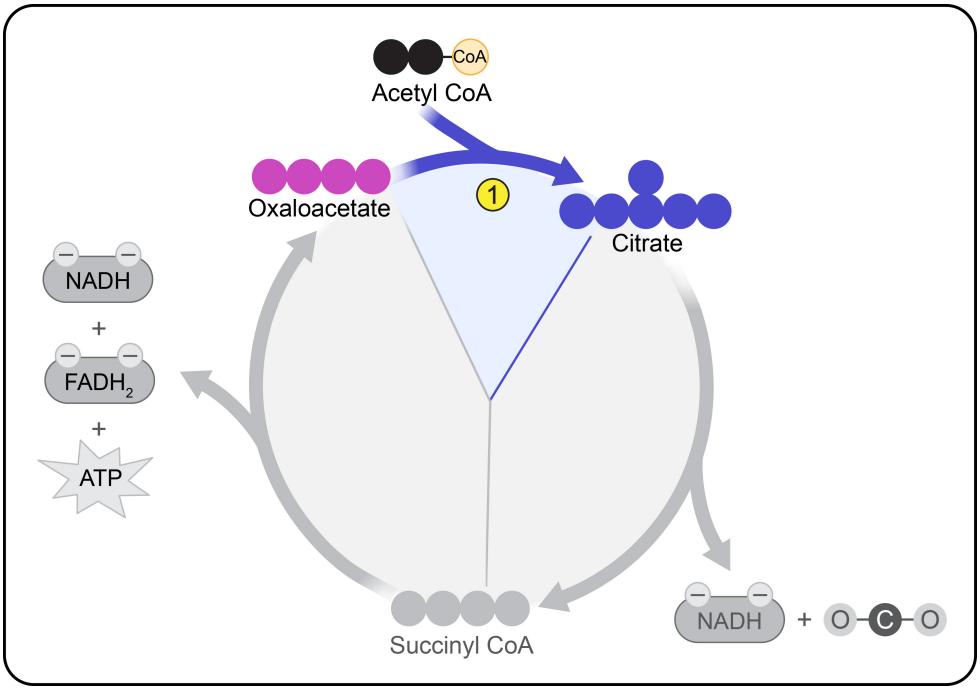
CONCEPT: THE CITRIC ACID CYCLE

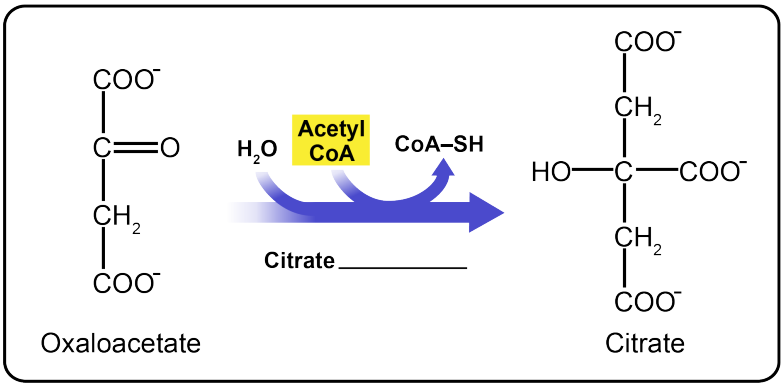
- The citric acid cycle is a sequence of ___ biochemical reactions.

Phase A – Citrate Formation

- Phase A consists of the _____ reaction of the pathway.



1 Citrate Formation: acetyl group from acetyl CoA combines with oxaloacetate to produce citrate.



EXAMPLE: How many carbon atoms are added to oxaloacetate to produce citrate?

a) One

b) Two

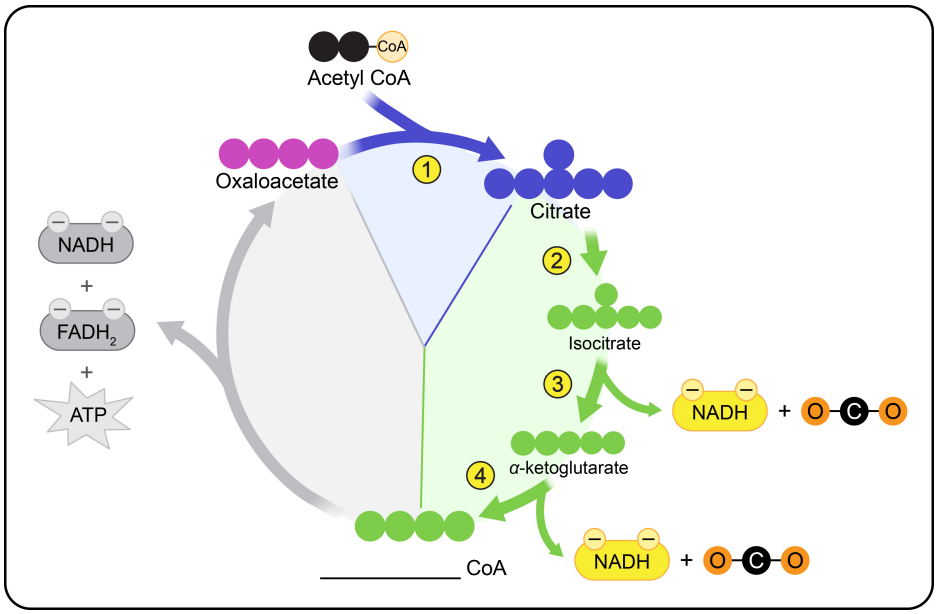
c) Three

d) Four

CONCEPT: THE CITRIC ACID CYCLE

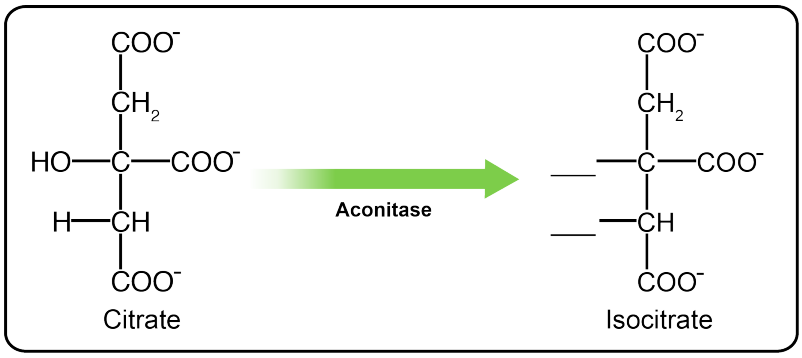
Phase B – Succinyl CoA Formation

- Phase B consists of the pathway's reactions ___, ___, and ___.
  - □ Produces ___ moles each of NADH and CO_2.



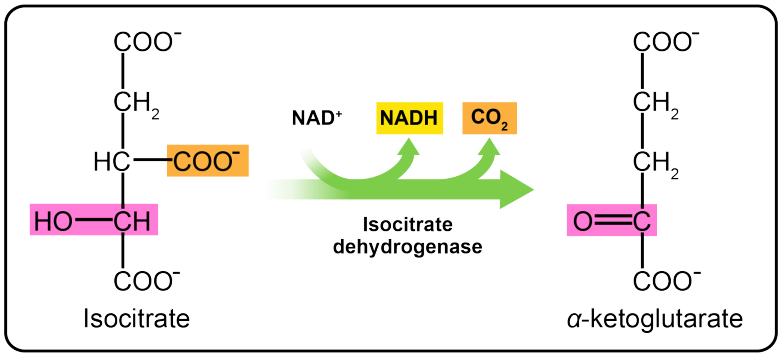
2 Isomerization: the 3° –OH in citrate must be isomerized to a 2° –OH for _____.

- □ The enzyme _____ isomerizes citrate to isocitrate.



3 Oxidation & Decarboxylation (1st): the enzyme isocitrate _____ oxidizes isocitrate to α-ketoglutarate.

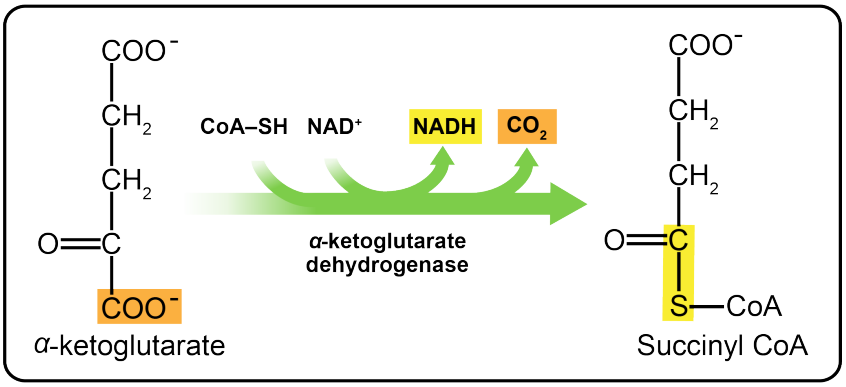
- □ 1 NAD^+ is reduced to 1 _____.
- □ 1 C atom is lost as _____.



CONCEPT: THE CITRIC ACID CYCLE

4 Oxidation & Decarboxylation (2nd): α-ketoglutarate _____ oxidizes α-ketoglutarate to succinyl CoA.

□ 1 NAD^+ is reduced to 1 _____. □ 1 C atom is lost as _____.



EXAMPLE: For each of the following reactions described below, identify a corresponding step of the citric acid cycle.

a) ____ Oxidation of α-ketoglutarate produces succinyl CoA.

b) ____ Oxaloacetate is converted to citrate.

c) ____ An oxidation reaction is catalyzed by isocitrate dehydrogenase.

d) ____ Aconitase catalyzes the isomerization of citrate to isocitrate.

PRACTICE: Which enzyme oxidizes α-ketoglutarate in step 4 of the citric acid cycle?

a) isocitrate dehydrogenase

b) α-ketoglutarate oxidase

c) succinyl CoA synthase

d) α-ketoglutarate dehydrogenase

PRACTICE: Which two steps of the citric acid cycle produce CO_2?

a) 1 and 3

b) 3 and 4

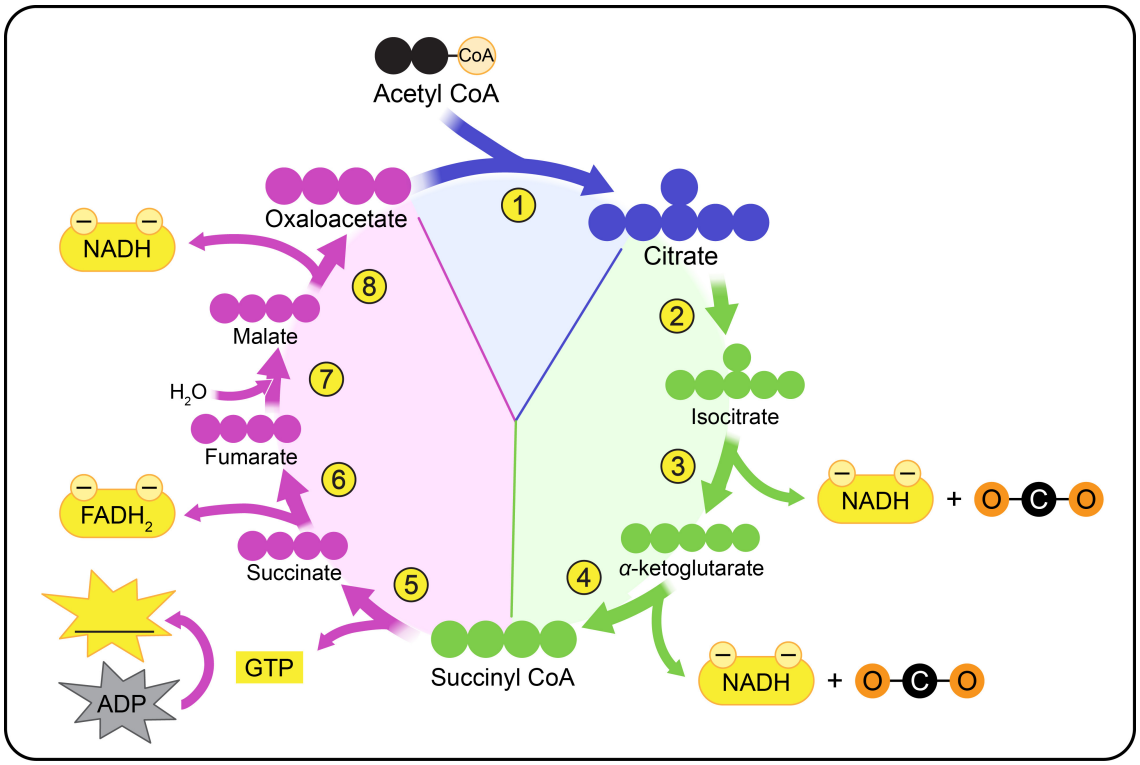
c) 2 and 4

d) 2 and 3

CONCEPT: THE CITRIC ACID CYCLE

Phase C – Oxaloacetate Regeneration

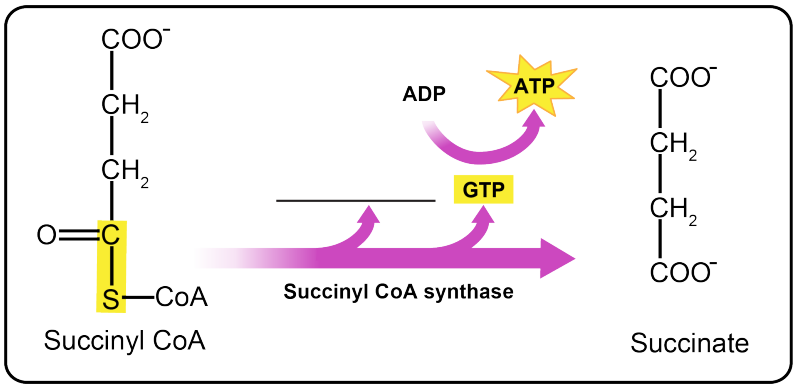
● Phase C consists of the pathway's reactions ___ to ___.



5 Hydrolysis: the enzyme succinyl CoA _____ hydrolyzes succinyl CoA to succinate.

□ Energy _____ from the hydrolysis reaction produces GTP.

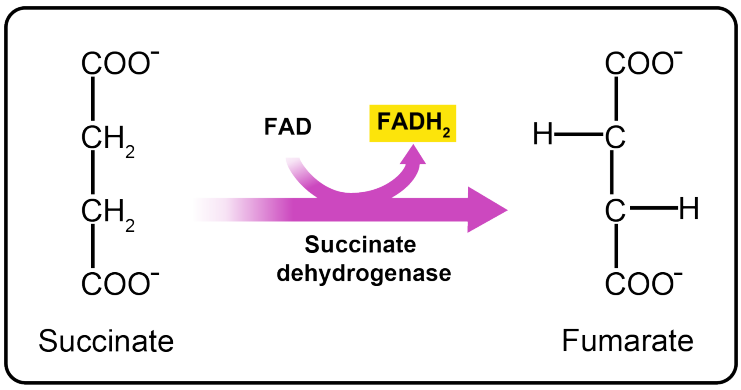
- _____ of GTP provides energy to produce ATP.



CONCEPT: THE CITRIC ACID CYCLE

6 **Oxidation:** the enzyme succinate dehydrogenase oxidizes succinate to fumarate.

□ 1 FAD is reduced to 1 _____.



● Dehydrogenases utilize FAD to convert _____ bonds to _____ bonds.

EXAMPLE: Which one of the following statements is incorrect about the citric acid cycle?

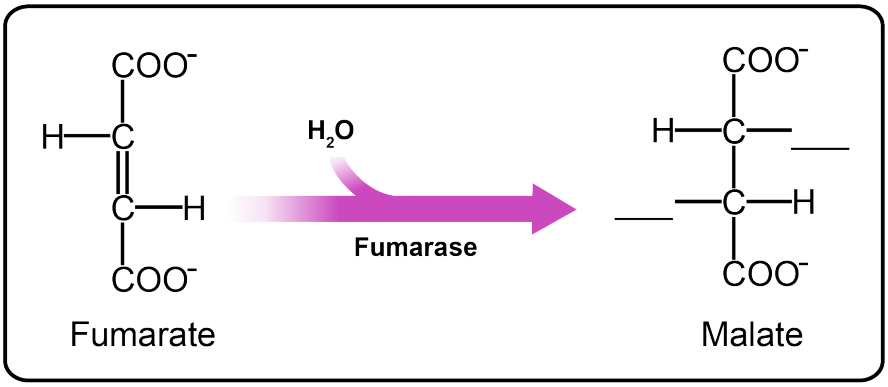
a) Reaction 5 of the cycle converts succinyl CoA to succinate.

b) Oxidation of succinate in reaction 6 produces fumarate.

c) Phase C of the citric acid cycle does not result in the loss of any C atoms.

d) Energy required for the hydrolysis of succinyl CoA comes from GTP.

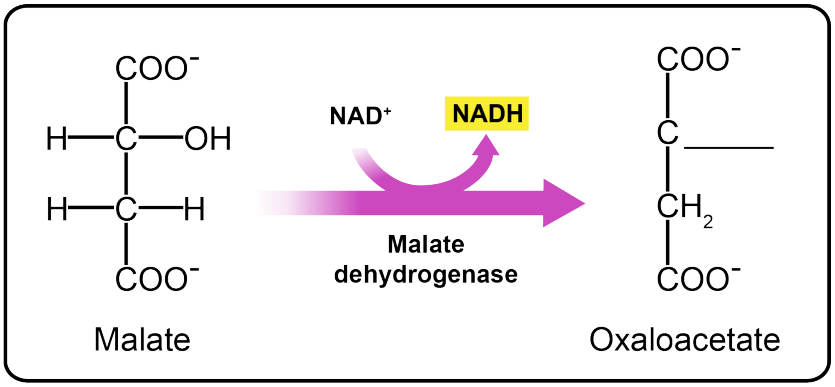
7 **Hydration:** the enzyme fumarate _____ (fumarase) converts fumarate to malate by adding H_2O.



CONCEPT: THE CITRIC ACID CYCLE

8 **Oxidation:** the enzyme malate dehydrogenase oxidizes malate to oxaloacetate.

□ 1 NAD^+ is reduced to 1 _____.



EXAMPLE: For each of the following reactions described below, identify a corresponding step of the citric acid cycle.

a) ____ Malate dehydrogenase catalyzes the oxidation of malate to oxaloacetate.

b) ____ Succinate loses two H atoms to yield fumarate.

c) ____ Succinyl CoA undergoes hydrolysis to produce succinate.

d) ____ Malate is produced from hydration of fumarate.

PRACTICE: Which one of the following enzymes catalyzes the addition of water to the C=C bond in fumarate?

a) Fumarate reductase

b) Malate synthase

c) Fumarase (Fumarate hydratase)

d) Malate dehydrogenase

PRACTICE: How many final high-energy molecules are produced in phase C of the citric acid cycle?

a) 2

b) 4

c) 1

d) 3

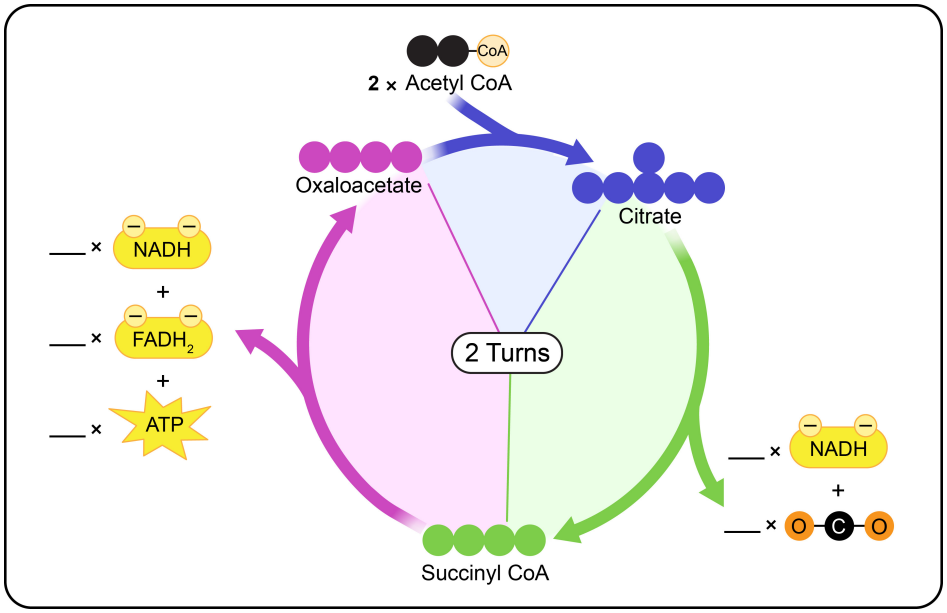
CONCEPT: THE CITRIC ACID CYCLE

Citric Acid Cycle Summary

- The citric acid cycle degrades acetyl groups to produce _____ and high-energy molecules.

MEMORY TOOL 1: Krebs cycle is **A** **B**ig **C**rab. **MEMORY TOOL 2:** ___ Owls and __ ____ Hawk in a circus ring.

- □ ___ oxidation reactions each in phases **B** and **C**.
- □ Oxidation reactions yield _____ and/or _____. - Hydrolysis reaction yields _____.



	Krebs Cycle (Citric Acid)
Start Molecule	2 Acetyl-CoA
O C O	
ATP	
$FADH_2$	
NADH	
End Molecule	Oxaloacetate

MEMORY TOOL 3: u____er trees in a forest, there lived 5 __nts and 6 __lies.
u____er __'s in a __ __, there lived 5 __nts and 6 __lies.

MEMORY TOOL 4: C1 O2 __ __

EXAMPLE: How many reactions in the citric acid cycle produce high-energy molecules?

a) 4 b) 5 c) 3 d) 6

PRACTICE: Complete the following net equation for one turn of the citric acid cycle.

Acetyl CoA + ___H_2O + 3 NAD^+ + FAD + GDP + ____ ⟶ CoA + ___NADH + ___H^+ + $FADH_2$ + GTP + ___CO_2

PRACTICE: Which reaction of the citric acid cycle produces ATP *directly*?

a) Reaction 3 b) Reaction 5 c) Reaction 4

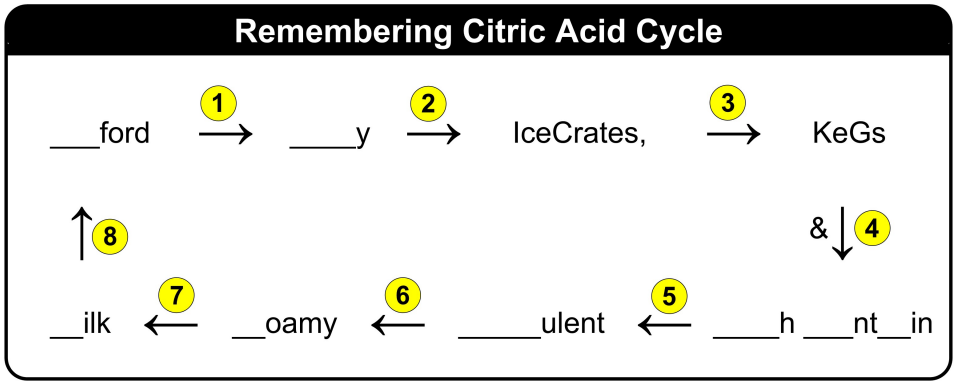
d) Reaction 6 e) Reaction 8 f) None of these

CONCEPT: THE CITRIC ACID CYCLE

Remembering Citric Acid Cycle

● Each reaction of the citric acid cycle can be remembered by memorizing the intermediate (_____) names.

MEMORY TOOL 1: ____ford ____y IceCrates, KeGs, & _____h ____nt__in _____ulent ___oamy ___ilk.



● The name of the enzyme can be predicted by knowing the substrate and the _____ of reaction.

HINT 1: Reaction 1 (Citrate formation) is catalyzed by citrate _____.

HINT 2: Reaction 2 (Citrate isomerization) is catalyzed by aconitase.

HINT 3: Reactions 3, 4, 6, & 8 are _____ reactions catalyzed by dehydrogenases.

HINT 4: Reaction 5 is hydr_____ and reaction 7 is hydr_____.

EXCEPTION: Reaction 5 is catalyzed by a _____ instead of a hydrolase.

EXAMPLE: Write the name for the enzyme that catalyzes the first reaction of the citric acid cycle.

a) Isocitrate synthase

b) Oxaloacetate reductase

c) Malate dehydrogenase

d) Citrate synthase

PRACTICE: Write the name for the substrate, enzyme, and product of reaction 6 of the citric acid cycle.

a) Succinyl CoA, succinyl CoA synthase, succinate

b) Succinate, succinate dehydrogenase, and fumarate

c) Succinyl CoA, succinate dehydrogenase, and fumarate

d) Fumarate, fumarase, and malate

CONCEPT: THE CITRIC ACID CYCLE

PRACTICE: Identify the two reactions that involve oxidation and decarboxylation.

a) Reactions 1 and 5

b) Reactions 3 and 6

c) Reactions 6 and 8

d) Reactions 2 and 7

e) Reactions 3 and 4

PRACTICE: Write the name of the substrate and the enzyme of reaction 8 of the citric acid cycle.

a) Oxalate, oxalate oxidase

b) Malate, malate dehydrogenase

c) Succinate, succinate dehydrogenase

d) Fumarate, fumarase

PRACTICE: What is the name of the enzyme for the reaction that produces a GTP molecule in the citric acid cycle?

a) Succinyl CoA synthase

b) Succinate dehydrogenase

c) α-ketoglutarate dehydrogenase

d) Fumarate hydratase

PRACTICE: Which reactions of the citric acid cycle produce NADH?

a) Reactions 1, 2, and 8

b) Reactions 2, 4, and 6

c) Reactions 2, 5, and 7

d) Reactions 3, 4, and 8

e) Reactions 3, 4, and 6