

Vitamins

- Names and roles
- Deficiencies and sources
- Role in pathways
- Neurotransmitter overview
- Neurotransmitter pathway
- Tetrahydrofolate conversions
- Tetrahydrofolate examples
- **B₁₂ pathways**

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Names and Roles

A	retinol	phototransduction
B₁	thiamine	carbohydrate metabolism
B₂	riboflavin	redox, respiration
B₃	niacin	redox
B₅	Pantothenic acid	tca, fa and cholesterol
B₆	pyridoxine pyridoxamine pyridoxal	aa metabolism glycogenolysis
B₇	Biotin	gluconeogenesis, tca, fa, aa
B₉	Folic acid	1C metabolism
B₁₂	cobalamin	1C&H metabolism
C	ascorbic acid	hydroxylation
D	cholecalciferol	bone remodeling
E	tocopherols	antioxidant
K	phytylmenaquinone multiprenylmenaquinone	coagulation bone remodeling
Choline		ac, pl

aa: amino acid

fa: fatty acid

pl: phospholipid

A - retinal

B₂ - pyruvate dehydrogenase

B₅ - part of CoA

B₇ - acetyl CoA carboxylase (fatty acid synthesis) and pyruvate carboxylase

B₉ - thymidylate synthase

tca: tricarboxylic acid cycle

ac: acetylcholine

1C & H: one-carbon and hydrogen transfer

B₁ - transketolase, pyruvate dehydrogenase

B₃ - pyruvate dehydrogenase

B₆ - transaminases

B₁₂ - methionine synthase

Deficiencies and Sources	
● A - night blindness	preformed: liver, egg yolk, butter, milk β-carotene: dark green and yellow veggies
● B₁ - beri-beri	seeds, nuts, wheatgerms, legumes, lean meat
● B₂ - pellagra	meats, nuts, legumes
● B₃ - pellagra	meats, nuts, legumes
● B₅ - none known	yeast, grains, egg yolk, liver
● B₆ - neurologic disease	yeast, liver, wheatgerm, nuts, beans, bananas
● B₇ - widespread injury	corn, soy, egg yolk, liver, kidney, tomatoes
● B₉ - anemia	yeast, liver, leafy veggies
● B₁₂ - pernicious anemia	liver, kidney, egg, cheese
● C - scurvy	citrus and soft fruits
● D - ricketts, osteomalacia	milk, fortified food, fish oils, egg yolks, liver
● E - neurologic?, hemolytic anemia	veggie oils, nuts
● K - bleeding disorders	green leafy veggies, fruits, dairy products, veggie oils, cereals, meats
● Choline - rare	whole eggs, liver, beef steak, and soy (lecithin)

A deficiency in B₉ (folate) can mask B₁₂ deficiency.

Several months supply of B₉ in the body.

Two- to three-year supply of B₁₂ in the body; pernicious = harmful or deadly

B₇ (biopterin) rabies appears to induce deficiency

Overdose (OD) values

A > 25,000 IU; concentrated in polar bear liver (toxic levels)

B₃ > 2.5 g

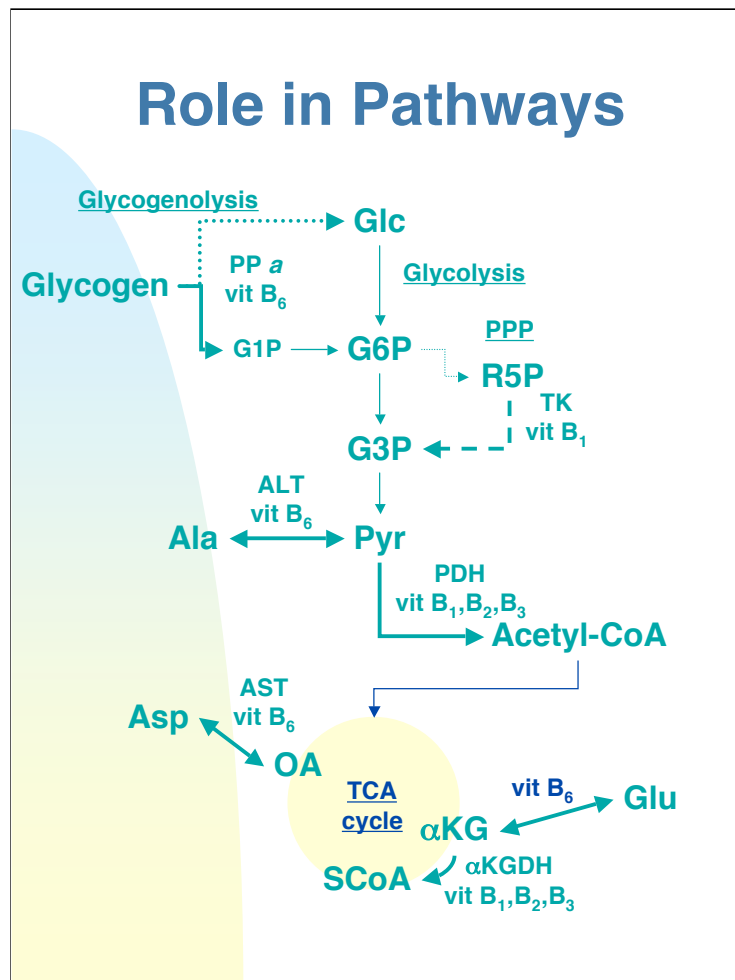
B₆ > 400 mg

B₉ > 1 mg

D > 50,000 IU

E > 50,000 IU

Clinical assays (lab tests) for A, B₁, B₉, B₁₂, C, and D₃



Glc: glucose

G3P: glyceraldehyde-3-phosphate

PDH: pyruvate dehydrogenase

TCA: tricarboxylic acid

αKGDH: α-ketoglutarate dehydrogenase

SCoA: succinyl coenzyme A

PPa: phosphorylase a

R5P: ribose-5-phosphate

Ala: alanine

Asp: aspartate

OA: oxaloacetate

Glu ⇌ αKG can occur in liver using glutamate dehydrogenase

G6P: glucose-6-phosphate

Pyr: pyruvate

Acetyl-CoA: acetyl coenzyme A

αKG: α-ketoglutarate

G1P: glucose-1-phosphate

PPP: pentose phosphate pathway

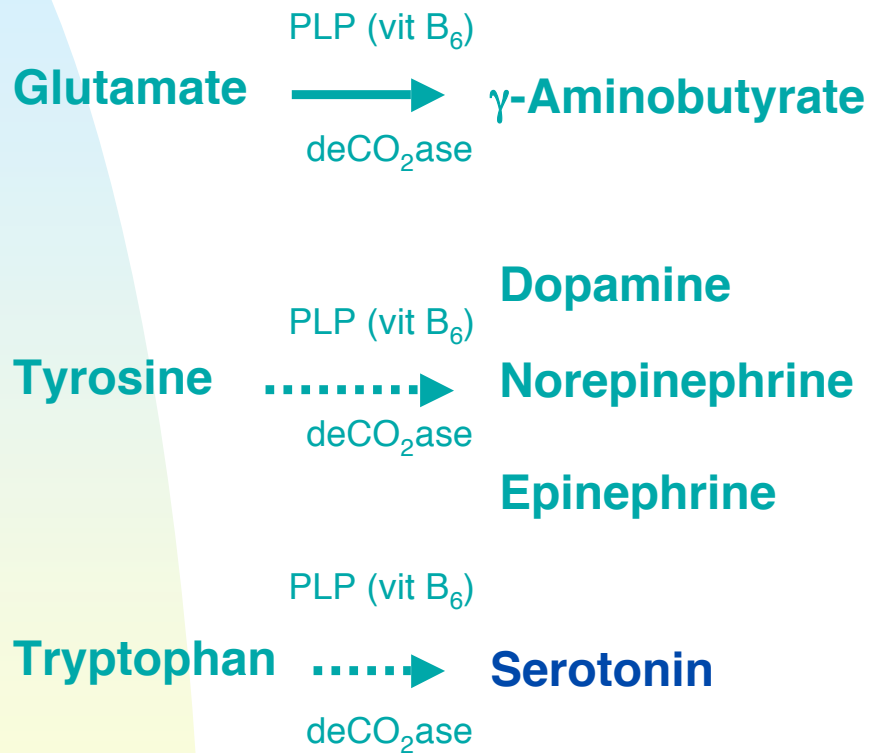
TK: transketolase

ALT: alanine transaminase

AST: aspartate transaminase

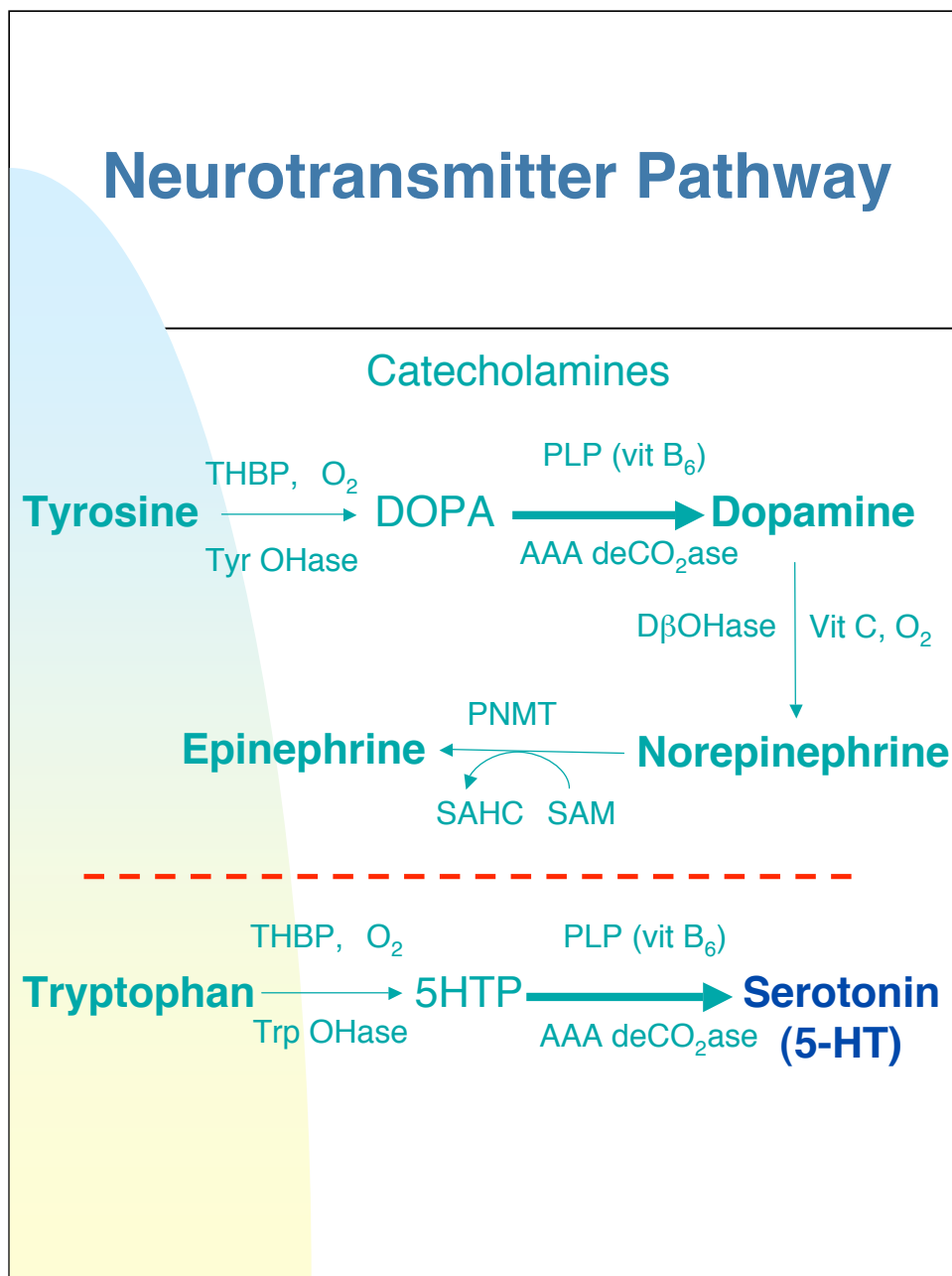
Glu: glutamate

Neurotransmitter Overview



PLP: pyridoxal phosphate

deCO₂ase: decarboxylase



THBP: tetrahydrobiopterin

TyrOHase: tyrosine hydroxylase, Fe-dependent

DOPA: dihydroxyphenylalanine

PLP: pyridoxal phosphate

AAA deCO₂ase: aromatic amino acid decarboxylase

DβOHase: dopamine β-hydroxylase, Cu-dependent

Vit C: vitamin C, ascorbic acid

PNMT: phenylethanolamine-*N*-methyltransferase (the degradation enzyme is catechol-*O*-methyltransferase, acts on norepinephrine and epinephrine)

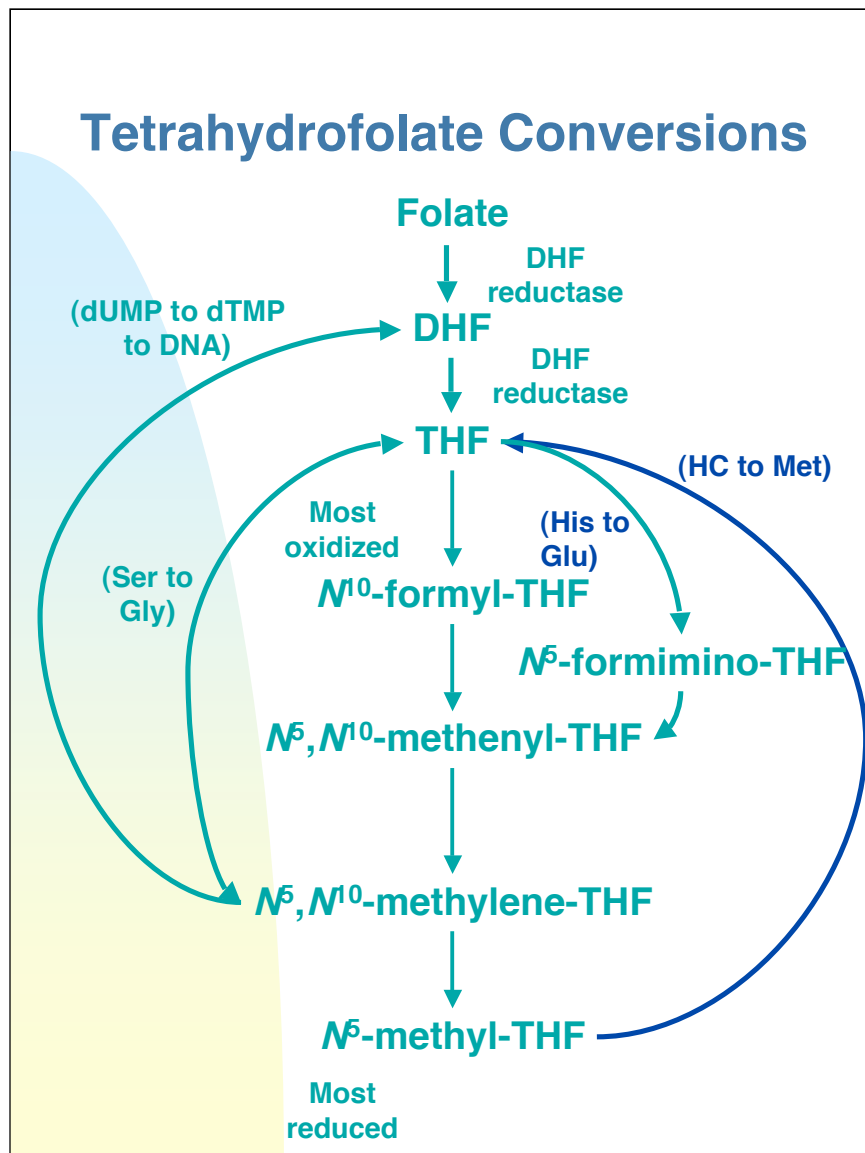
SAM: *S*-adenosylmethionine

SAHC: *S*-adenosylhomocysteine

TrpOHase: tryptophan hydroxylase, Fe-dependent

5HTP: 5-hydroxytryptophan

5-HT: 5-hydroxytryptamine (serotonin)



DHF: 7,8-dihydrofolate

THF: tetrahydrofolate

HC: homocysteine; degraded by Vit B₆-dependent cystathionine synthase

Met: methionine

Ser: serine

Gly: glycine

dUMP: deoxyuridine-5'-monophosphate

dTMP: deoxythymidine-5'-monophosphate

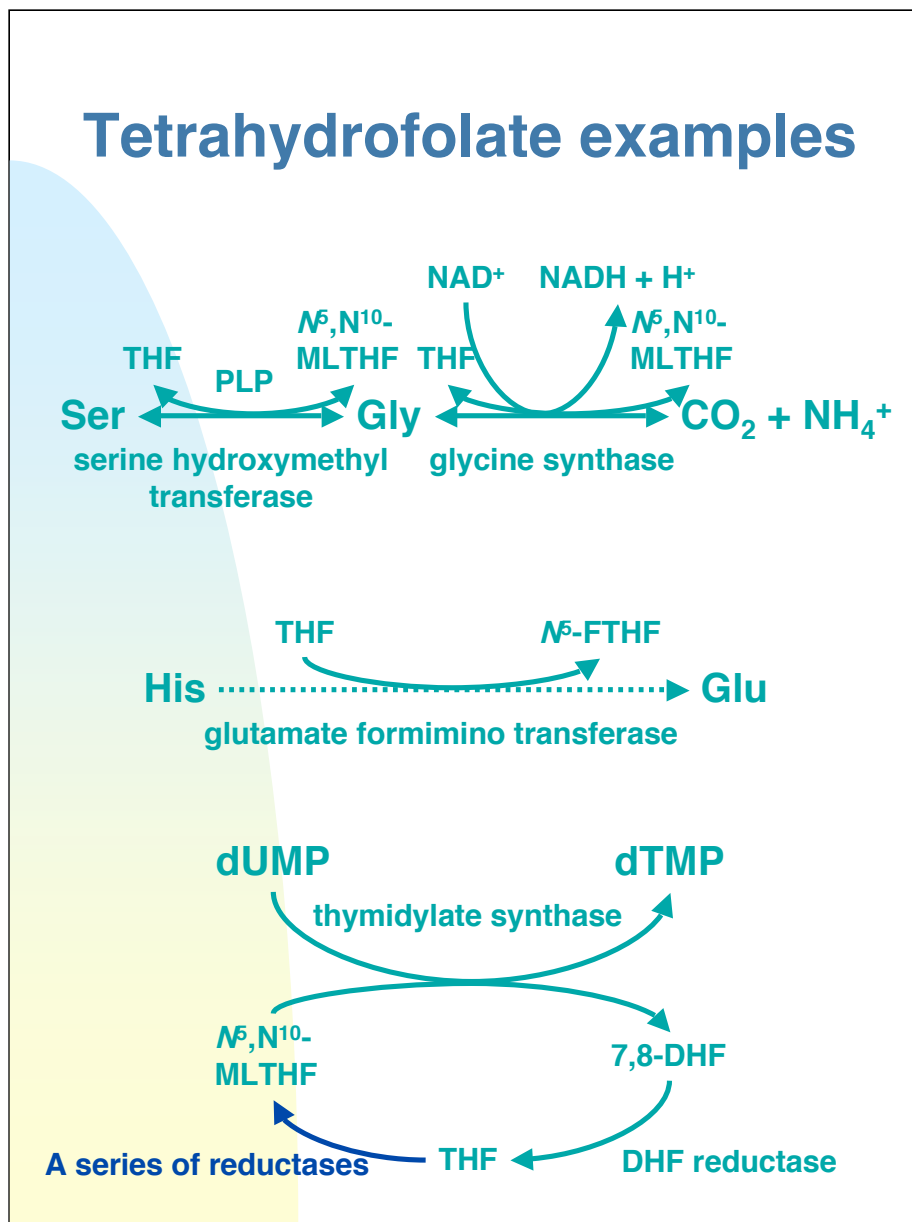
His: histidine

Glu: glutamate

Methotrexate is a folate antagonist used in chemotherapy to inhibit DHF reductase.

Ribose-5-phosphate (pentose phosphate pathway) is the starting point for dUMP synthesis

Tetrahydrofolate examples



Ser: serine

Gly: glycine

THF: tetrahydrofolate

PLP: pyridoxal phosphate

N^5, N^{10} -MLTHF: N^5, N^{10} -methylene-tetrahydrofolate

NAD⁺/NADH: oxidized/reduced nicotinamide adenine dinucleotide

His: histidine

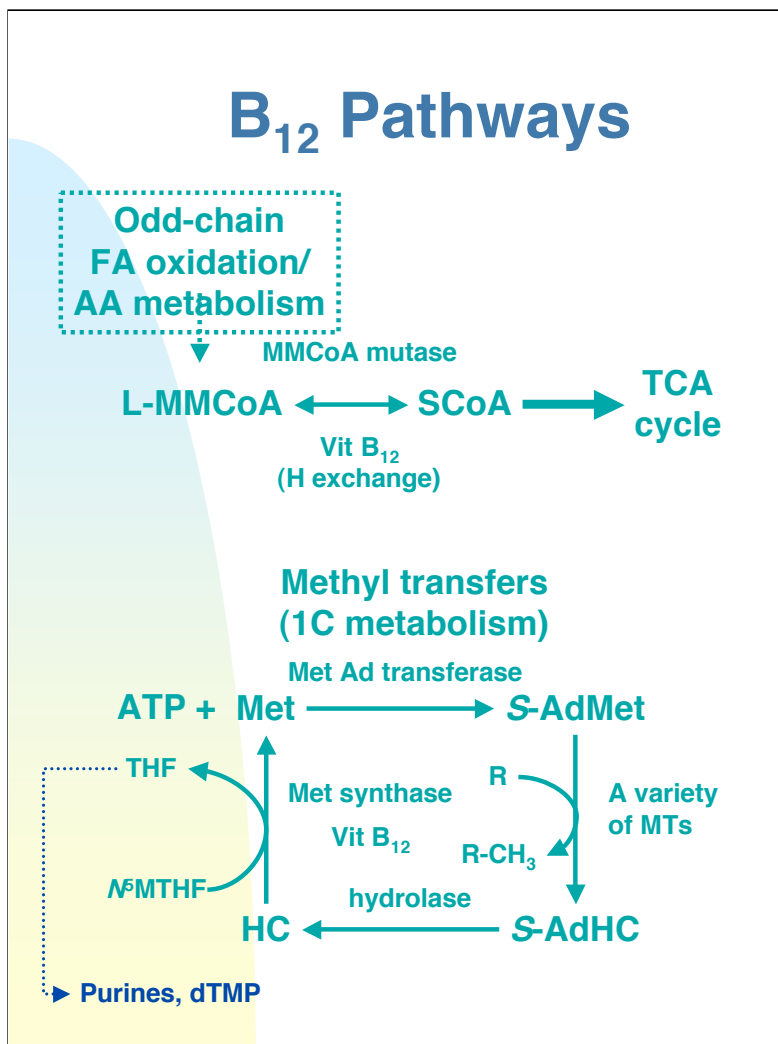
Glu: glutamate

N^5 -FTHF: N^5 -formimino-tetrahydrofolate

dUMP: deoxyuridine-5'-monophosphate

dTMP: deoxythymidine-5'-monophosphate

7,8-DHF: 7,8-dihydrofolate



FA: fatty acid

L-MMCoA: L-methylmalonyl-CoA (competitive inhibitor of malonyl CoA in fatty acid synthesis, can also substitute for malonyl CoA in fatty acid synthesis leading to branched chain fatty acids), build up leads to neuropathy (methylmalonic aciduria).

SCoA: succinyl-CoA

Vit B₁₂: vitamin B₁₂, cobalamin (if patient is deficient in both folate and cobalamin, giving folate only can mask cobalamin deficiency (cures anemia but leaves neuropathy))

TCA: tricarboxylic acid

ATP: adenosine triphosphate

Met: methionine

S-AdMet: S-adenosyl-methionine

MT: methyl transferases

S-AdHC: S-adenosyl-homocysteine (homocysteine is thought to be the connection between folic acid and neural tube defects, atherosclerosis, blood clot formation & adult vascular disease)

N⁵MTHF: N⁵-methyltetrahydrofolate

dTMP: deoxythymidine-5'-monophosphate

Review Questions

- What are the different names for vitamins A, B₁, B₂, B₃, B₅, B₆, C, and B₁₂?
- Which pathway depends on vitamin A?
- Which pathways and enzymes depend on vitamin B₁, B₂, B₃, B₆ and B₁₂?
- Which pathway and enzyme depends on choline?
- Which pathways and enzymes depend on folic acid?