Hormonal Regulation of Metabolism

	Insulin	Glucagon	Epinephrine	Cortisol	Growth Hormone
Liver					
Glycogen breakdown	↓	↑	↑		
Glycogen synthesis	↑	↓	↓	↑	
Gluconeogenesis	↓	↑	↑	↑	
Glycolysis	↑	↓	↓		
Glucose release	↓	↑	↑	↑	
Glucose uptake	↑	↓	↓		
Glucagon receptor				↑	
Skeletal Muscle					
Glycogen breakdown	↓		↑		
Glycogen synthesis	↑		↓		
Glycolysis			↑†	↓	
Glucose uptake	↑		†	↓	
Protein catabolism	↓			↑	
Amino acid uptake	↑			↓	↑
Amino acid release	↓			↑	
Adipose Tissue					
Lipolysis	↓		↑	↑	↑
Glucose uptake	↑			↓	
Pancreas					
Insulin release	↓	↑	↓	↓	
Glucagon release	↓	↓	↑		
Systemic Effects					
Insulin action	↑*			↓	↓

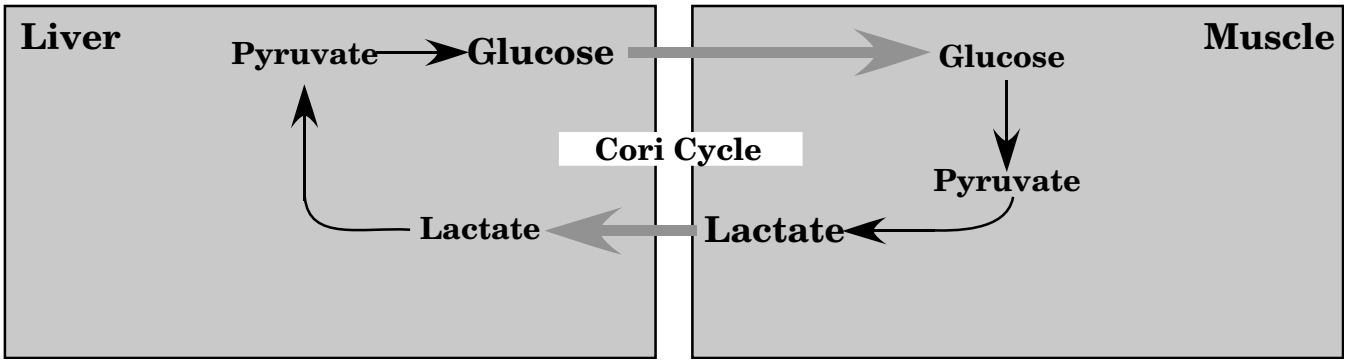
*Note: Insulin obviously has "insulin actions", hence the ↑; however, prolonged high levels of insulin decrease the insulin response in target tissues.

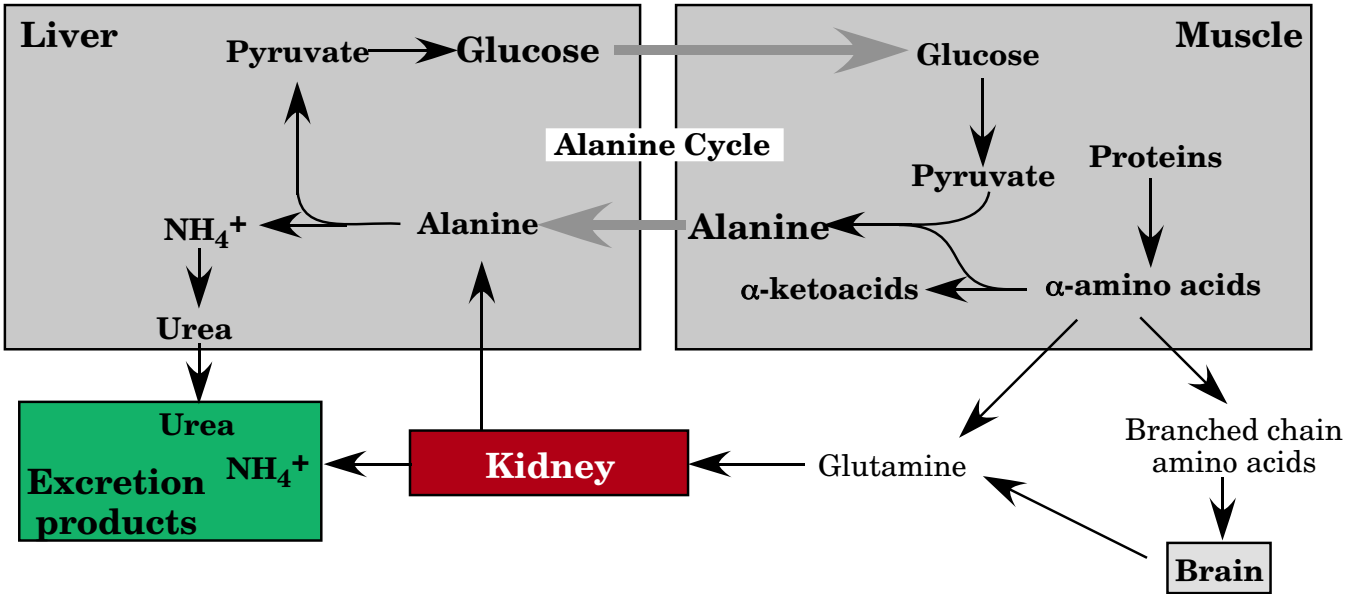
†Note: epinephrine-induced effects on muscle glucose metabolism are relatively small in the absence of exercise. Glucose uptake in muscle is stimulated by exercise, but is probably not directly affected by epinephrine.

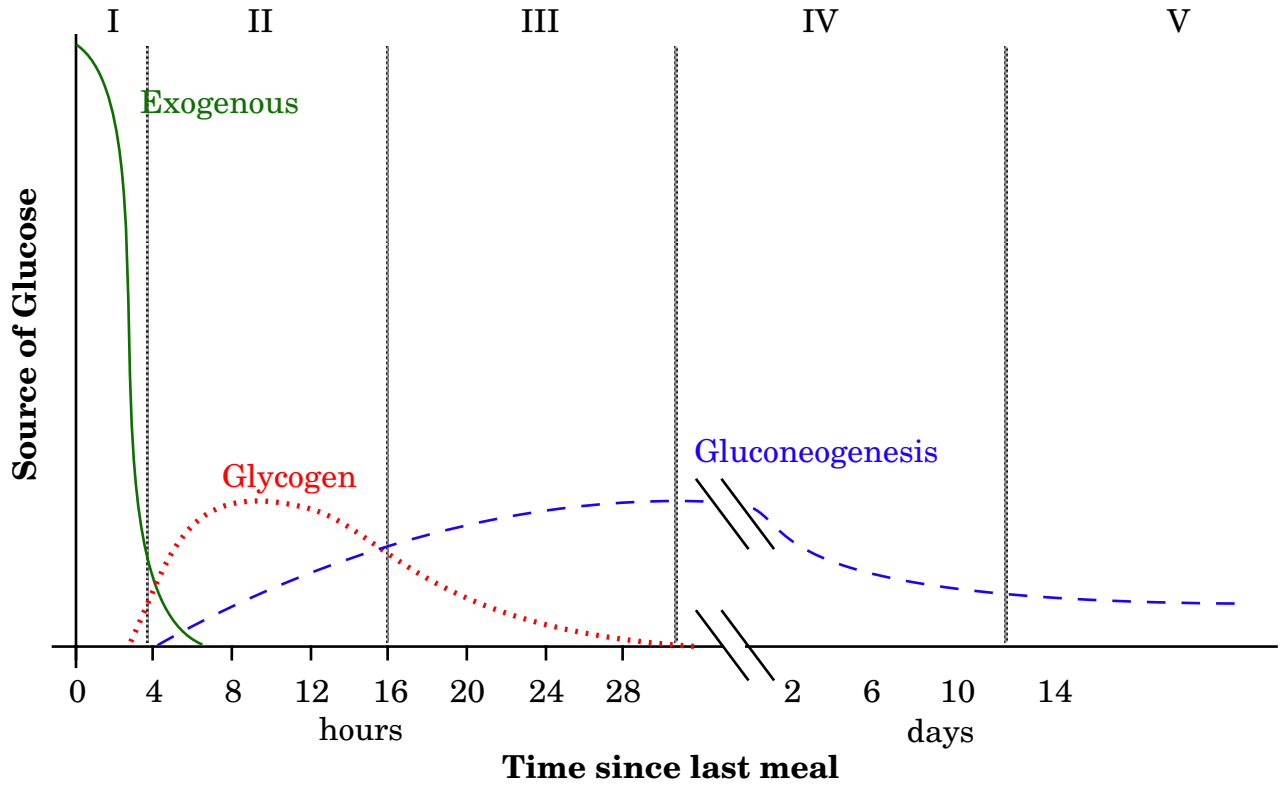
Fuel reserves of "typical" 70 kg individual

Organ	Available energy (kcal)		
	Glucose/glycogen	Triacylglycerols	Degradable Protein
Brain	8	0	0
Blood	60	45	0
Liver	400	450	400
Muscle	1200	450	24,000
Adipose tissue	80	135,000	40

(modified from Stryer (1995) *Biochemistry*, 4th Ed.)







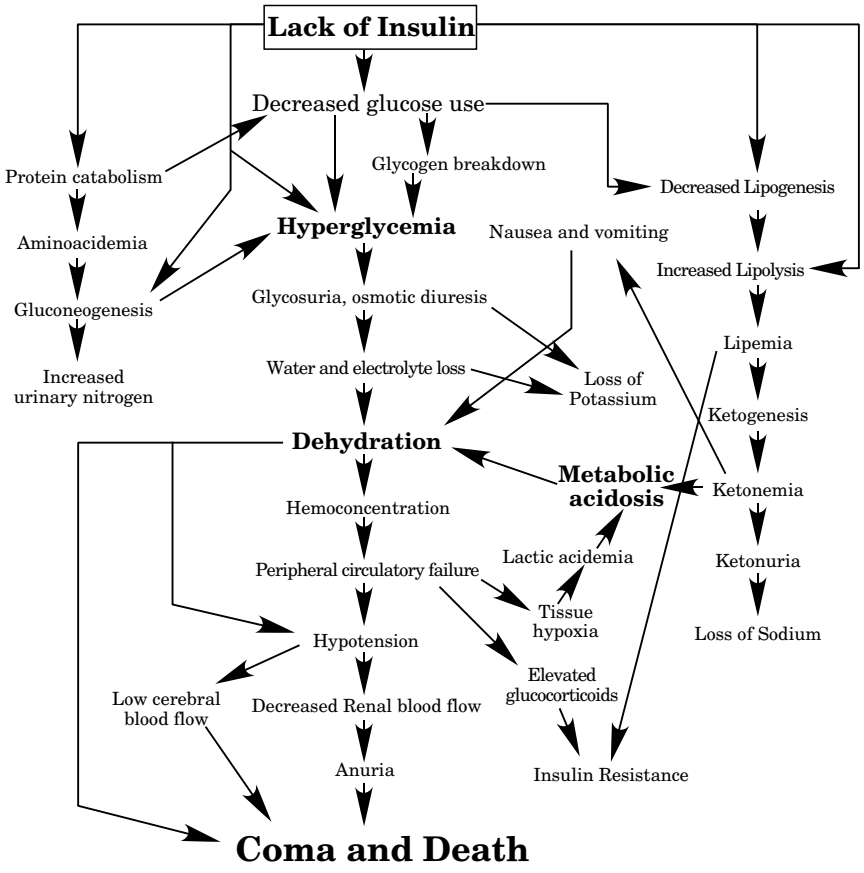
	I	II	III	IV	V
Origin of glucose	Diet	Glycogen, Hepatic Gluconeogenesis	Hepatic Gluconeogenesis, Glycogen	Hepatic Gluconeogenesis, Renal Gluconeogenesis	Hepatic Gluconeogenesis, Renal Gluconeogenesis
Major Brain fuel source	Glucose	Glucose	Glucose, branched chain AA	Glucose, AA, Ketone bodies	Ketone bodies, Glucose
Tissues using glucose	All	All except liver	All except liver	Brain, Blood cells, muscle (for exercise)	Brain, Blood cells
Hormonal response	Insulin ↑	Insulin ↓ Glucagon ↑	Insulin ↓↓ Glucagon ↑ Cortisol ↑	Insulin ↓↓ Glucagon ↑ Thyroid hormone ↓	Insulin ↓↓ Glucagon ↑ Thyroid hormone ↓
Change in Muscle protein	↑	—	↓↓↓	↓↓	↓
Change in Adipose stores	↑	↓	↓↓	↓↓↓	↓↓

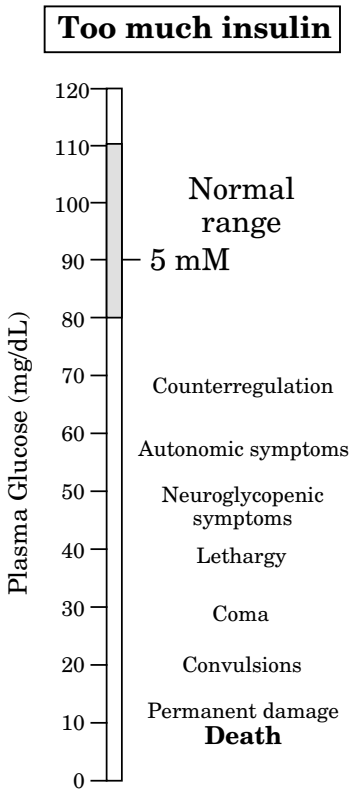
Diabetes Mellitus: Type I

Insulin-dependent diabetes mellitus (IDDM)
"Juvenile-onset" diabetes

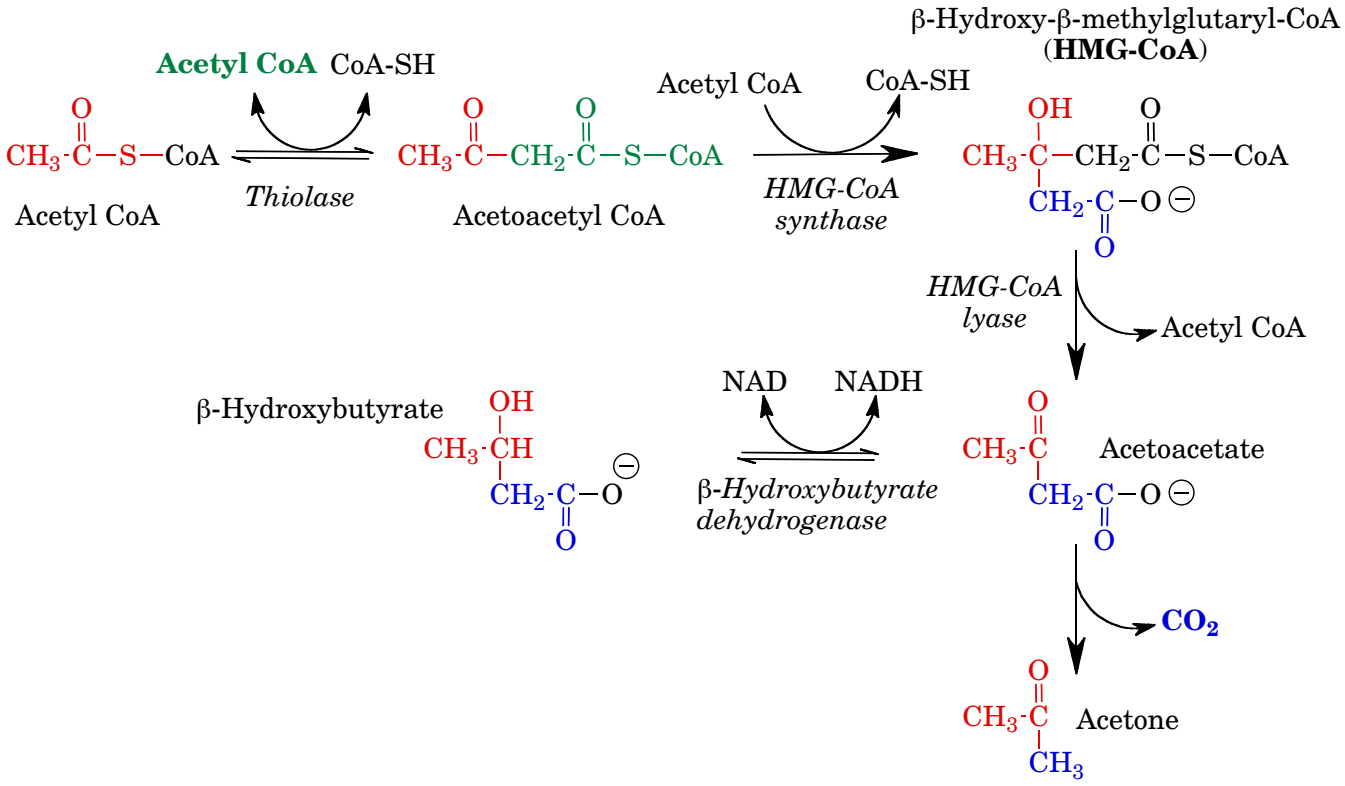
Diabetic Ketoacidosis (DKA)

Frequent urination (Polyuria) – Osmotic diuresis
Extreme thirst (Polydipsia)
Extreme hunger (Polyphagia)
Peripheral neuropathy
Weakness
Kussmaul respiration
Vision alterations





Ketone Body Synthesis

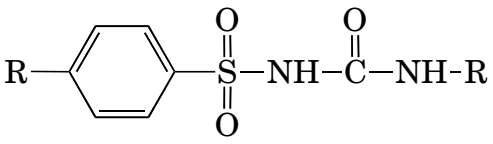


Diabetes Mellitus: Type II

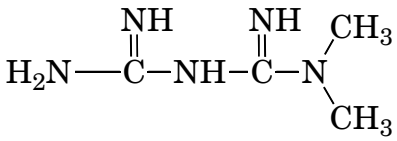
Non-insulin-dependent diabetes mellitus (NIDDM)
"Adult-onset" diabetes

Hyperglycemic HyperOsmotic Non-Ketotic Coma (HONK)

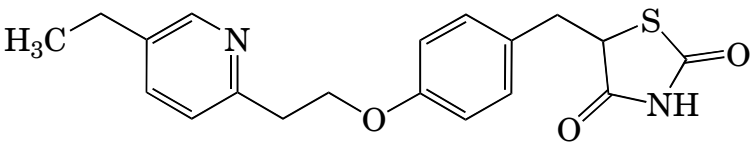
Oral Antihyperglycemic Drugs



Sulfonylurea



Biguanide
(metformin)



Thiazolidinedione
(pioglitazone)