

Yeast Metabolism for Brewers and Beer Geeks

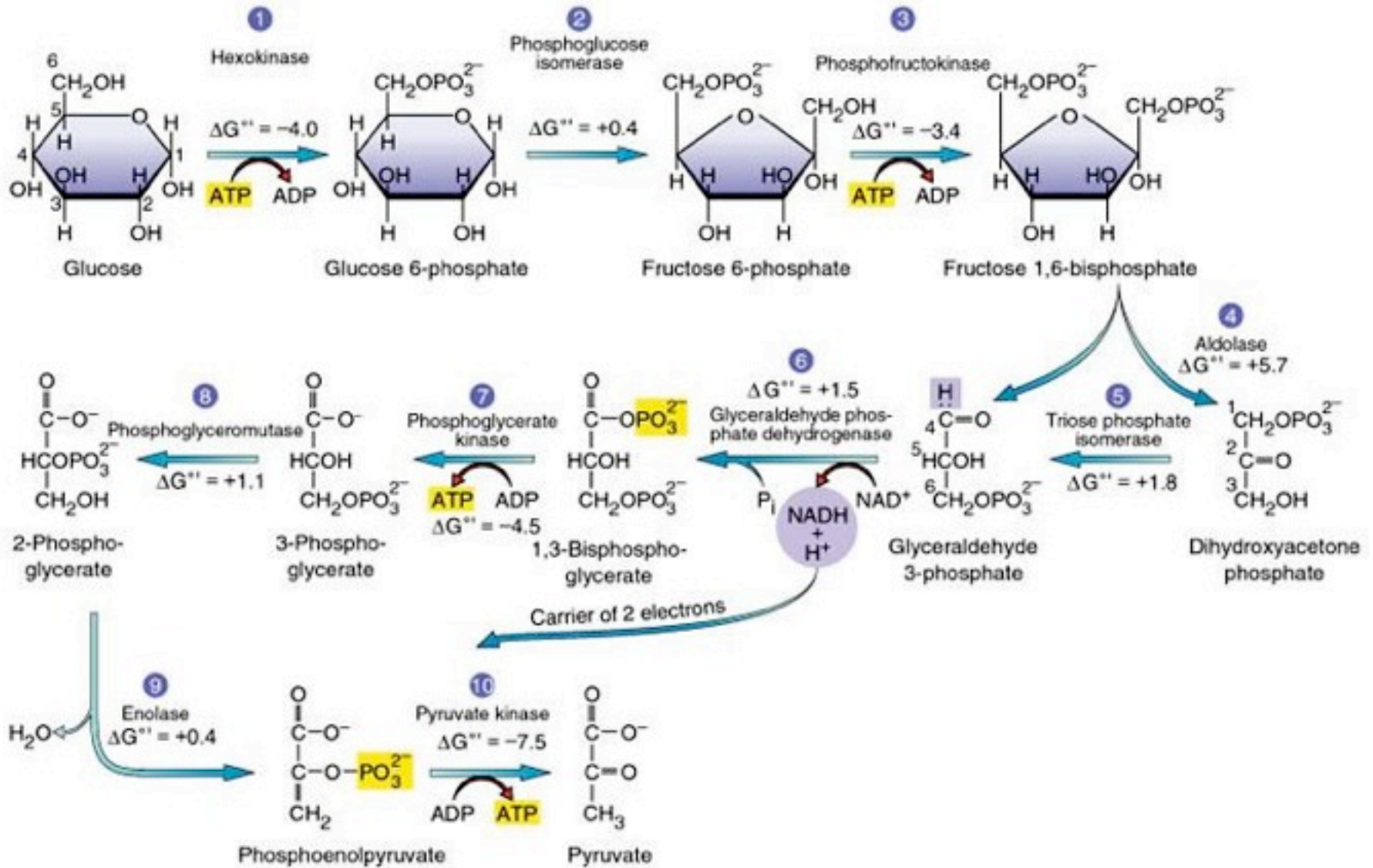
"There are no applied sciences.

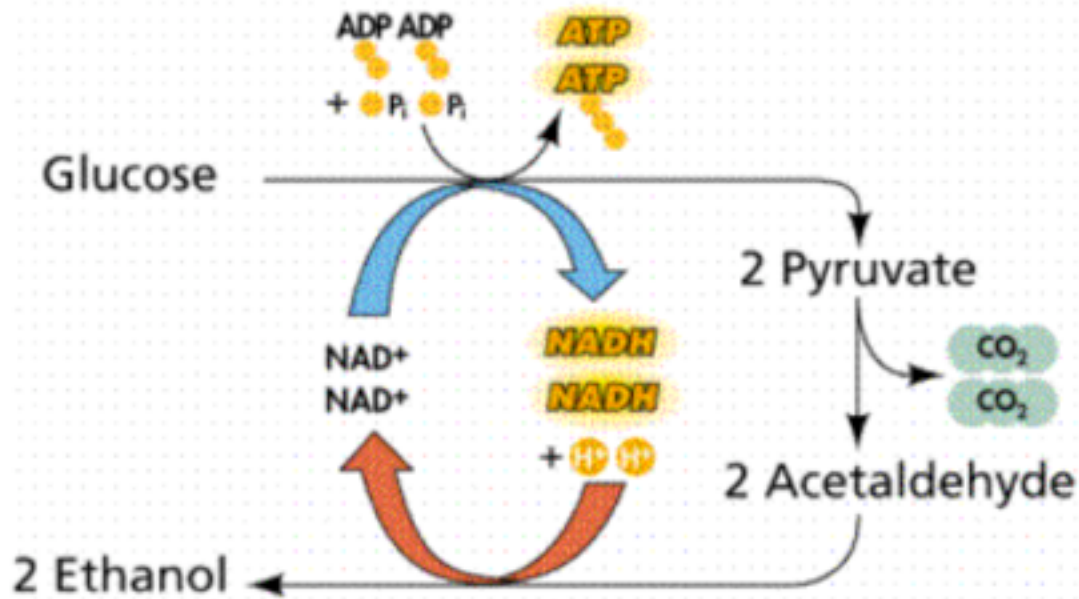
There are only applications of science
and this is a very different thing.

The applications of science is easy to
one who is master of the theory of it."

Louis Pasteur

Glycolysis





ADH and PDC - The Best Enzymes EVAR!

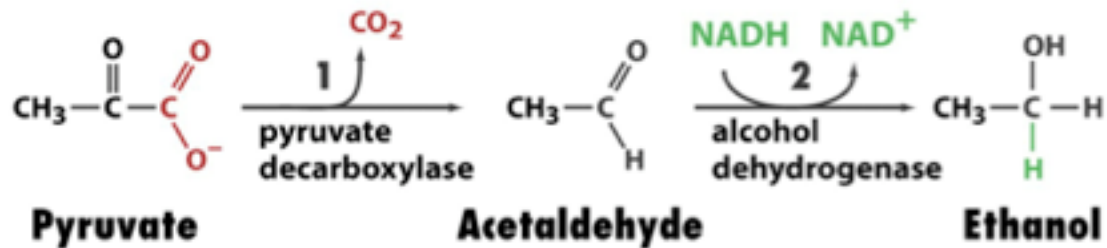


Figure 14-18 Fundamentals of Biochemistry, 2/e
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Other Fates of Pyruvate

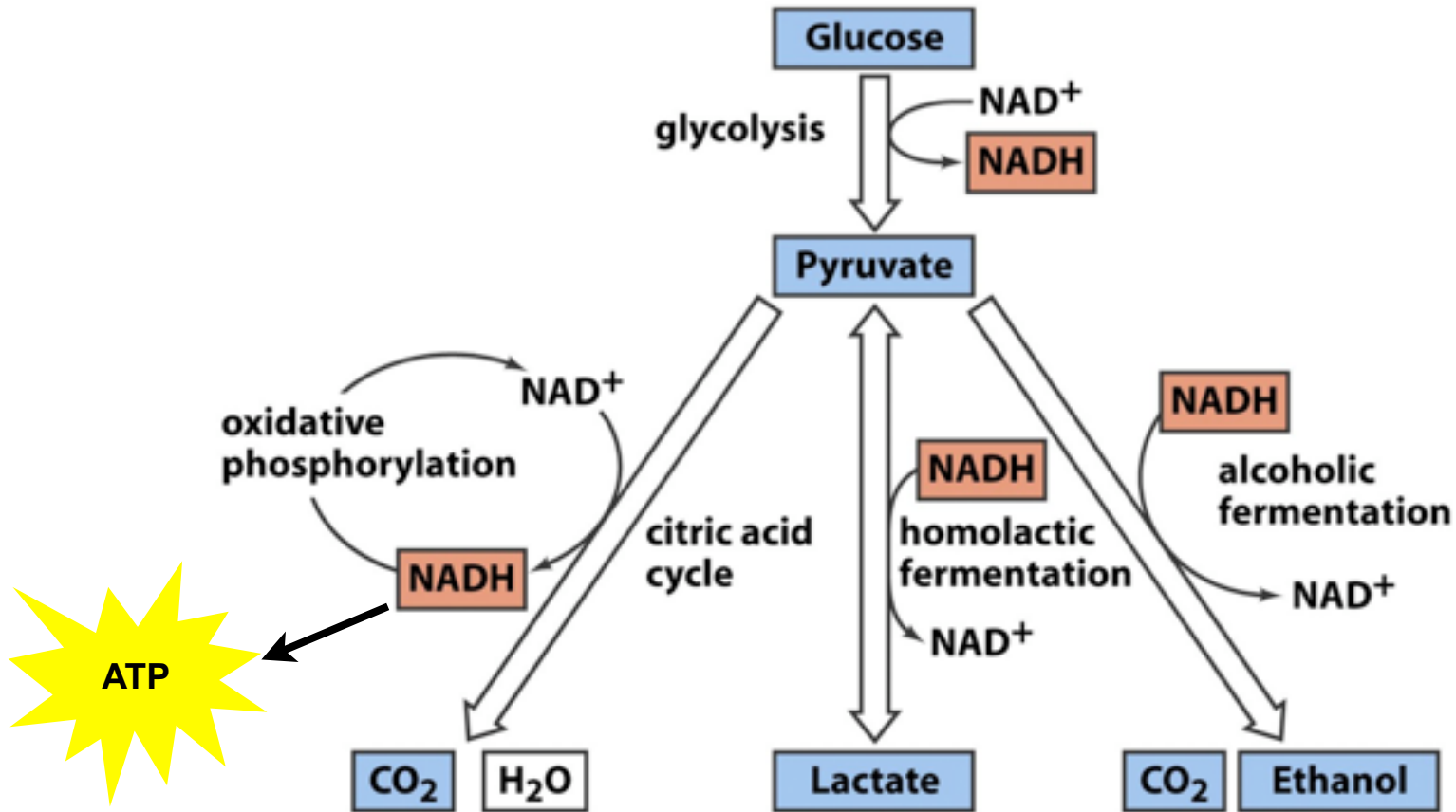


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Weird Yeast Metabolism 'Effects'

- The Pasteur Effect
- The Crabtree Effect
- Brewing Yeast are essentially always using fermentative metabolism

The Citric Acid Cycle

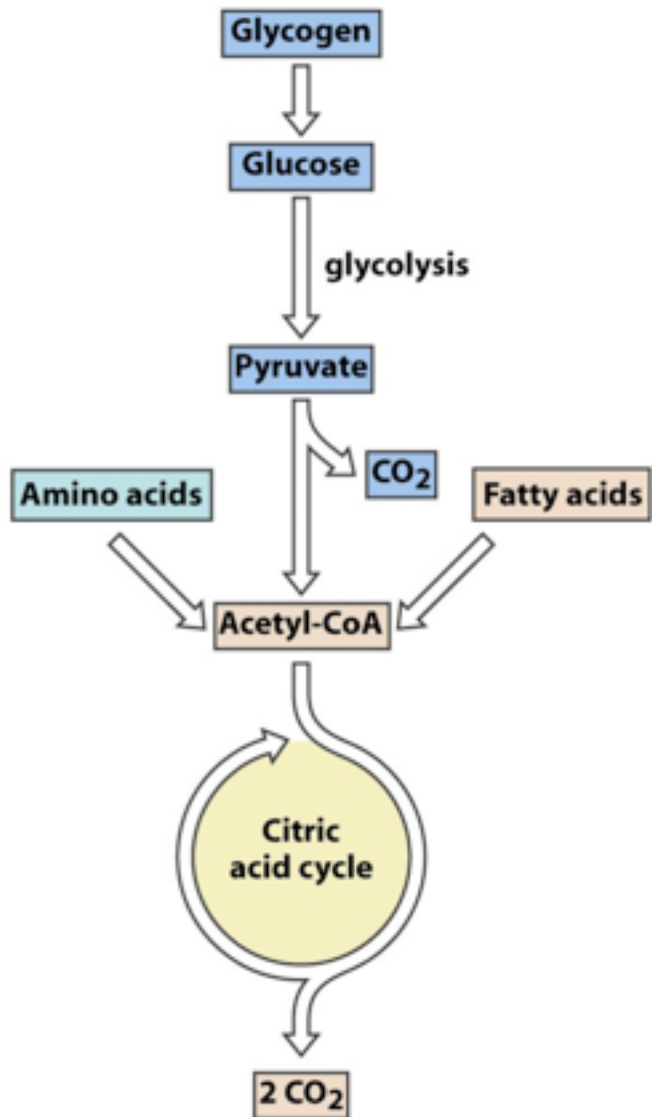


Figure 16-1 Fundamentals of Biochemistry, 2/e
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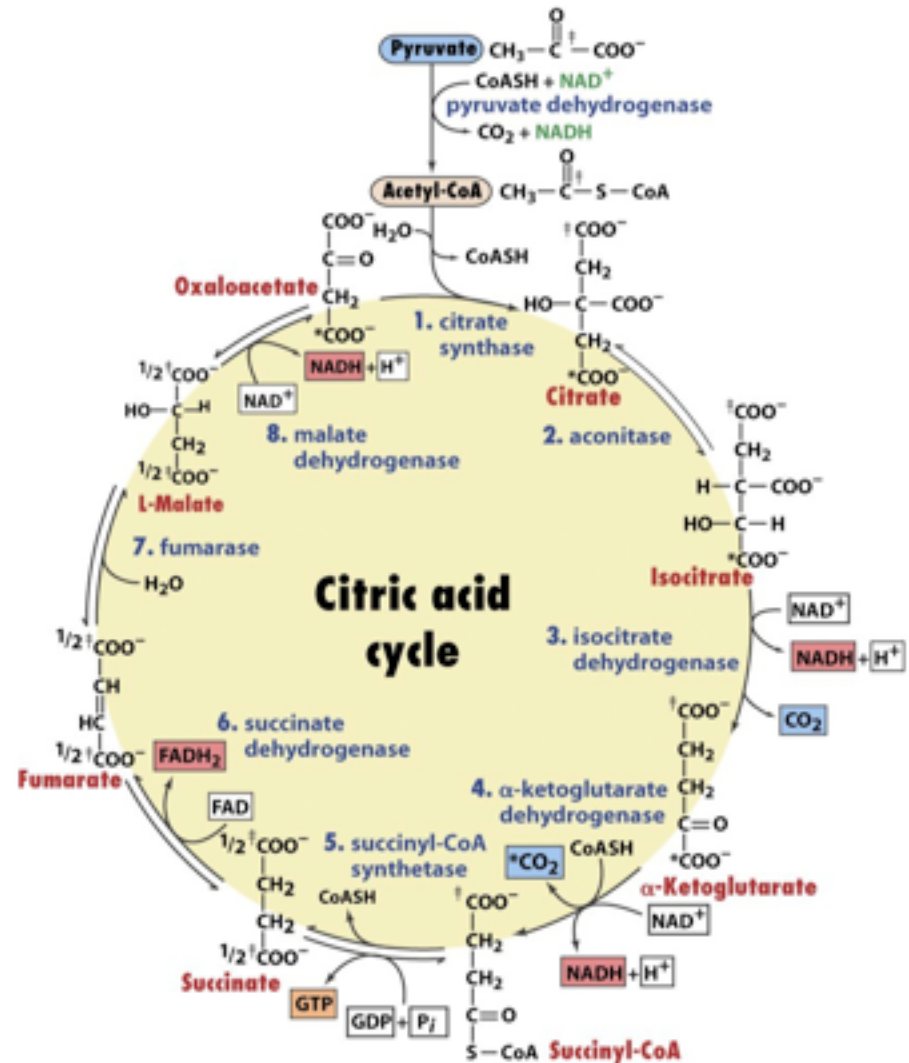
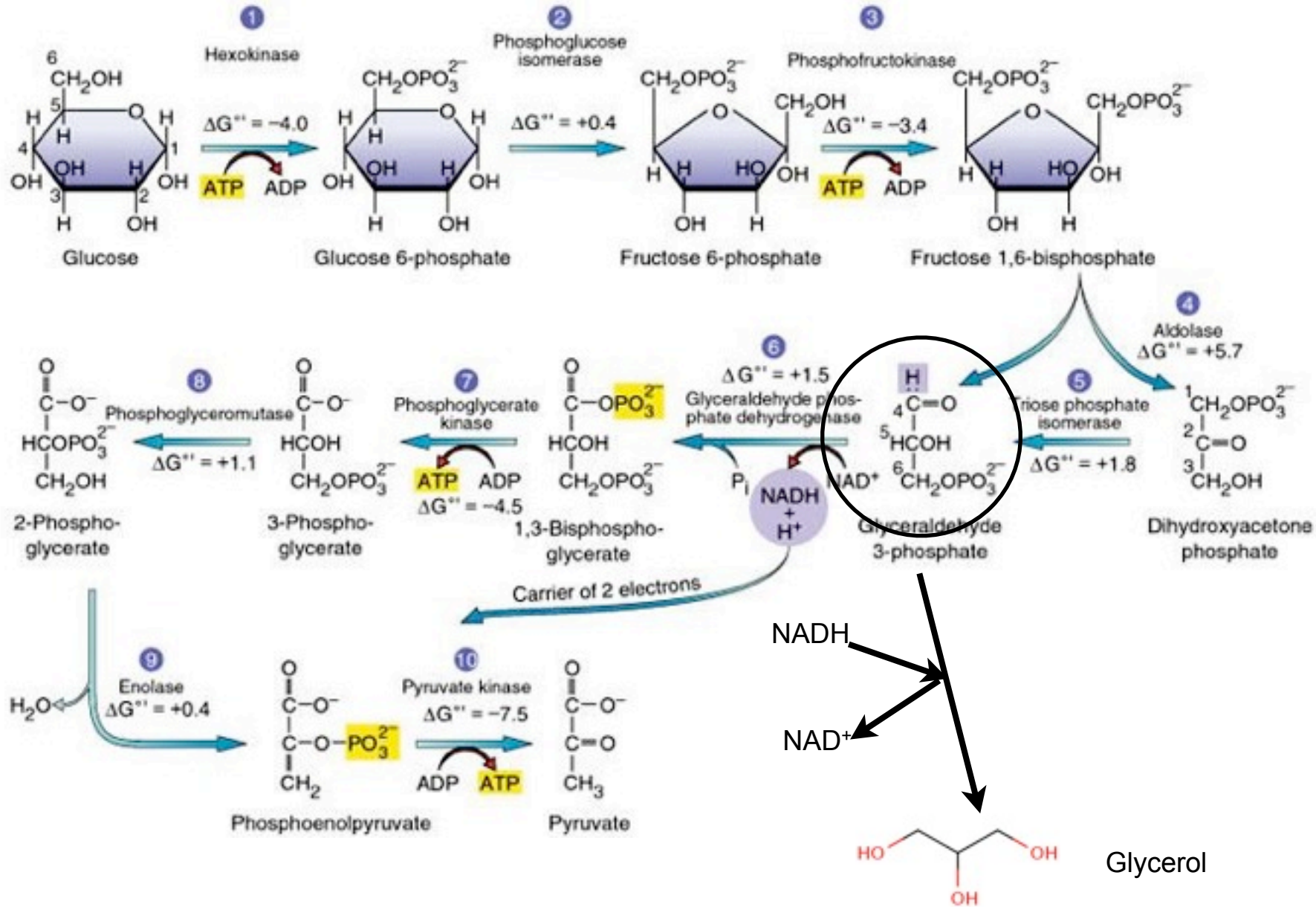
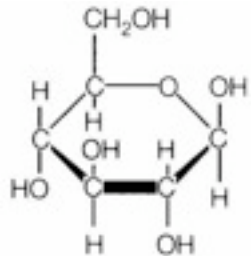


Figure 16-2 Fundamentals of Biochemistry, 2/e
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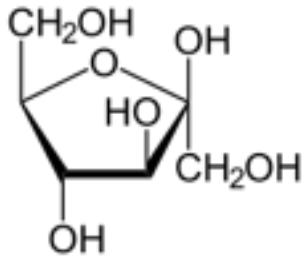
Glycerol Production



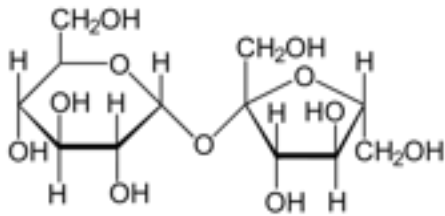
Wort Carbohydrate Composition



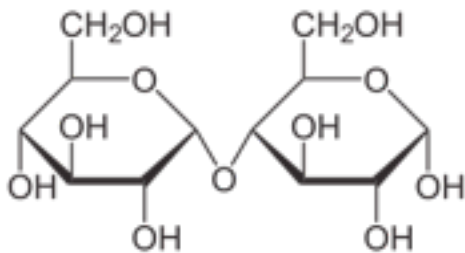
Glucose



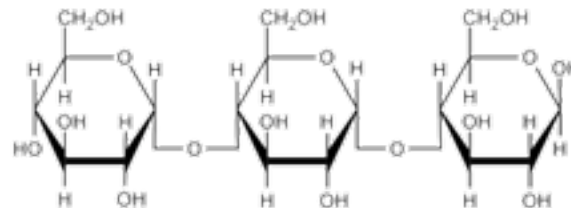
Fructose



Sucrose



Maltose



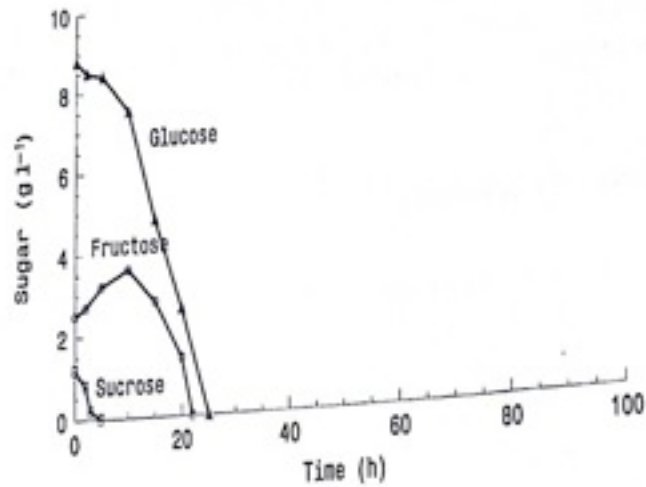
Maltotriose

Table 2.3 Carbohydrate composition of worts ($\text{g } 100 \text{ ml}^{-1}$) (from MacWilliam, 1968).

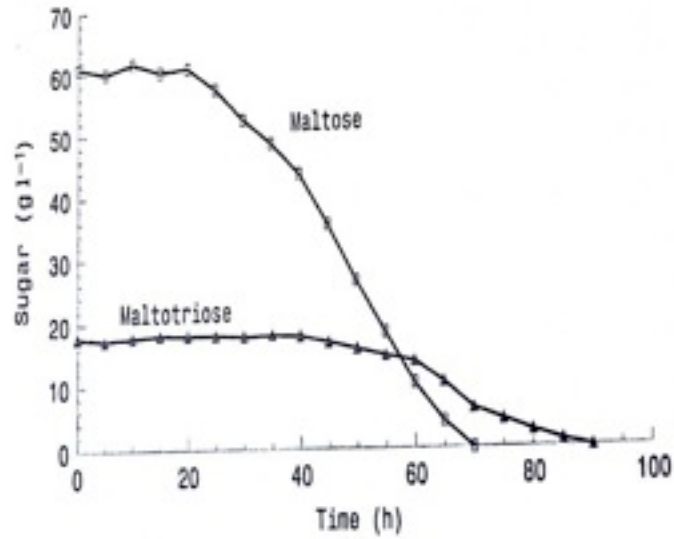
Origin	Danish	Canadian	Canadian	Canadian	German	UK	UK
Wort type	Lager	Lager	Lager	Lager	Lager	Pale ale	Pale ale
Wort concentration ("Plato)	10.7	12.32	11.9	11.55	12.0	10.0	10.0
Fructose	0.21	0.15	0.13	0.10	0.39	0.33	0.97
Glucose	0.91	1.03	0.87	0.50	1.47	1.00	-
Sucrose	0.23	0.42	0.35	0.10	0.46	0.53	0.60
Maltose	5.24	6.04	5.57	5.50	5.78	3.89	3.91
Maltotriose	1.28	1.77	1.66	1.30	1.46	1.14	1.39
Maltotetrose	0.26	0.72	0.54	1.27	-	0.20	0.53
Total dextrins	2.39	3.40	3.06	4.21	-	2.52	2.48
Total fermentable sugars	7.87	9.41	8.58	7.50	9.56	6.89	6.78
Total sugars	10.26	12.81	11.64	11.71	-	9.41	9.26
Fermentability (%)	76.7	73.7	73.7	64.1	-	73.3	73.2

Generated by CamScanner from intsig.com

Brewing Yeast Carbohydrate Selectivity



(a)



(b)

From Brewing Yeast and Fermentation p.74

What about nitrogen?

- Wort nitrogen compounds (Ingledew, 1975):
 - protein 20%
 - polypeptides 30-40%
 - amino acids 30-40%
 - nucleotides 10%

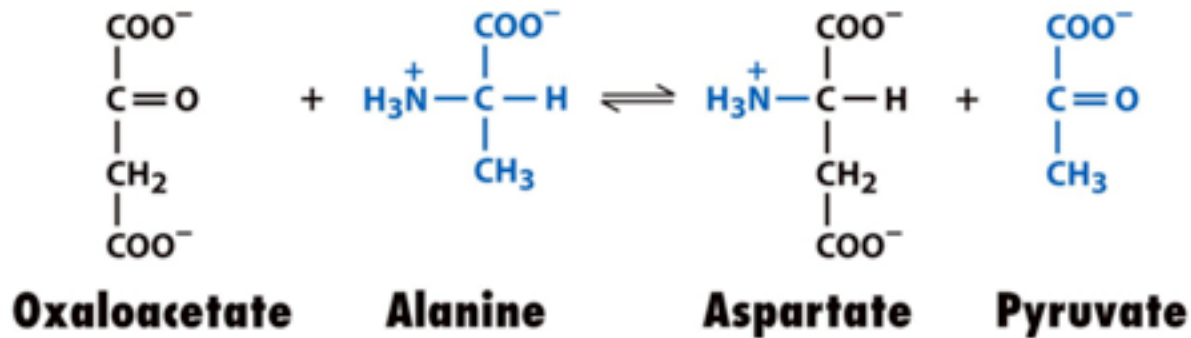
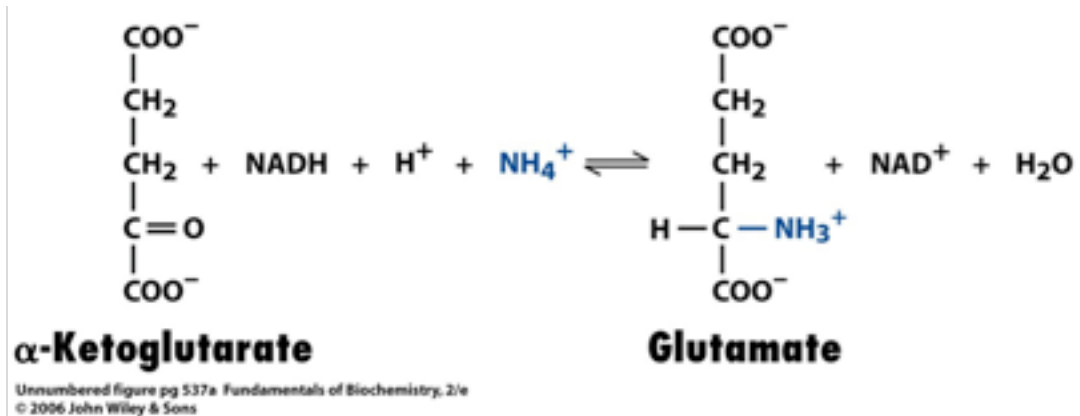
Table 3.1 Classes of wort amino acids in order of assimilation during fermentation (Pierce, 1987).

Class A	Class B	Class C	Class D
Arginine	Histidine	Alanine	Proline
Asparagine	Isoleucine	Ammonia	
Aspartate	Leucine	Glycine	
Glutamate	Methionine	Phenylalanine	
Glutamine	Valine	Tyrosine	
Lysine		Tryptophan	
Serine			
Threonine			

Table 2.7a Amino acid contents of worts ($\text{mg } 100 \text{ ml}^{-1}$) produced at various mashing temperatures and green beers from ale fermentations performed at $17\text{--}22^\circ\text{C}$ (from Chen *et al.*, 1973).

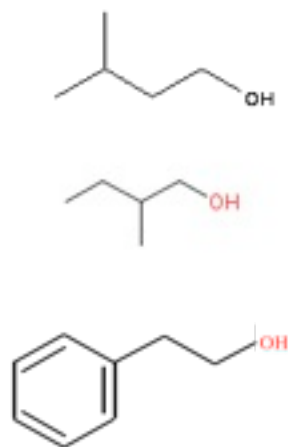
Mashing temperature	40°C		60°C		70°C	
	Wort	Beer	Wort	Beer	Wort	Beer
Glycine	12.4	7.3	13.5	4.3	12.1	5.3
Alanine	22.0	7.8	30.2	10.4	22.3	9.3
Valine	27.4	17.5	47.2	22.0	22.8	14.9
Leucine	14.2	8.3	32.4	11.5	8.2	3.5
Isoleucine	8.9	5.9	10.4	5.5	5.3	3.6
Phenylalanine	20.1	6.8	20.7	12.0	8.2	6.4
Tyrosine	12.5	5.2	11.5	5.9	7.9	5.2
Tryptophan	11.9	5.8	9.0	6.3	2.2	2.1
Serine	9.9	5.7	10.7	4.5	7.8	3.3
Threonine	17.2	10.7	20.4	7.9	12.4	6.9
Aspartic acid	12.9	5.8	16.0	7.4	8.1	3.5
Glutamic acid	16.4	7.9	27.7	15.8	16.6	9.5
Lysine	12.4	8.8	21.4	9.7	21.3	10.3
Arginine	23.4	17.3	32.9	25.3	34.3	24.0
Histidine	2.4	1.6	2.3	1.4	4.6	4.1
Methionine	7.2	3.2	9.7	4.5	6.8	3.9
Cystine	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected
Cysteine	13.9	6.5	6.2	5.0	12.3	7.6
Proline	48.7	45.7	61.3	58.4	49.2	45.7
Hydroxyproline	3.7	2.8	4.9	4.5	3.5	2.6
Ornithine	Trace	3.9	Not detected	4.9	1.0	6.4
4-aminobutyric acid	15.5	13.6	21.4	16.5	11.3	9.1
Total	313.0	198.1	409.7	243.7	278.2	187.2

Transaminase Reactions

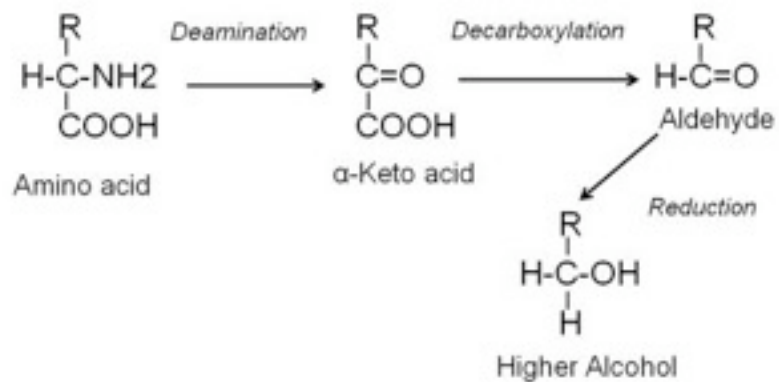


Unnumbered figure pg 537b Fundamentals of Biochemistry, 2/e
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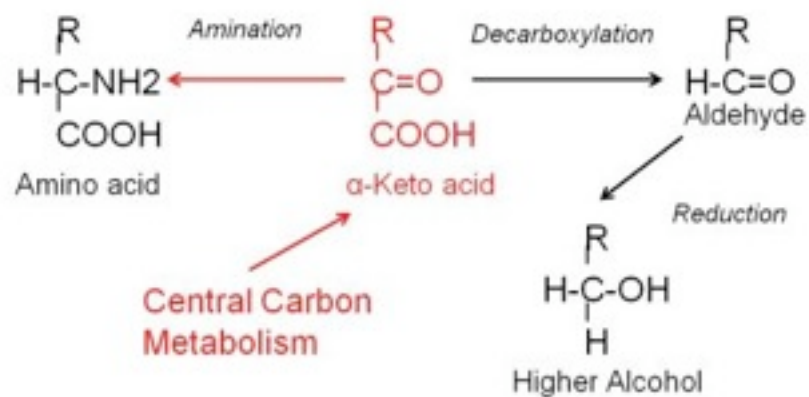
Fusel Alcohols



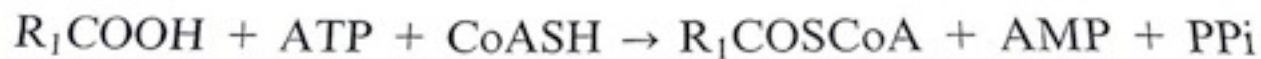
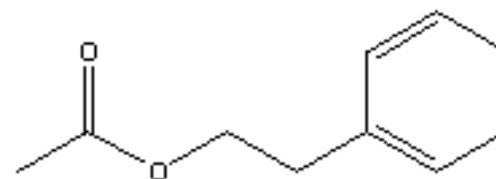
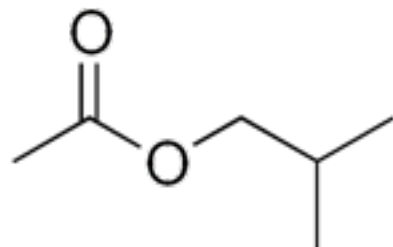
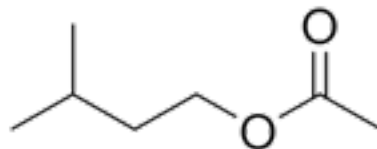
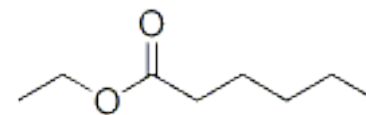
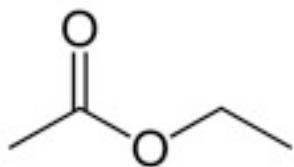
Ehrlich Pathway



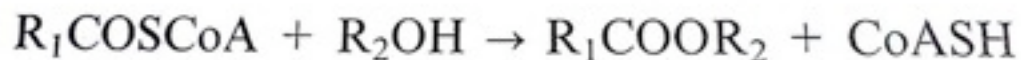
Amino Acid Biosynthesis



Esters

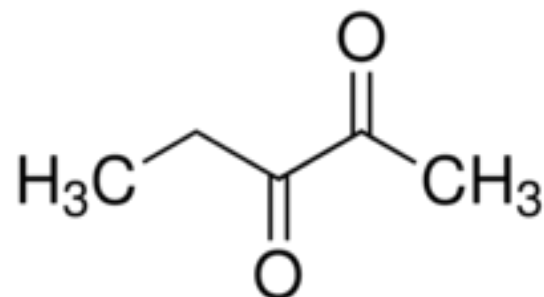
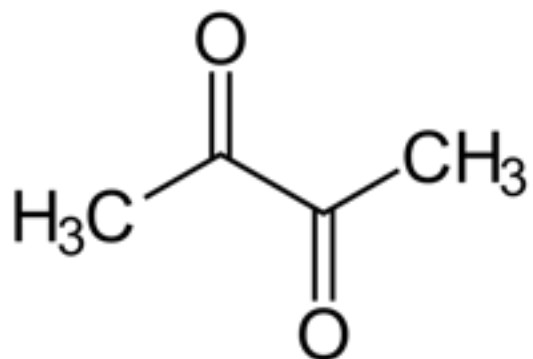


Acyl Coenzyme A synthetase

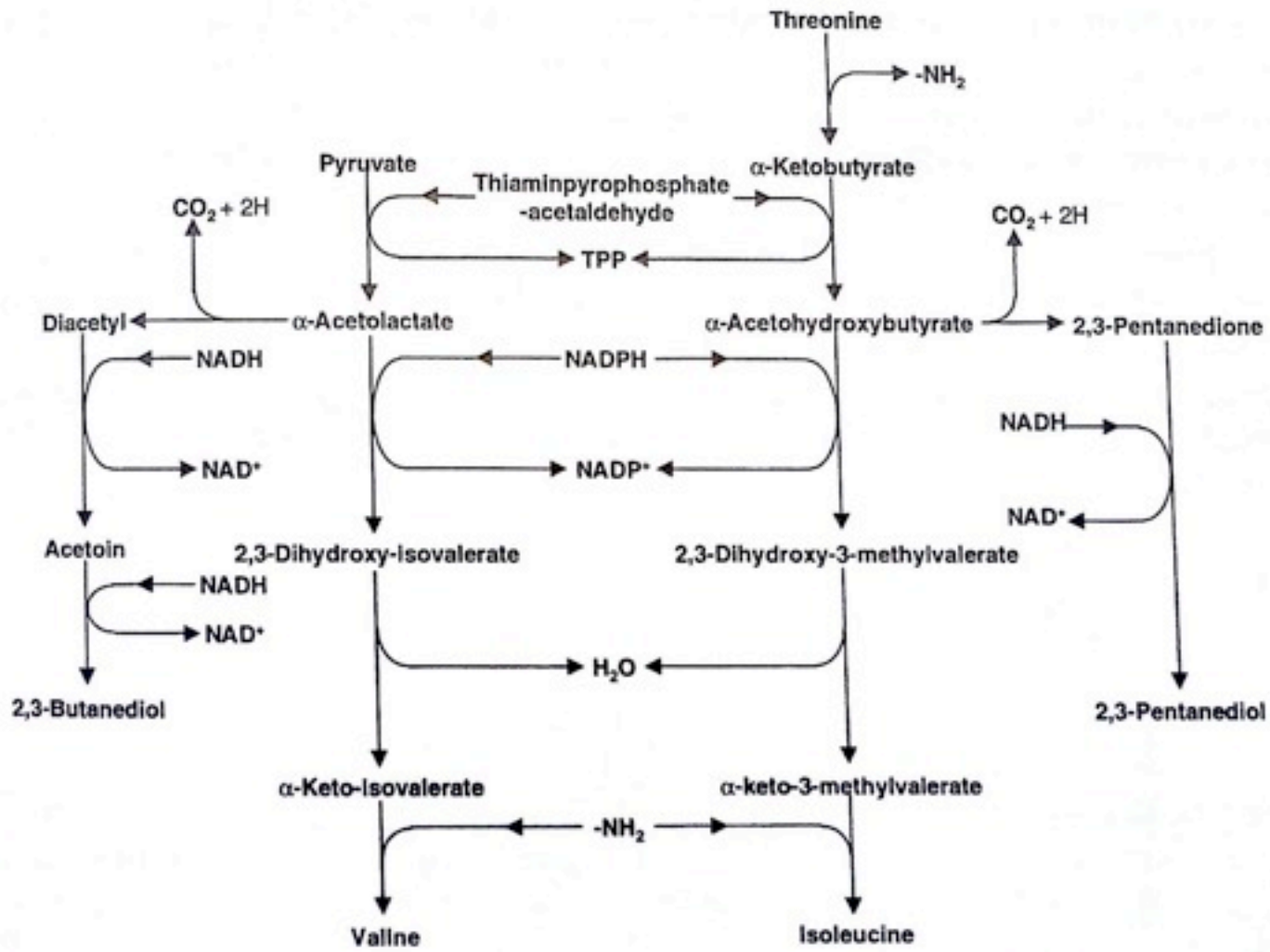


Alcohol acyl transferase

Vicinal diketones



Vicinal diketones



Allain Lab Research

Natural vs. Artificial Carbonation of Beer

Is there a difference?

If so ... what is the difference?

Effect of yeast pitch rate on production of flavor and aroma compounds.

Online Beer Analysis Database And Statistics Server
(BADASS)

Sulfur compounds

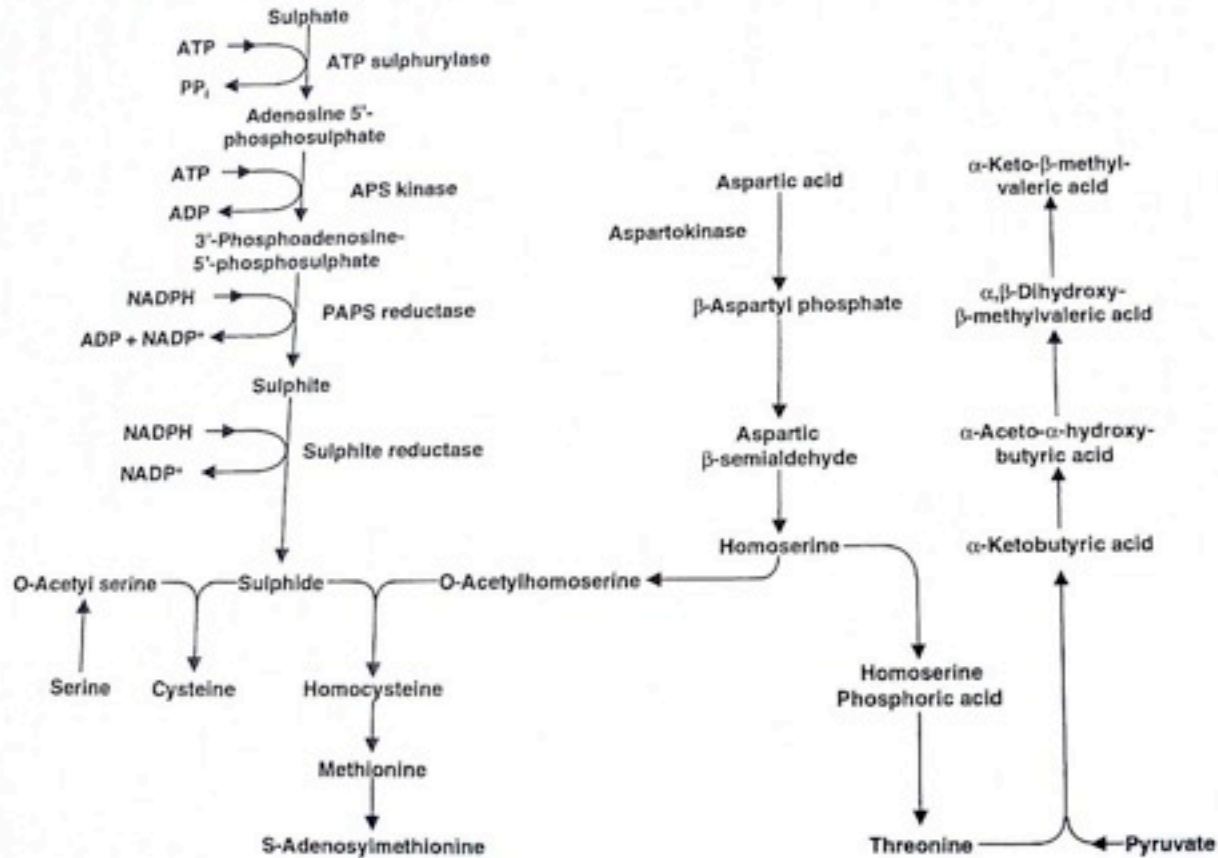


Fig. 3.22 Pathways of assimilation of sulphate, reduction to sulphite and sulphide and incorporation into amino acids.

Sulfur compounds

