Residual feed intake (RFI), used as a metabolic efficiency measurement, is BW and growth rate independent and also is a moderately heritable trait. Previous research reported RFI was correlated to feed activity and behavior, ruminal fermentation nutrient digestion, body composition, blood hormones and metabolites as well as mitochondria function. Since mitochondria are responsible for producing 90% of the energy for the cell, some of the variations in growth performance and phenotypic expression of feed efficiency might be due to differences or inefficiencies in mitochondria function. Three studies were conducted to understand how AA requirement and mitochondria function influence different RFI phenotypes. The first study had 3 diets with increasing RUP (LOW, MID and HIGH) fed to continuous culture fermenters to characterize RUP supplementation using forage-based diet. We observed RUP supplementation in forage-based diets increased RUP flow from the rumen without influencing microbial fermentation. Reduced RUP for HIGH compared to MID may be due to microbial adaptation to greater RUP levels. The second study evaluated the effects of postruminal AA supply during the GP on growth performance, carcass measurements, RFI, and blood metabolites using roughage-based diet. We reported no interaction between level of bypass AA during growing phase and RFI, leading to main effects examination. Calves consuming diets with postruminal AA supplied above requirements may respond with greater gain rate, however improved growth was not sustained throughout the feeding period. As RFI decreased, steers consumed less feed and were more efficient with no change in BW during all periods. Steers classified as efficient during growing phase were not necessary in the same category during finishing phase. The last study conducted determined if mitochondria complex I, complex III and subunits (from complex I) differed among RFI phenotypes and if mitochondria measurements could account for additional differences in DMI. Examination of lymphocyte mitochondria proteins (complex I, complex I subunits and complex III) found a relationship between mitochondria band I, band VI and RFI. Mitochondrial measurements increased coefficient of determination for intake prediction. These results led to the conclusion that mitochondrial function is in part responsible for animals metabolic efficiency differences.