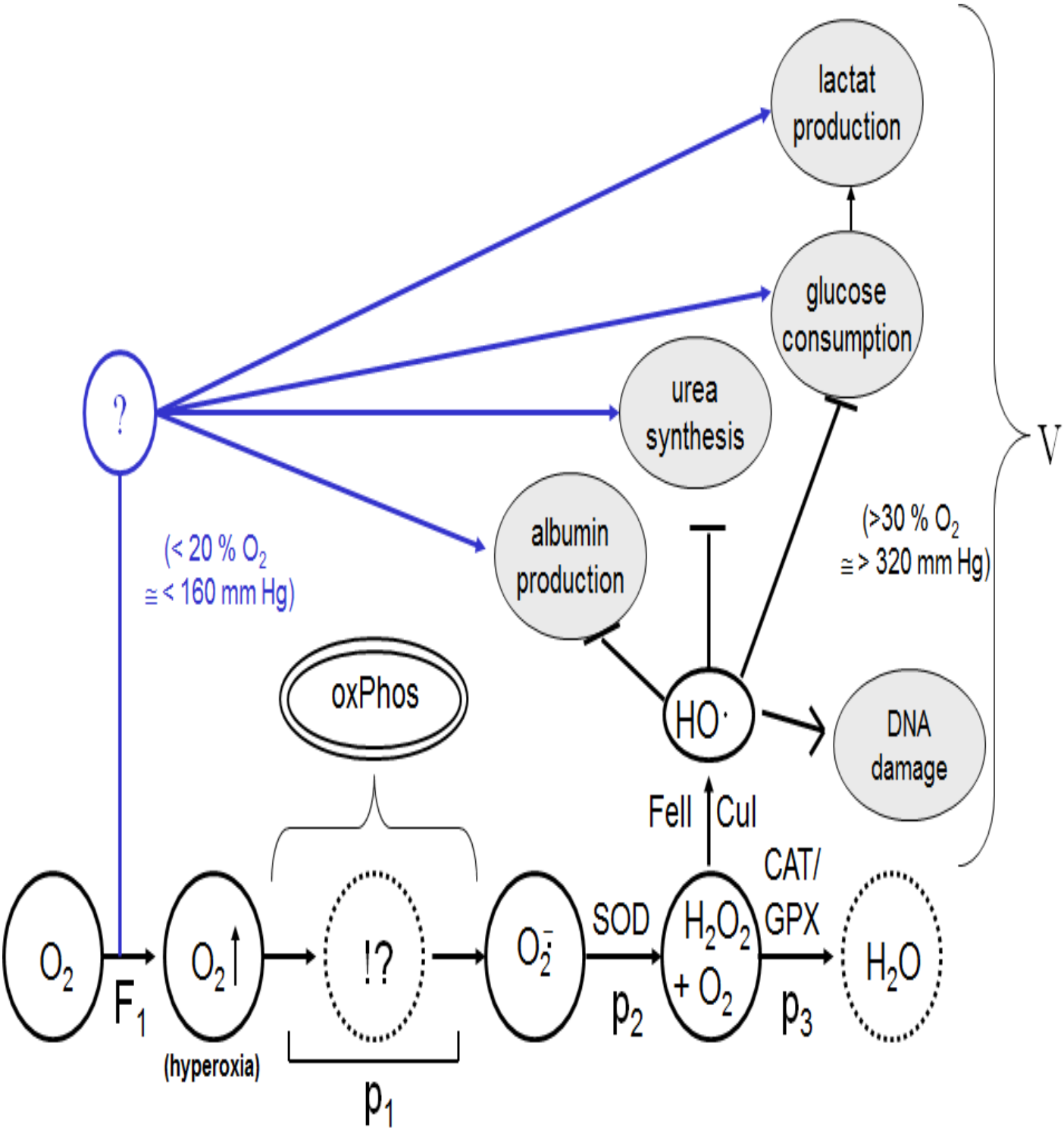
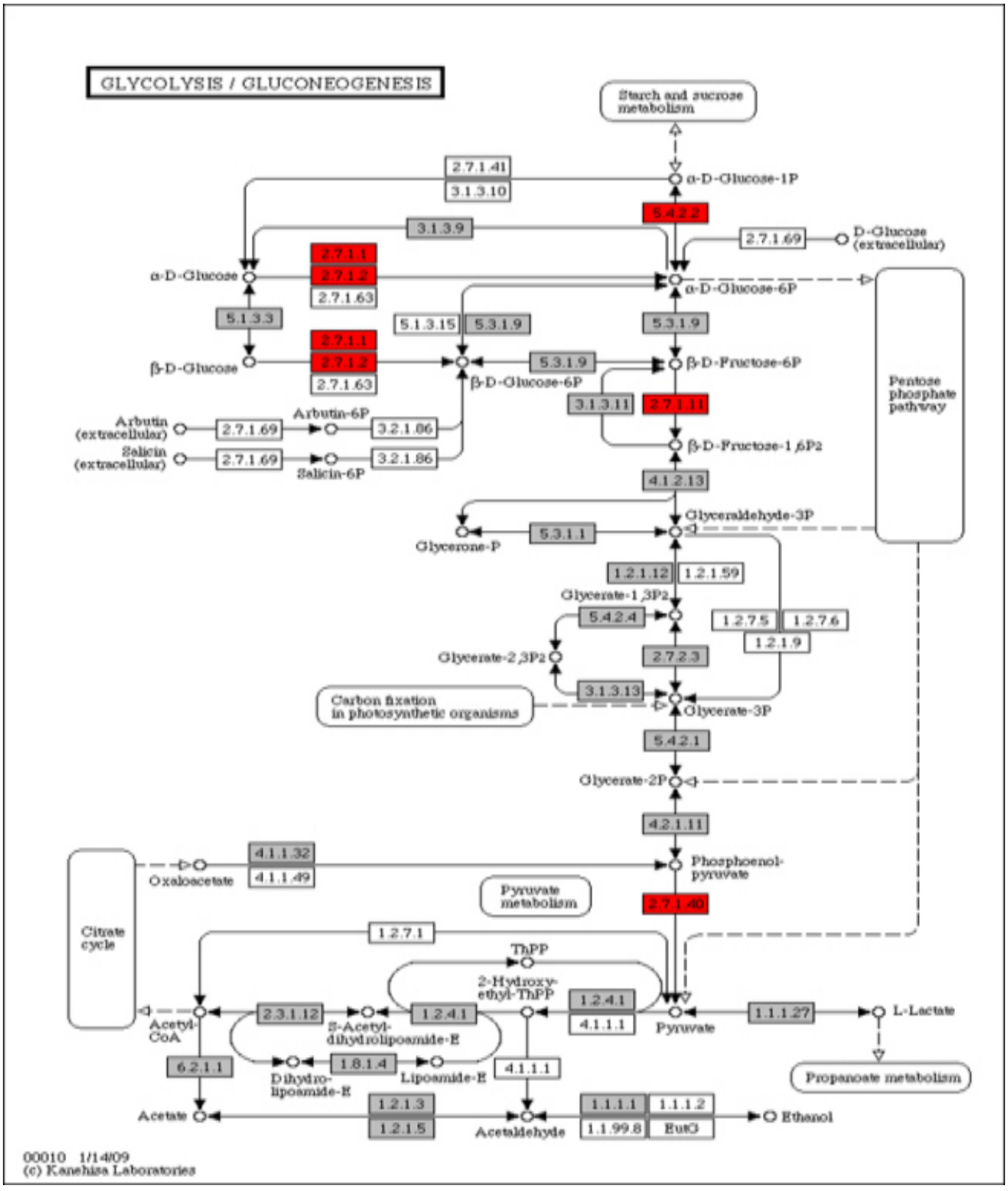
**Supplementary Fig. 1.** A) Representation of the optimum oxygen condition for albumin production, urea synthesis, glucose consumption, and lactate production. (B) Representation of the metabolic pathways of glycolysis/gluconeogenesis. (C) Representation of the metabolic pathways of arginine and proline metabolism in the urea cycle. (D) Representation of the metabolic pathways of starch and sucrose metabolism in glycogen synthesis. (E) Representation of the metabolic pathways of galactose metabolism.


lactat production
glucose consumption
urea synthesis
albumin production
?
(< 20 % O2 ≅ < 160 mm Hg)
(>30 % O2 ≅ > 320 mm Hg)
V
oxPhos
HO·
DNA damage
FeII CuI
CAT/ GPX
SOD
O2
F1
O2↑
(hyperoxia)
!?
O2-
H2O2 + O2
H2O
p1
p2
p3

(A )


GLYCOLYSIS / GLUCONEOGENESIS
Starch and sucrose metabolism
α-D-Glucose-1P
2.7.1.41
3.1.3.10
5.4.2.2
3.1.3.9
2.7.1.69
D-Glucose (extracellular)
α-D-Glucose
2.7.1.1
2.7.1.2
2.7.1.63
α-D-Glucose-6P
5.1.3.3
5.1.3.15
5.3.1.9
β-D-Glucose
β-D-Glucose-6P
β-D-Fructose-6P
3.1.3.11
2.7.1.11
Pentose phosphate pathway
Arbutin (extracellular)
Arbutin-6P
3.2.1.86
Salicin (extracellular)
Salicin-6P
β-D-Fructose-1,6P2
4.1.2.13
Glyceraldehyde-3P
Glycerone-P
5.3.1.1
1.2.1.12
1.2.1.59
Glycerate-1,3P2
5.4.2.4
1.2.7.5
1.2.7.6
1.2.1.9
Glycerate-2,3P2
2.7.2.3
3.1.3.13
Carbon fixation in photosynthetic organisms
Glycerate-3P
5.4.2.1
Glycerate-2P
4.2.1.11
Phosphoenol-pyruvate
4.1.1.32
4.1.1.49
Oxaloacetate
Pyruvate metabolism
2.7.1.40
Citrate cycle
1.2.7.1
ThPP
2-Hydroxy-ethyl-ThPP
1.2.4.1
4.1.1.1
Pyruvate
1.1.1.27
L-Lactate
Acetyl-CoA
2.3.1.12
S-Acetyl-dihydrolipoamide-E
1.2.4.1
6.2.1.1
1.8.1.4
Dihydro-lipoamide-E
Lipoamide-E
4.1.1.1
Propanoate metabolism
Acetate
1.2.1.3
1.2.1.5
Acetaldehyde
1.1.1.1
1.1.99.8
1.1.1.2
EutG
Ethanol
00010 1/14/09
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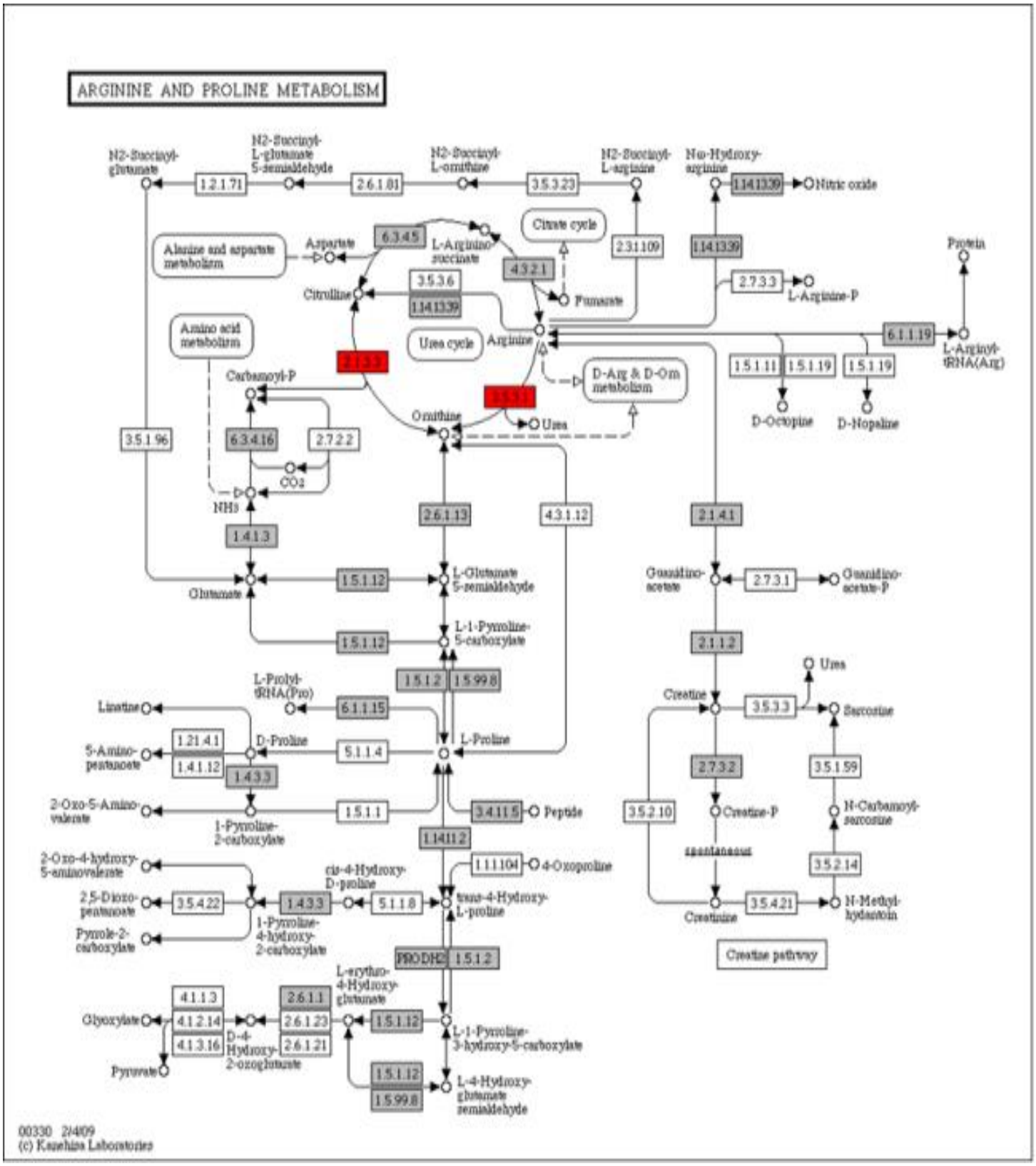
**(B)**


ARGININE AND PROLINE METABOLISM
N2-Succinyl-glutamate
1.2.1.71
N2-Succinyl-L-glutamate 5-semialdehyde
2.6.1.81
N2-Succinyl-L-ornithine
3.5.3.23
N2-Succinyl-L-arginine
Nω-Hydroxy-arginine
1.14.13.39
Nitric oxide
Citrate cycle
Alanine and aspartate metabolism
Aspartate
6.3.4.5
L-Arginino-succinate
4.3.2.1
2.3.1.109
Citrulline
3.5.3.6
1.14.13.39
Fumarate
2.7.3.3
L-Arginine-P
Protein
Amino acid metabolism
Urea cycle
Arginine
6.1.1.19
L-Arginyl-tRNA(Arg)
2.1.3.3
3.5.3.1
D-Arg & D-Orn metabolism
1.5.1.11
1.5.1.19
1.5.1.19
D-Octopine
D-Nopaline
Carbamoyl-P
Ornithine
Urea
3.5.1.96
6.3.4.16
2.7.2.2
CO2
NH3
1.4.1.3
2.6.1.13
4.3.1.12
2.1.4.1
Glutamate
1.5.1.12
L-Glutamate 5-semialdehyde
Guanidino-acetate
2.7.3.1
Guanidino-acetate-P
1.5.1.12
L-1-Pyrroline-5-carboxylate
2.1.1.2
Urea
1.5.1.2
1.5.99.8
L-Prolyl-tRNA(Pro)
6.1.1.15
Creatine
3.5.3.3
Sarcosine
Linatine
1.21.4.1
1.4.1.12
D-Proline
5.1.1.4
L-Proline
5-Amino-pentanoate
1.4.3.3
2.7.3.2
3.5.1.59
2-Oxo-5-Amino-valerate
1.5.1.1
3.4.11.5
Peptide
3.5.2.10
Creatine-P
N-Carbamoyl-sarcosine
1-Pyrroline-2-carboxylate
spontaneous
1.14.11.2
2-Oxo-4-hydroxy-5-aminovalerate
1.11.1.04
4-Oxoproline
3.5.2.14
cis-4-Hydroxy-D-proline
2,5-Dioxo-pentanoate
3.5.4.22
1.4.3.3
5.1.1.8
trans-4-Hydroxy-L-proline
3.5.4.21
N-Methyl-hydantoin
Pyrrole-2-carboxylate
1-Pyrroline-4-hydroxy-2-carboxylate
Creatinine
Creatine pathway
PRODH2
1.5.1.2
L-erythro-4-Hydroxy-glutamate
4.1.1.3
2.6.1.1
Glyoxylate
4.1.2.14
2.6.1.23
1.5.1.12
L-1-Pyrroline-3-hydroxy-5-carboxylate
4.1.3.16
D-4-Hydroxy-2-oxoglutarate
2.6.1.21
Pyruvate
1.5.1.12
1.5.99.8
L-4-Hydroxy-glutamate semialdehyde
00330 2/409
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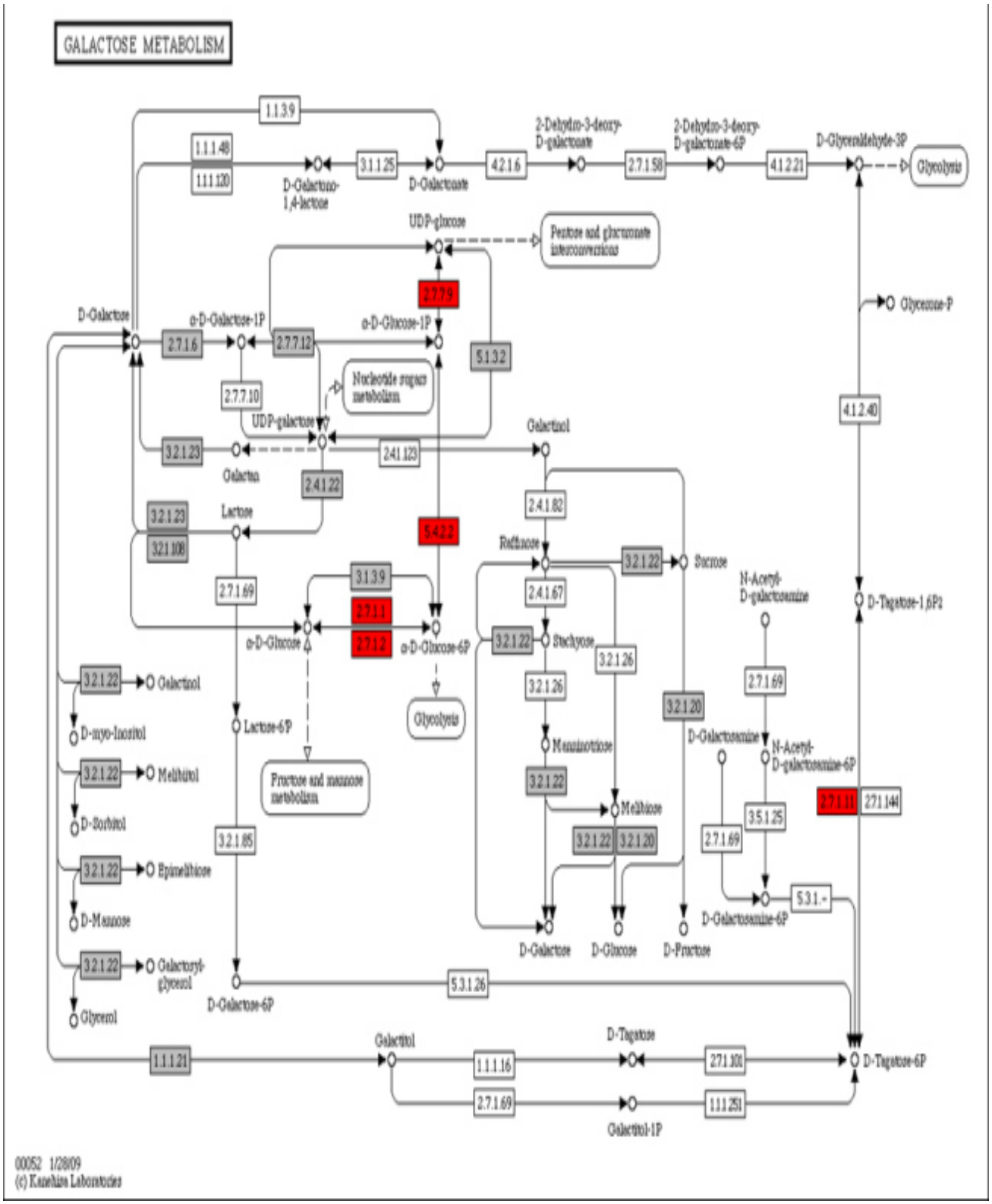
**( c)**


GALACTOSE METABOLISM
1.1.3.9
1.1.1.48
1.1.1.120
D-Galactono-1,4-lactone
3.1.1.25
D-Galactonate
4.2.1.6
2-Dehydro-3-deoxy-D-galactonate
2.7.1.58
2-Dehydro-3-deoxy-D-galactonate-6P
4.1.2.21
D-Glyceraldehyde-3P
Glycolysis
UDP-glucose
Pentose and glucuronate interconversions
2.7.7.9
D-Galactose
α-D-Galactose-1P
2.7.1.6
2.7.7.12
α-D-Glucose-1P
5.1.3.2
Glycerone-P
2.7.7.10
Nucleotide sugars metabolism
UDP-galactose
4.1.2.40
Galactinol
3.2.1.23
2.4.1.123
Galactose
2.4.1.22
3.2.1.23
3.2.1.108
Lactose
2.4.1.82
5.4.2.2
Raffinose
3.2.1.22
Sucrose
3.1.3.9
2.7.1.69
2.7.1.1
2.7.1.2
α-D-Glucose
α-D-Glucose-6P
2.4.1.67
N-Acetyl-D-galactosamine
D-Tagatose-1,6P2
3.2.1.22
Stachyose
3.2.1.26
3.2.1.22
Galactinol
2.7.1.69
3.2.1.20
D-myo-Inositol
Lactose-6P
Glycolysis
Manninotriose
D-Galactosamine
N-Acetyl-D-galactosamine-6P
3.2.1.22
Melibiitol
Fructose and mannose metabolism
3.2.1.22
Melibiose
2.7.1.11
2.7.1.144
D-Sorbitol
3.2.1.85
3.2.1.22
3.2.1.20
3.5.1.25
2.7.1.69
3.2.1.22
Epimelibiose
5.3.1.-
D-Mannose
D-Galactosamine-6P
D-Galactose
D-Glucose
D-Fructose
3.2.1.22
Galactosyl-glycerol
5.3.1.26
Glycerol
D-Galactose-6P
Galactitol
D-Tagatose
1.1.1.21
1.1.1.16
2.7.1.101
D-Tagatose-6P
2.7.1.69
1.1.1.251
Galactitol-1P
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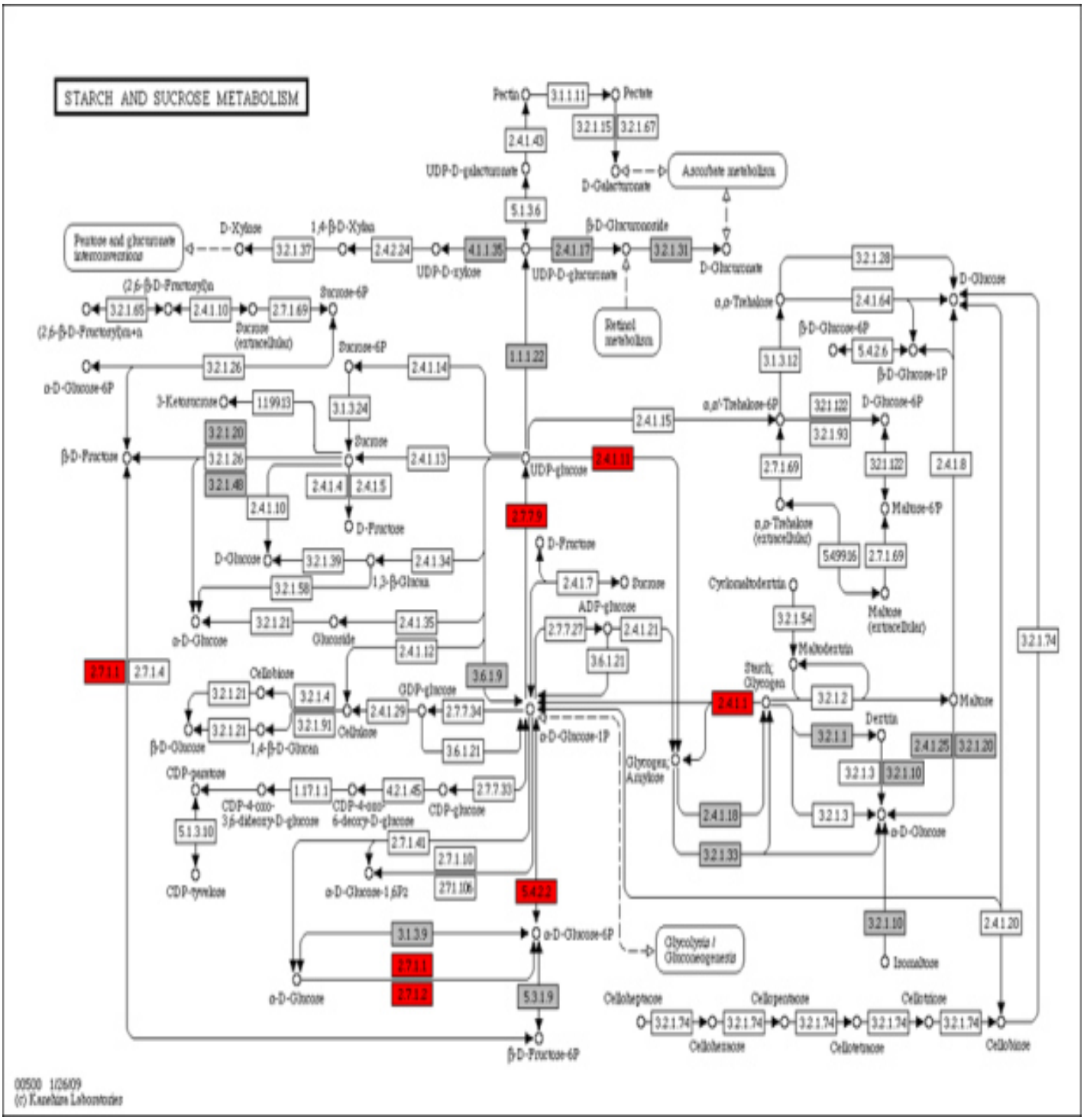
**(D )**


STARCH AND SUCROSE METABOLISM
Pectin
Pectate
UDP-D-galacturonate
D-Galacturonate
Ascorbate metabolism
D-Xylose
1,4-β-D-Xylan
Pentose and glucuronate interconversions
UDP-D-xylose
β-D-Glucuronoside
UDP-D-glucuronate
D-Glucuronate
Retinol metabolism
(2,6-β-D-Fructosyl)n
(2,6-β-D-Fructosyl)n+a
Sucrose (extracellular)
Sucrose-6P
α-D-Glucose-6P
3-Ketosucrose
Sucrose
β-D-Fructose
UDP-glucose
D-Fructose
D-Glucose
1,3-β-Glucan
α-D-Glucose
Glucoside
Cellobiose
β-D-Glucose
1,4-β-D-Glucan
GDP-glucose
Cellulose
CDP-paratose
CDP-4-oxo-3,6-dideoxy-D-glucose
CDP-4-oxo-6-deoxy-D-glucose
CDP-glucose
CDP-tyvelose
α-D-Glucose-1,6P2
α-D-Glucose-1P
ADP-glucose
Sucrose
α,α'-Trehalose
α,α-Trehalose
α,α'-Trehalose-6P
α,α-Trehalose (extracellular)
β-D-Glucose-6P
β-D-Glucose-1P
D-Glucose-6P
Maltose-6P
Maltose (extracellular)
Cyclomaltodextrin
Maltodextrin
Starch, Glycogen
Maltose
Dextrin
Glycogen, Amylose
α-D-Glucose
α-D-Glucose-6P
Glycolysis / Gluconeogenesis
β-D-Fructose-6P
Isomaltose
Cellopentaose
Cellotetraose
Cellotriose
Cellobiose
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**(E)**