Machine Learning
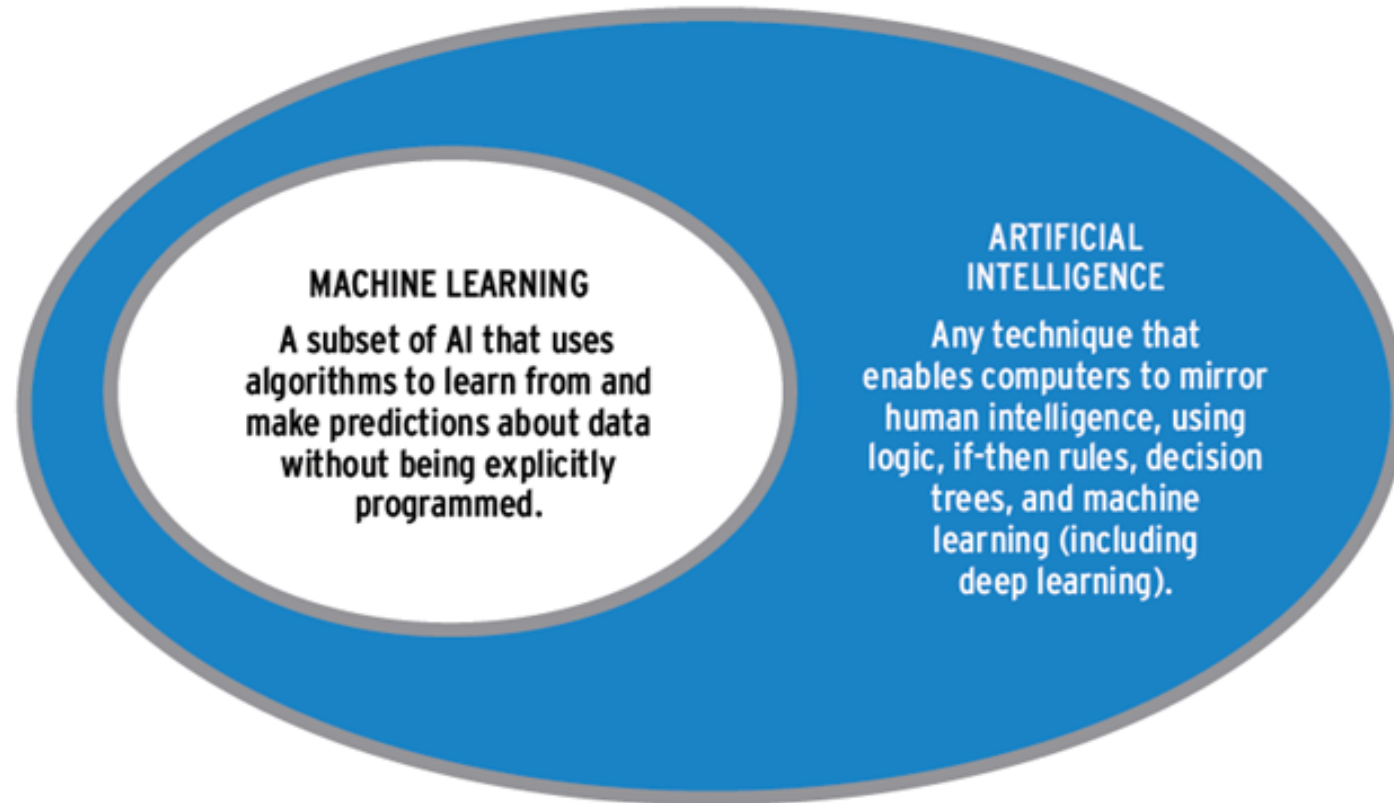
Evolutionary Perspectives and Stimuli from the Causal (Inference) Revolution
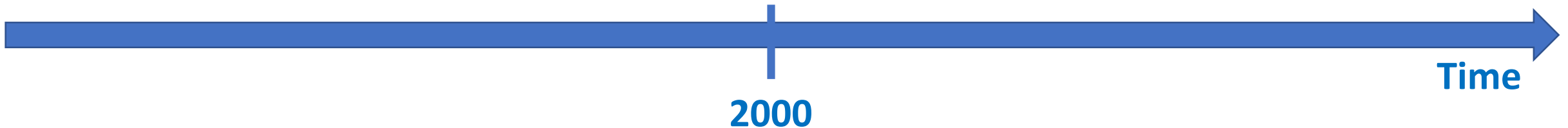
Tibor Schuster

Assistant Professor
Department of Family Medicine

Canada Research Chair for Biostatistical Methods in Primary Health Care Research

Context and Definition

MACHINE LEARNING

A subset of AI that uses algorithms to learn from and make predictions about data without being explicitly programmed.

ARTIFICIAL INTELLIGENCE

Any technique that enables computers to mirror human intelligence, using logic, if-then rules, decision trees, and machine learning (including deep learning).

(R)evolution of learning about reality

Time

2000

(R)evolution of learning about reality

Statistical Modeling: The Two Cultures

Leo Breiman

Data Modelling Culture vs **Algorithmic Modelling Culture**

$$a + b\,\mathbf{X} = \mathbf{Y}$$
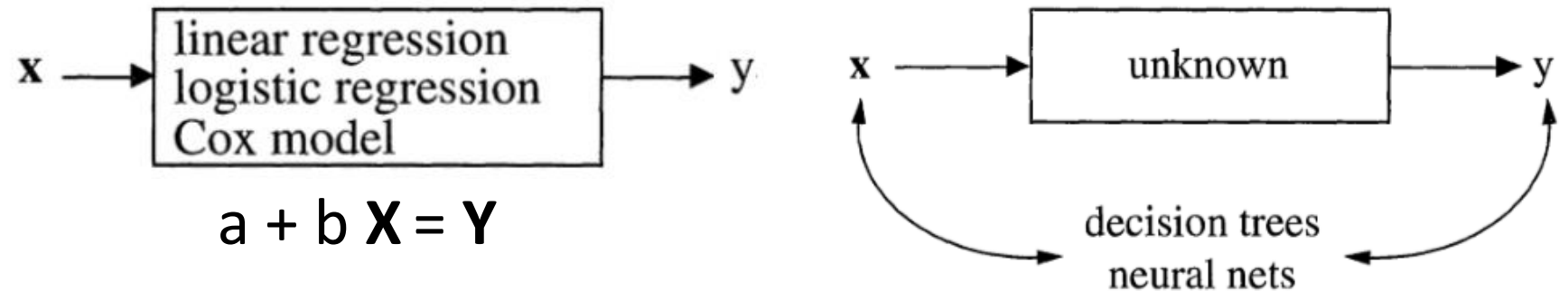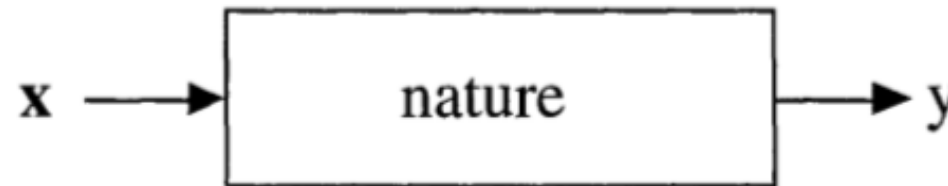
Truth

"Nature has no obligation to be simple"

(R)evolution of learning about ~~reality~~ the truth

Video Assistant Referees (VARs) were used for the FIRST time last summer (2018) in the FIFA World Cup to support decision making.

(R)evolution of learning about reality

a+b**X** **=** **Y**
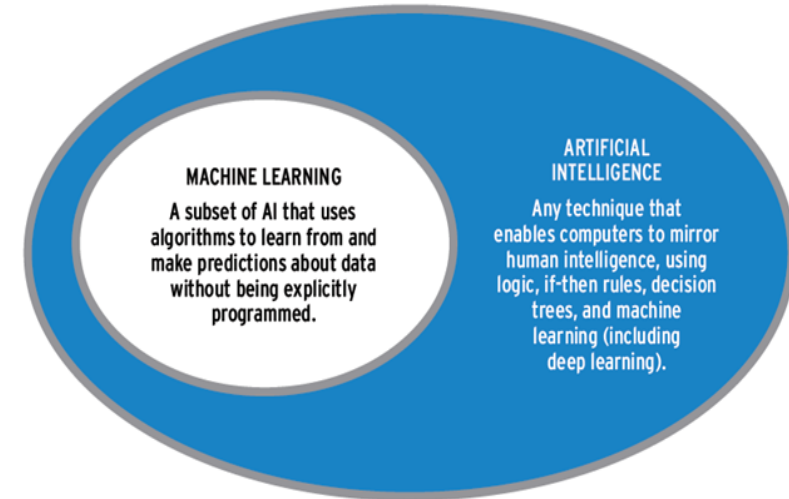
vs

a+b**X** **→** **Y**

disease → symptoms
rain → mud
temp → thermometer …

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deliberate purging of causal thinking

Time

1921

2000

Sewall Wright

(R)evolution of learning about reality

(R)evolution of learning about reality

Theoretical Impediments to Machine Learning
With Seven Sparks from the Causal Revolution

Judea Pearl
University of California, Los Angeles
Computer Science Department
Los Angeles, CA, 90095-1596, USA
judea@cs.ucla.edu

January 15, 2018

(R)evolution of learning about reality

- How effective is a given treatment in **preventing** a disease?

- What is the annual health-care costs **attributed** to obesity?

- Can health records provide proof for sex or race **discrimination**?

Key words like ***preventing, attributing, discriminating***…

…common in everyday language.

However, until very recently, no formal framework to articulate them available!

(R)evolution of learning about reality

machine learning systems operate, almost exclusively, in a statistical, or model-free mode ("black box") based on observed data

→ limited performance in reasoning about policies (population-wide interventions) and retrospections ("**What if we had...**")
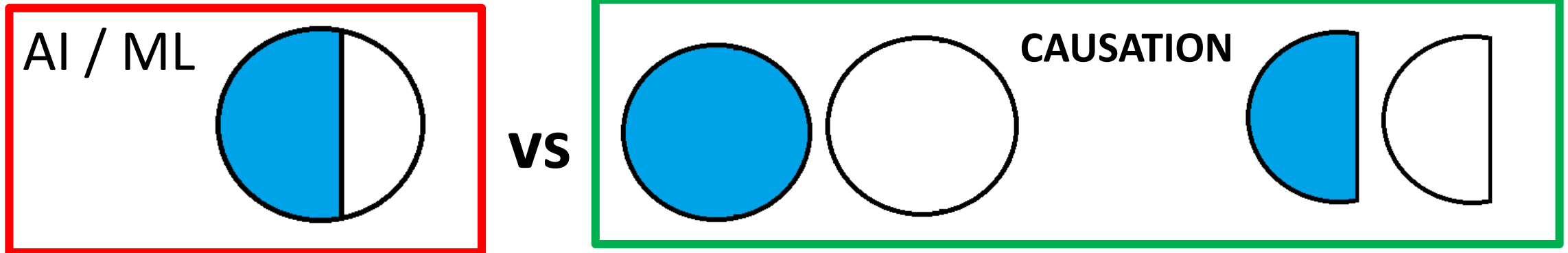
Causal Inference aims to...

- infer aspects of the *data generation process*

- understand **dynamics of events** *under changing conditions* (not just under **static condition**)
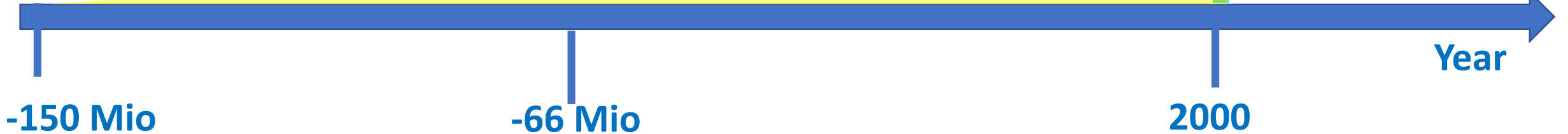

VS | FORCE →
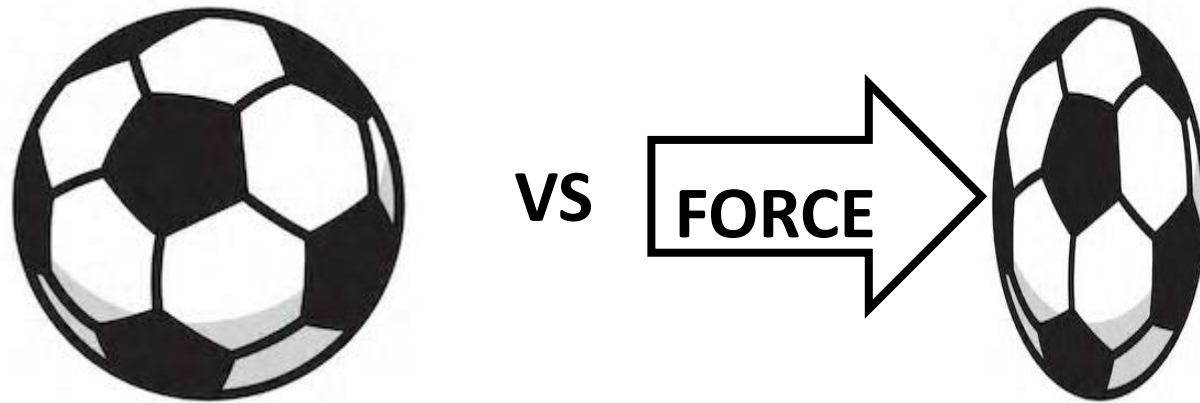
This allows to...

- *predict* the effect of actions (e.g., treatments or policy decisions),
- *identify causes* of reported events, and assessing *responsibility* and *attribution* (e.g., whether event x was necessary (or sufficient) for the occurrence of event y).
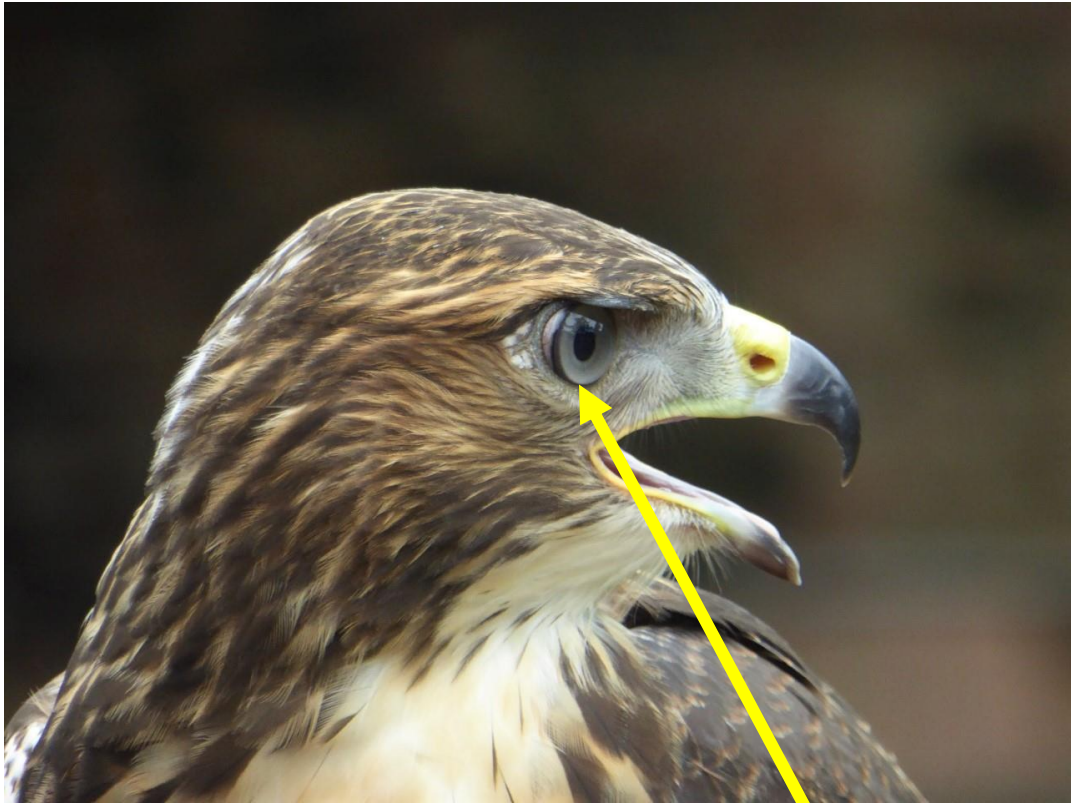
Few thousand years human intelligence

millions of years of refinement

-150 Mio   -66 Mio   2000   Year

(R)evolution of learning about reality

What made humans so different from other species on this planet?

→ most likely the ability of **IMAGINATION** i.e. to picture a
     mental representation of the environment that they were able to
     manipulate to envision different hypothetical environments:

"What if act…"?
"What if I acted differently…?"

**-> No present learning machine can answer such questions, as these rely on
     environmental assumptions ("data") that have not been observed before.**

Three Layers of Causal Hierarchy proposed by JUDEA PEARL

	Activity	Typical Questions	Examples
1. Association ML / AI	*seeing*	**- What is?** **- How does seeing X change my believe in Y?**	**- Symptom indicating presence of a disease.** **- Spatial distribution of obese people in Laval.**
2. Intervention Causal Inference	*doing intervening*	**- What if (I do..)?**	**- What if I take that pill, will my pain go away?** **- What if we ban soda drinks?**
3. Intervention Causal Inference	*imagining retrospection*	**- Why?** **- What if I had acted differently?**	**- What if I had skipped Soda for the past 2 yrs?**

"Counterfactuals are the building blocks of scientific thinking as well as legal and moral reasoning."

"A child learns the effects of interventions through playful manipulation of the environment (usually in a deterministic playground)"

"Interventional expressions cannot be inferred from passive observations alone, regardless of how big the data."

An Architect's dream is an Engineer's nightmare.

Trust Me, I'm an "Architect"

source: http://arch-student.com/pin/an-architects-dream-is-an-engineers-nightmare/

MERCI / THANK YOU!