# Bio-Engineering of Insulin

Biol4241 – Advanced Genetics
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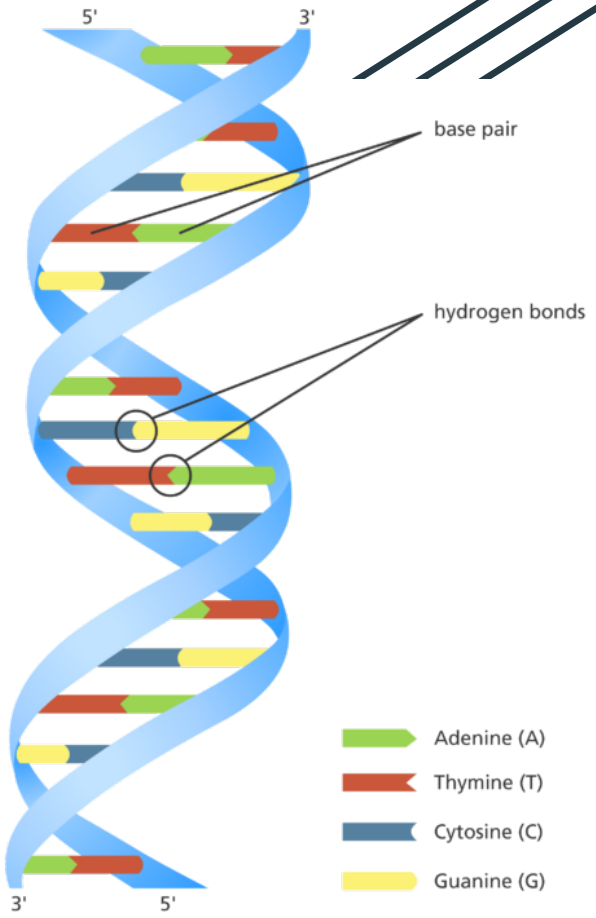
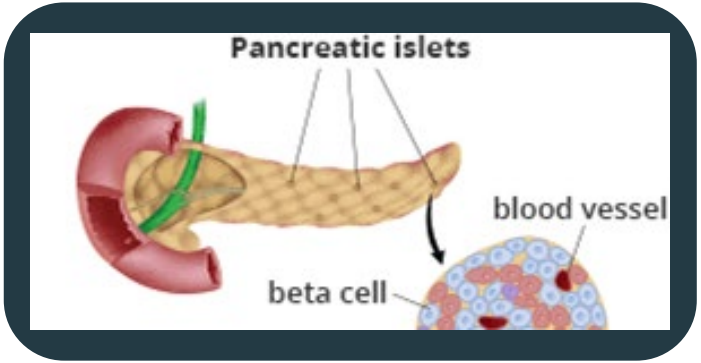
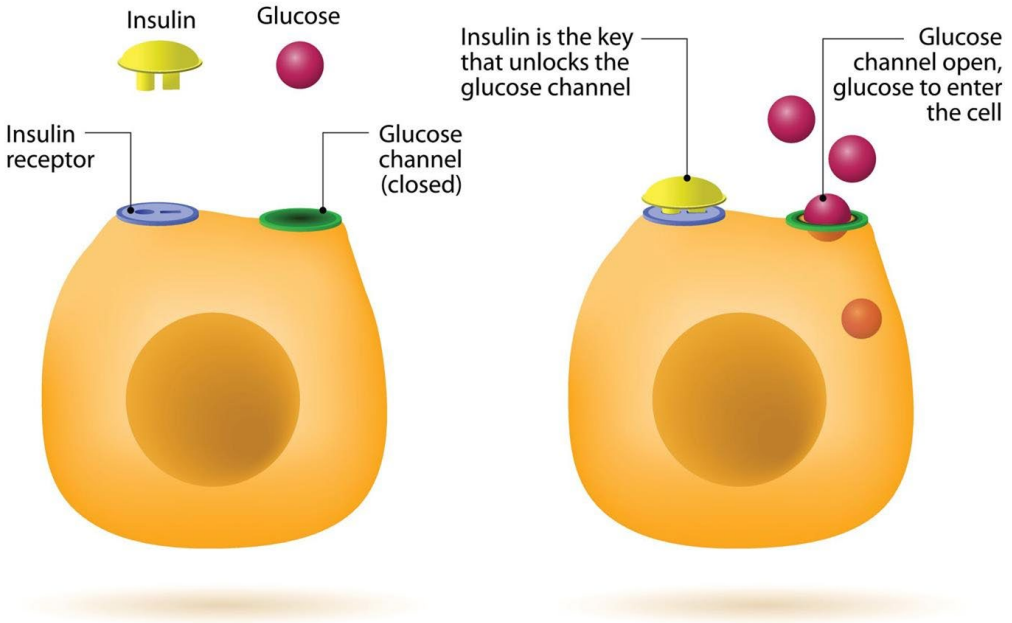


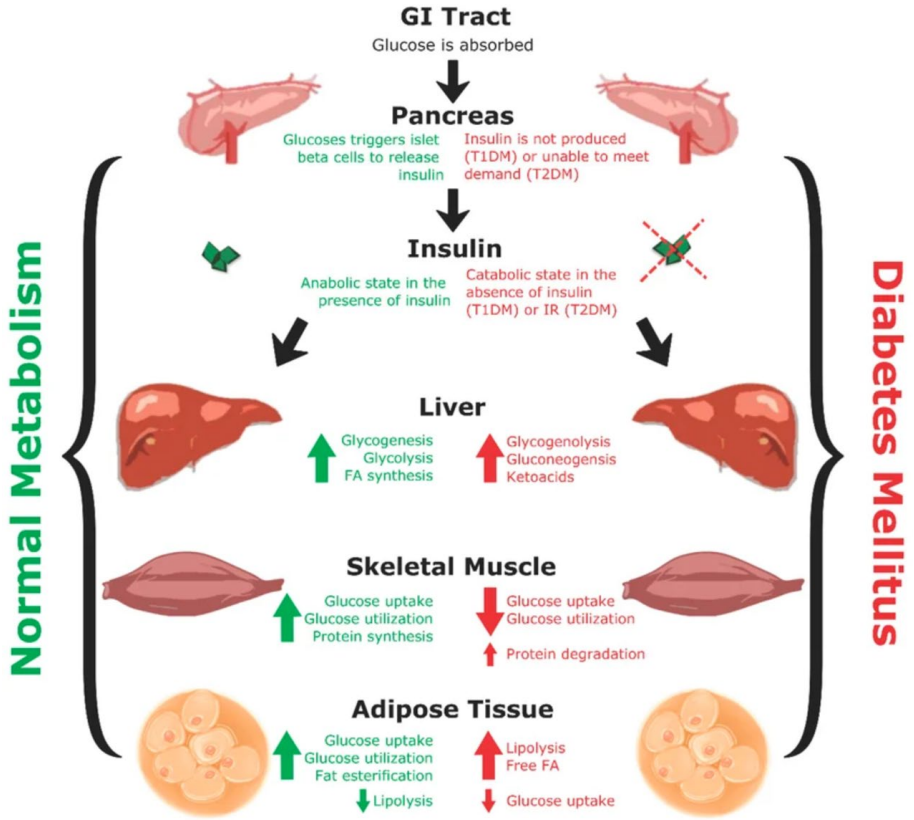
# Introduction: What is Insulin?

- Hormone that regulates blood glucose
- Produced by **beta cells in pancreas**
- Released when blood sugar rises
- Signals cells to absorb glucose from bloodstream



# Introduction: Why is Insulin Essential?



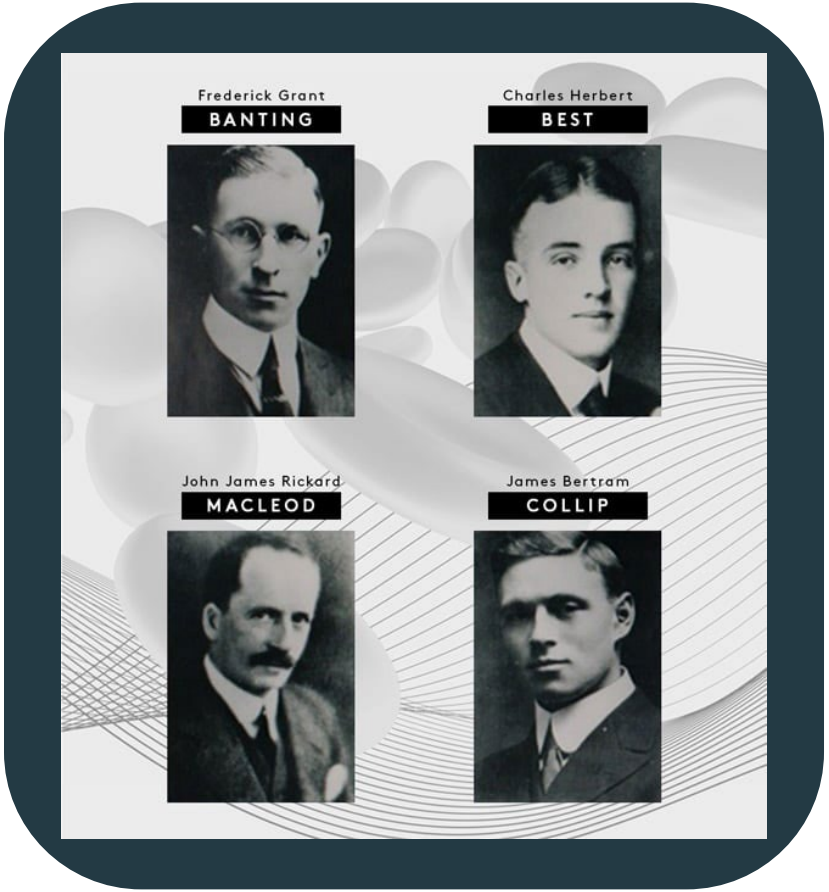

- **Diabetes**: body cannot produce or use insulin
- **Glucose *remains* in bloodstream**
- **→ dangerously high [blood sugar]**
- **Type 1 Diabetes:** requires **insulin** for survival

# Discovery of Insulin (1921)

- **1921**: Discovered at **University of Toronto**
- **1922:** Successful **treatment** of human patient
- **1923: Nobel Prize** awarded for discovery

Key researchers:

- **Frederick Banting**
- **Charles Best**
- **John Macleod**
- **James Collip**



# Early Insulin Production


Bottle of **Iletin** (Lilly insulin), as labeled, package, and sold (1920s)

As treatment for diabetes, initially isolated from the pancreas of pigs and cows, seen in this slaughter house pile.

**Early Insulin Sources:**

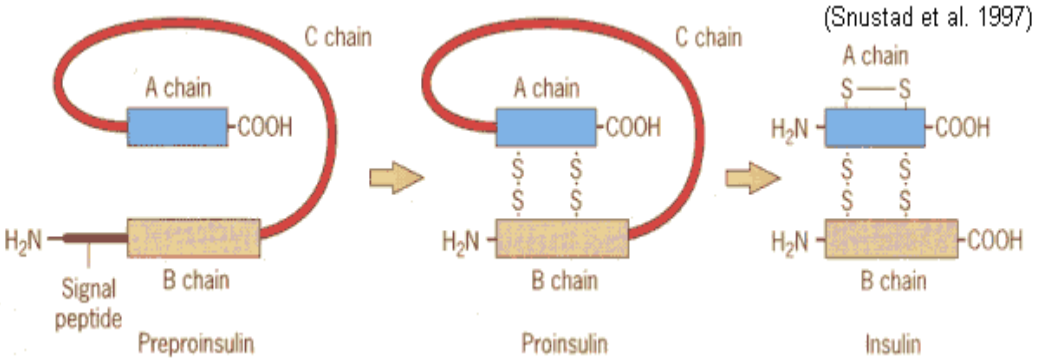
- Insulin extracted from **pancrease** of **cow** or **pig**
- Required **thousands of animal** for production
- Used worldwide for decades.

**Limitations:**

- **Impurities** in early insulin preparations.
- Some patients developed **allergic reactions.**
- Supply depended on **slaughterhouse byproduct**.

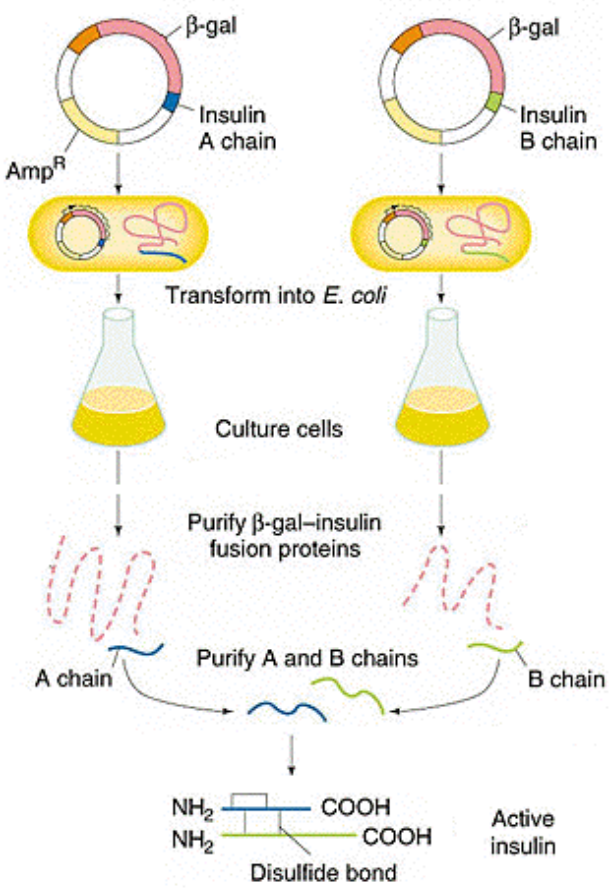
# Transcription & Expression of Human Insulin

Post-Transcriptional processing cleaves Amino Acids out of primary structure
Biologically active **Insulin** less than half of primary sequence




**preproinsulin** (110 aa's) → **proinsulin** (86 aa's)→ **insulin** (51 aa's)

**The Case of the Insolent Insulin**

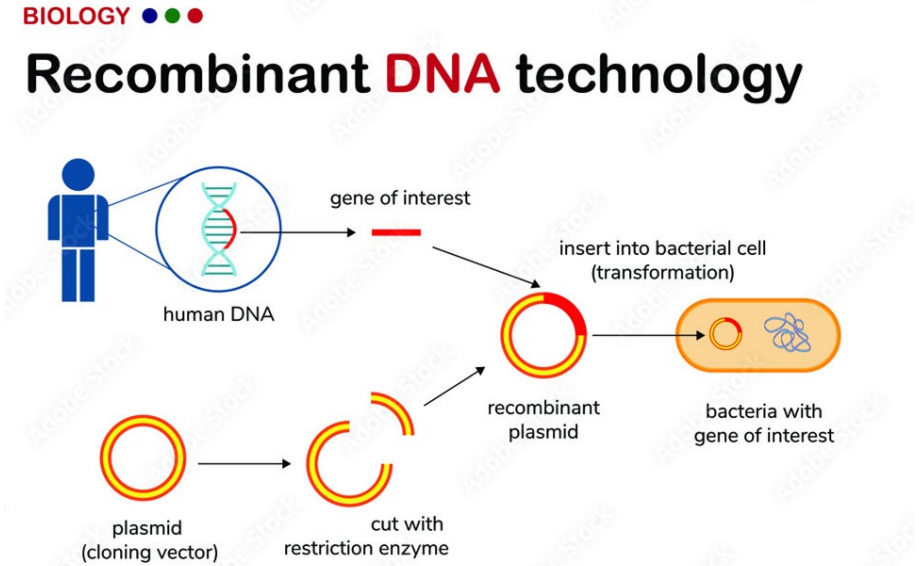



## Bio-Engineering of Human Insulin

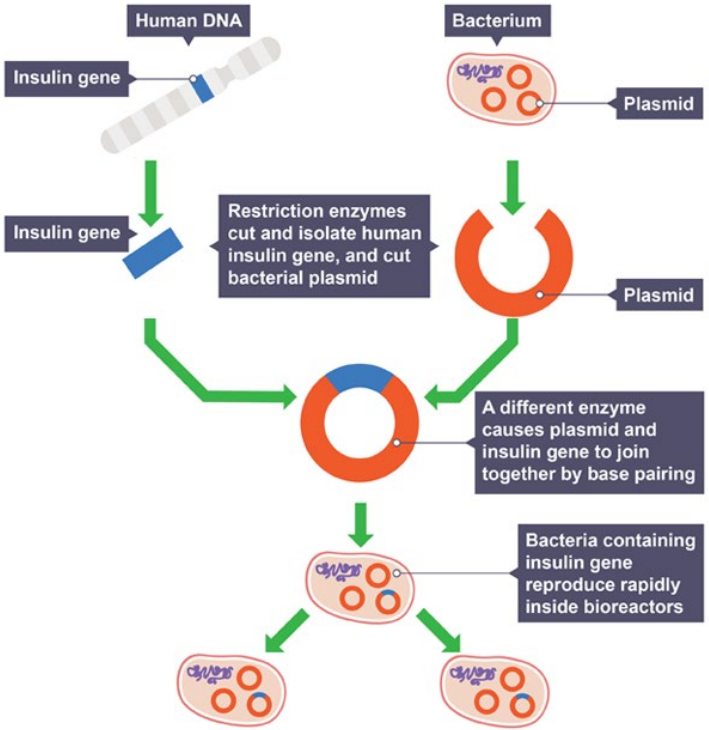
1. **Identify A & B chains** of Human insulin gene
2. **Clone separately** into **plasmid DNAs**
3. **Transform** plasmids into separate ***E. coli*** genomes
4. ***E. coli*** cultured in bulk in **bio-reactors**
5. **Insulin A & B chains extracted & purified.**
6. **Chains spontaneously assemble**
    1. **Disulfide bonds** stabilize **Tertiary** structure
    2. **Two** bx **A** & **B** chains; **One** within **A** chain

# Genetic Engineering and Bio-Engineering

- **Genetic engineering:** Modifying **DNA** to produce useful **proteins**
- **Human DNA inserted into bacteria**
- Bacteria produce **human protein**
- Uses **recombinant DNA technology**
- **Recombinant proteins:** Proteins produced by genetically engineered organisms



# How Bioengineered Insulin is Made




Producing Bioengineered Insulin:

1. **Identify insulin gene** in human **DNA**
2. Insert gene into **plasmid** (circular **DNA**)
3. Insert plasmid inside ***E. coli*** genome
4. Bacteria produce **human insulin protein**
5. Insulin **collected** & **purified.**

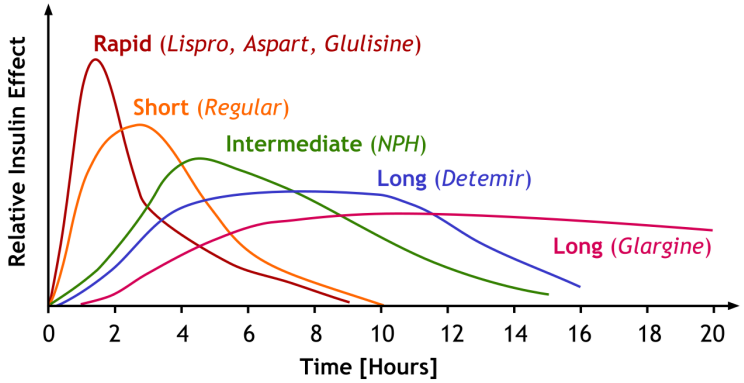
# First Recombinant Insulin (1982)

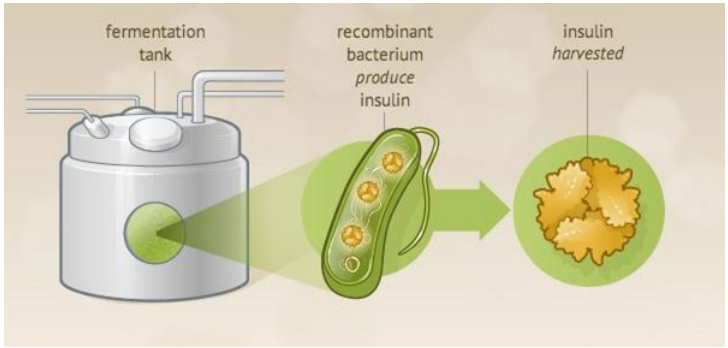
- **Humulin:** First **recombinant** human insulin.
- Approved **1982.**
- Developed by **Genentech** & **Eli Lilly and Company**

**Why was it revolutionary?**

- Produced in **large quantities.**
- Chemically **identical to human insulin.**
- **Reduced allergic reaction** compared to animal insulin.


# Modern Insulin Engineering




- Design of **insulin analogs** (modified insulin molecules).

**Examples:**

- Insulin **Lispro** - Rapid Acting
- Insulin **Glargine** - Long Acting

**Why Modified Insulin?**

- **Faster** absorption.
- **Longer** duration of action.
- **Improved** blood sugar control.

**Large-scale production:**

- Produced from engineered bacteria in **bioreactors**.

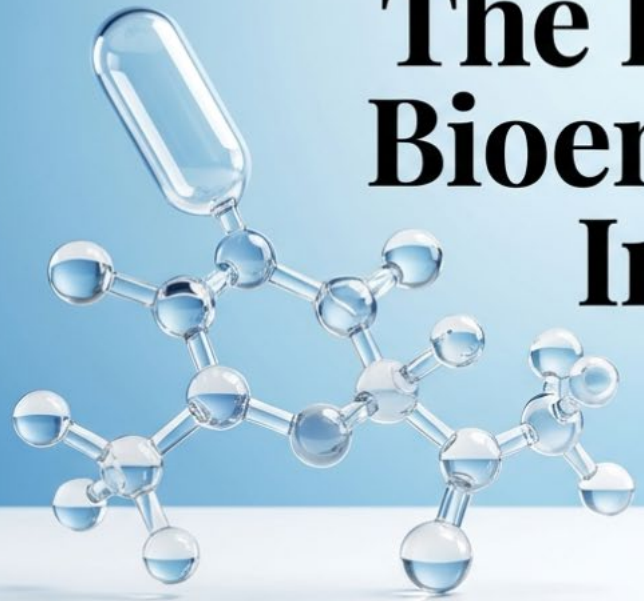
# Why Bio-engineered Insulin Matters

- **Millions of lives** saved by insulin therapy
- **Reliable global production** by biotechnology
- **Early major success** of modern biotechnology.

**Continuing Challenges**

- **Accessibility** & **cost**
- **Global healthcare differences**.

# The Politics of Bioengineered Insulin



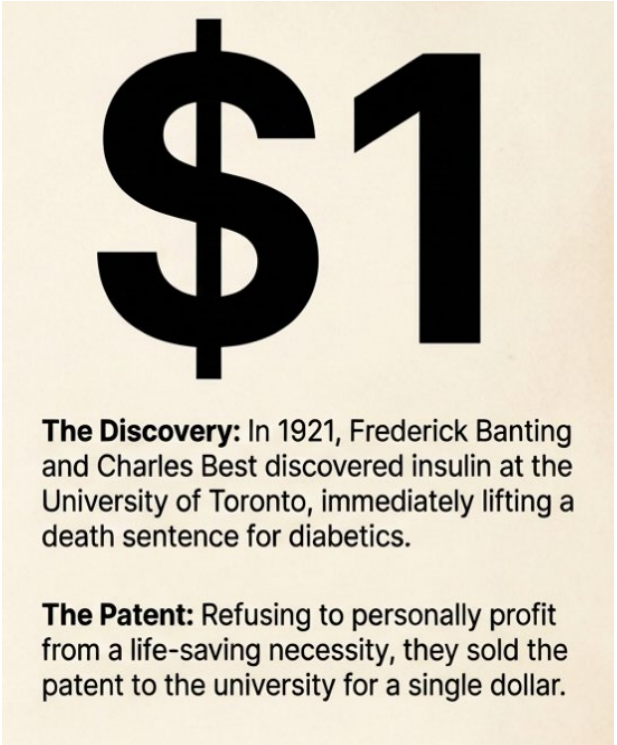

**The Breakthrough:** Recombinant DNA technology birthed the first bioengineered pharmaceutical, promising an infinite supply of life-saving medicine.

**The Burden:** Decades later, a triumph of innovation is overshadowed by 1200% price hikes, market monopolies, and devastating rationing.

How did a medicine created to save the world become a symbol of healthcare inequity?

# A Gift to Humanity

- **Frederick Banting** believed insulin **“belonged to the world”**: life-saving treatments should be accessible to everyone
- Instead of keeping the patent for profit, sold it for **CDN$1**: insulin could be widely available



## THE BUREAUCRATIC OBJECTIVE

Systems optimize for measurable metrics, risk aversion, and theoretical fairness.

MEASURABLE METRICS

RISK AVERSION

THEORETICAL FAIRNESS

## THE END-USER EXPERIENCE

Individuals experience friction, compounding costs, stigma, and physical/cognitive exhaustion.


FRICTION & STIGMA

PHYSICAL/ COGNITIVE EXHAUSTION

COMPOUNDING COSTS

TIME BURDEN

- Across **Healthcare**, **federal rulemaking** and **tech regulations**;
- **Abstract policy** may fail, ***if*** it prioritizes **Bureaucratic objectives** over **Human outcomes**.

# The Fatal Consequence

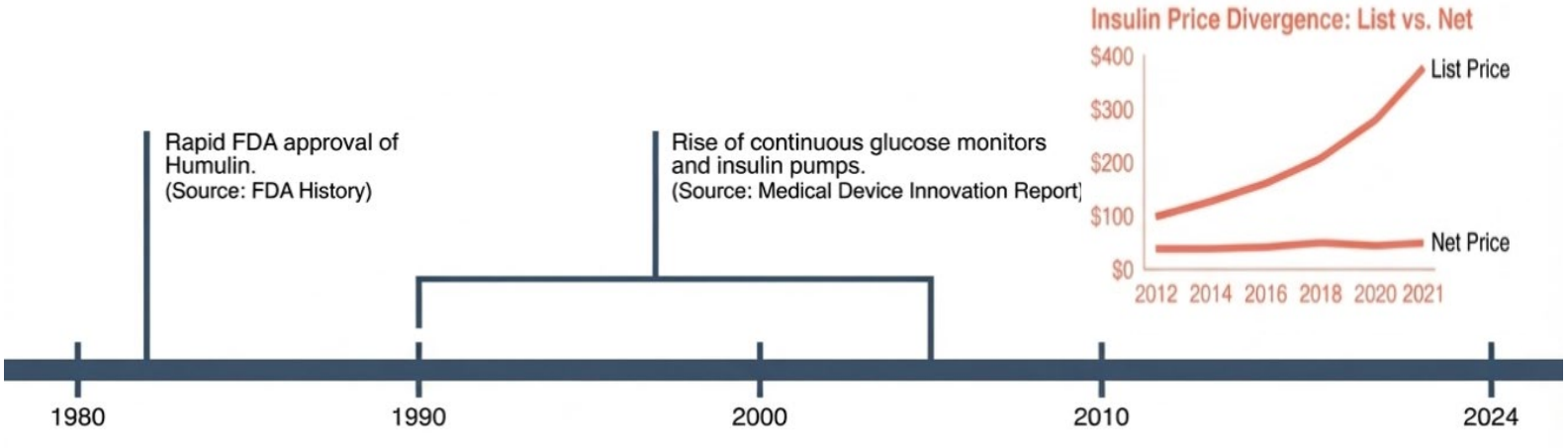
When a 100-year-old essential medicine is enclosed by biocapitalism, the result is forced, lethal rationing.

Approximately half of those who need insulin globally lack reliable access.
The economic trap is not just a market failure; it is an active threat to human life.
The system cannot be optimized; it must be bypassed.

# The Big Three and Market Control

- **Three companies** control most of global insulin market.
- They produce majority of insulin used worldwide.
- Their dominance influences **insulin pricing** & **access**.
- Biologic **Complexity**
- **Patent** Thickets

# Institutional Progress and Systemic failure




- A **1,200%** increase in the cost of the exact same insulin formulation.

# The Human Toll of 1,200% price hike

- Insulin prices increased by over **1,200%** (**12-fold**) since 1990s, **$21** per vial to **$275** today.
- Many patients pay **hundreds of dollars per month** for insulin.
- Some people **ration insulin** because they cannot afford full doses.
- Rationing can lead to **serious health complications** or death.
- The **crisis** sparked debates about drug pricing and healthcare access.

# When Biology is easier than Politics

- Scientists can produce insulin by **genetic engineering**,

  but **politics** & **economics** make access difficult.

- The science of making insulin is **solvable**:
  pricing and policy debates remain unresolved.

- **Healthcare policies & patents** affect insulin access more than biological challenges.

# The Unifying Root Cause


- **U.S. Food & Drug Administration (FDA)**: Drug approval takes **10 ~ 12 years** and **US$ Billions**
- **Government Regulation**: Extensive **rules & restrictions** slow innovation.
- **Antitrust / Finance Policies**: Market regulations limit competition & protect large companies.

# Conclusions

- **Bioengineered insulin is a major scientific breakthrough** that saves millions of lives.
- **Pricing, patents, and market control** have created political challenges.
- **Case-study of insulin** shows conflict between **medical innovation** & **healthcare access**.
- **Future policies** must focus on making life-saving medicines more **affordable** & **accessible**.

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