Entner-Doudoroff Pathway

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ED Pathway

- The **Entner-Doudoroff Pathway** (ED Pathway) is a metabolic pathway that is most notably in Gram-negative bacteria, certain Gram-positive bacteria *(Enterococcus faecalis)* and archaea.
- Although the ED pathway is most prevalent among strictly aerobic Gram-negative bacteria, including species of *Pseudomonas* (e.g., *P. aeruginosa*), *Agrobacterium* (e.g., *A. tumefaciens*), *Azotobacter* (e.g., *A. vinelandii*), *Xanthomonas*, *Arthrobacter*, *Caulobacter*, and *Neisseria*, it is also present in many Gram-negative facultative anaerobes such as *E. coli* and *Vibrio* spp. (e.g., *V. cholerae*) as well as the nitrogen-fixing *Sinorhizobium*, photoheterotrophic *Rhodobacter* (e.g., *R. sphaeroides*), the nitrogen-oxidizing *Paracoccus* (e.g., *P. versutus*), and the cyanobacteria.
- Glucose is the starting product in the ED pathway and through a series of enzyme assisted chemical reactions it is catabolized into pyruvate.
- Michael Doudoroff and Nathan Entner in 1952 first reported the ED pathway in the bacterium *Pseudomonas saccharophila.*

...ED Pathway

- The ED pathway (**Figure 1**) represents an offshoot of the oxidative branch of the Pentose Phosphate Pathway.
- Glucose-6-phosphate, formed from the phosphorylation of D-glucose by ATP-dependent hexokinase, is converted to 6-phosphogluconate by the subsequent actions of Glc-6P dehydrogenase (Glc-6PDH) and 6-phosphogluconolactonase producing one $NADPH/H^+$.
- 6-Phosphogluconate is then converted to 2-keto-3-deoxy-6-phosphogluconate (KDPG) through the removal of a water molecule by the enzyme 6-phosphogluconate dehydratase.
- KDPG is then split by the enzyme KDPG aldolase into pyruvate and glyceraldehyde 3-phosphate (GAP).
- GAP can then be converted to pyruvate through the triose phosphate portion of the EMP pathway producing two ATP and one $NADH/H^+$.
- **Thus, a single glucose molecule catabolized through the ED pathway can be degraded to two pyruvates yielding a net one ATP plus one $NADPH/H^+$ and one $NADH/H^+$ depending on the microbe.**
- As a result, the ED pathway yields half the net amount of energy in the form of ATP from the catabolism of a single glucose molecule to two pyruvates compared with the EMP pathway.

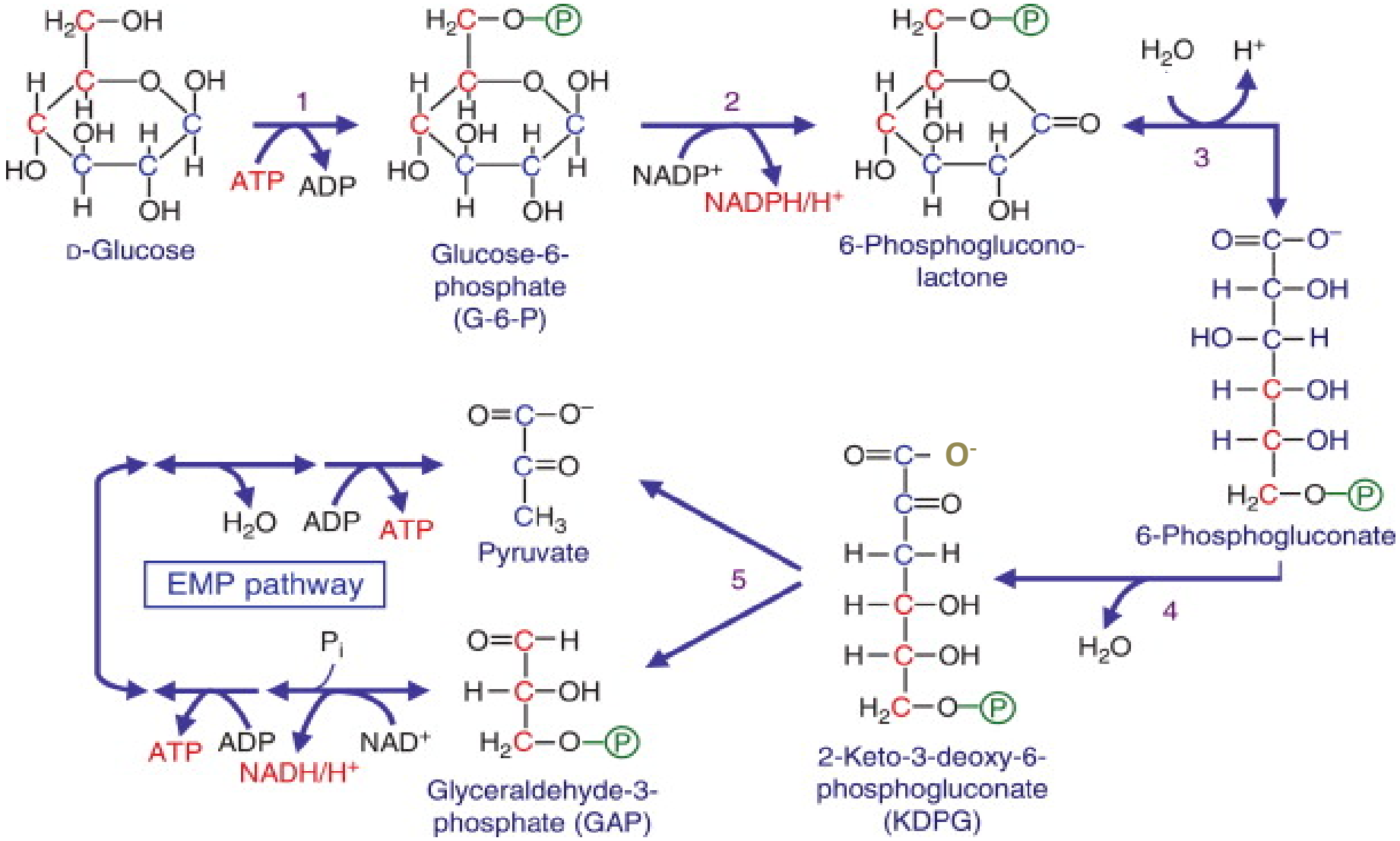
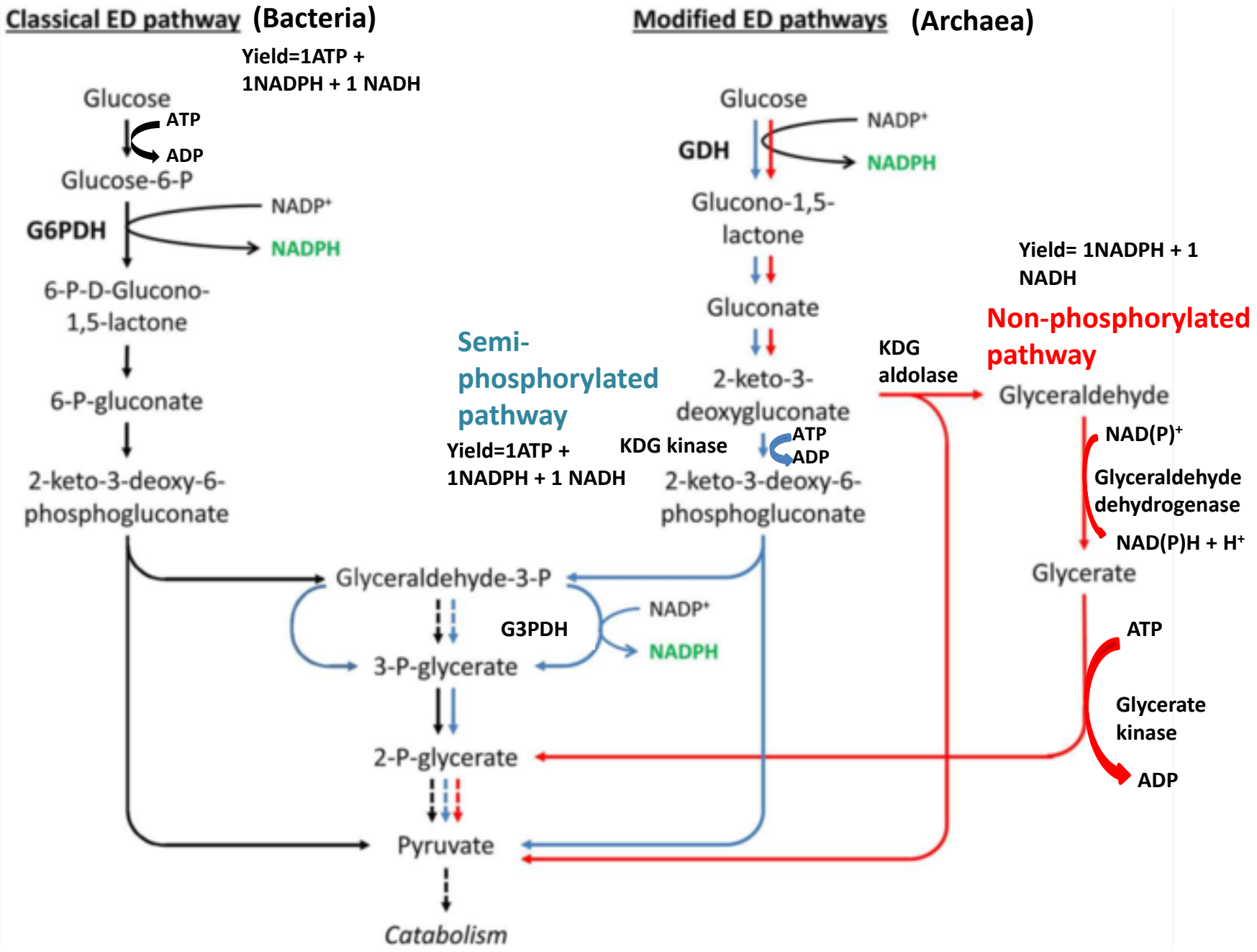


Figure 1. Entner–Doudoroff (ED) pathway. Enzymes catalyzing each step are as follows: (1) (ATP-dependent) hexokinase (aka, glucokinase), (2) glucose-6-phosphate dehydrogenase (Glc-6PDH), (3) 6-phosphogluconolactonase, (4) 6-phosphogluconate dehydratase, and (5) 2-keto-3-deoxy-6-phosphogluconate (KDPG) aldolase.

Modified ED Pathway

- It has been fund that in certain halobacteria, glucose is catabolized via a modified ED pathway in which phosphorylation occurs after the formation of 2-keto 3-deoxy gluconate (Figure 2).
- In contrast *Sulfolobus, Thermoplasma* metablizes glucose via an ED pathway in which no phospholylated intermediates are present (Figure 2).
- Thus, a single glucose molecule catabolized through the ED pathway can be degraded to two pyruvates yielding a net one ATP plus one $NADPH/H^+$ and one $NADH/H^+$ depending on the microbe.


Classical ED pathway (Bacteria)
Yield=1ATP + 1NADPH + 1 NADH
Glucose
ATP
ADP
Glucose-6-P
G6PDH
NADP+
NADPH
6-P-D-Glucono-1,5-lactone
6-P-gluconate
2-keto-3-deoxy-6-phosphogluconate
Modified ED pathways (Archaea)
Glucose
GDH
NADP+
NADPH
Glucono-1,5-lactone
Gluconate
Semi-phosphorylated pathway
Yield=1ATP + 1NADPH + 1 NADH
2-keto-3-deoxygluconate
KDG kinase
ATP
ADP
2-keto-3-deoxy-6-phosphogluconate
KDG aldolase
Yield= 1NADPH + 1 NADH
Non-phosphorylated pathway
Glyceraldehyde
NAD(P)+
Glyceraldehyde dehydrogenase
NAD(P)H + H+
Glycerate
ATP
Glycerate kinase
ADP
Glyceraldehyde-3-P
G3PDH
NADP+
NADPH
3-P-glycerate
2-P-glycerate
Pyruvate
Catabolism

Questions

- Explain Entner Duodoroff pathway.
- Explain modified ED pathways.
- Discuss differences between classical-ED and modified ED pathways.
- Explain ED pathway found in bacteria.
- Explain ED pathway found in archaea.