

# Vitamins and Vitamin-Like Substances

- Names and roles - vitamins
- Names and roles - vitamin-like
- Deficiencies and sources -vitamins
- Deficiencies and sources - vitamin-like
- Role in pathways
- Neurotransmitter overview
- Neurotransmitter pathway
- Tetrahydrofolate conversions
- Tetrahydrofolate examples
- B<sub>12</sub> pathways**

Eric Niederhoffer  
SIU-SOM

# Names and Roles Vitamins

<b>A</b>	<b>retinol</b>	<b>phototransduction</b>
<b>B<sub>1</sub></b>	<b>thiamine</b>	<b>carbohydrate metabolism</b>
<b>B<sub>2</sub></b>	<b>riboflavin</b>	<b>redox, respiration</b>
<b>B<sub>3</sub></b>	<b>niacin</b>	<b>redox</b>
<b>B<sub>5</sub></b>	<b>Pantothenic acid</b>	<b>tca, fa and cholesterol</b>
<b>B<sub>6</sub></b>	<b>pyridoxine pyridoxamine pyridoxal</b>	<b>aa metabolism glycogenolysis</b>
<b>B<sub>7</sub></b>	<b>Biotin</b>	<b>gluconeogenesis, tca, fa, aa</b>
<b>B<sub>9</sub></b>	<b>Folic acid</b>	<b>1C metabolism</b>
<b>B<sub>12</sub></b>	<b>cobalamin</b>	<b>1C&amp;H metabolism</b>
<b>C</b>	<b>ascorbic acid</b>	<b>hydroxylation</b>
<b>D</b>	<b>cholecalciferol</b>	<b>bone remodeling</b>
<b>E</b>	<b>tocopherols</b>	<b>antioxidant</b>
<b>K</b>	<b>phytylmenaquinone multiprenylmenaquinone</b>	<b>coagulation bone remodeling</b>

**aa:** amino acid

**fa:** fatty acid

**pl:** phospholipid

**A** - retinal

**B<sub>2</sub>** - pyruvate dehydrogenase

**B<sub>5</sub>** - part of CoA

**B<sub>7</sub>** - acetyl CoA carboxylase (fatty acid synthesis) and pyruvate carboxylase

**B<sub>9</sub>** - thymidylate synthase

**tca:** tricarboxylic acid cycle

**ac:** acetylcholine

**1C & H:** one-carbon and hydrogen transfer

**B<sub>1</sub>** - transketolase, pyruvate dehydrogenase

**B<sub>3</sub>** - pyruvate dehydrogenase

**B<sub>6</sub>** - transaminases

**B<sub>12</sub>** - methionine synthase

# Names and Roles Vitamin-Like Substances

<b>Choline</b>	<b>ac, pl</b>
<b>Carnitine</b>	<b>fa acyl group transfer</b>
<b>Bioflavonoids</b>	<b>antioxidants</b>
<b>Lipoic acid</b>	<b>tca acyl group transfer</b>
<b>Coenzyme Q</b>	<b>electron transport</b>
<b>Inositol</b>	<b>phospholipids</b>
<b><i>p</i>-Aminobenzoic acid</b>	<b>folate component</b>

**ac:** acetylcholine

**fa:** fatty acid

**pl:** phospholipid

**tca:** tricarboxylic acid cycle

Deficiencies and Sources Vitamins	
● <b>A - night blindness</b>	preformed: liver, egg yolk, butter, milk β-carotene: dark green and yellow veggies
● <b>B<sub>1</sub> - beri-beri</b>	seeds, nuts, wheatgerms, legumes, lean meat
● <b>B<sub>2</sub> - pellagra</b>	meats, nuts, legumes
● <b>B<sub>3</sub> - pellagra</b>	meats, nuts, legumes
● <b>B<sub>5</sub> - none known</b>	yeast, grains, egg yolk, liver
● <b>B<sub>6</sub> - neurologic disease</b>	yeast, liver, wheatgerm, nuts, beans, bananas
● <b>B<sub>7</sub> - widespread injury</b>	corn, soy, egg yolk, liver, kidney, tomatoes
● <b>B<sub>9</sub> - anemia</b>	yeast, liver, leafy veggies
● <b>B<sub>12</sub> - pernicious anemia</b>	liver, kidney, egg, cheese
● <b>C - scurvy</b>	citrus and soft fruits
● <b>D - ricketts, osteomalacia</b>	milk, fortified food, fish oils, egg yolks, liver
● <b>E - neurologic?, hemolytic anemia</b>	veggie oils, nuts
● <b>K - bleeding disorders</b>	green leafy veggies, fruits, dairy products, veggie oils, cereals, meats

A deficiency in B<sub>9</sub> (folate) can mask B<sub>12</sub> deficiency.

Several months supply of B<sub>9</sub> in the body.

Two- to three-year supply of B<sub>12</sub> in the body; pernicious = harmful or deadly

B<sub>7</sub> (biopterin) rabies appears to induce deficiency

Overdose (OD) values

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

B<sub>3</sub> > 2.5 g; (can be made from tryptophan, amide preferred, acid is vasodilator)

B<sub>6</sub> > 400 mg

B<sub>9</sub> > 1 mg

D > 50,000 IU

E > 50,000 IU

Clinical assays (lab tests) for A, B<sub>1</sub>, B<sub>9</sub>, B<sub>12</sub>, C, and D<sub>3</sub>

## Deficiencies and Sources Vitamins-Like Substances

<b>Choline - rare</b>	whole eggs, liver, beef steak, and soy (lecithin)
<b>Carnitine - unlikely</b>	meat, dairy products, asparagus, wheat germ
<b>Bioflavonoids - none known</b>	fruits, vegetables, tea, coffee, cocoa, wine, beer
<b>Lipoic acid - none known</b>	liver
<b>Coenzyme Q - rare</b>	fruits, vegetables, meats
<b>Inositol - none known</b>	cereal grains
<b><i>p</i>-Aminobenzoic acid - see B9</b>	liver, rice bran, whole wheat

Choline is not really consider to be a vitamin in humans.

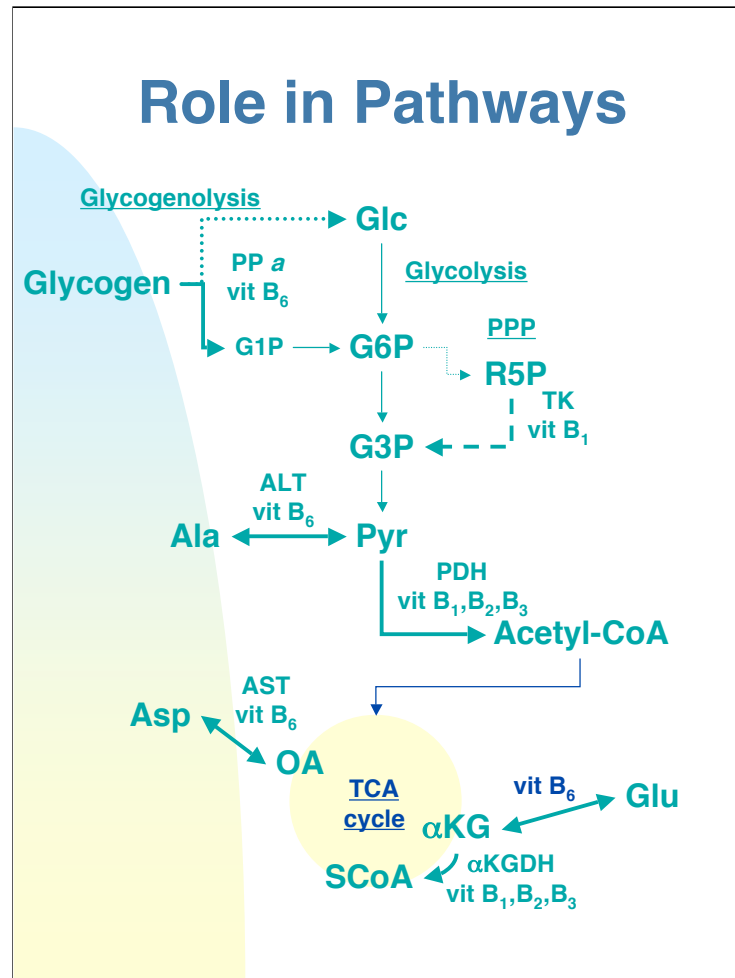
Carnitine deficiency limited to people with specific metabolic disorders.

Bioflavonoid deficiency in animals associated with vascular problems.

Lipoic acid has not been demonstrated to be required in the diet.

Coenzyme Q deficiency associated with specific genetic diseases.

*P*-aminobenzoic acid is not accepted as a vitamin.



**Glc:** glucose

**G3P:** glyceraldehyde-3-phosphate

**PDH:** pyruvate dehydrogenase

**TCA:** tricarboxylic acid

**$\alpha$ KGDH:**  $\alpha$ -ketoglutarate dehydrogenase

**S<sub>CoA</sub>:** succinyl coenzyme A

**PP<sub>a</sub>:** phosphorylase *a*

**R5P:** ribose-5-phosphate

**Ala:** alanine

**Asp:** aspartate

**OA:** oxaloacetate

Glu  $\Leftrightarrow$   $\alpha$ KG can occur in liver using glutamate dehydrogenase

**G6P:** glucose-6-phosphate

**Pyr:** pyruvate

**Acetyl-CoA:** acetyl coenzyme A

**$\alpha$ KG:**  $\alpha$ -ketoglutarate

**G1P:** glucose-1-phosphate

**PPP:** pentose phosphate pathway

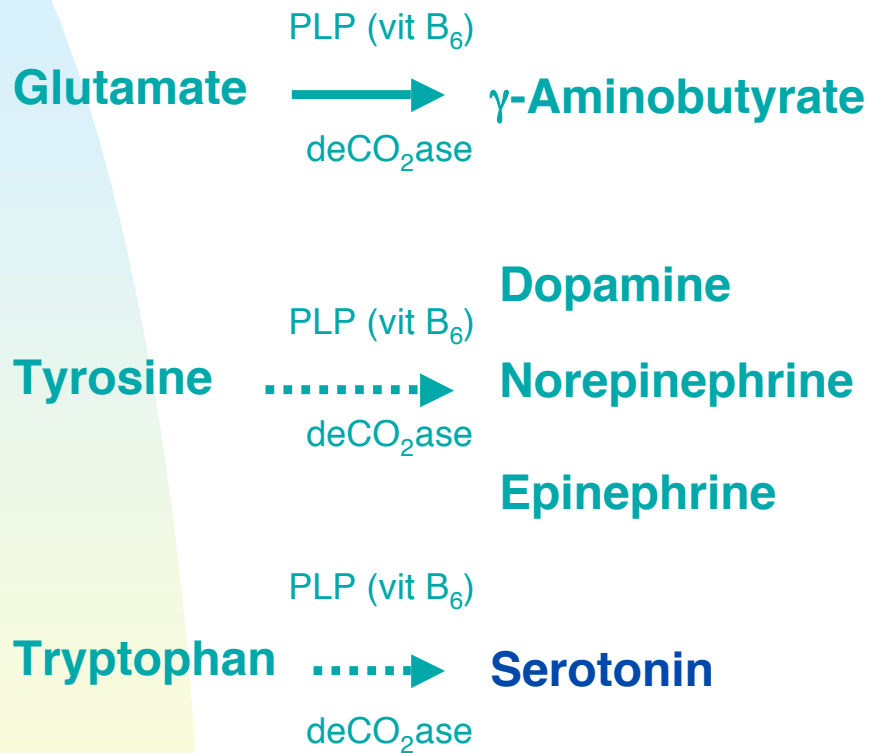
**TK:** transketolase

**ALT:** alanine transaminase

**AST:** aspartate transaminase

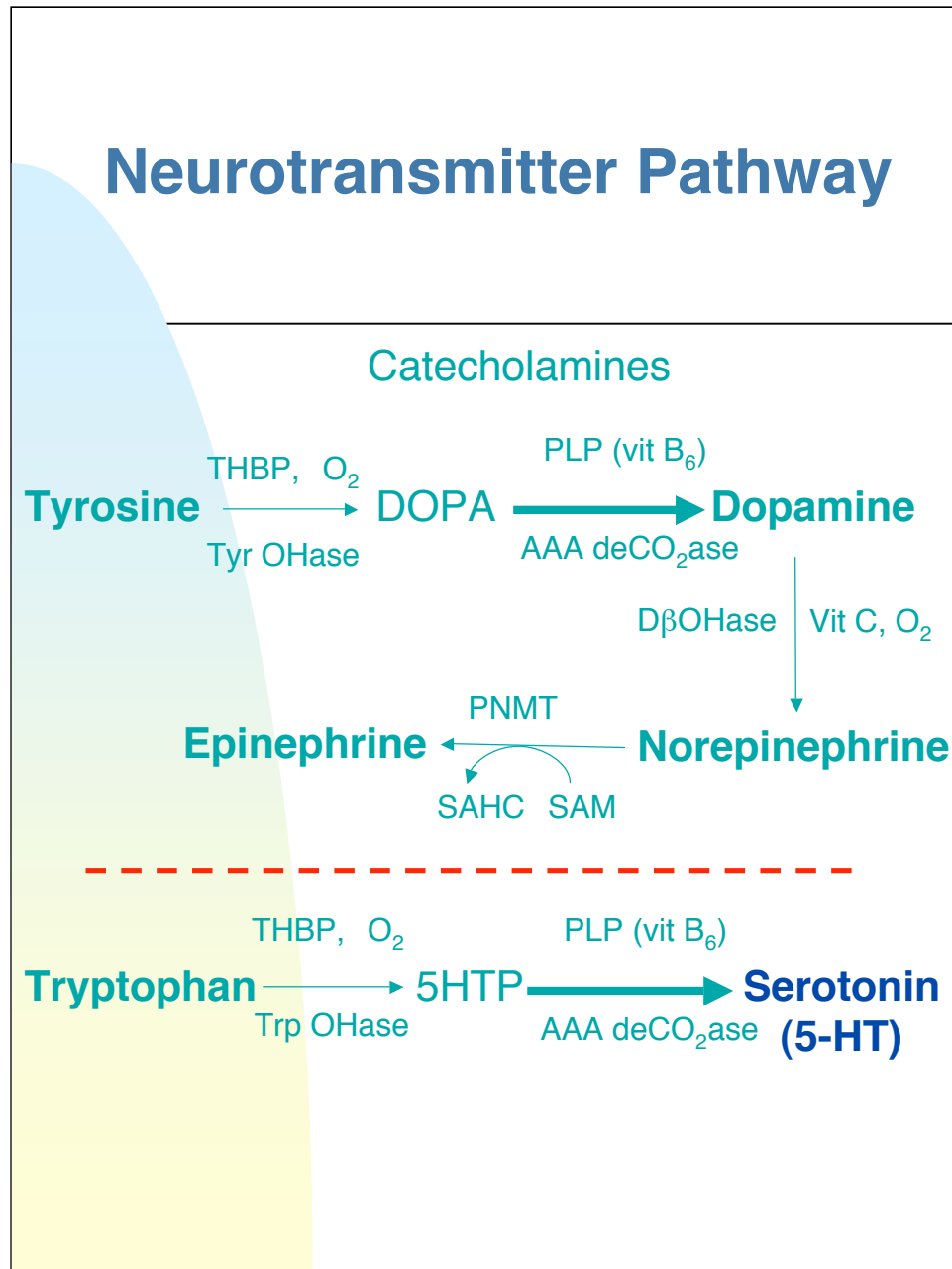
**Glu:** glutamate

# Neurotransmitter Overview



**PLP:** pyridoxal phosphate

**deCO<sub>2</sub>ase:** decarboxylase



**THBP:** tetrahydrobiopterin

**TyrOHase:** tyrosine hydroxylase, Fe-dependent

**DOPA:** dihydroxyphenylalanine

**PLP:** pyridoxal phosphate

**AAA deCO<sub>2</sub>ase:** 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)

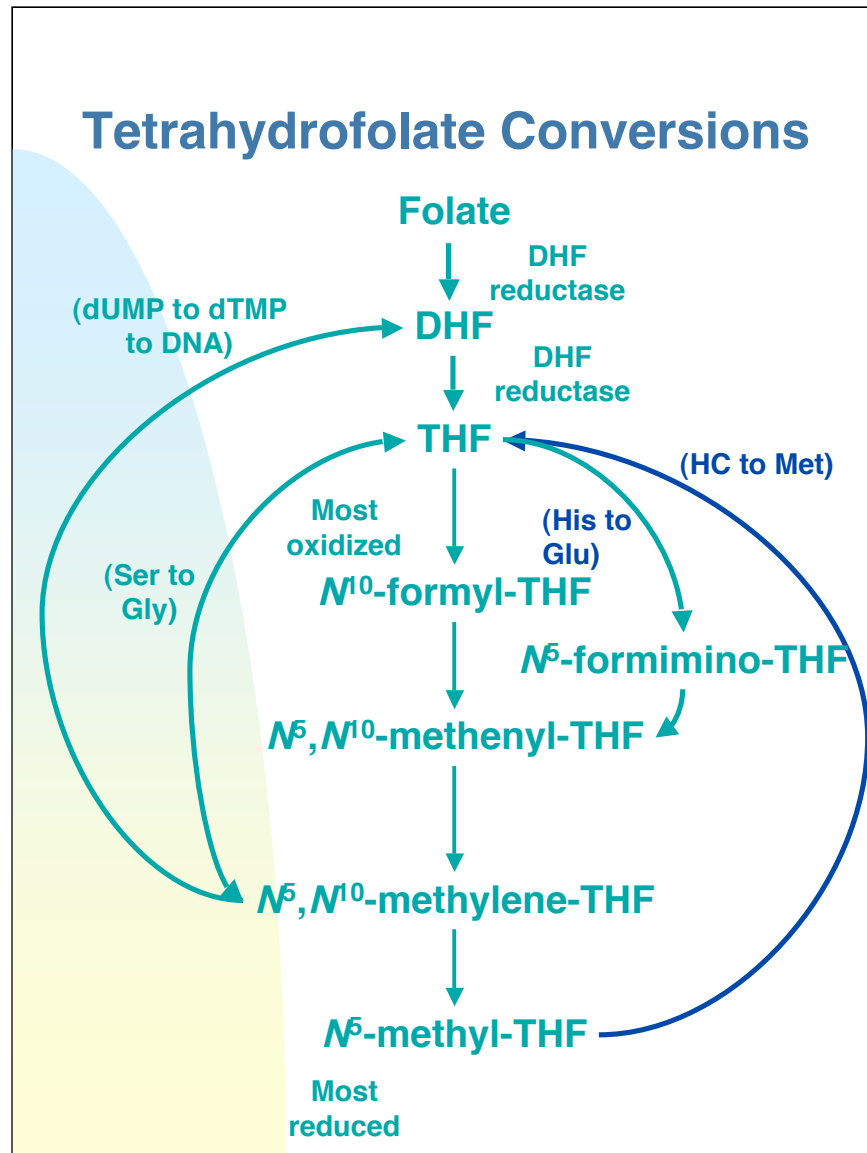
**SAM:** *S*-adenosylmethionine

**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 B<sub>6</sub>-dependent cystathionine synthase

**Met:** methionine

**Ser:** serine

**Gly:** glycine

**dUMP:** deoxyuridine-5'-monophosphate

**dTMP:** deoxythymidine-5'-monophosphate

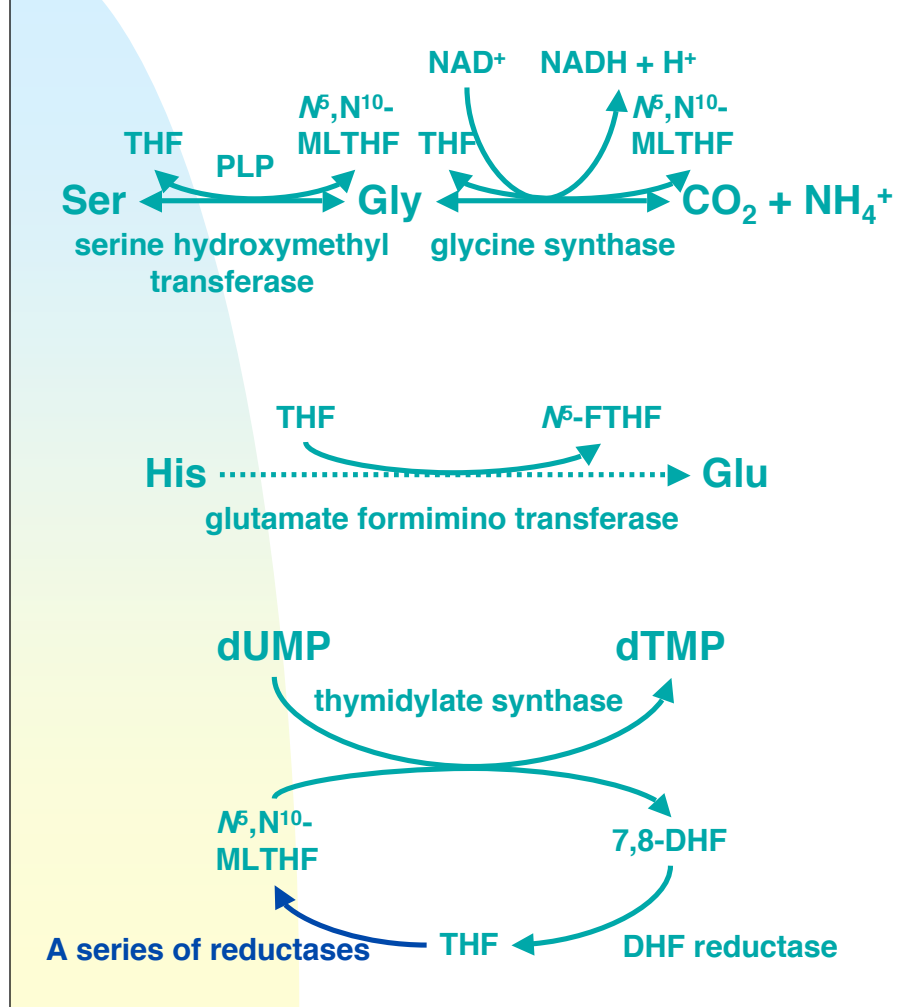
**His:** histidine

**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

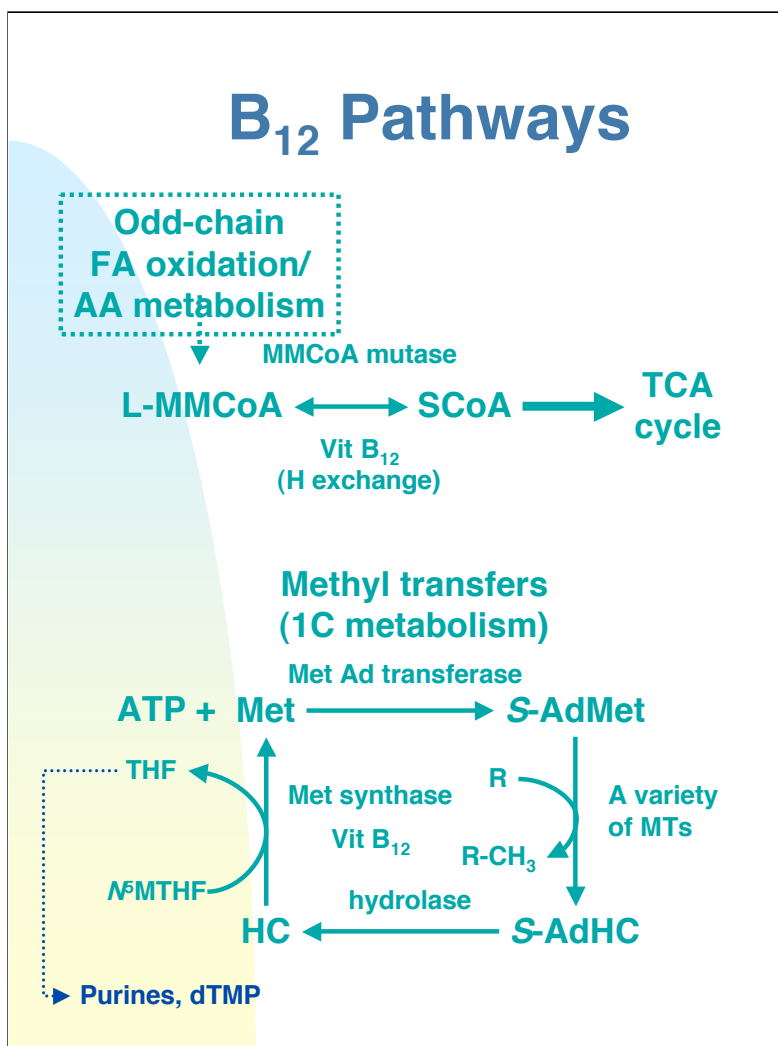
**Glu:** glutamate

**$N^5$ -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 B<sub>12</sub>:** vitamin B<sub>12</sub>, 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)

**N<sup>5</sup>MTHF:** N<sup>5</sup>-methyltetrahydrofolate

**dTMP:** deoxythymidine-5'-monophosphate

## Review Questions

- What are the different names for vitamins A, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, B<sub>5</sub>, B<sub>6</sub>, C, and B<sub>12</sub>?
- Which pathway depends on vitamin A?
- Which pathways and enzymes depend on vitamin B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, B<sub>6</sub> and B<sub>12</sub>?
- Which pathway and enzyme depends on choline?
- Which pathways and enzymes depend on folic acid?