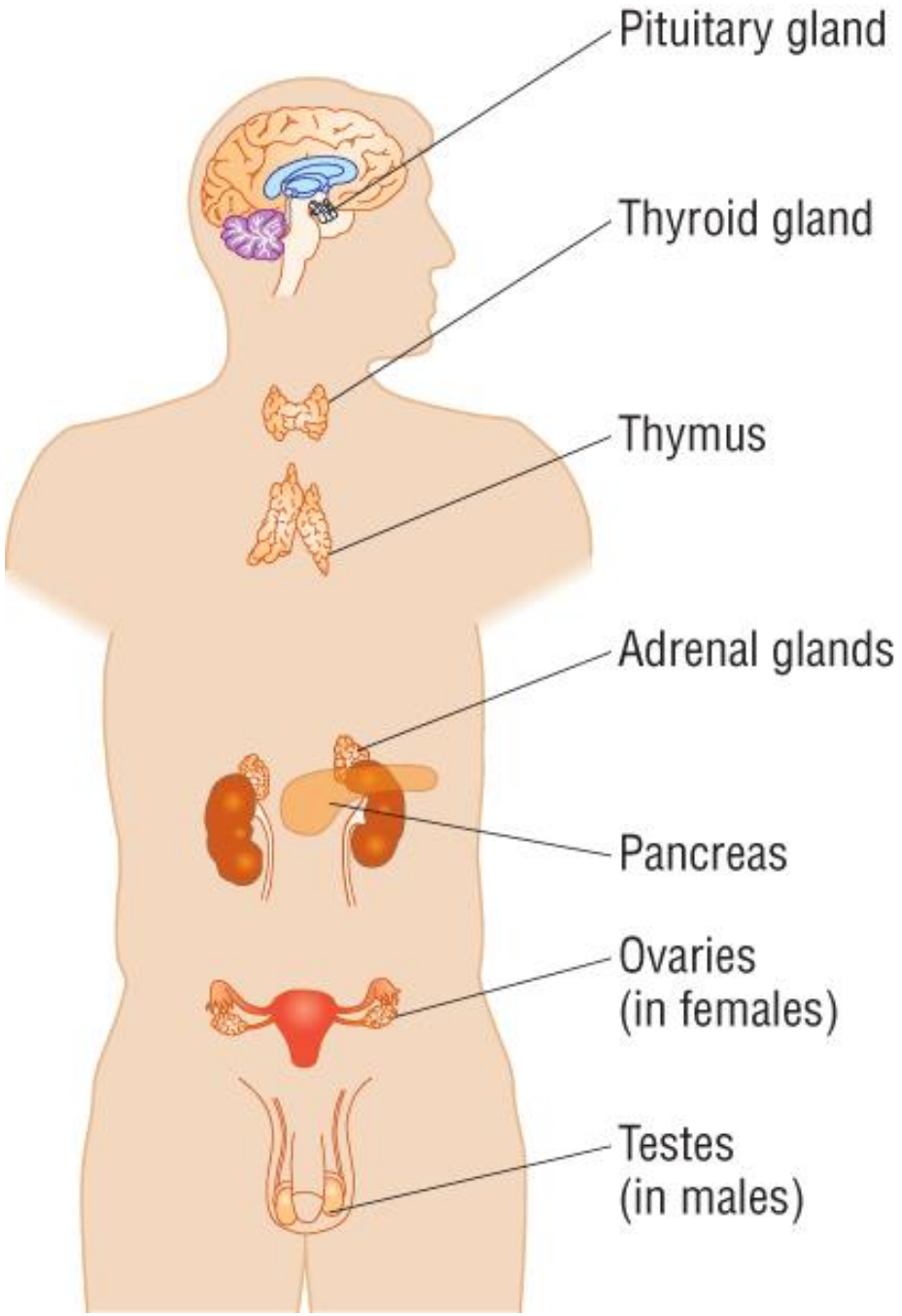
The Endocrine System

- Define the terms: *endocrine gland*; *exocrine gland*; *hormone*; and *target tissue*.
- Explain the meaning of the terms: *first messenger*; and *second messenger* .
- Describe the functions of the adrenal glands.
- Describe with the histology of the pancreas, and outline its role as an endocrine and exocrine gland.
- Explain how blood glucose concentration is regulated.
- Compare and contrast the causes of type I (insulin-dependent) and type II (non-insulin- dependent) diabetes mellitus.
- Discuss the use of insulin produced by genetically modified bacteria and the potential use of stem cells to treat diabetes mellitus.
- Outline the hormonal and nervous mechanisms involved in the control of heart rate in humans.

The Endocrine System

- Uses hormones released into the blood.
  - Hormones released from endocrine glands.
    - Ductless glands (bunch of cells) that produce & release hormones directly into blood capillaries.

Endocrine glands



Target Cells

- Have shape-specific receptors on their surface that fit a particular hormone.
  - Only the cells that contain the receptor for a hormone can respond to it.

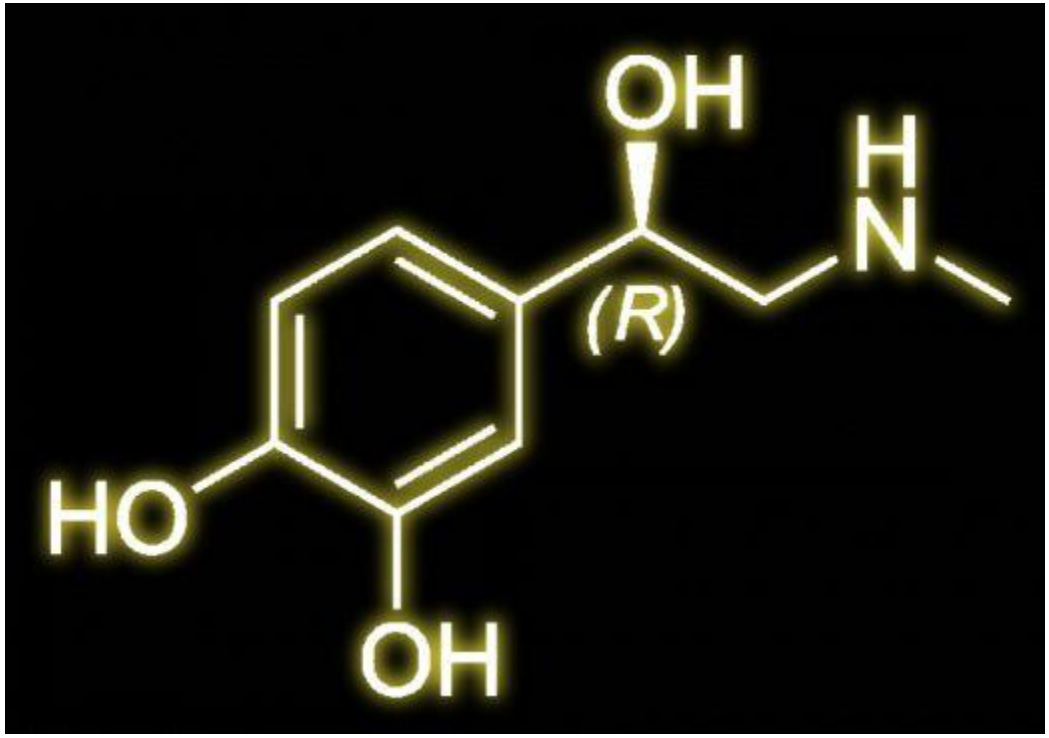
Two types of hormone. Two types of action.

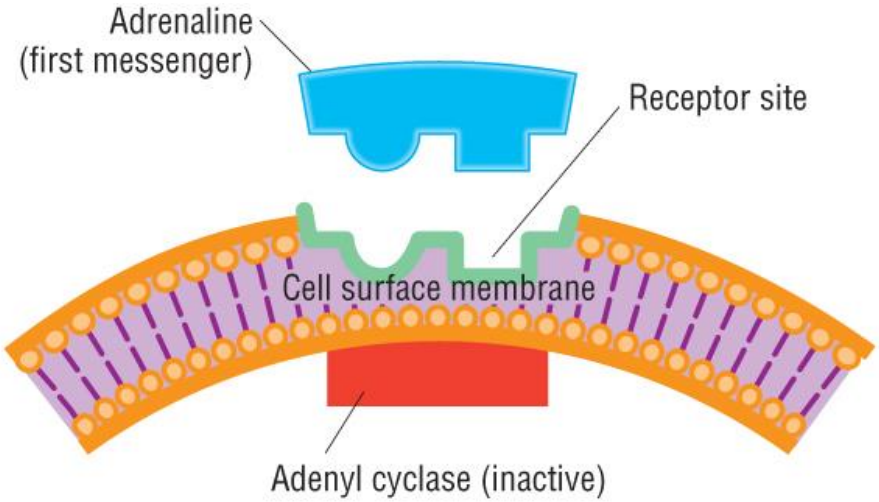
- Protein/peptide hormones.
  - Bind to receptors on the target cell membrane.
  - The hormone-receptor complex causes chemical changes within the cell & produces a specific response.

- Steroid hormones.
  - Soluble in lipids so can pass across the cell membrane.
  - Hormone binds with a receptor protein and is taken into the nucleus.
  - Hormone-receptor complex binds to a specific gene, turning it on or off.
  - Therefore controls protein synthesis

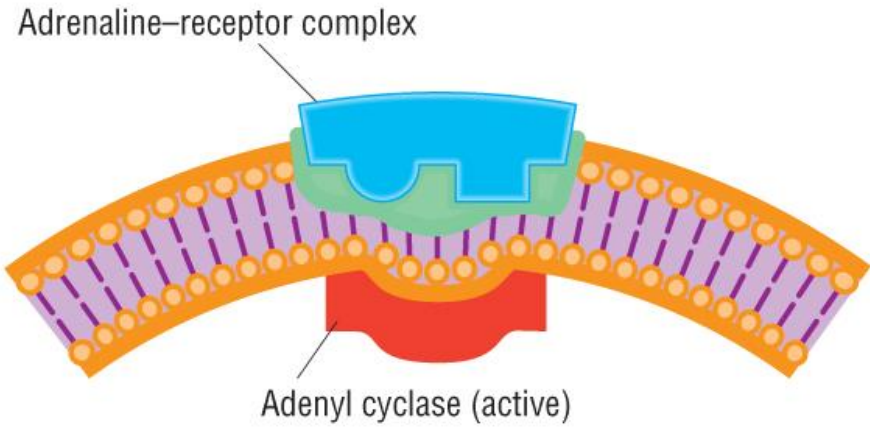
Adrenaline

- An amino acid derivative (polar).
  - So unable to enter cells

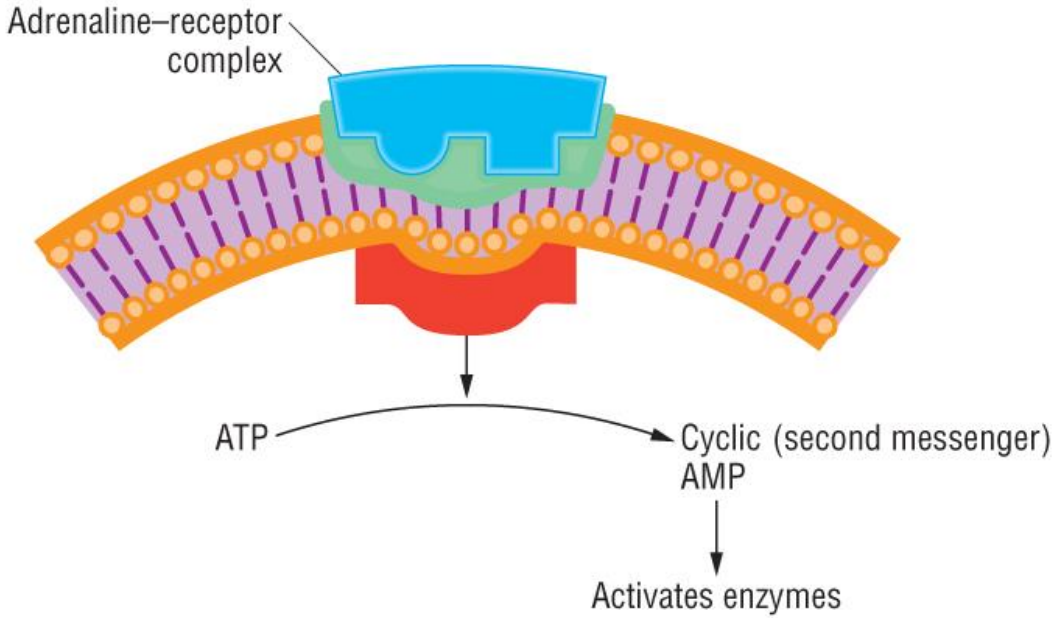




1. Adrenaline receptor site has shape complementary to adrenaline



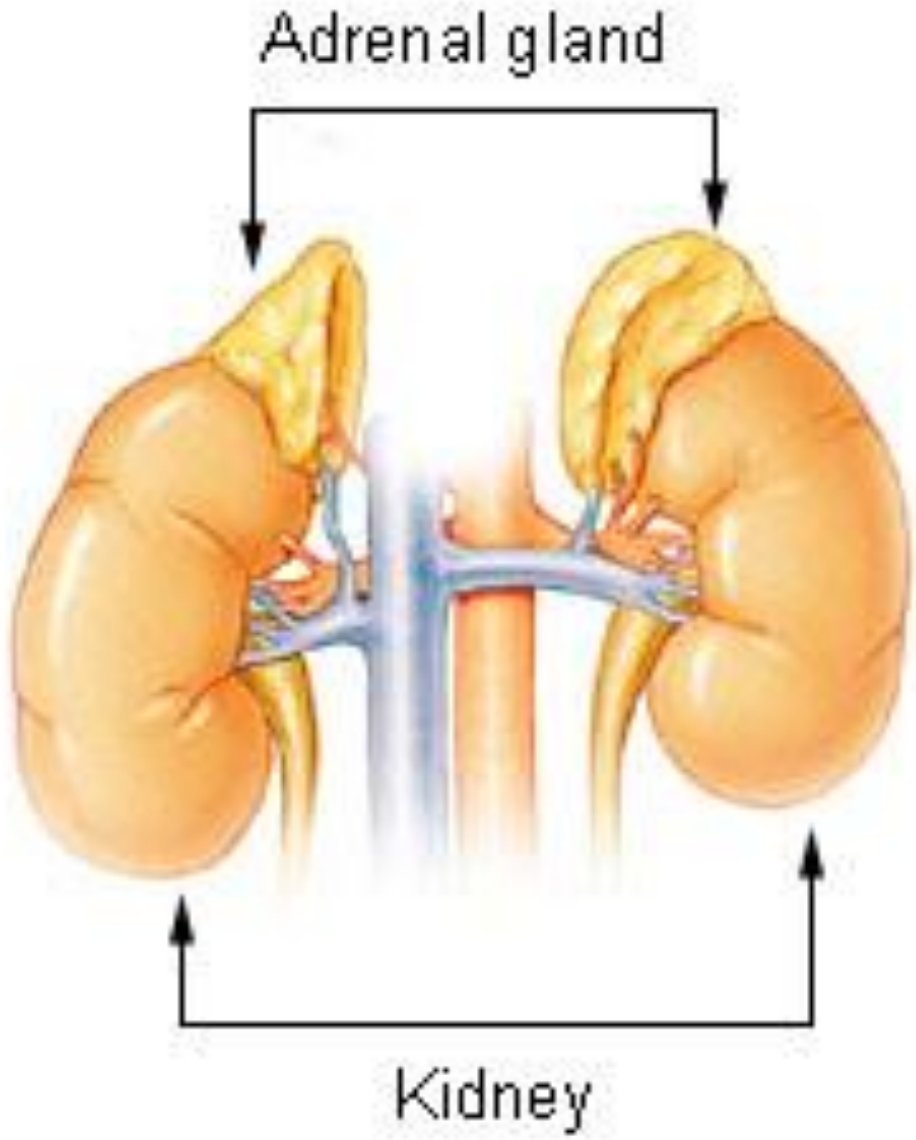
2. Adrenaline activates the enzyme adenyl cyclase



3. Adenyl cyclase converts ATP to cAMP, which can activate other enzymes inside the cell

The action of adrenaline

Adrenal Gland



Each gland is divided into Medulla & Cortex regions

Adrenal Medulla

- The centre of the gland
- Cells manufacture & release adrenaline in response to pain or shock.
  - Relaxes bronchiole smooth muscle.
  - Increase cardiac stroke volume & heart rate.
  - Stimulates glycogen → glucose.
  - Causes widespread vasoconstriction.
  - Inhibits gut actions.
  - Increases mental awareness.
  - Dilates pupils.
  - Causes body hair to erect.

Adrenal Cortex

- Outer part of the gland.
- Produces steroid hormones from cholesterol.
  - Aldosterone: controls Na^+ & K^+ in blood.
  - Cortisol: stimulates production of glucose from amino acids & glycerol in liver cells.

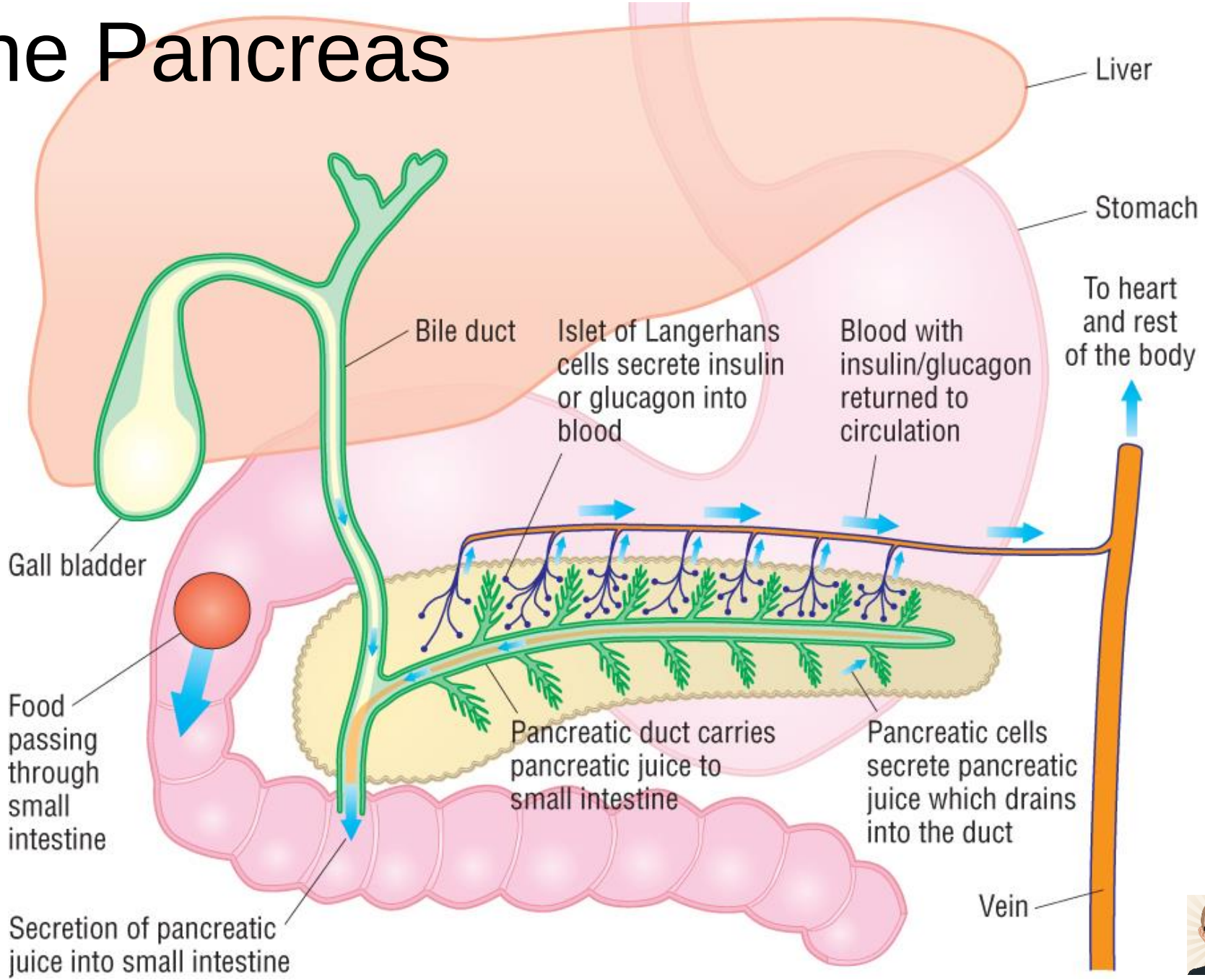
Regulation of Blood Glucose.

- Homeostatic control of blood glucose is essential:
  - Hypoglycaemia (low blood glucose).
    - Cells deprived of energy.
    - Brain is particularly sensitive as it can only respire glucose.
  - Hyperglycaemia (high blood glucose).
    - Lowers water potential of blood.
    - Causes osmotic problems & dehydration.

Why does blood glucose vary?

- Glucose in:
  - From the diet.
  - From the breakdown of glycogen (glycogenolysis).
  - From gluconeogenesis.
- Glucose out:
  - Cellular respiration.
  - Glycogenesis.

The Pancreas



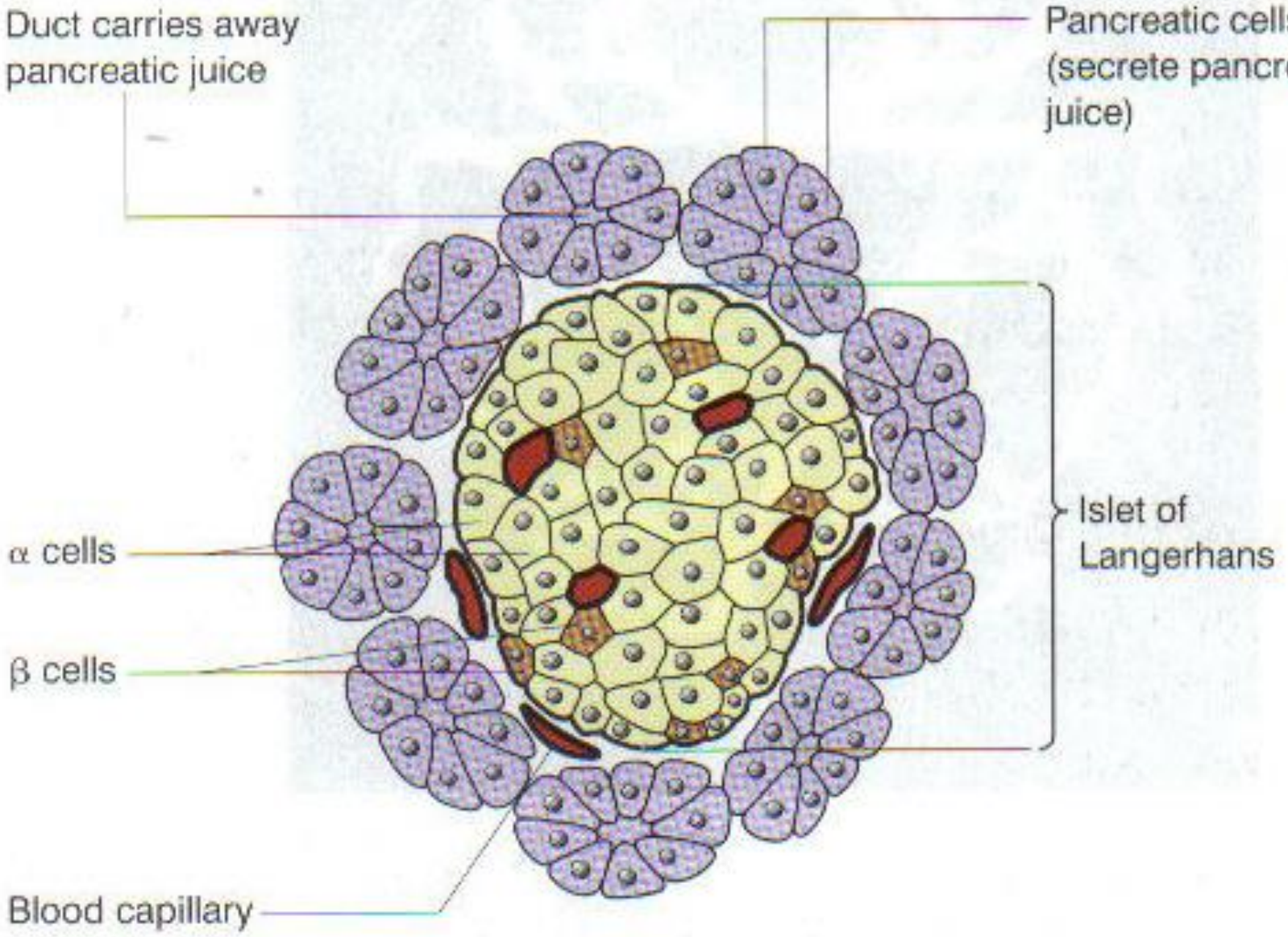


Fig 6.32 *Section through the pancreas showing an islet of Langerhans*

Insulin binds to receptors on almost all cell membranes

Blood glucose level lowered by one of 4 ways.

β cells respond by secreting insulin into the blood

Hyperglycaemia

Return of blood glucose level to normal.

Blood glucose level rises

An example of negative feedback.

β cells reduce insulin secretion

Normal blood glucose level

Blood glucose level falls

α cells reduce glucagon secretion

An example of negative feedback.

α cells respond by secreting glucagon into the blood

Hypoglycaemia

Return of blood glucose level to normal.

Glucagon binds to receptors on hepatocyte membranes only

Blood glucose level raised by one of 2 ways.

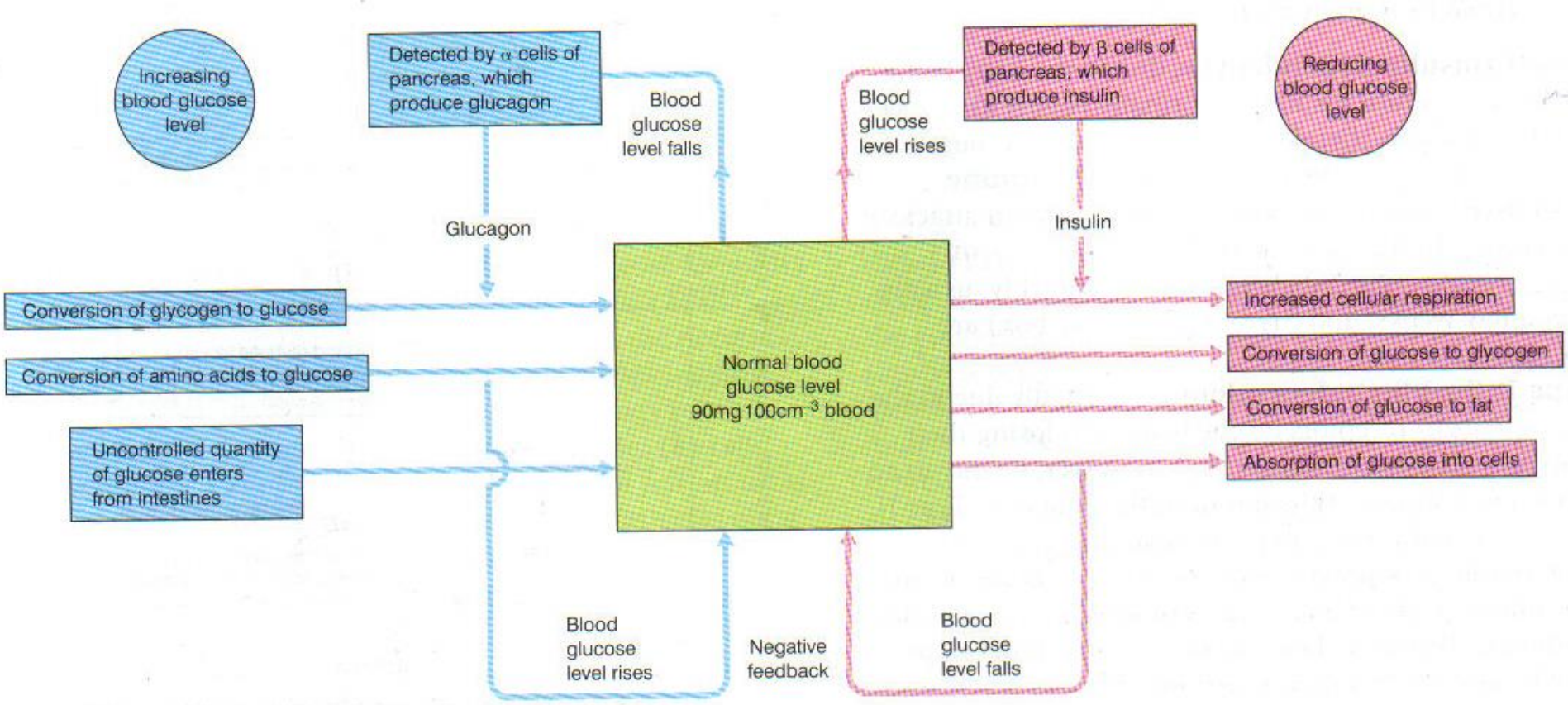
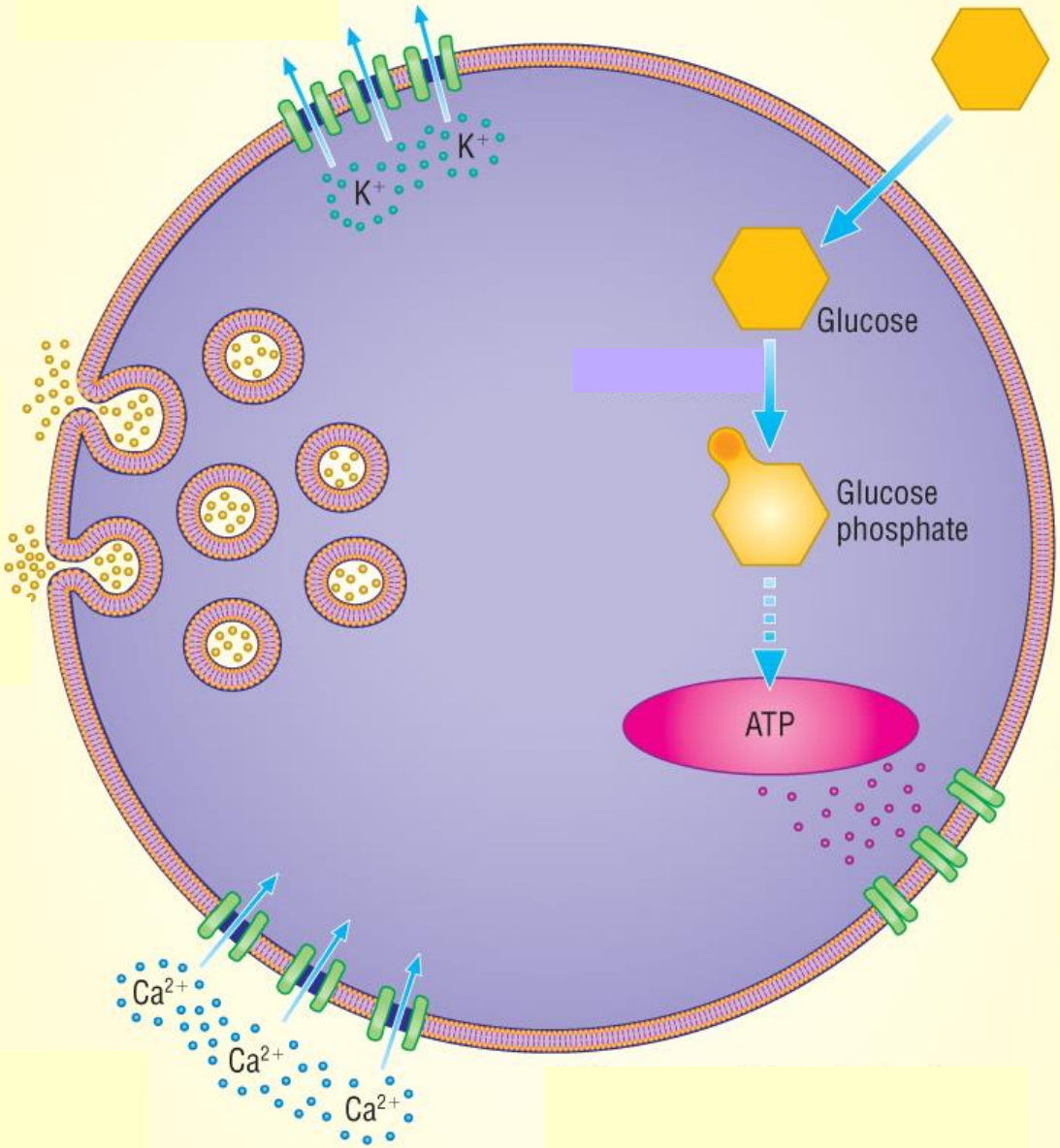


Fig 6.33 *Summary of regulation of blood glucose*

Regulating insulin levels



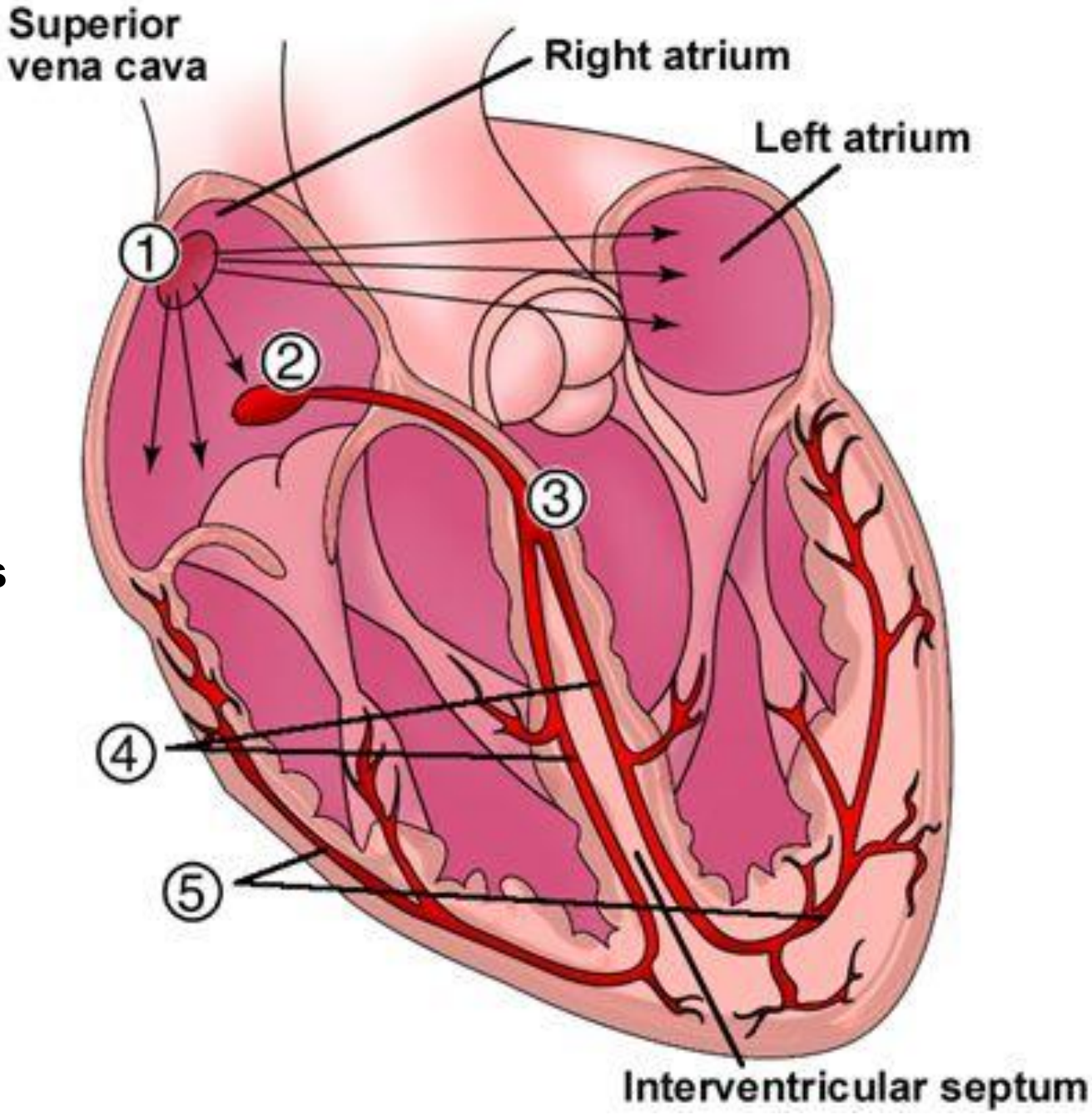
Diabetes Mellitus (Diabetes)

- Inability to control blood glucose concentration.
- Type I Diabetes
  - Called insulin dependant or early onset diabetes.
  - Body's immune system attacks β cells so insufficient insulin produced.
- Type II Diabetes
  - Non insulin dependant diabetes.
  - Reduced number of insulin receptors on muscle & liver cells with age.

Control of Heart Rate

- Essential that the heart rate responds to the needs of the individual.
  - Homeostasis of blood composition
- Variations can occur to:
  - Heart rate
  - Strength of each beat
  - Stroke volume

1. SA Node
2. AV Node
3. Bundle of His
4. Left & right branches of the bundle
5. Bundle branches

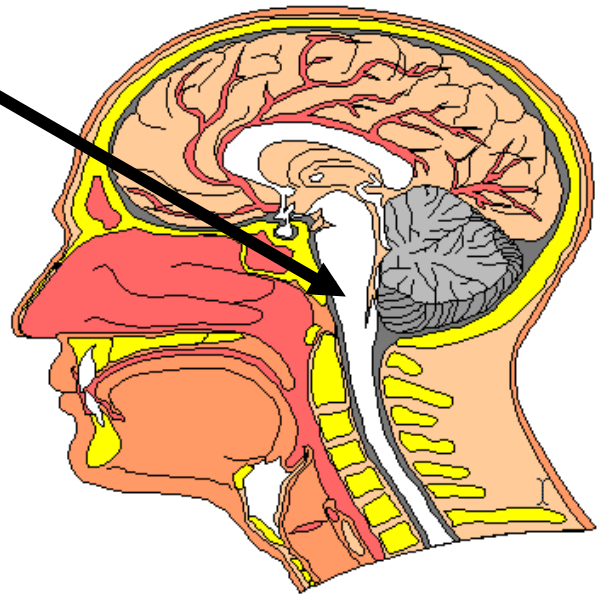


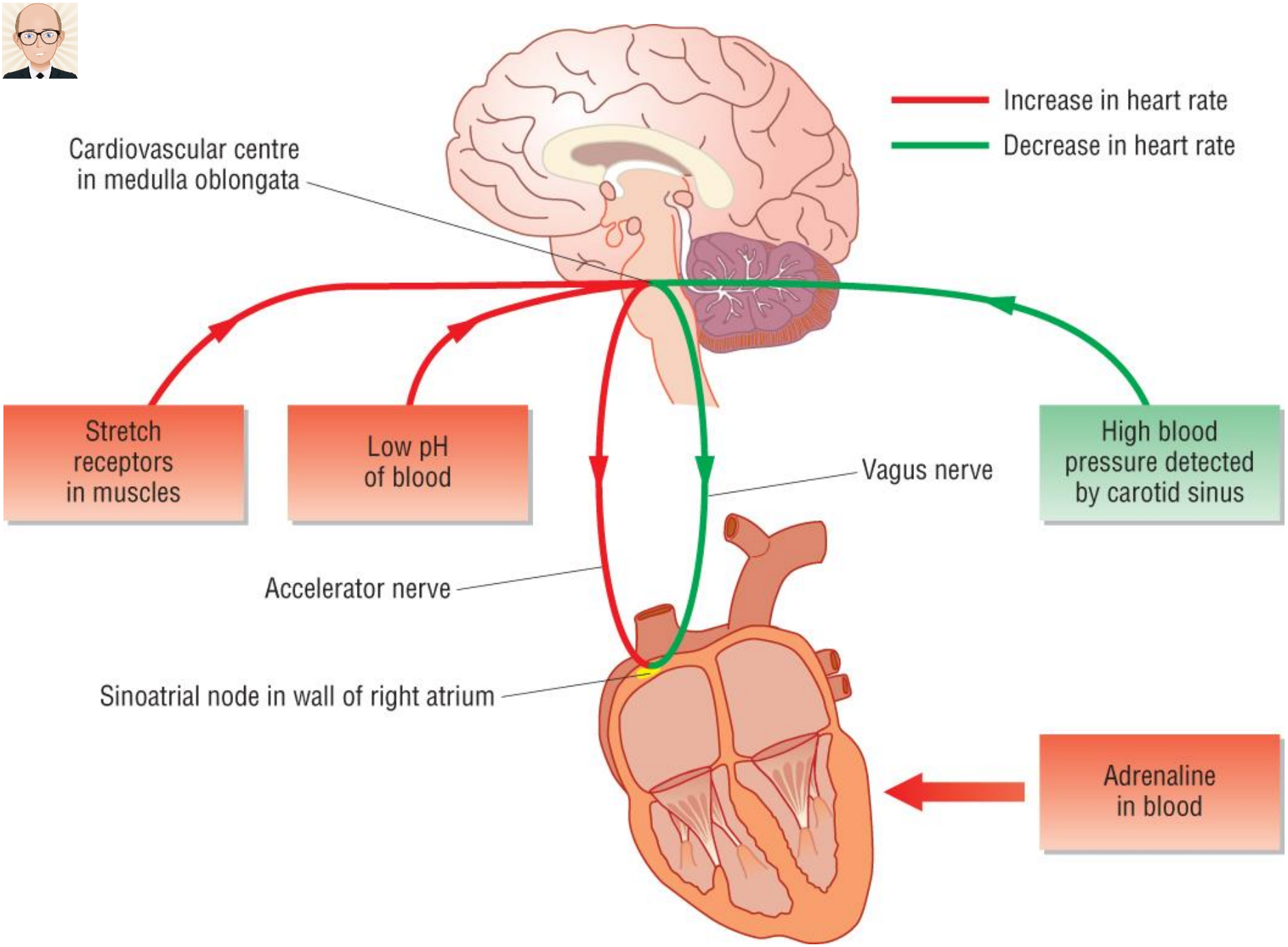
Regulation of Heartbeat

- The SA Node is responsible for initiating the heartbeat.
  - Has a set frequency of 60-80 bpm.
- The SA Node is supplied with nerves from the autonomic nervous system.
  - This is divided into two parts:
    - Sympathetic system.
    - Parasympathetic system.
  - The two parts are antagonistic.

What controls the autonomic nerves?

- The medulla oblongata.
  - Contains a cardiovascular centre.
  - This receives sensory information from receptors.
  - Sympathetic or parasympathetic systems are activated accordingly.




Increase in heart rate
Decrease in heart rate
Cardiovascular centre in medulla oblongata
Stretch receptors in muscles
Low pH of blood
Vagus nerve
High blood pressure detected by carotid sinus
Accelerator nerve
Sinoatrial node in wall of right atrium
Adrenaline in blood

An artificial pacemaker…

- Can be used to correct slow or disrupted heartbeats caused by disease or old age.
- Are electronic devices implanted under the skin.
- Generate a pulse to one or more chambers of the heart.
  - Some send regular pulses to the heart.
  - Some react to the heartbeat & only send a pulse when the ventricles miss a beat.