Digital Drug Detectives: Designing Tomorrow's Medicines

Medicine Development Goes Virtual Modeling, Simulation & In Silico Trials in Drug Development for Kids & Rare Diseases

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What We'll Learn Today (Overview)

What are Models & Simulations?

Simple definitions and examples.

What is an "In-Silico" Trial?

How virtual clinical trials work.

Why Use These for Kids & Rare Diseases?

Challenges in pediatric/rare drug research.

Real-World Benefits

How virtual experiments help make medicines safer and faster.

Interactive Fun

Quiz and an activity to test your knowledge! 🎉

Combining Your Voice with Powerful Predictions – Patient Preferences in Action _ If we have time and enough energy (or for next session) 😅

What is a Model?

- A **model** is a **simplified representation** of something real.
- Think of a **model airplane** or **model car** – it's not full-size, but it shows the important parts.
- In science, models can be **physical** (like a plastic human organ) or **mathematical** (like equations in a computer).
- **Computer models** use math and data to imitate real systems (for example, modeling how a disease affects the body).

Computer Model video

YouTube

What is a computer model?

You might not notice it, but computer models are everywhere around us, from your smartphone calculating the fastest route to work to the aerodynamic simulations of cars and planes. In this video, we will discover how we can make the...

https://youtu.be/gAeHWcKxDZI?si=9TGhdKbLUIBw11HB

invents

What is a Simulation?

Running a Model Over Time

A **simulation** is what happens when we **run a model over time** to see what might happen.

Playing Out Scenarios

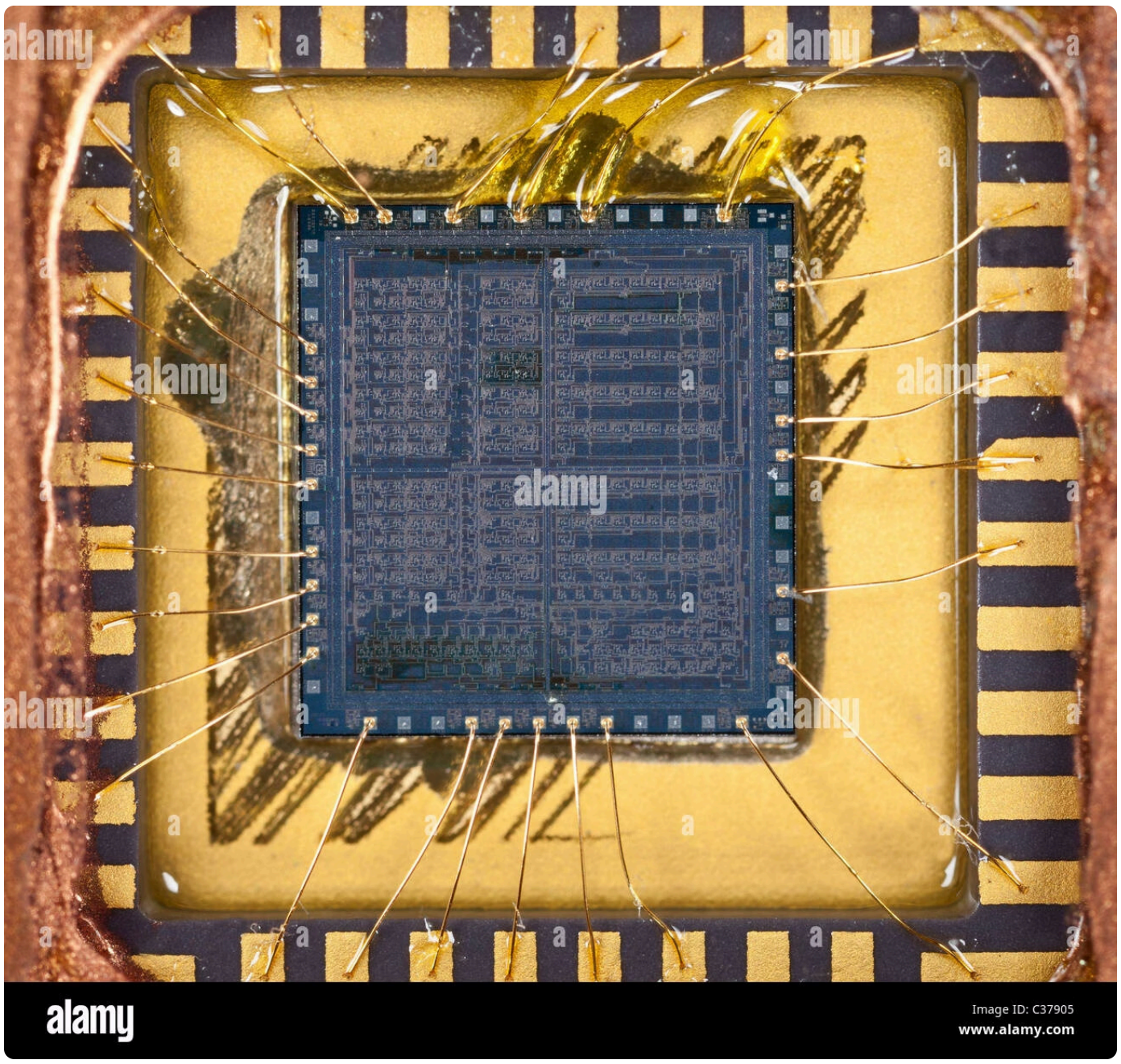
It's like **playing out a scenario**: "If I do X, what will Y be?"

Real-World Examples

Example: A flight simulator – pilots train on computers that simulate flying using a model of an airplane.

Scientists simulate things like **weather** (to predict storms) or **epidemics** (to see how a virus spreads) by running models on computers.

What is an "In-Silico" Trial?



In-Silico = Computer-Based

"In-silico" means **performed on a computer** (silicon = material in computer chips)*.

Virtual Clinical Trial

An **in-silico trial** (aka virtual clinical trial) is a **computer simulation** of a real clinical trial.

Virtual Patients

Instead of real patients, we have **virtual patients** inside the computer.

Scientific Context

Scientists use in-silico trials to **predict** how a drug might work, before or alongside testing it in people.

Comparison*: In vitro = in the lab, In vivo = in living organisms, In silico = in the computer.

In-Silico Trials Video

YouTube

Episode 5: In Silico Trials

Before a drug or medical device can be used, it undergoes extensive pre-clinical and clinical trials to ensure safety and effectiveness. This process...

https://youtu.be/iR0QhppwKL8?si=x3z_4y4td2XgOXKm

Why Not Just Do Regular Trials? (Challenges for Kids)

Children Are Different

Testing medicines on **children** is **hard** – and sometimes not safe or ethical.

Kids aren't just "small adults" – their bodies process drugs differently (they grow, organs mature).

Limited Volunteers

Fewer children are available to volunteer for trials, especially if the illness is rare.

Ethical Concerns

Ethical concerns: We must protect kids. We can't experiment on children as freely as on adults.

Result: We often have **limited data** about medicines in kids.

Why So Hard? (Challenges for Rare Diseases)

Few Patients

Rare diseases affect very few people (sometimes only a few hundred or less worldwide).

Creative Solutions Needed

We need **creative approaches** (like simulations) to test treatments when large trials aren't possible.

Geographic Dispersion

Patients might be scattered across the world – hard to gather in one study.

Time & Urgency

Time & urgency: Rare diseases (especially in kids) can be serious; waiting years for enough trial data can be harmful.

With so few patients, a traditional trial is tough: how do you find enough volunteers?

How Modeling & In-Silico Trials Help

Fills the Gap

Models use all available data (like adult trial data, lab studies) to predict outcomes for **kids or small populations.**

Finds Safe Doses

We can simulate different doses in a virtual child to estimate a safe, effective dose before giving it to a real child.

Designs Better Trials

Simulations can test various trial designs on a computer to see which design might work best (e.g., how many patients are needed, what age groups).

Reduces Risk

We can try out "what if" scenarios (like rare side effects or long-term effects) virtually, so fewer children are exposed to potential harm.

Saves Time and Money

Virtual experiments are faster to run, so promising drugs can move forward sooner.

Building & Validating Virtual Models & In Silico Trials

Define the Context of Use

What question will the model answer? (e.g., "What dose is safe for a 5 year old?")

Specify exactly how the model output will be used in decision making.

Perform a Risk Analysis & Set Credibility Goals

Assess **model influence** (how much the model drives the decision) vs. **decision consequence** (what happens if it's wrong).

Higher risk → more rigorous testing.

Verification (Code & Calculation Checks)

Code verification: Confirm the software correctly implements the mathematical equations.

Calculation verification: Check numerical solutions for accuracy (e.g., refine time-steps until results stabilize).

Validation & Uncertainty Quantification

Compare model outputs to **real world data** (bench tests, animal studies, adult clinical data) to assess predictive performance.

Run **sensitivity analyses** to see which inputs most affect results, and **quantify uncertainty** in predictions.

Platform Qualification & Regulatory Standards

Demonstrate the **software platform** (e.g., Phamacologically-Based Pharmacokinetic modelling [PBPK] toolkit) reliably reproduces known scenarios before use in a new context.

Follow guidelines like **EMA (Europe) PBPK Guideline**, **ICH M15 Guideline (International)**, and **FDA (USA) Credibility Guidance**.

Real-World Impact & Support

1-2

In-Silico Trials in 2012

The number has grown dramatically since then

15

In-Silico Trials by 2021

This is becoming a normal part of research

Success stories: Many new pediatric medicines have relied on modeling to guide dosing or approval. (E.g., using adult data + simulations to approve a cancer drug for kids).

Regulators are on board:

EMA (Europe)

"highly recommends" model-informed approaches in pediatric plans.

FDA (USA)

Runs programs to advance modeling (Model-Informed Drug Development) and is even an "active user" of in-silico trial data.

MHRA (UK)

Supports in-silico trials for rare diseases.

Global collaboration: Scientists, universities, and companies worldwide are working on virtual patient models (sometimes called **"digital twins"**) for various diseases.

Quick Quiz! (Interactive)

Question 1

Q: What does "in-silico" mean?

▼ **Answer**

> It means done on a computer (simulated digitally). (If you said "in a silicon computer chip," you're right!)

Question 2

Q: True or False – Scientists can replace all real drug trials with computer simulations now.

▼ **Answer**

> False. In-silico trials **supplement** (add to) real trials, but don't fully replace them. We still need human data, though maybe fewer people if simulations are good.

Question 3

Q: Name one reason why testing drugs in kids is hard.

▼ **Answer**

> Possible answers: Kids' bodies are different (growing/maturing); fewer kids in studies; ethical concerns about safety.

Activity – Match the Terms (Interactive)

Term	Description
A. Model	1. Running a virtual experiment using a computer program.
B. Simulation	2. A simplified representation of a system (can be physical or virtual).
C. In-silico trial	3. A full experiment/test of a treatment done via computer with virtual patients.

▼ **Solution:**

> Model – 2, Simulation – 1, In-silico trial – 3.

Summary – Key Takeaways

Virtual Exploration

Models and Simulations let scientists explore "What if?" in a **virtual** way – safer, faster, and cheaper than only real-life testing.

Powerful Tools

They are **powerful tools** in drug development, especially when real trials are challenging (like for kids or rare conditions).

Complementary Approach

In-Silico trials = using computer models to simulate a clinical trial. These **don't replace** real trials but **strengthen** drug research.

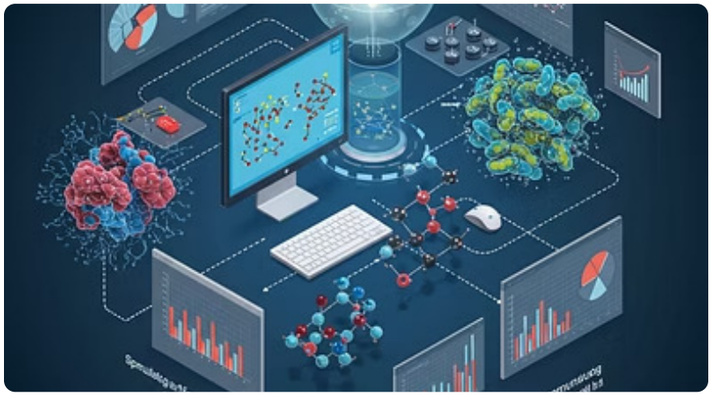
Patient Protection

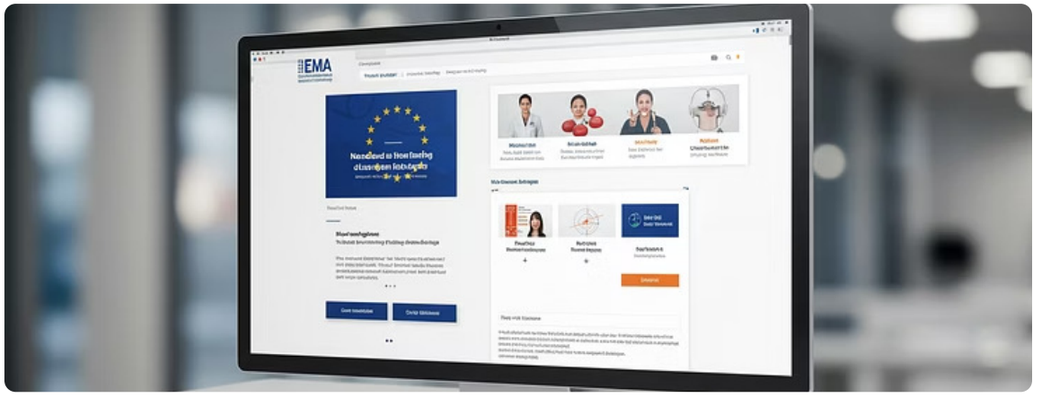
Using these methods can **protect patients** (fewer unnecessary experiments on kids) and get **medicines to patients sooner**.

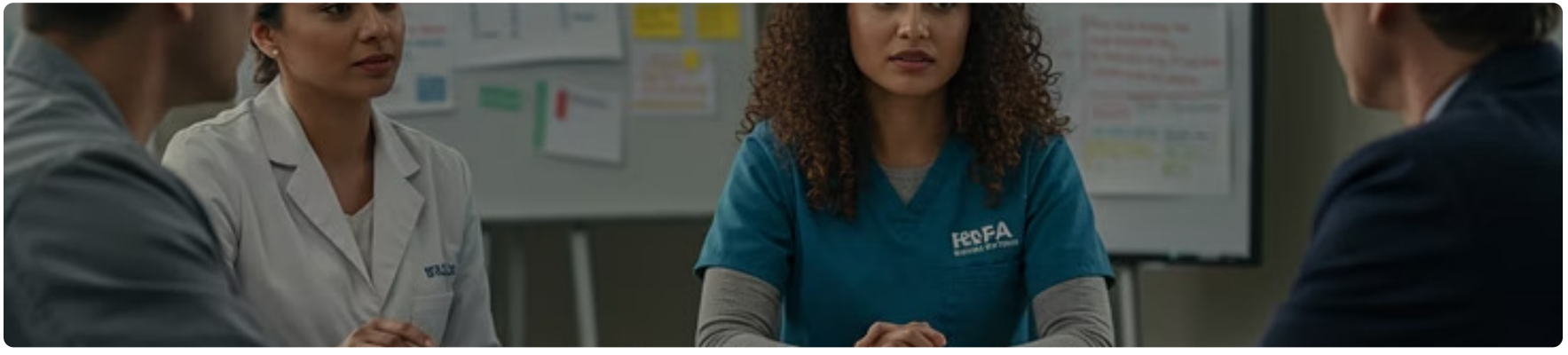
Future of Medicine

Future of medicine: likely to involve more virtual testing – maybe one day every new drug will be designed with the help of a digital twin!

Explore More – Resources for You







Videos

What is a Model: https://youtu.be/gAeHWcKxDZI?si=9TGhdKbLUIBw11HB

What are in-silico trials: https://youtu.be/iR0QhppwKL8?si=x3z_4y4td2XgOXKm

The benefits of using modelling and simulation in drug development: https://youtu.be/o2ntCRCgpUM?si=VM3weIW5sZssHfeR