Synthesis summaries (\*\*All of them depend on phosphate because they use ATP; only exception may be Ala)

* Alanine
  + Uses NH3 directly (rxn00278\_c0) with pyruvate to form L-Alanine
  + Pyruvate derives from Acetyl-CoA, through CODH/ACS from methanogenesis
* Arginine
  + Gets its nitrogen from GOGAT (uses Glu, Gln, and Asp in its pathway)
    - Type 2 pathway in between cycles ornithine and other intermediates
  + Uses pyruvate, which traces back to methanogenesis through CODH/ACS
* Asparagine
  + Derived from Asp + NH3, so it uses both direct NH3 and the GOGAT cycle
    - Essentially GOGAT plus one ATP-requiring reaction
* Aspartate
  + Formed in the GOGAT cycle itself
* Cysteine
  + Derives directly from Ser plus sulfide
    - Serine ties back to Glu (GOGAT) and a glycolysis intermediate, which comes from methanogenesis and free phosphate
* Glutamate
  + Formed in the GOGAT cycle itself
* Glutamine
  + Formed in the GOGAT cycle itself
* Glycine
  + Major formation step is directly from Thr
    - Thr ties to Asp (GOGAT) and nothing else it appears
  + Minor Formation step is directly from Ser and a derivative of Asp, which is in GOGAT. It also has ties to Met, Gln (GOGAT), CO2, and sulfide.
    - Serine ties back to Glu (GOGAT) and a glycolysis intermediate, which comes from methanogenesis and free phosphate
    - Met depends directly on Ser synthesis, Gln (GOGAT), CO2, sulfide, Gly, the glycolysis intermediates that depend on methanogenesis
* Histidine
  + Ties back to Gln (GOGAT) and two glycolysis intermediates (F6P and G3P). Through those, it ties back to Pyruvate (methanogenesis) and phosphate itself. So it depends on:
    - GOGAT
    - Methanogenesis
    - Phosphate
* Isoleucine
  + Final synthesis step uses Glu (GOGAT), it also ties back to pyruvate (methanogenesis)
    - Pyruvate forks to create something else that reacts with itself
* Leucine
  + Final synthesis step uses Glu (GOGAT), it also ties back to pyruvate (methanogenesis)
    - Pyruvate forks to create something else that reacts with itself
* Lysine
  + Synthesis depends on Glu (GOGAT), pyruvate (methanogenesis), and Asp (GOGAT)
* Methionine (basically comes from EVERYWHERE)
  + Depends directly on Ser synthesis (steps follow), Gln (GOGAT), CO2, sulfide, Gly, the glycolysis intermediates that depend on methanogenesis
    - Serine Ties back to Glu (GOGAT) and a glycolysis intermediate, which comes from methanogenesis and free phosphate
* Phenylalanine
  + Depends on 2-oxoglutarate which goes back to GOGAT, plus on pyruvate and glycolysis, which are both tied to methanogenesis
* Proline
  + Ties to Glu (GOGAT) and nothing else it appears
* Serine
  + Ties back to Glu (GOGAT) and a glycolysis intermediate, which comes from methanogenesis and free phosphate
* Threonine
  + Ties to Asp (GOGAT) and nothing else it appears
* Tryptophan
  + Comes directly from Ser and an intermediate derived from glycolysis and pyruvate, so we have another tie two ties to methanogenesis
    - Serine Ties back to Glu (GOGAT) and a glycolysis intermediate, which comes from methanogenesis and free phosphate
* Tyrosine
  + Comes directly from Glu (GOGAT) and traces back to glycolysis and pyruvate, so it ties to methanogenesis
* Valine
  + Comes directly from Glu (GOGAT) and from intermediates deriving from pyruvate (methanogenesis)

Amino Acids Synthesis Categories

1. Involved in GOGAT Cycle
   1. L-Aspartate
   2. L-Glutamate
   3. L-Glutamine
2. Requires only GOGAT Cycle
   1. L-Asparagine
3. Requires only Methanogenesis
   1. L-Alanine
4. Requires only GOGAT cycle and Methanogenesis
   1. L-Arginine
5. Requires GOGAT, Methanogenesis, and other pathways (but not sulfide)
6. Requires GOGAT, Methanogenesis, sulfide, and other pathways
   1. L-Cysteine