Forget Moonshots

Biomedicine Needs an
Air Traffic Control System

Jeff Shrager

Cancer Commons
xCures
Stanford Symbolic Systems Program (Adjunct)

Easy AI: Self-Driving Cars

Small, local decision environment, in both space and time

Mostly static, mostly well-understood rules and principles

Data is plentiful

Computer simulation is nearly trivial

Physical simulation is easy

Expert guidance is instantaneous, cheap, and nearly perfect

** Immune system: 1 trillion T cells, 1 trillion B cells, all circulating 50x/day, plus 10 billion antigen-presenting cells. Human Brain: 100 billion neurons, trillions of synapses, and 1 billion glial cells. And it pretty much doesn't move.

AND BOTH LEARN!

Hard AI: Cancer

Extremely broad decision environment, in both space and time

Dynamic "rules" (biology doesn't change but everything else does)

Data is essentially non-existent

Simulation is essentially impossible (The immune system is as complex as the brain!)**
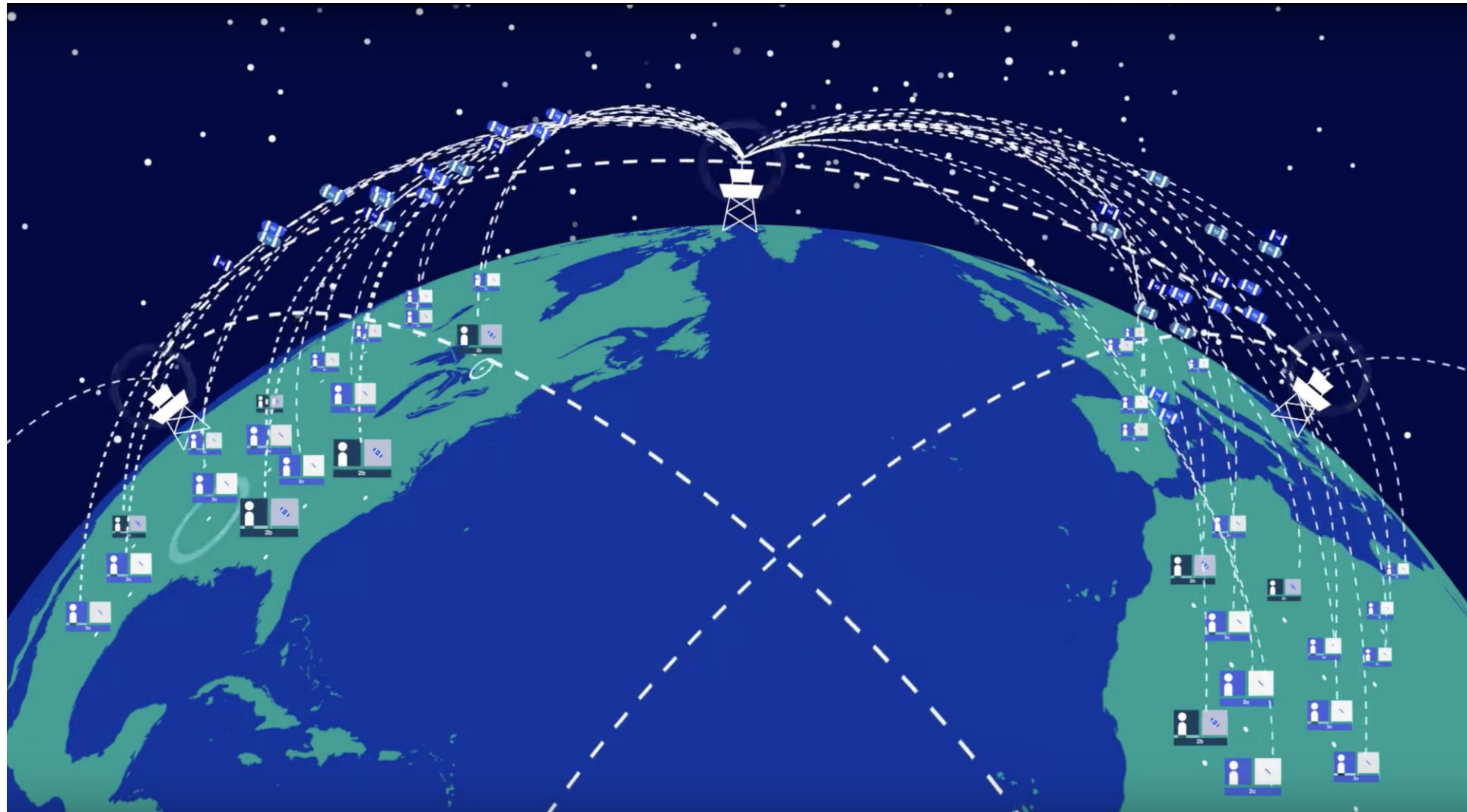
Physical simulations is extremely expensive, and every experiment kills people or animals in horrible ways!

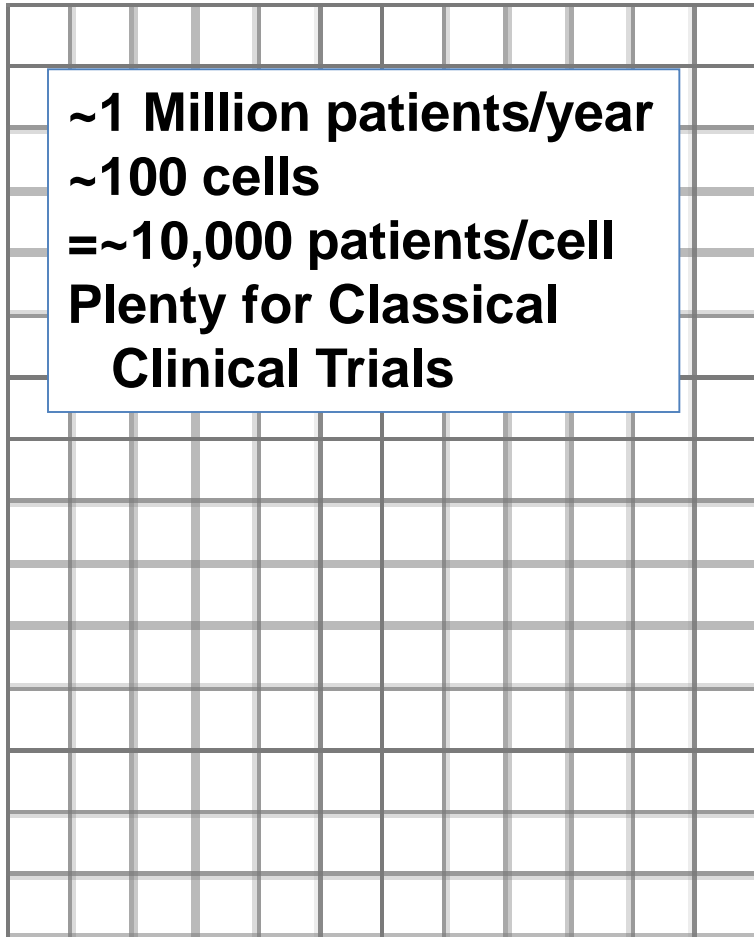**Feedback can take years and is very noisy; There are NO EXPERTS!**

Global Cumulative/Coordinated/Continuous Treatment Analysis

Why is Cancer so Hard?

pre-OMIC era: Tissue x Chemos

Treatments: Chemo1, Chemo2, ...

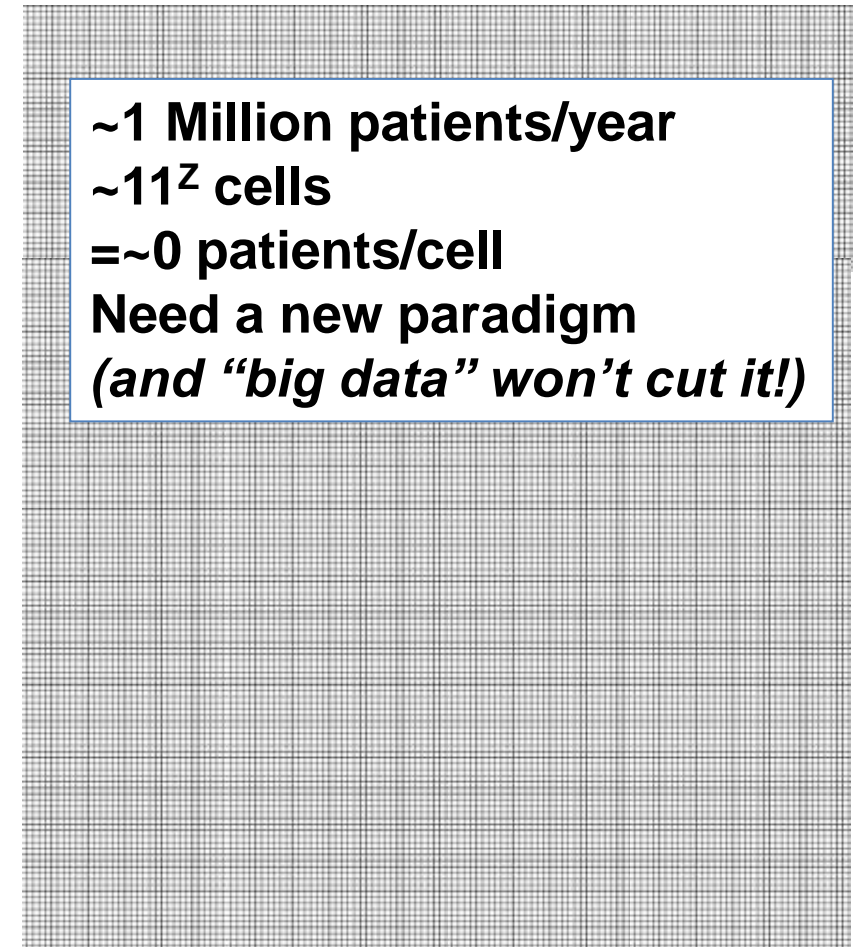~1 Million patients/year
~100 cells
=~10,000 patients/cell
Plenty for Classical
   Clinical Trials

Phenotypes: Lung, Breast, ...

We're treating an extremely high dimensionality, low data density, problem the same way that ants search for food!
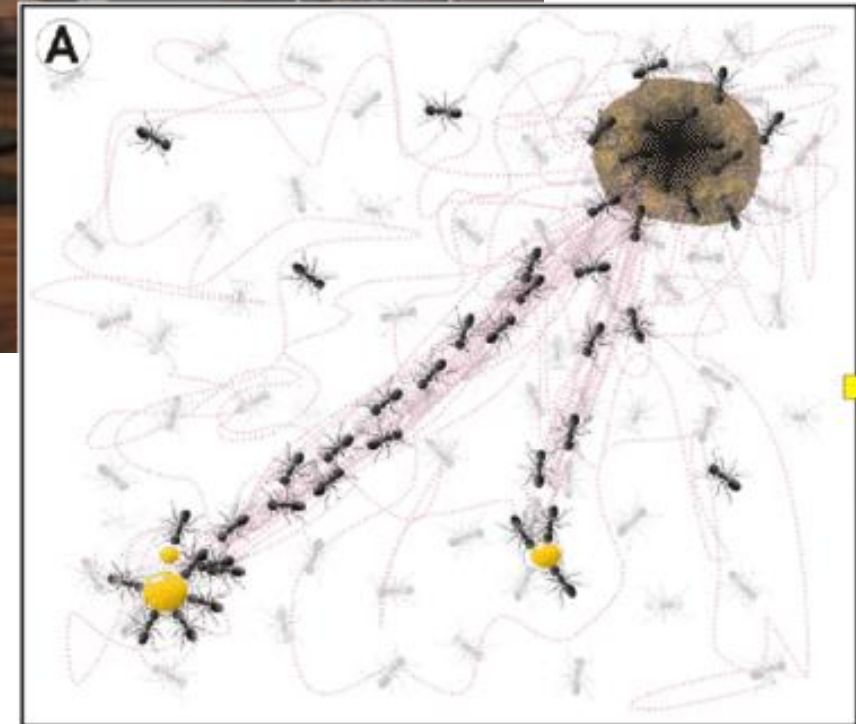
Now: Features x Targeted Combos

Thousands of drugs in combination

~1 Million patients/year
~11^Z cells
=~0 patients/cell
Need a new paradigm
(and "big data" won't cut it!)

Millions of molecular features

This is the State-of-the-Art Statistical Model for Adaptive Trials:

And this is the State-of-the-Art Algorithm:

GCTA is a redesign of clinical research in the image of a "Learning Air Traffic Control System", where entropy-minimizing reinforcement learning routes hypotheses in real time to the patients who at the same time have the most to gain, and the most information to offer to the overall system.

GCTA is *NOT* a fantasy!

The VA just hasn't put AI Engineers on the problem yet!

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Biomarkers in Cancer
www.la-press.com

The VA Point-of-Care Precision Oncology Program: Balancing Access with Rapid Learning in Molecular Cancer Medicine

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Abstract

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The Department of Veterans Affairs (VA) recognized the need to balance patient-centered care with responsible creation of generalizable knowledge on the effectiveness of molecular medicine tools. Embracing the principles of the rapid learning health-care system, a new clinical program called the Precision Oncology Program (POP) was created in New England. The POP integrates generalized knowledge about molecular medicine in cancer with a database of observations from previously treated veterans. The program assures access to modern genomic oncology practice in the veterans affairs (VA), removes disparities of access across the VA network of clinical centers, disseminates the products of learning that are generalizable to non-VA settings, and systematically presents opportunities for patients to participate in clinical trials of targeted therapeutics.

Keywords: veterans, precision oncology, learning health-care system, lung cancer, Bayesian

Introduction

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Oncology clinical practice guidelines recommend more than 30 molecular tumor biomarkers across all cancers to aid treatment selection, a list of potential biomarkers that continues to grow.[1–3] In addition to reimbursable, standard-of-care assays, physicians can order biomarker panel tests that sequence large regions of the tumor genome. The proximate goal of biomarker panel testing is to identify potential, even unproven, therapeutic agents that may offer longer survival and improved quality of life than existing