



EPFL References

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- Chapter 78 - Guyton, Textbook of Medical Physiology
- Glucose Sensors Chapter - Wiley, Encyclopedia of Medical Devices and Instrumentation
- Yoo EH, Lee SY. Glucose biosensors: an overview of use in clinical practice. Sensors (Basel).
- Chamberlain JJ. Continuous Glucose Monitoring Systems: Categories and Features. In: Role of Continuous Glucose Monitoring in Diabetes Treatment. Arlington (VA): American Diabetes Association
- Ghosh N, Verma S. Technological advancements in glucose monitoring and artificial pancreas systems for shaping diabetes care. Curr Med Res Opin. 2024
- Guilbault, G.G. and Lubrano, G.J., 1973. An enzyme electrode for the amperometric determination of glucose. Analytica chimica acta, 64(3), pp.439-455.
- Martynko, Ekaterina & Kirsanov, Dmitry. (2020). Application of Chemometrics in Biosensing: A Brief Review. Biosensors.
- Hossain MJ, Al-Mamun M, Islam MR. Diabetes mellitus, the fastest growing global public health concern: Early detection should be focused. Health Sci Rep. 2024 Mar 22
- The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group.
- Manov AE, Chauhan S, Dhillon G, Dhaliwal A, Antonio S, Donepudi A, Jalal YN, Nazha J, Banal M, House J. The Effectiveness of Continuous Glucose Monitoring Devices in Managing Uncontrolled Diabetes Mellitus: A Retrospective Study. Cureus. 2023 Jul 27
- <https://www.abbott.com>
- <https://www.fortunebusinessinsights.com/industry-reports/blood-glucose-monitoring-market-100648>
- <https://www.vantagemarketresearch.com/industry-report/glucose-monitoring-devices-market-3020>
- <https://www.meticulousresearch.com/product/continuous-glucose-monitoring-market-5960>

EPFL Introduction: insulin and its metabolic effects

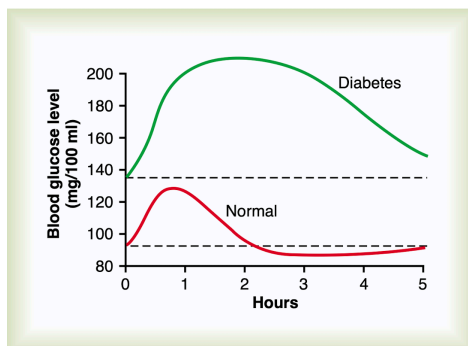
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- Role of Insulin:
 - Hormone produced by the pancreas, critical for glucose regulation.
 - Promotes glucose uptake by cells for energy and storage as glycogen in the liver.
- Metabolic Effects:
 - High sugar level: secretion of insulin which lowers blood glucose by promoting storage in liver, muscle, and fat. Also inhibits glucose production (gluconeogenesis) in the liver.
 - Low sugar level: insulin secretion decrease; liver glycogen is split back into glucose
- Importance in Health:
 - Maintains blood glucose balance (hyperglycemia and hypoglycemia)
 - Dysregulation linked to diabetes are a major threat to health

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EPFL Physiology aspects

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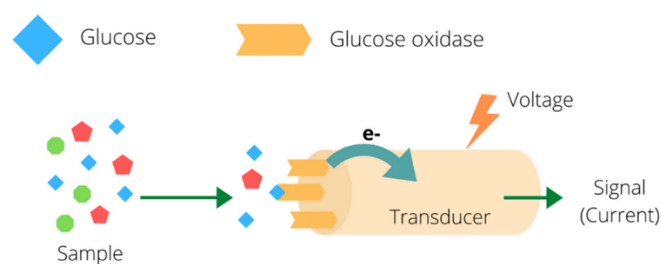


- Blood Glucose Regulation:
 - Maintained by the balance between insulin and glucagon.
 - Fluctuates based on food intake, physical activity, and hormonal changes.
- Normal Blood Glucose Levels
 - Fasting: 70–100 mg/dL.
 - Postprandial (after meals): 120–140 mg/dL.
- Impact of Dysregulation:
 - Hyperglycemia: Risk of long-term complications: loss of glucose in the urine, cell dehydration, tissue injury, increased utilisation of fats, metabolic acidosis and proteins
 - Hypoglycemia: Immediate risks like confusion, seizures, or loss of consciousness (brain, retina can only use glucose as nutrient).

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- Components:
 - Biological Recognition Elements: Detect target molecules (e.g., enzymes, antibodies).
 - Transducer: Converts recognition events into measurable signals.
 - Signal Processing System: Converts signals into readable data.
- Transducer Types:
 - Electrochemical, optical, thermometric, piezoelectric, magnetic.
 - Electrochemical sensors dominate for glucose (sensitive, reproducible, low-cost).
- Electrochemical Sensors:
 - Types: Potentiometric, amperometric, conductometric.
 - Amperometric sensors: Most common, measure currents from electron exchange.
- Enzymes in Glucose Biosensors:
 - Common enzymes: Hexokinase, glucose oxidase (GOx), glucose-1-dehydrogenase (GDH).
 - GOx: High glucose selectivity, cost-effective, robust (handles pH, temperature, storage).

- **Enzymatic:** Glucose Oxidase (GOx), generally present as a coat of the electrode, catalyses the oxidation of glucose in the blood producing hydrogen peroxide (H_2O_2). This reaction produces an electron transfer.
- **Amperometric:** a d.d.p. of 0.6-0.8V is present between anode and cathode, and the current flow is detected. The current is directly proportional to the concentration of the analyte that is oxidised at the electrode surface (H_2O_2).



EPFL Main Categories

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- Continuous Glucose Monitoring (CGM)
 - Real-time glucose data transmitted automatically
 - Consists of sensor, transmitter, and receiver/smartphone
 - Alarms for high/low glucose levels
 - Some integrate with insulin pumps for closed-loop systems
 - Subtype: flash CGM (requires manual scanning of sensor)
- Blood Glucose Meters (BGM)
 - Require multiple finger pricks to obtain blood samples
 - Limited ability to detect trends due to infrequent measurements
 - Require active user initiative

EPFL Dexcom G7

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- Sensor life: 10 days
- Cost: \$378/month
- Real-time glucose readings through a smartphone app
- Standalone receiver (optional)
- FDA-approved for people with all types of diabetes ages 2 years and older
- Mean Absolute Relative Difference (MARD): 8.2%

EPFL Abbott FreeStyle Libre 3

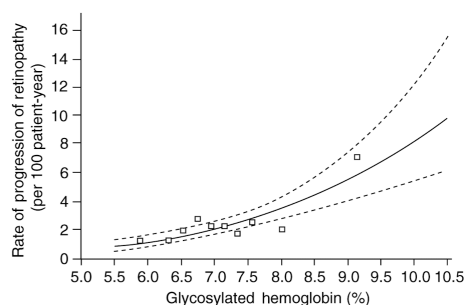
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- Sensor life: 14 days
- Cost: \$132/month
- Real-time glucose readings through a smartphone app
- Standalone receiver (optional)
- FDA-approved for people with all types of diabetes ages 4 years and older
- Mean Absolute Relative Difference (MARD): 7.9%

EPFL Medical Efficacy of CGM

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- Result of Diabetes Control and Complications Trial show that improved glucose control, measured by a reduction in the fraction of glycosylated hemoglobin (HbA1c), leads to reduced long-term complications of diabetes (photo).
- Time in Range (TIR) improved from 18% with self-monitoring of blood glucose to 74% with CGM, exceeding the American Diabetes Association's recommended goal of 70% TIR.
- Modest but statistically significant declines in HbA1c among individuals with type 2 Diabetes.

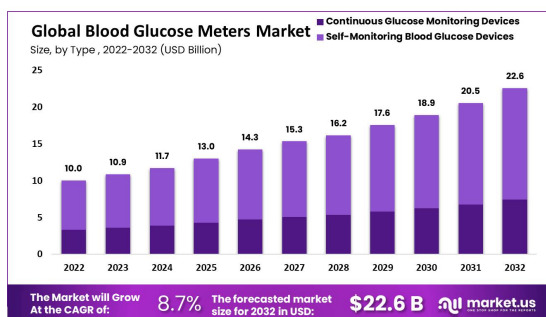
Future development paths



- Non-invasive technologies (ex: Nemaaura Medical's SugarBEAT and LifePlus' smartwatch) requiring no needle like optical or radio frequency sensors
- Implantable CGM Systems like the Swiss' Eversense solution
- Better algorithms (ML) for managing closed loop systems (insuline pumps)
- Improvements in CGM devices: longer duration between sensor swaps, better accuracy, smaller sensor footprint...

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Market considerations



- The CGM market is projected to reach \$31.41 billion by 2031, growing at a CAGR (compound annual growth rate) of 15% from 2024 to 2031
- Market drivers
 - Increasing adoption of CGM devices in emerging markets
 - Technological advancements in glucose monitoring devices (like CGMs)
 - Rising diabetes prevalence globally
 - Rising awareness and detection

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EPFL

Thank you

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