Maintain Blood Glucose Levels

BLOOD GLUCOSE LEVELS (mg/dL)

Fasting range: 80-100

After eating: 170-200

NOT GOOD

survive!

range
How does your body do this?

NEED GLUCOSE:

1. glycogen — quickly converts into glucose
   - skeletal muscle
   - liver

2. make glucose!
   - gluconeogenesis (uses amino acids)

3. use alternative energy sources
   - fatty acid oxidation

GLUCAGON
How does your body do this?

Too much glucose?

- call insulin (hormone)
  - β cells
  - pancreas

T1D: Type 1 Diabetes

- T1D: β cells die
- no insulin available

Insulin resistance
- insulin does not work anymore
HORMONES DEDICATED FOR GLUCOSE IN BLOOD

I need ~120g of glucose/day! Approx. 70% of calories

YIN + YANG OF GLUCOSE MANAGEMENT
GLUCOSE IN BLOOD → mg/dL

Fasting level = diabetes

HYPERGLYCEMIA

Eat food

Insulin release

Glucagon release

HYPOGLYCEMIA → tired, lethargic, coma...

TIME OF DAY
Insulin
- use glucose
  - Glucose is oxidized
    - glycolysis $\Rightarrow$ ATP

GLYCOGENESIS
- make glycogen
  - liver/muscle

LIPOGENESIS
- make lipids
  - fatty acids
  - adipose tissue
Glucagon

glycogen → glucose

glycogen → glucose

amino acids → glucose

Fatty acids → ketone bodies

Glycogenolysis: breaking down glycogen

Gluconeogenesis: making glucose from AA

Ketogenesis: "starvation energy" used by brain
inhibit

each other

*mostly,
Blood → Glucose → Insulin Receptor → Nucleus → Muscle Cell
BLOOD

Glucose

Insulin receptor

Nucleus

Insulin binds to insulin receptor

Muscle cell
glucose

insulin receptor

nucleus

insulin binds to insulin receptor

CELL SIGNAL

glucose transporters

muscle cell
LIVER

arrow pointing to small intestine labeled "small intestine"

arrow pointing to "arterial blood O₂ rich"
LIVER

arterial blood O₂ rich

venous blood O₂ poor

nutrient rich blood flow

portal vein

trigger hormone release

small intestine
CROSS-SECTION OF THE PANCREAS:

- DIGESTION
- HORMONAL

mixed gland

1. exocrine
2. endocrine

glucose regulation!
endocrine

Islets of Langerhans

β cells

insulin
endocrine

Islets of Langerhans

α cells (glucagon)
endocrine

Islets of Langerhans

S cells

somatostatin
endocrine

Islets of Langerhans

F-cells

Pancreatic polypeptide
ORGANIZATIONAL STRUCTURE:

Islet of Langerhans

Endocrine

Exocrine

α cells

Glucagon

Around the edge

β cells (Insulin) ↓ centrally located
INSULIN SECRETION β CELLS:
How does a β-cell secrete insulin into the blood?

Insulin is inside a secretory vesicle.
How does a β-cell secrete insulin into the blood?
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- Voltage-gated Ca++ Channel (opens when cell depolarizes)
- K+ (Rest)
- K+ channels
- ATP receptor
- Ca++ receptor

β-cell

insulin
GLUCOSE ENTERS VIA GLUT2

STEP 1:

GLUT2

GLUCOSE TRANSPORTER

β-cell

insulin

K+ (Rest)

K+ channels

ATP receptor

Ca++ channel

VG channel Ca++
GLUCOSE IS OXIDIZED

GLUCOSE → ATP

STEP 2

GLYCOLYSIS
KREBS

ATP

K+ (Rest)

K+ channels

ATP receptor

Ca++

ATP receptor

Ca++ channel
ATP binds to K+ channel

β-cell

GLUT2

insulin

cell channels

ATP

K+ (Rest)

GLYCOYSIS, KREBS

STEP 3
**STEP 4**

- ATP - K⁺ closes K⁺ channel
- K⁺ stays inside and depolarizes
- Glucose enters cell
- Glycolysis and Krebs cycle
- ATP production
- Glucose breaks down
- Cations (Ca⁺⁺) enter
- ATP receptor
- ATP channels
- K⁺ channels open
- K⁺ (rest)
VG Ca\(^{++}\) open

Ca\(^{++}\) enters

STEP 5

K\(^{+}\) stays inside

GLYCOLYSIS KREBS

GLUT\(\alpha\)

\(\beta\)-cell

insulin

Ca\(^{++}\) receptor

K\(^{+}\) channels

ATP

K\(^{+}\)

VG channel Ca\(^{++}\)

Ca\(^{++}\)

ATP receptor

ATP

ATP

ATP

K\(^{+}\)

K\(^{+}\)

K\(^{+}\)

K\(^{+}\)
Ca^2+ BINDS TO INSULIN & VESICLE FUSES → endocytosis

GLUCOSE

GLYCOLYSIS KREBS

Ca^2+ ATP

Ca^2+ receptor

ATP receptor

K^+ channels

β-cell

Insulin exocytosis

Ca^2+ channel
b-cell INSULIN release

- Glucose enters cell
- ATP production via glycolysis and Krebs cycle
- Insulin release
- ATP receptor activation
- K+ channels open
- GLUT2 glucose transport

Portal venus blood