Summary of Blood Glucose Regulation

In a normal person, the blood glucose concentration is narrowly controlled, usually between 80 and 90 mg/100 ml of blood in the fasting person each morning before breakfast. This concentration increases to 120 to 140 mg/100 ml during the first hour or so after a meal, but the feedback systems for control of blood glucose rapidly return glucose concentration back to the control level, usually within 2 hours after the last absorption of carbohydrates. Conversely, in a state of starvation, the gluconeogenesis function of the liver provides the glucose that is required to maintain the fasting blood glucose level.

The mechanisms for achieving this high degree of control have been presented in this chapter and may be summarized as follows:

1. *The liver functions as an important blood glucose buffer system.* That is, when blood glucose rises to a high concentration after a meal and insulin secretion also increases, as much as two thirds of the glucose absorbed from the gut is almost immediately stored as glycogen in the liver. Then, during the succeeding hours, when blood glucose concentration and insulin secretion fall, the liver releases the glucose back into the blood. In this way, the liver decreases fluctuations in blood glucose concentration to about one third of what they would be otherwise. In fact, in patients with severe liver disease, it becomes almost impossible to maintain a narrow range of blood glucose concentration.

2. *Both insulin and glucagon function as important feedback control systems for maintaining a normal blood glucose concentration.* When the glucose concentration rises too high, increased insulin secretion causes blood glucose concentration to decrease toward normal. Conversely, a decrease in blood glucose stimulates glucagon secretion; the glucagon then functions in the opposite direction to increase glucose toward normal. Under most normal conditions, the insulin feedback mechanism is more important than the glucagon mechanism, but in instances of starvation or excessive utilization of glucose during exercise and other stressful situations, the glucagon mechanism also becomes valuable.

3. In severe hypoglycemia, a direct effect of low blood glucose on the hypothalamus also stimulates the sympathetic nervous system. The epinephrine secreted by the adrenal glands further increases release of glucose from the liver, which also helps protect against severe hypoglycemia.

4. Finally, over a period of hours and days, both growth hormone and cortisol are secreted in response to prolonged hypoglycemia. They both decrease the rate of glucose utilization by most cells of the body, converting instead to greater amounts of fat utilization. This process, too, helps return the blood glucose concentration toward normal.

Importance of Blood Glucose Regulation.

One might ask, “Why is it so important to maintain a constant blood glucose concentration, particularly because most tissues can shift to utilization of fats and proteins for energy in the absence of glucose?” The answer is that glucose is the only nutrient that normally can be used by the brain, retina, and germinal epithelium of the gonads in sufficient quantities to supply them optimally with their required energy. Therefore, it is important to maintain the blood glucose concentration at a level sufficient to provide this necessary nutrition.

Most of the glucose formed by gluconeogenesis during the interdigestive period is used for metabolism in the brain. Indeed, it is important that the pancreas not secrete insulin during this time; otherwise, the scant supplies of glucose that are available would all go into the muscles and other peripheral tissues, leaving the brain without a nutritive source.

It is also important that blood glucose concentration not rise too high for several reasons:

1. Glucose can exert a large amount of osmotic pressure in the extracellular fluid, and a rise in glucose concentration to excessive values can cause considerable cellular dehydration.

2. An excessively high level of blood glucose concentration causes loss of glucose in the urine.

3. Loss of glucose in the urine also causes osmotic diuresis by the kidneys, which can deplete the body of its fluids and electrolytes.

4. Long-term increases in blood glucose may cause damage to many tissues, especially to blood vessels. Vascular injury associated with uncontrolled diabetes mellitus leads to increased risk for heart attack, stroke, end-stage renal disease, and blindness.