Deep Learning in Healthcare

Hossein Akhlaghpour
Hossein@MedicalBlockchain.ai
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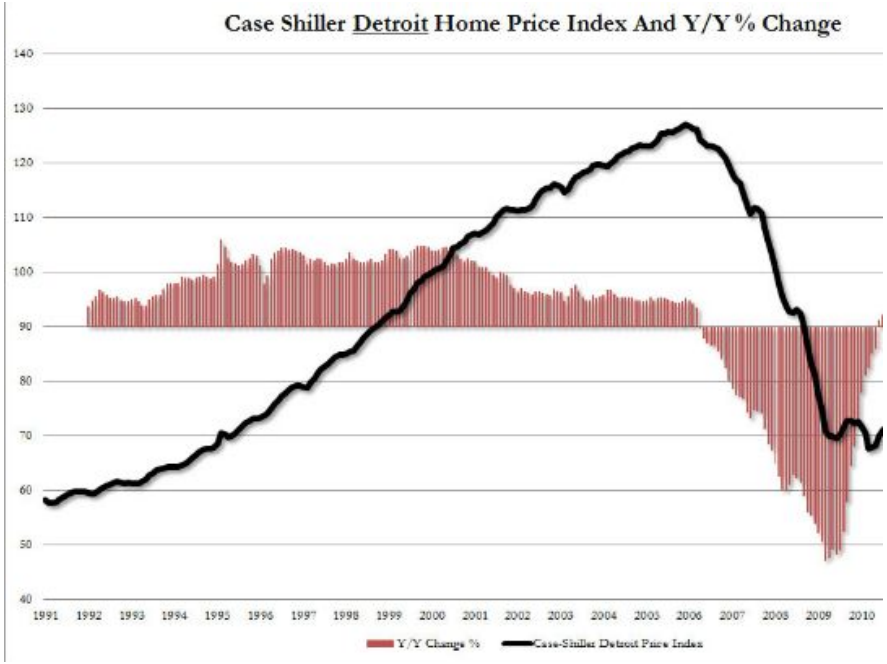
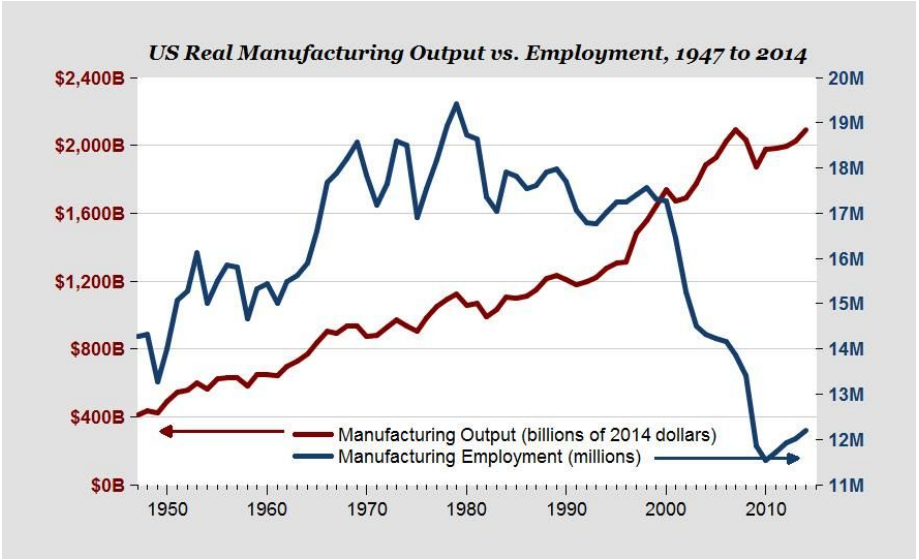
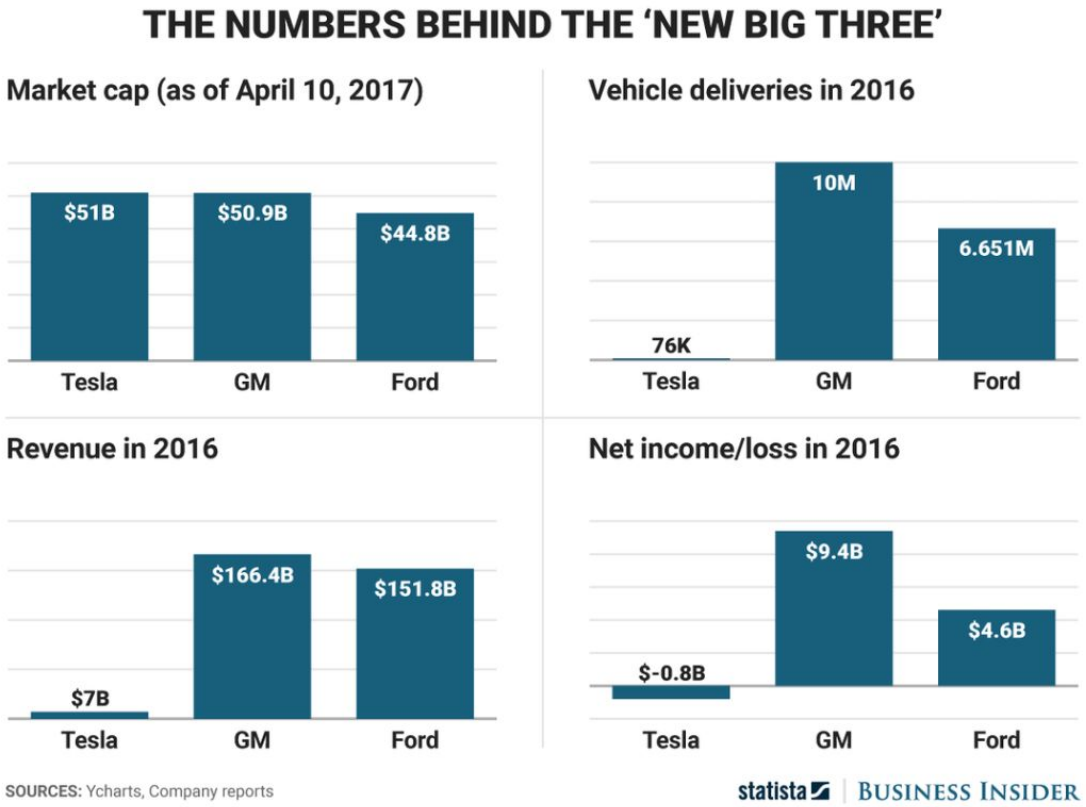
Crash of a City



Transition in Manufacturing Industry



Tesla is a Game Changer



Mike Nudelman/Business Insider/Statista

12 Disruptive Technologies

McKinsey&Company

McKinsey Global Institute

Renewable energy

- 21,000 TWh annual global electricity consumption
- 13 billion tons in annual carbon dioxide emission from electricity generation
- $3.5 trillion value of global electricity consumption
- 65% lower price for solar photovoltaic cell per watt since 2000

Advanced oil & gas exploration & recovery

- 3x increase in efficiency of US gas wells between 2007 & 2011; 2x increase for oil wells over the same period
- 30 billion barrels of crude oil produced globally
- $3.4 trillion revenue from global sales of crude oil

Advanced materials

- $1000 vs $50: Price difference of 1 gram of nanotube over a decade
- 115x strength-to-weight ratio of cabon nanotubes in steel
- $4 billion revenue from global carbon fibre sales

3D printing

- 90% decrease in price of home 3D printers compared to 2009
- 8 billion pieces of toys manufactured globally a year
- $11 trillion worth in global manufacturing GDP

Energy storage

- 40% price decline in Lithium-ion battery pack in an electric vehicle since 2009
- $100 billion estimated value of electricity for households currently without access
- 1.2 billion people without access to electricity

Next-generation genomics

- 10 months to double sequencing speed per dollar
- 100x increase in acreage of genetically modified crops between 1996 to 2012; 2.5 billion people employed in agriculture
- $6.5 trillion global health-care costs

Mobile Internet

- Fastest supercomputer in 1975 costs $5m, with equal performance as an iPhone 4, which costs $400
- 4.5 billion people yet to be connect to the Internet today
- $1.7 trillion worth of GDP related to the Internet

Automation of knowledge work

- 100x increase in computing power from IBM's Deep Blue (1997) to Watson (2011)
- 1.1 billion smartphone users, with potential to use automated digital assistance apps
- $9+ trillion global costs of employing knowledge workers, which is 27% of global employment costs

Internet of Things

- 300% increase in connected machine to machine devices since 2008
- 1 billion things that could be connected to the Internet across different industries
- $36 trillion operating costs of key affected industries
- mining
- health-care
- manufacturing

Cloud technology

- 18 months to double server performance per dollar
- 2.7 billion Internet users served by 10 million servers worldwide
- $3 trillion spending by enterprises on information technology

Advanced robotics

- 170% growth in sales of industrial robots between 2009 and 2011
- 320 million manufacturing workers may be potentially affected

Autonomous and near-autonomous vehicles

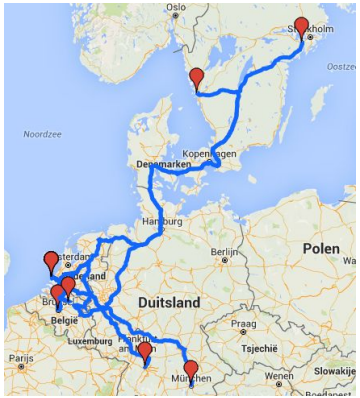
- 300,000+ miles driven by Google's autonomous cars with only 1 accident (which was human-caused)
- $4 trillion in global manufacturing employment costs, which is 19% of global workforce
- 1 billion cars & trucks, 450,000 civilian, military & general aviation aircrafts globally
- $4 trillion automobile industry revenues

Created by:
Daniel Tay
May 2013 Singapore
boingx5@gmail.com
www.tayxiongsheng.com
@tayxiongsheng

The source of information in this Mind Map comes from http://www.mckinsey.com/insights/business_technology/disruptive_technologies

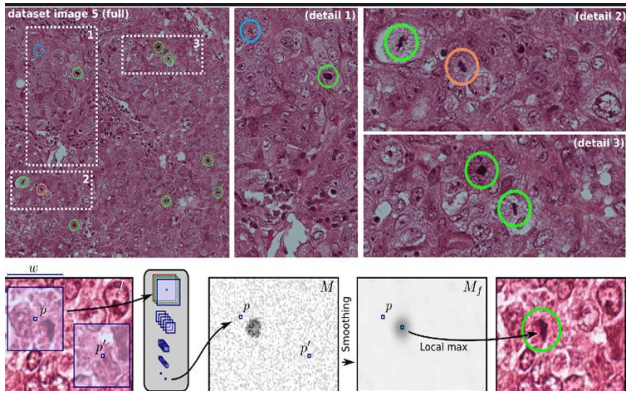
Impact of Machine learning on Jobs

Self-driving trucks: what's the future for America's 3.5 million truckers?

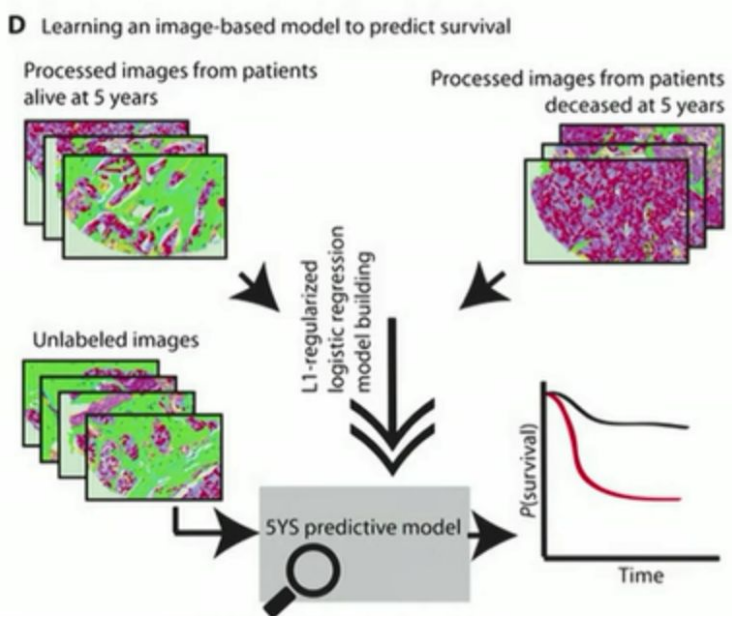


Robotics

Deep Learning applications in Medical Diagnosis



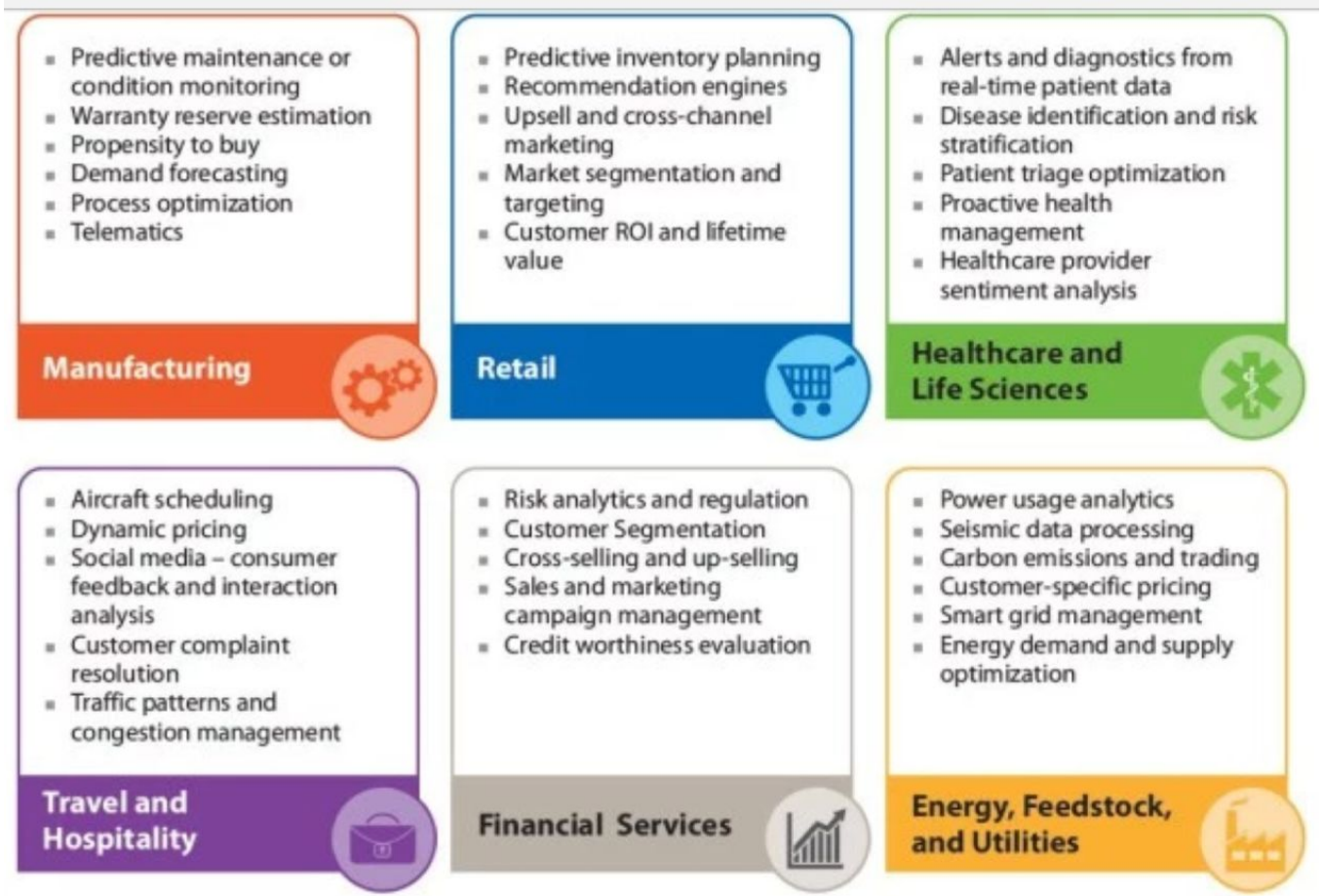
Cancer detection from Stanford, Predict survival rate better than pathologists



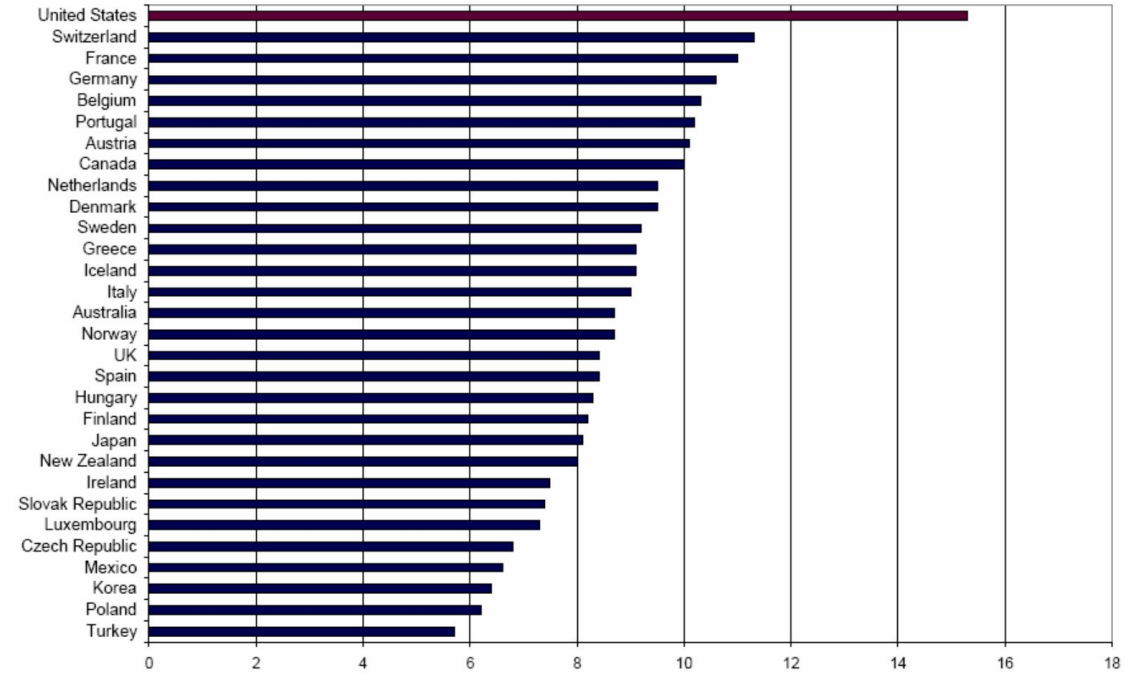
Geoffrey E. Hinton won the top prize in a contest sponsored by Merck to design software to help find molecules that might lead to new drugs (in 2 weeks with no background in life sciences)

Computer discover that cells around the cancer are as important as cancer cells in making the diagnosis

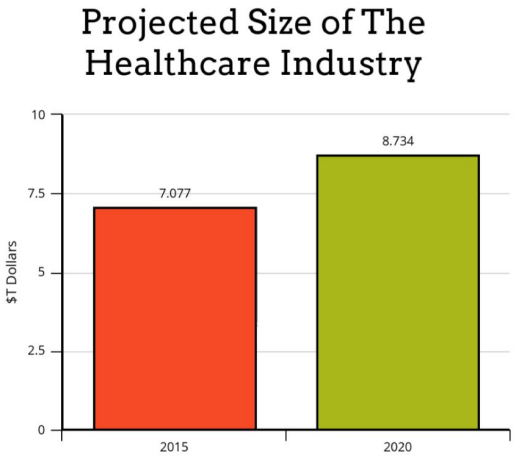
Industries Competing for AI



Healthcare industry

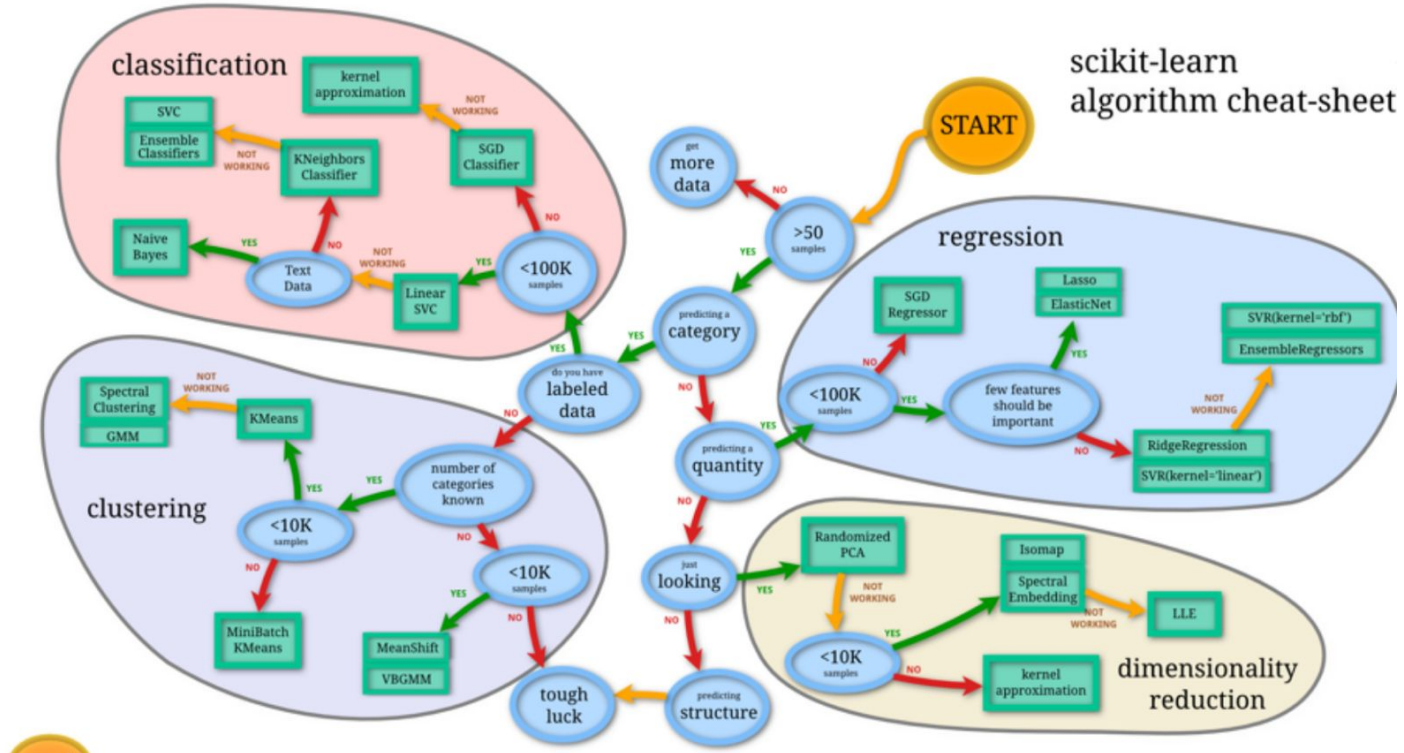


Source: Organization for Economic Cooperation and Development, OECD Health Data, 2008 (Paris: OECD, 2008).
Note: For countries not reporting 2006 data, data from previous years is substituted.

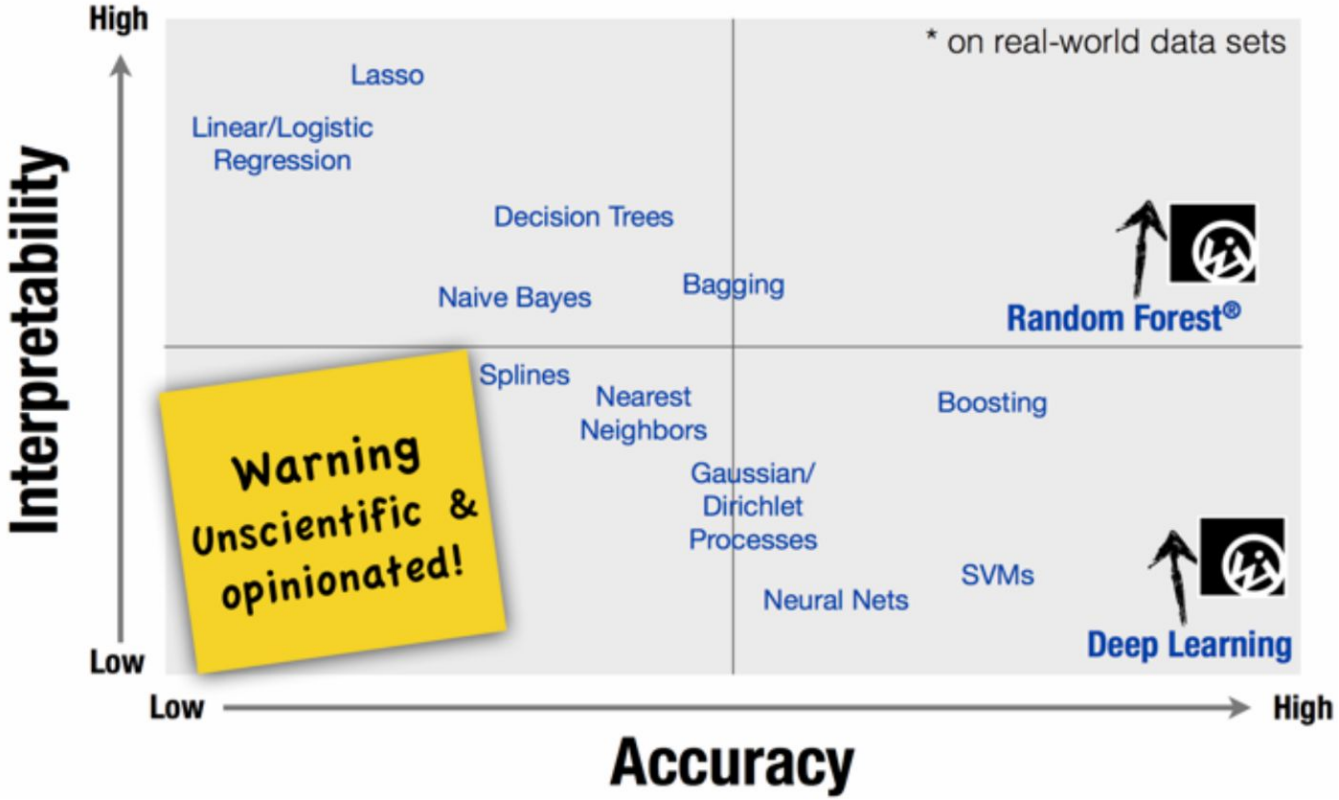


Source: The Economist Intelligence Unit

Conversation ML Algorithms



ML Algorithmic Trade-Off



What is Deep Learning

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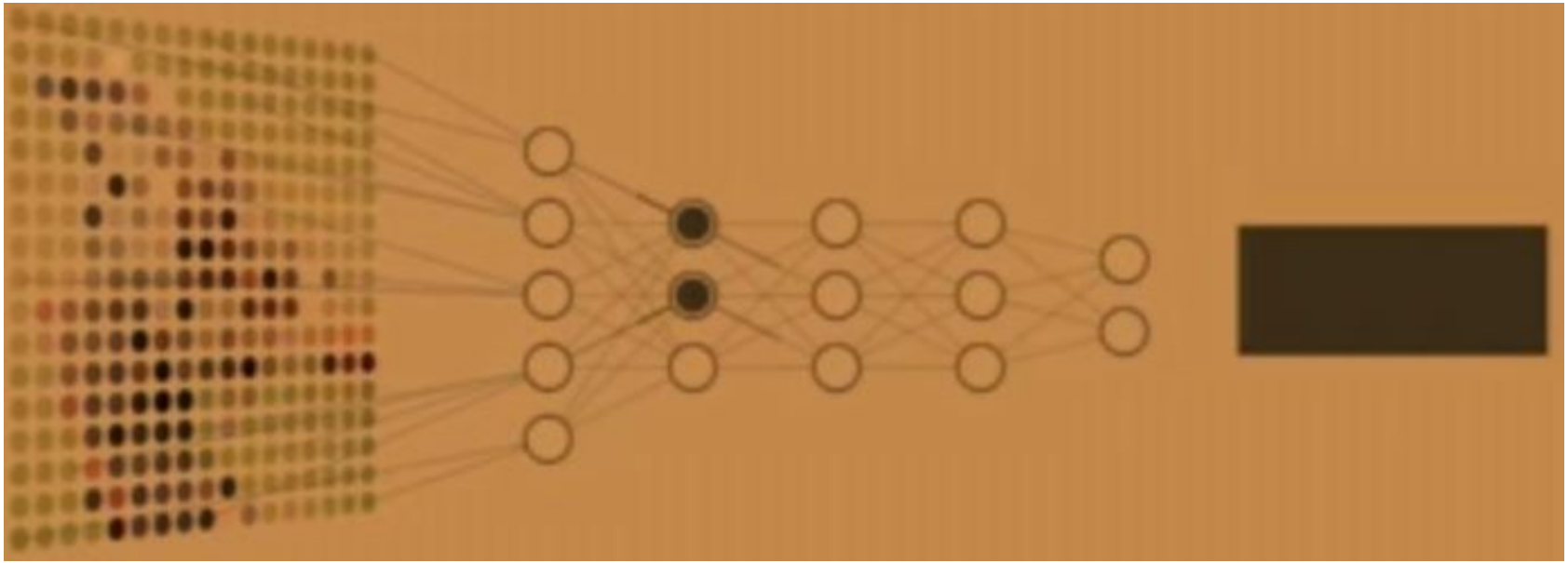
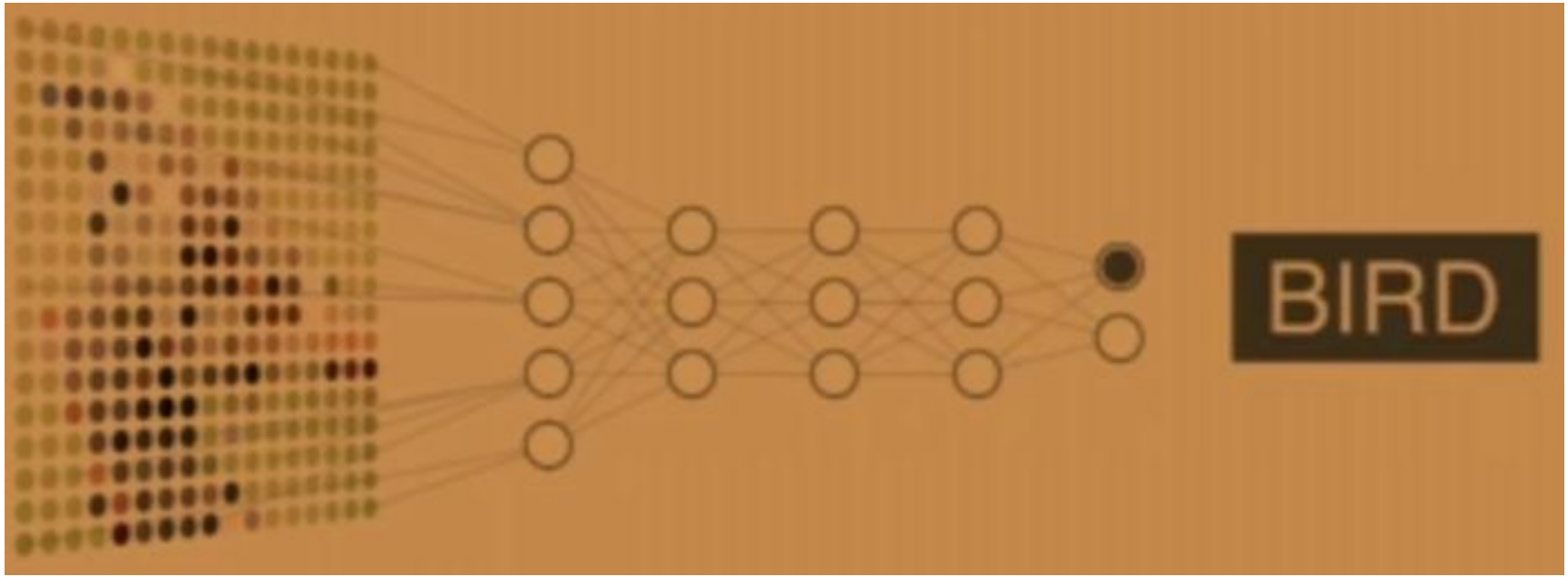
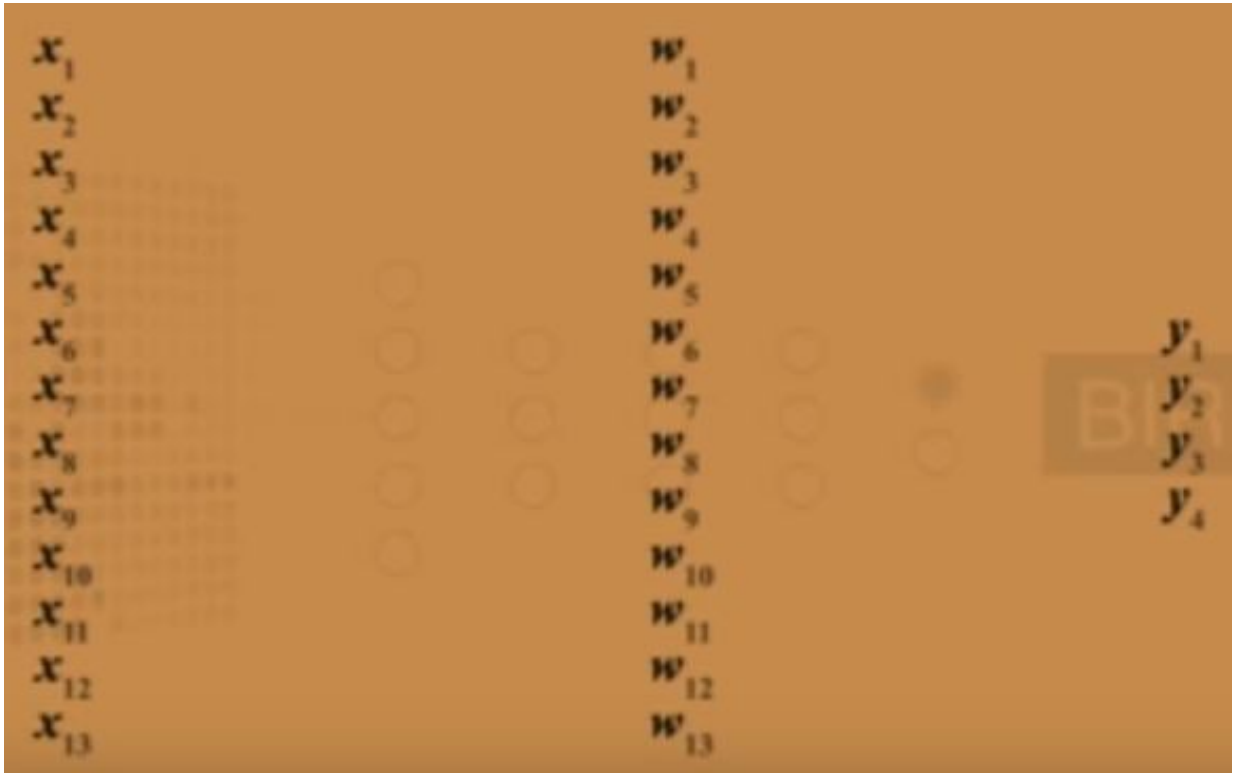


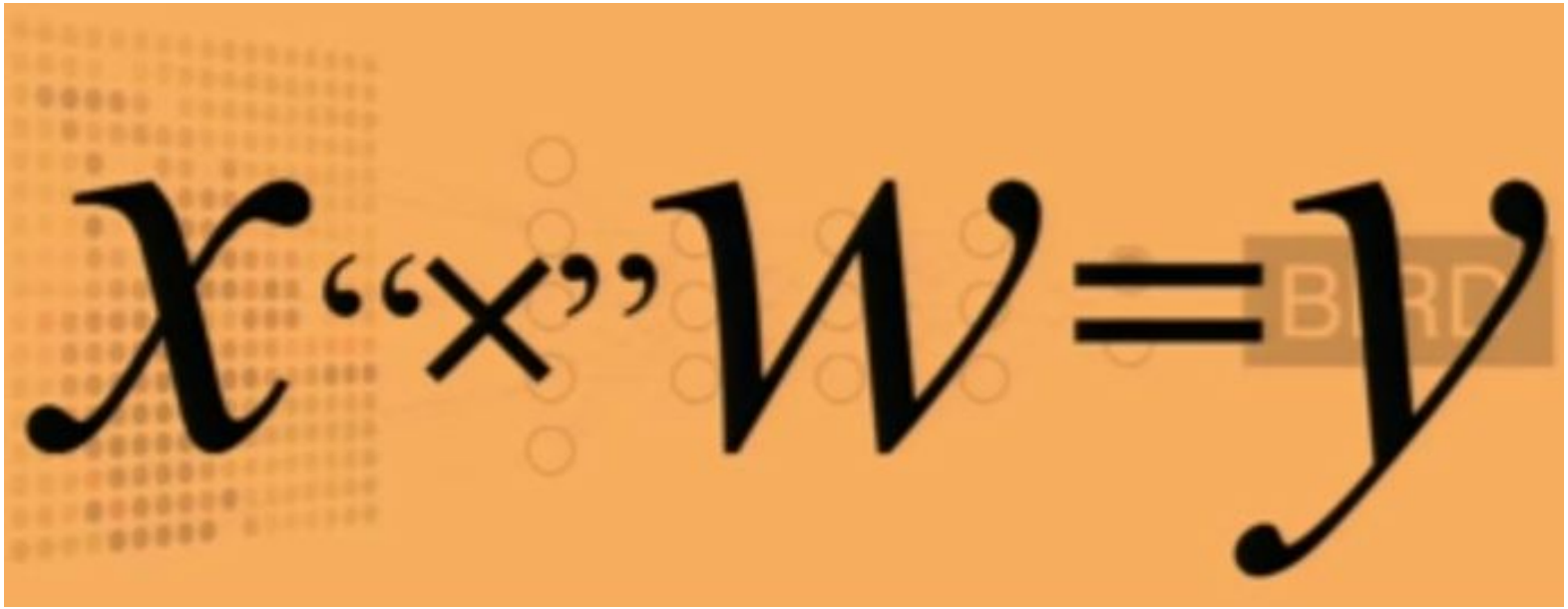
What is Deep Learning



What is Deep Learning



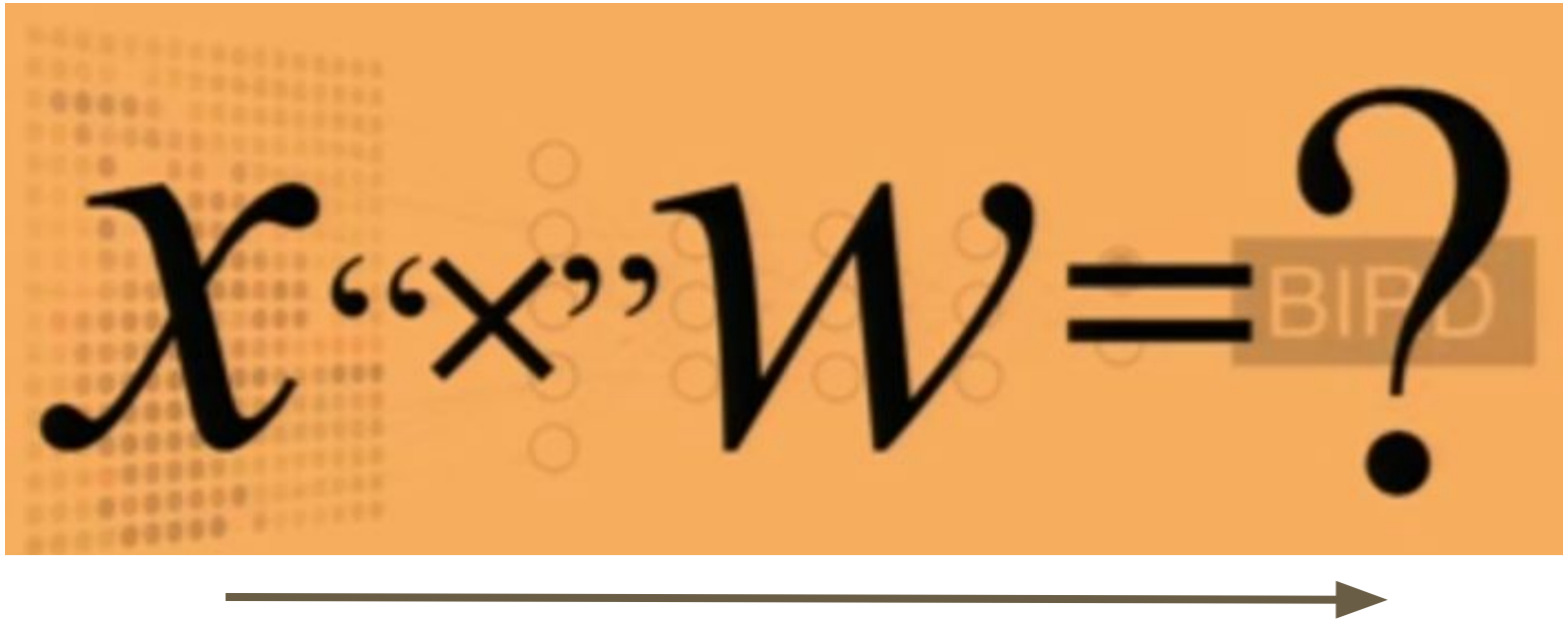
What is Deep Learning



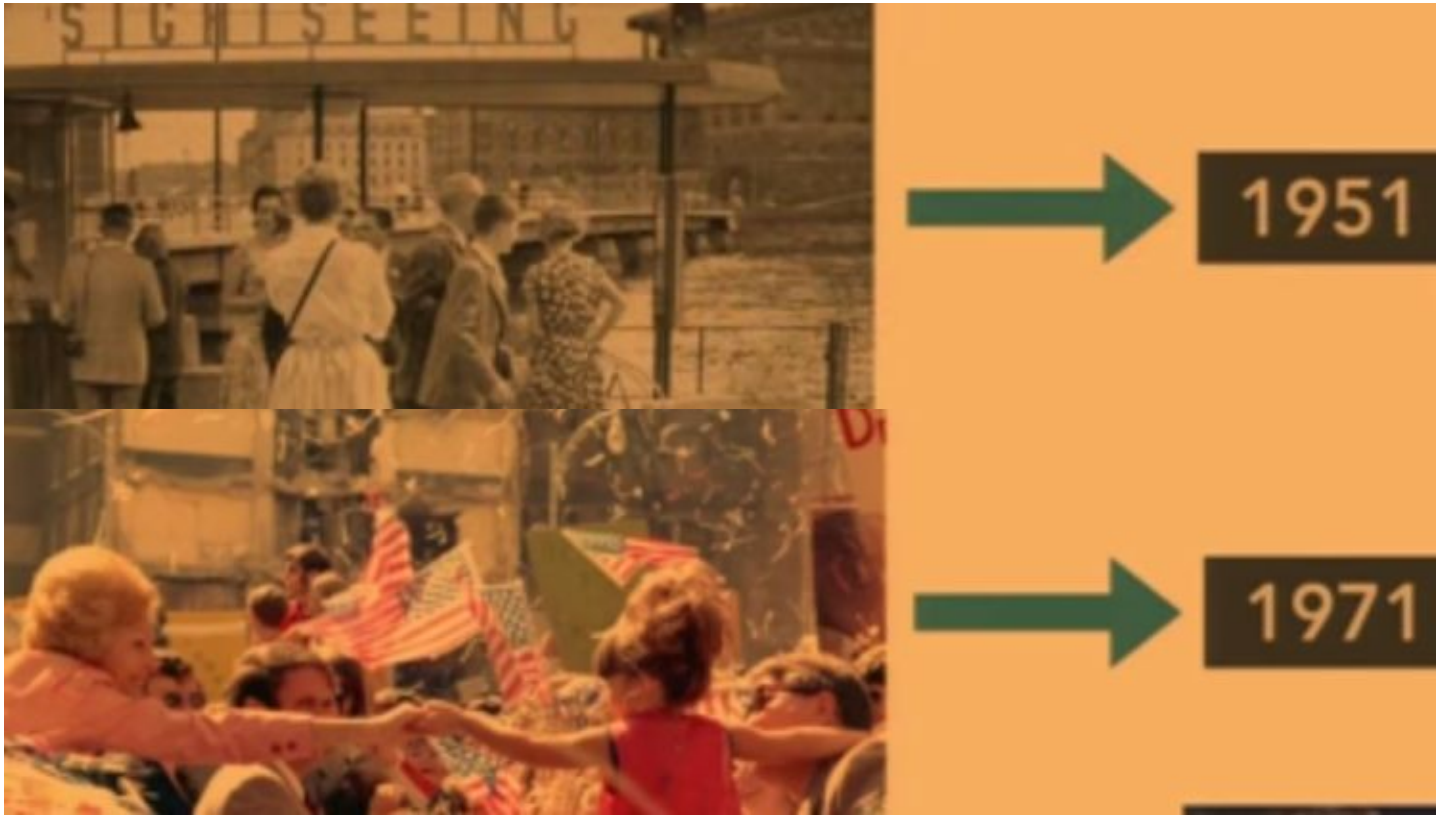
What is Deep Learning - Inference

Brain

What is Deep Learning - Perception

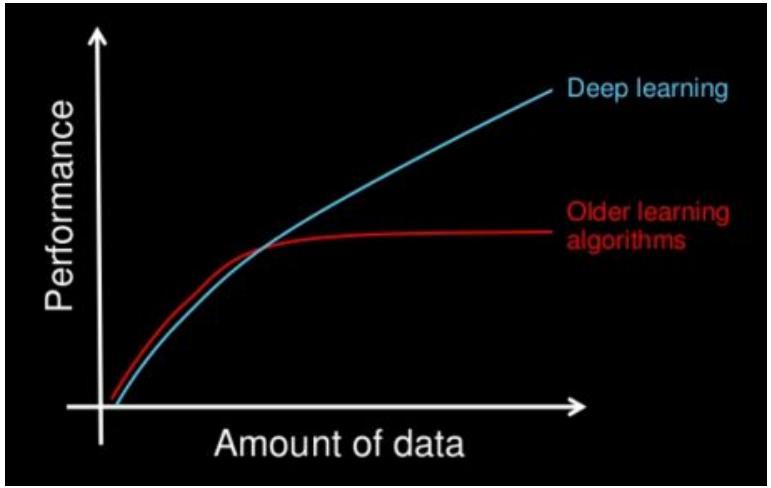


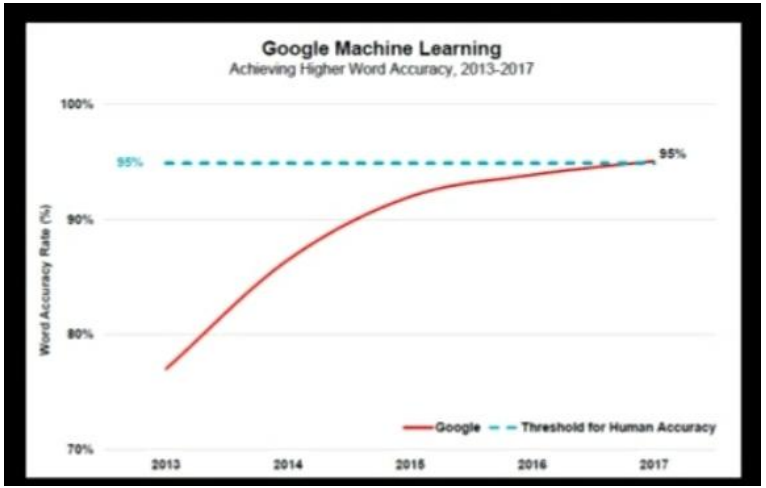
What is Deep Learning - Black box

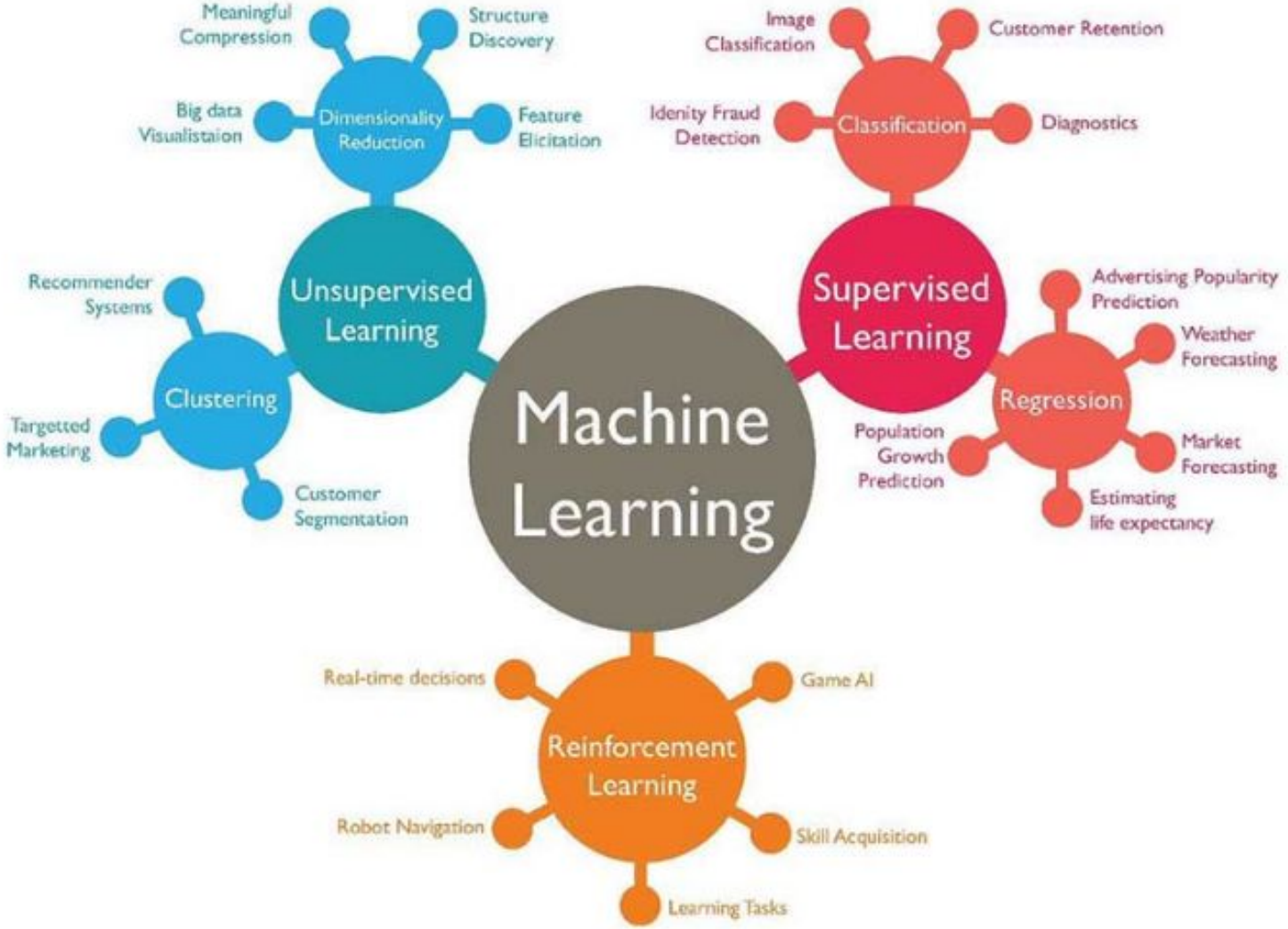


What Differentiates Deep Learning Technology

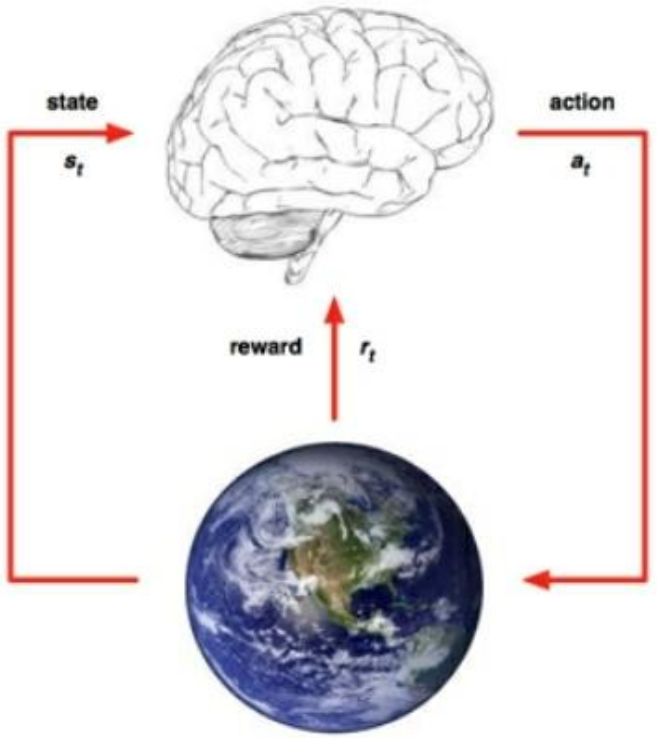
1. **Accuracy**: As the size of Data increases its accuracy goes up
2. **Generalization**: Applies for variety of applications
3. **Adaptive**: As the nature of problem varies so the algorithm
4. **Mimic Brain**: Closest algorithm to Human when it comes to detection






Machine Learning
Unsupervised Learning
Dimensionality Reduction
Meaningful Compression
Structure Discovery
Big data Visualisaion
Feature Elicitation
Clustering
Recommender Systems
Targetted Marketing
Customer Segmentation
Supervised Learning
Classification
Image Classification
Customer Retention
Idenity Fraud Detection
Diagnostics
Regression
Advertising Popularity Prediction
Weather Forecasting
Population Growth Prediction
Market Forecasting
Estimating life expectancy
Reinforcement Learning
Real-time decisions
Game AI
Robot Navigation
Skill Acquisition
Learning Tasks

Deep Reinforcement Learning

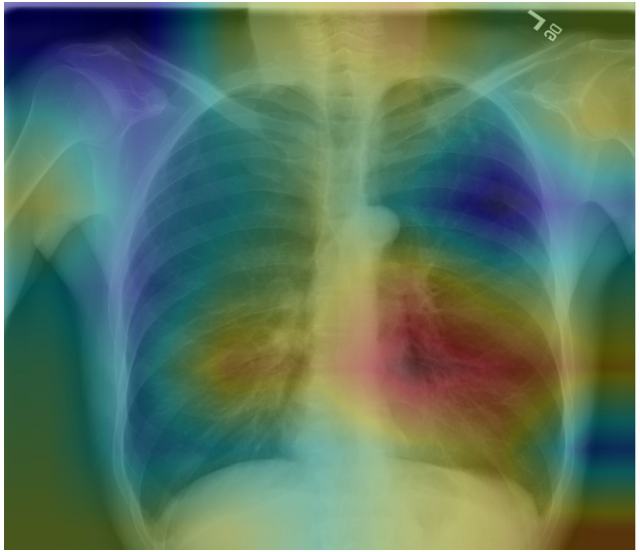


Supervised, Unsupervised and Reinforcement Learnings

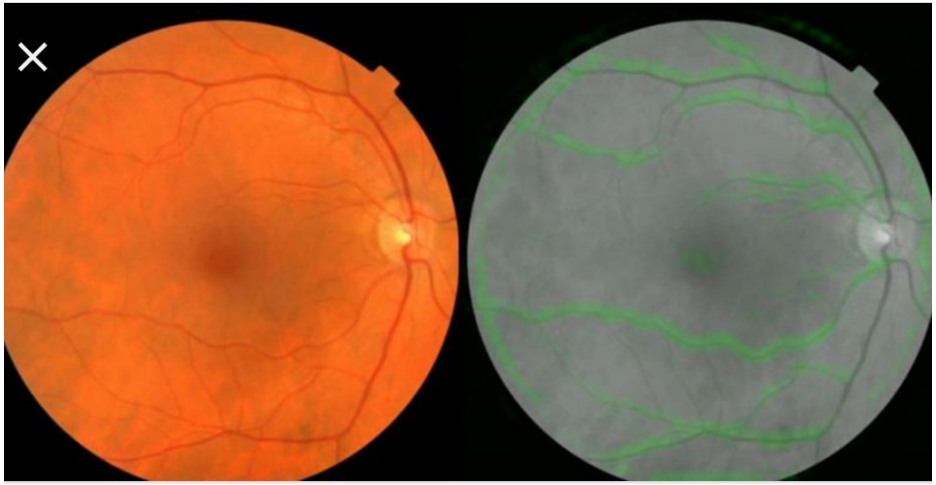
- **Pure Reinforcement Learning (cherry)**
  - The machine predicts a scalar reward given once in a while.
  - **A few bits for some samples**
- **Supervised Learning (icing)**
  - The machine predicts a category or a few numbers for each input
  - **10→10,000 bits per sample**
- **Unsupervised/Predictive Learning (génoise)**
  - The machine predicts any part of its input for any observed part.
  - Predicts future frames in videos
  - **Millions of bits per sample**

- **Unsupervised Learning is the Dark Matter (or Dark Energy) of AI**

Deep Learning app in reading Medical images



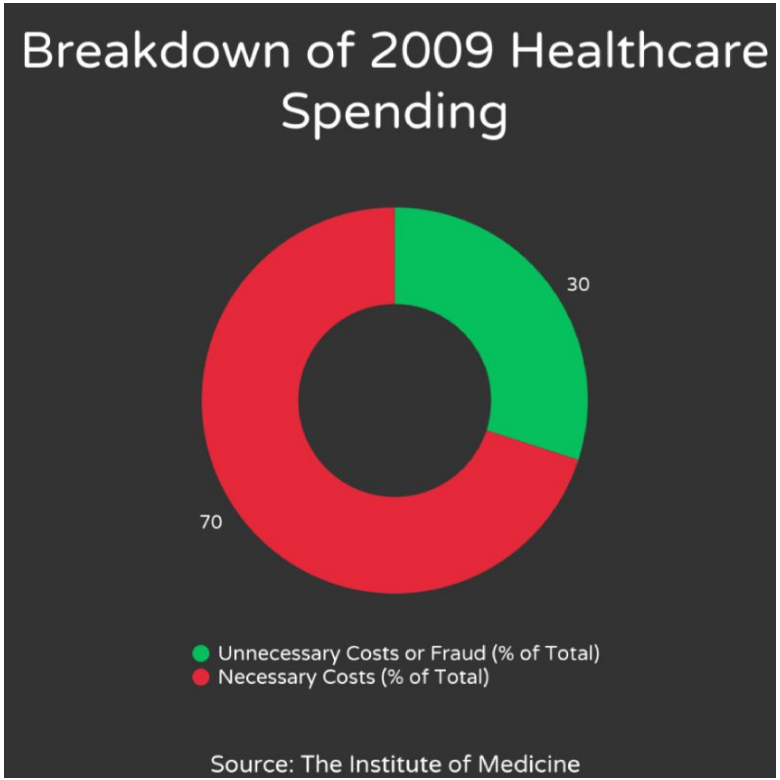
CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning



NDTV Gadgets

Google, Verily Life Sciences Use AI to Scan Eyes for Heart Risk ...

Other non trivial applications of ML in healthcare



Healthcare Admissions and Recruitements

Participant Recruitment Strategy

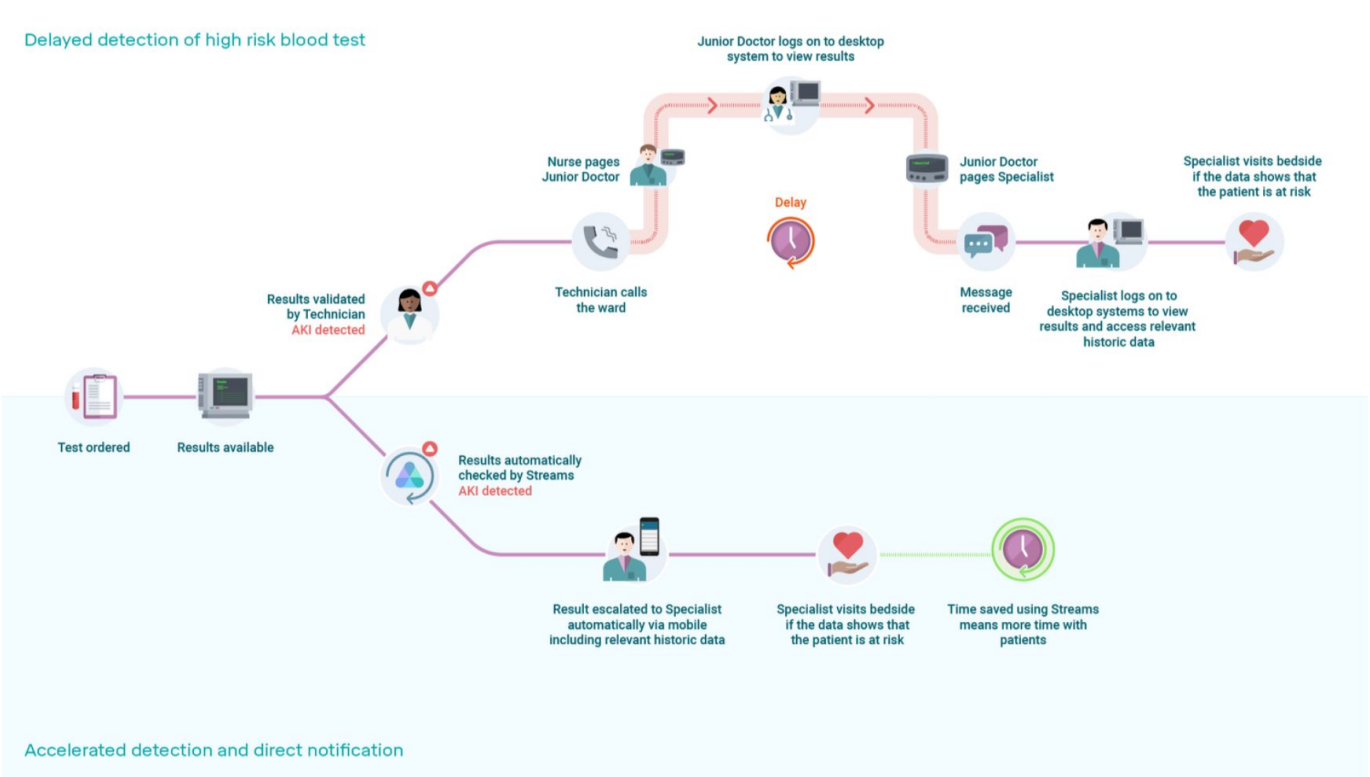
- Hospitals
University Healthcare Alliance
- Research Registries

- Participant Advisory Board
- Community Enrollment Center
- Business Talks

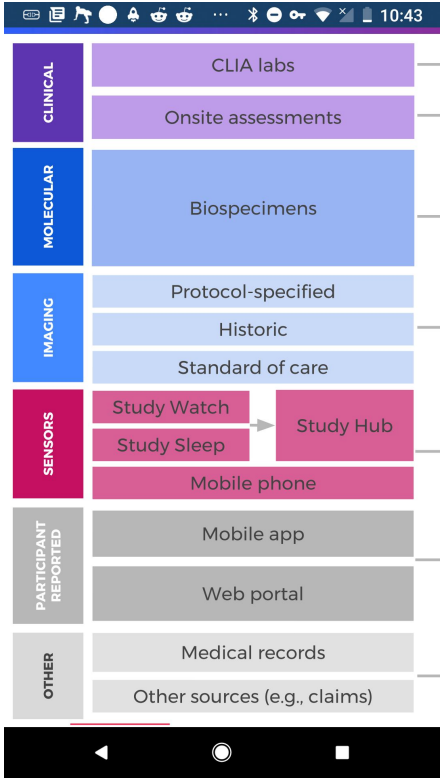
- Professional Medical Societie
- Teachers Association
- Patient Advocacy Groups

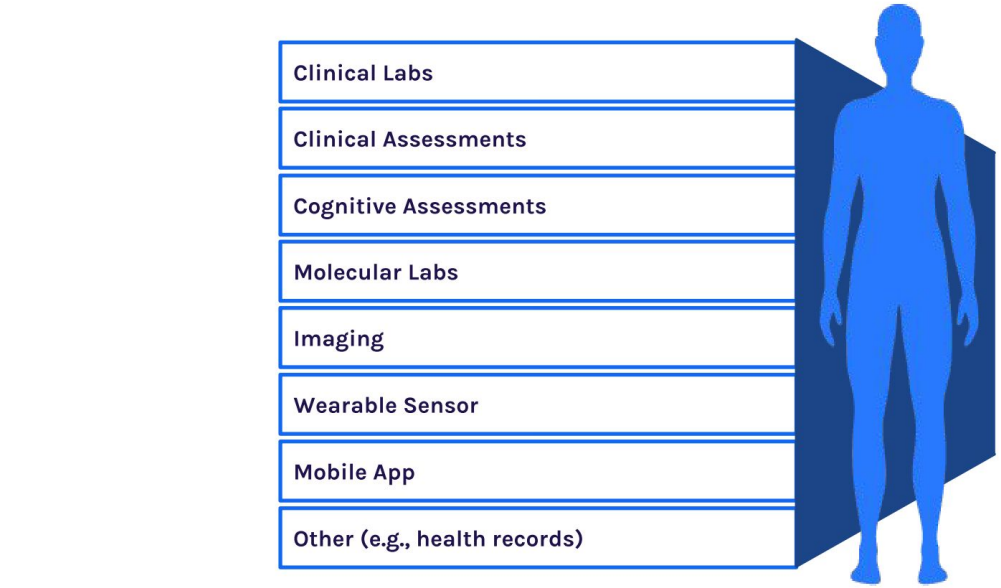
- Print (newspapers, flyers)
- Radio
- Social media

Deepmind Health

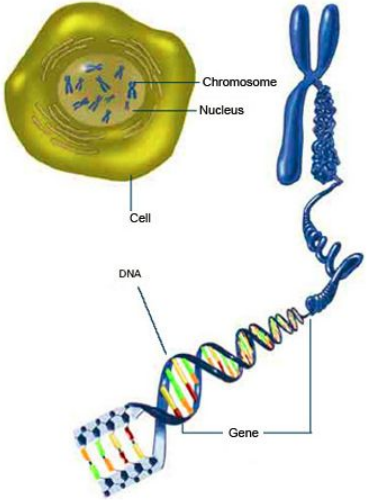


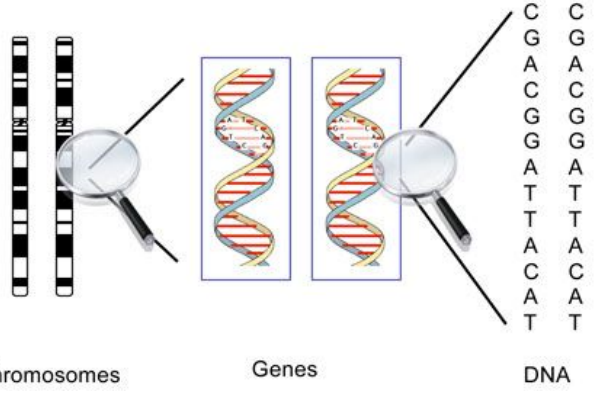
How to structure data



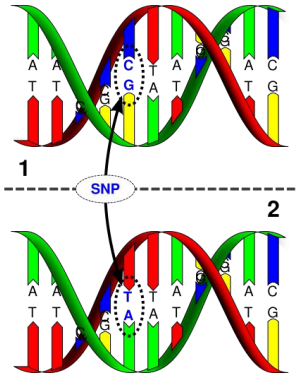


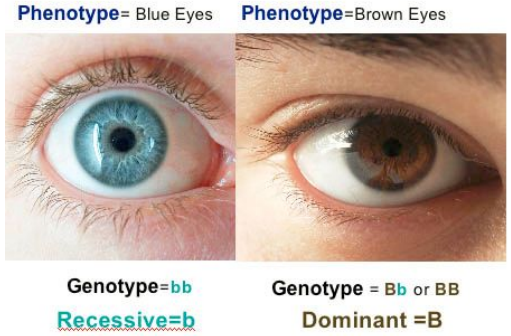
Genotype & Phenotype



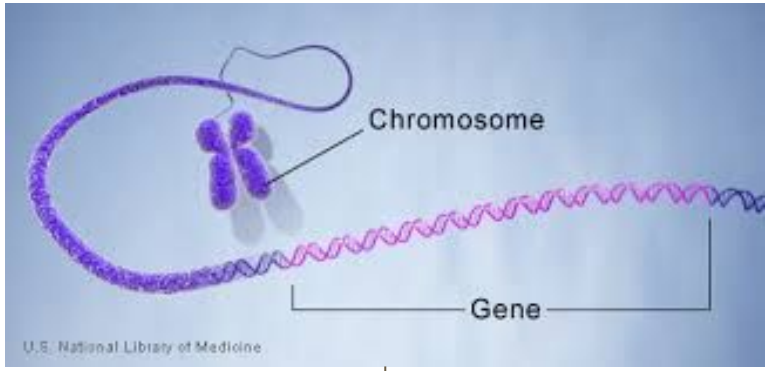


Single Nucleotide Polymorphism





Genome v.s. Exome



3000 Megabases

Variation ~ 30 million rSNP

Data Size ~ 200 G (38x Coverage)

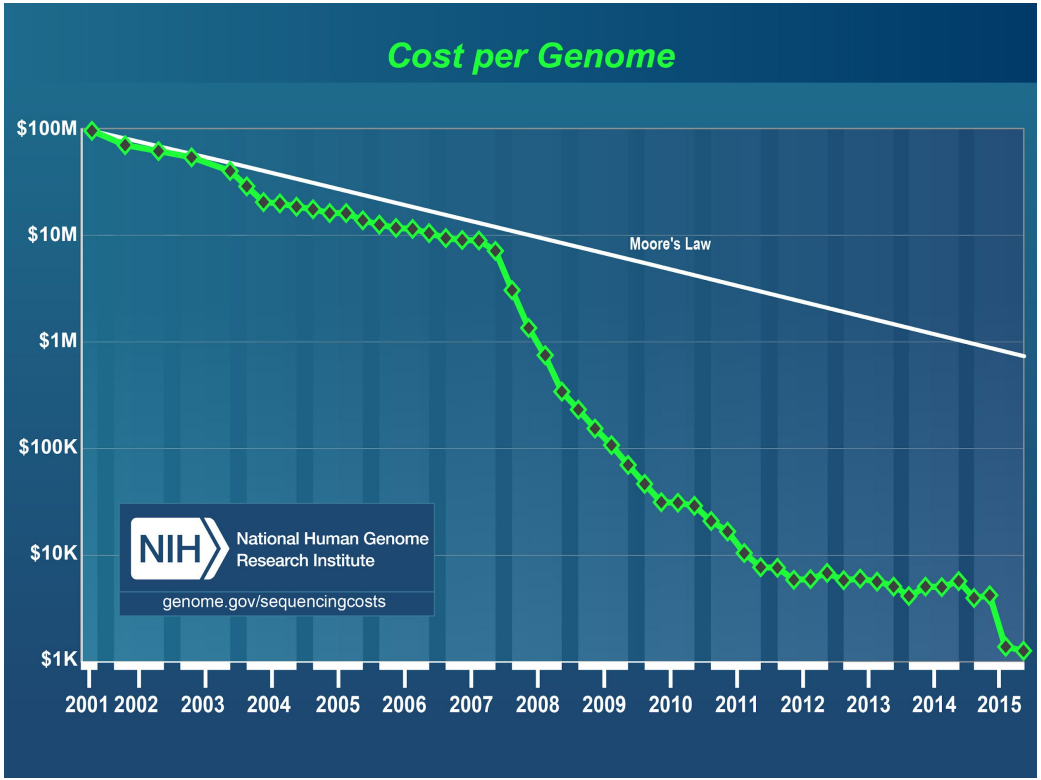
30 Megabases

20,000 Genes

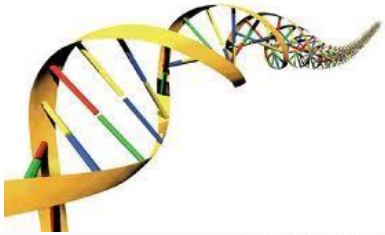
Variation ~ 5 million SNP

Data Size ~ 7 G (40x Coverage)

Growth of Genomics Industry



Genomics ⇒ Preventive / Personalized Medicine



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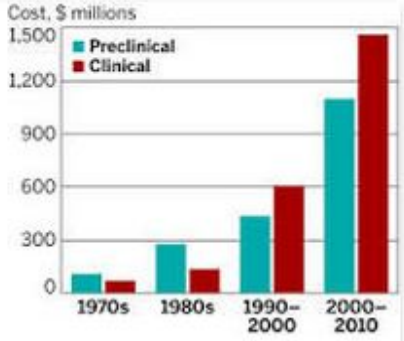
$2.6 billion

A new report published by the Tufts Center for the Study of Drug Development (CSDD) pegs the cost of developing a prescription drug that gains market approval at **$2.6 billion**, a 145% increase, correcting for inflation, over the estimate the center made in 2003. Nov 24, 2014

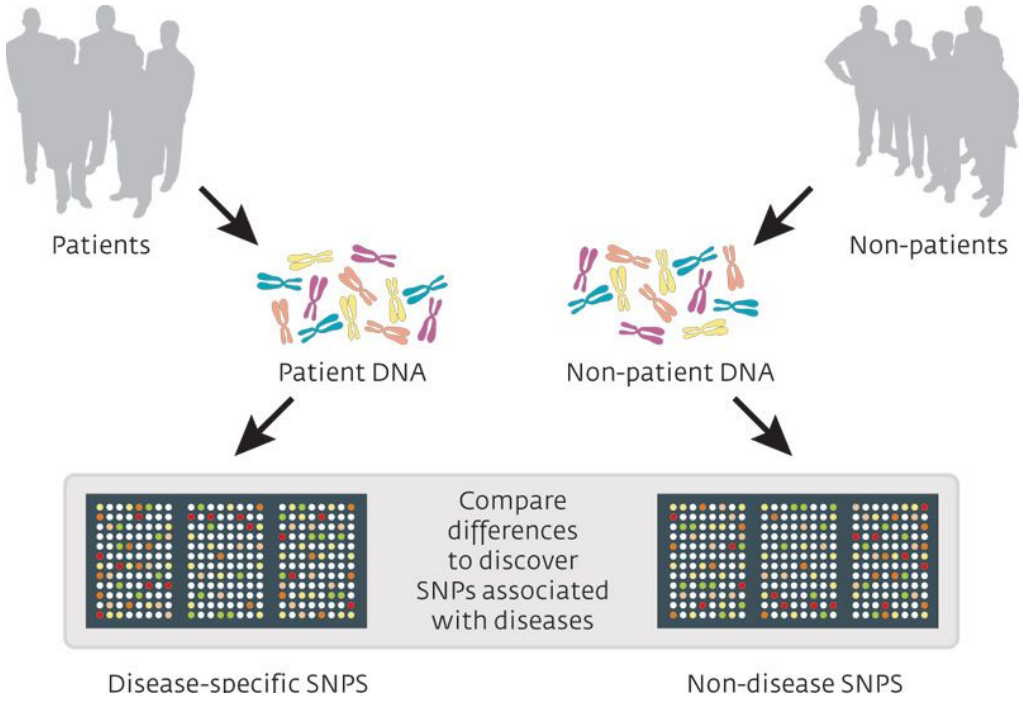


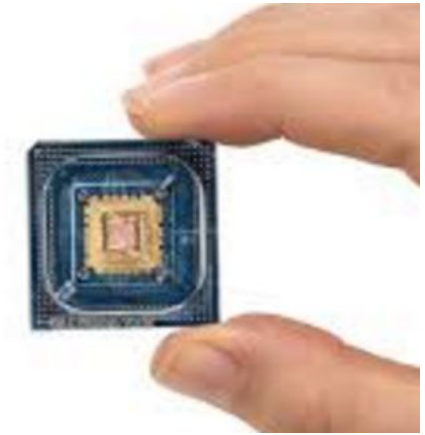
http://www.scientificamerican.com/article/cost-to-develop-new-pharmaceutical-drug-now-exceeds-2-5b/

http://www.forbes.com/sites/matthewherper/2013/08/11/how-the-staggering-cost-of-ir
g-new-drugs-is-shaping-the-future-of-medicine/

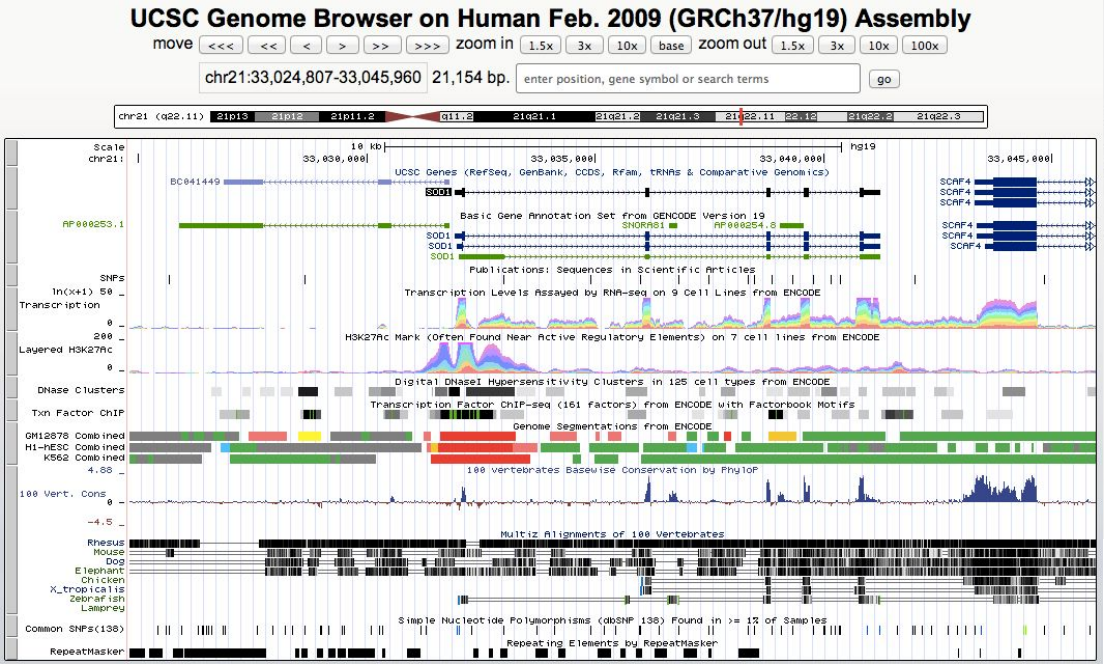
Genome Wide Association Study (GWAS)

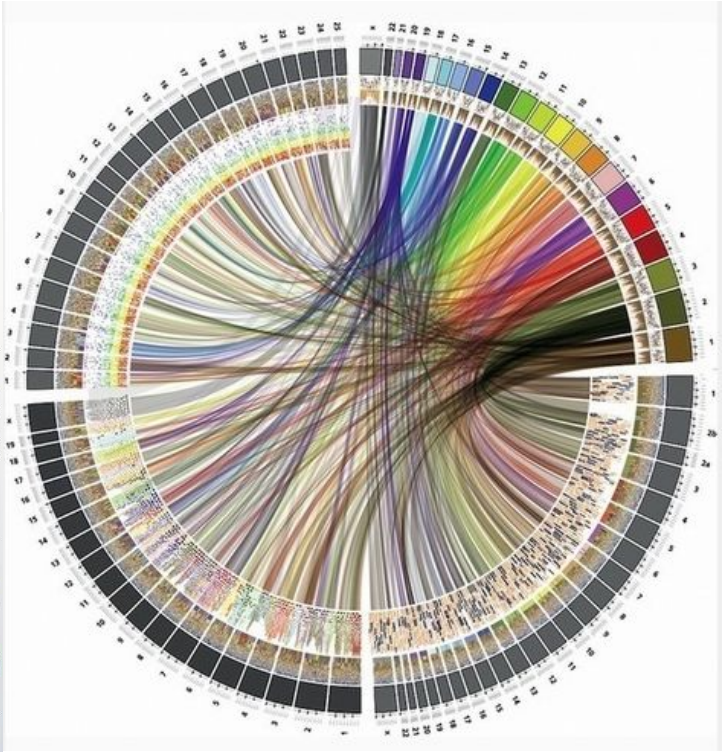
1000 Genomes Project, which sequenced one thousand individuals from 26 human populations





DNA Visualization

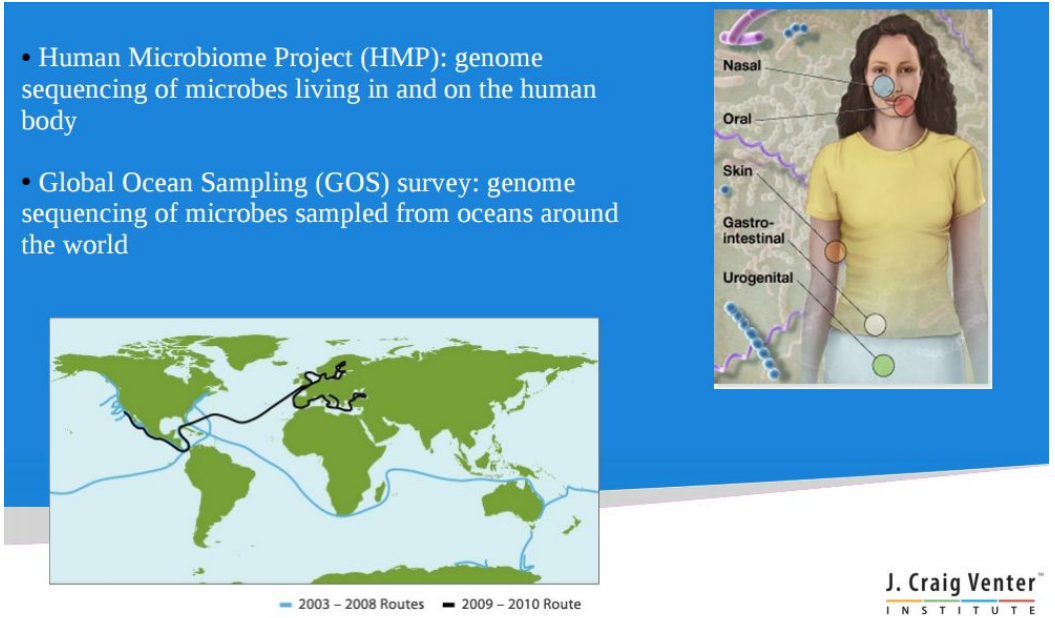




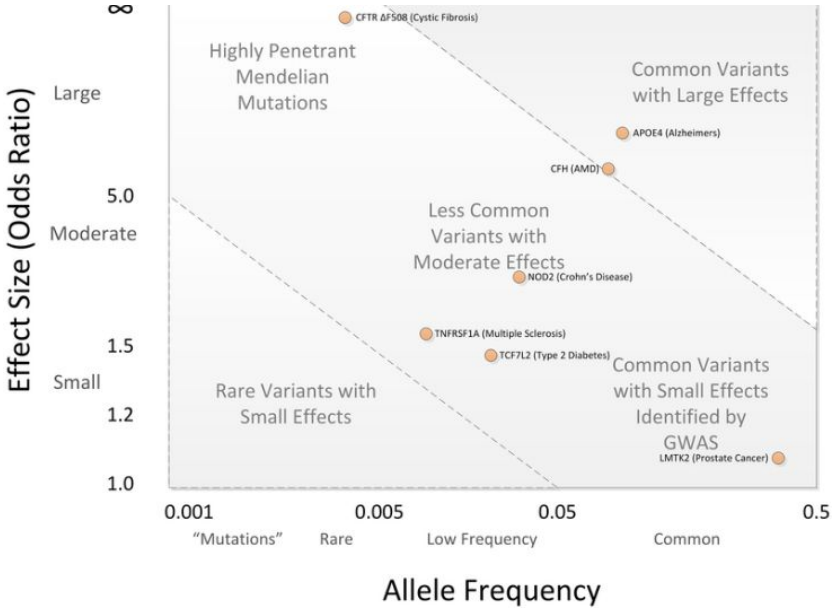
CLOCKWISE FROM TOP right, the genomes of a human, a chimpanzee, a mouse and a zebrafish are arranged in a circle, with each color square corresponding to a pair of chromosomes. Lines connect similar DNA sequences, visually emphasizing just how much DNA we share with other species. (Image: Martin Krzywinski/EMBO)

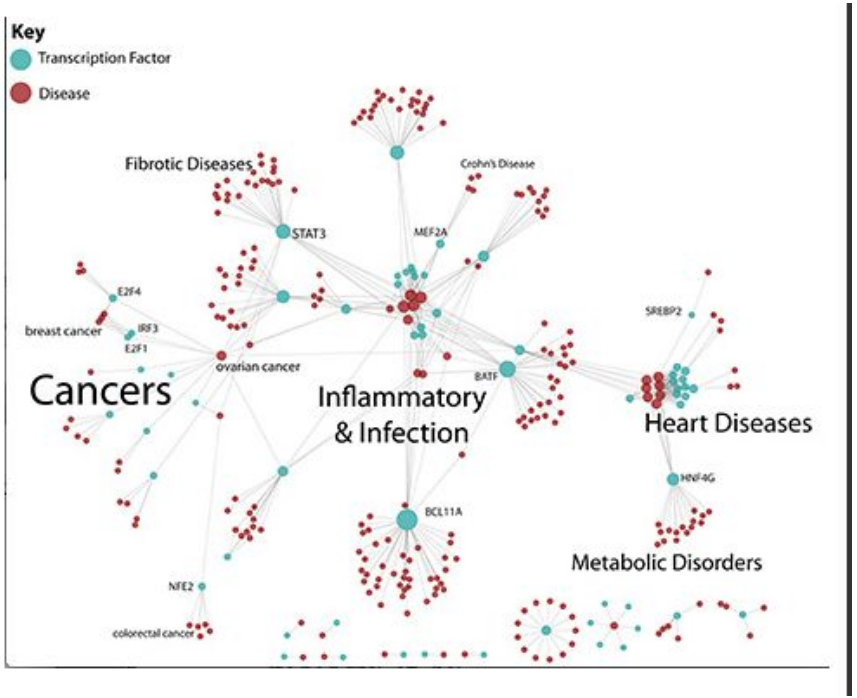
Microbiome

The human body contains trillions of microorganisms — outnumbering human cells by 10 to 1. Because of their small size, however, microorganisms make up only about 1 to **3 percent** of the body's mass (in a 200-pound adult, that's 2 to 6 pounds of bacteria), but play a vital role in human health.

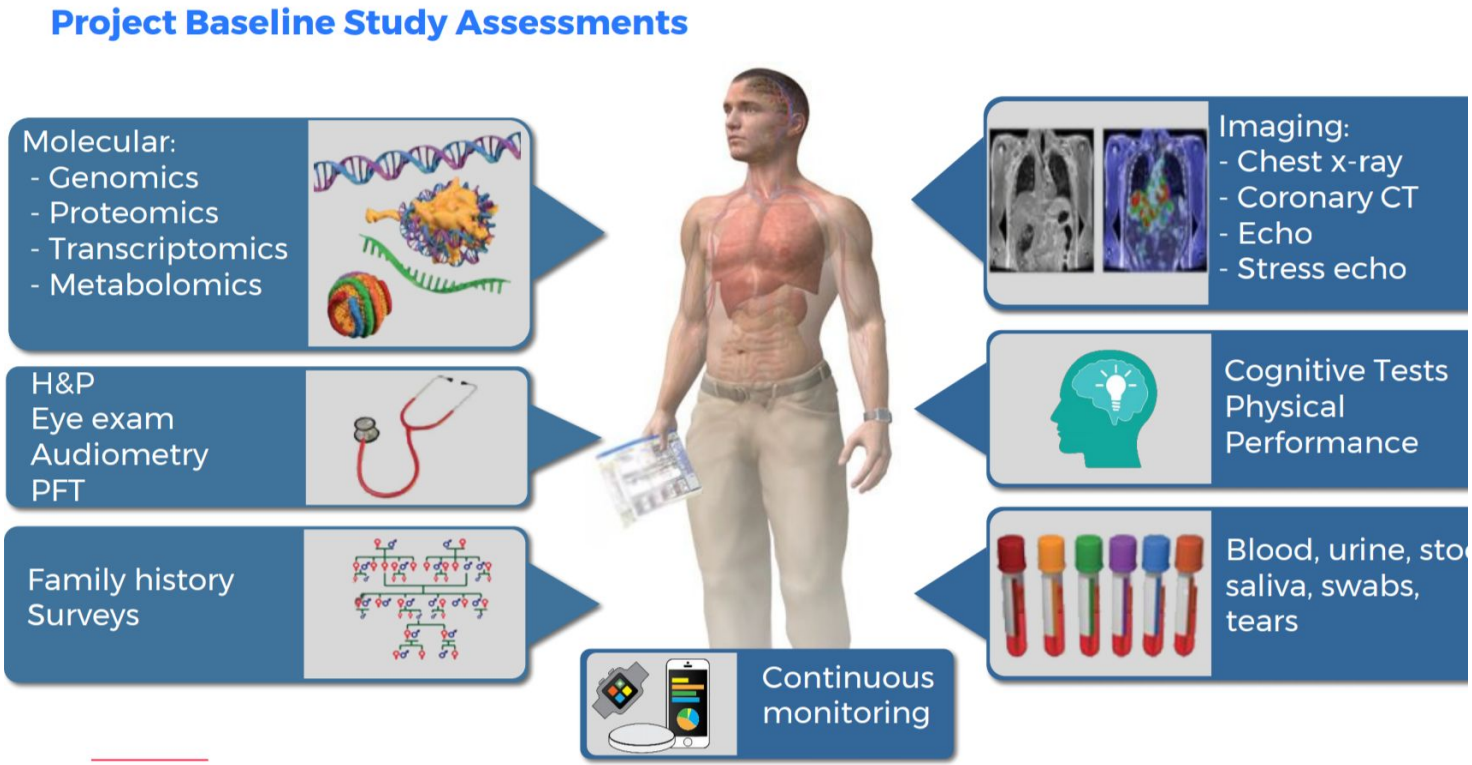


Epidemiology Landscape

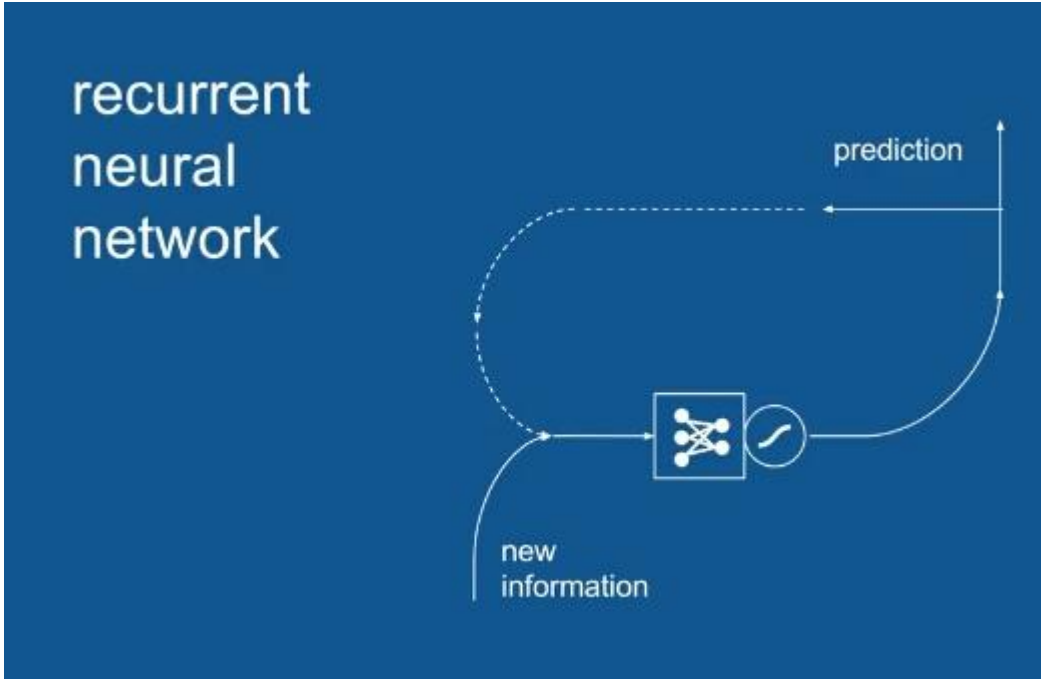




Project Baseline, a holistic view of data



RNN



If we have time Proceed

Long Short Term Memory

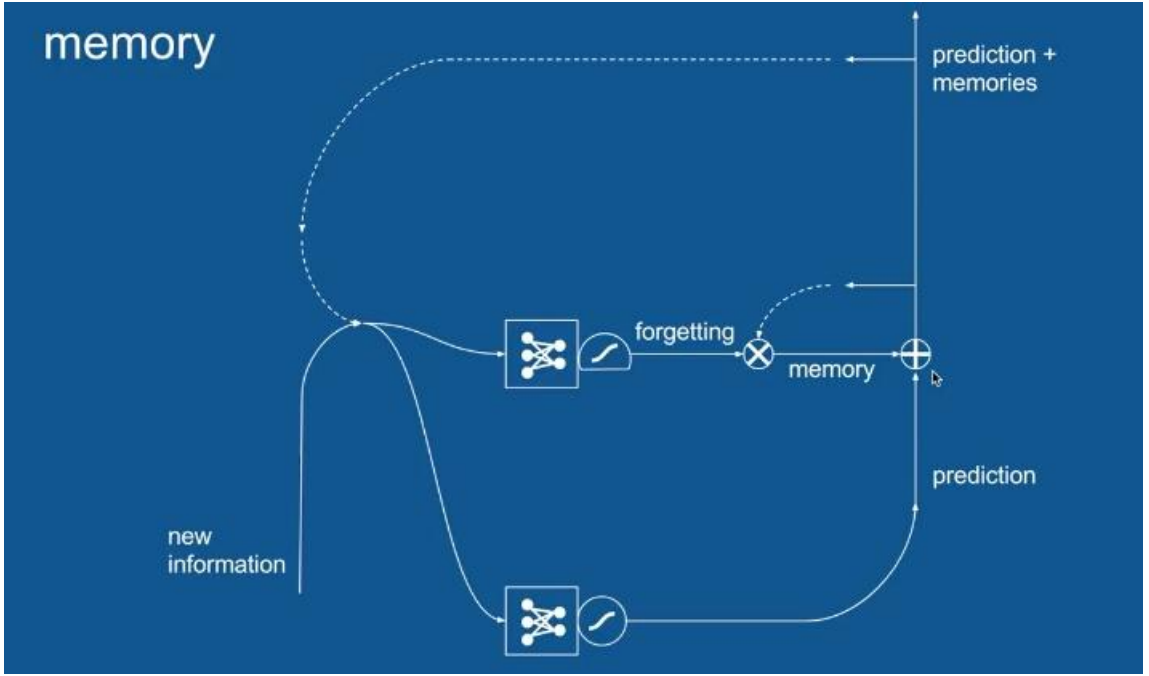
Write a children's book

Doug saw Jane.

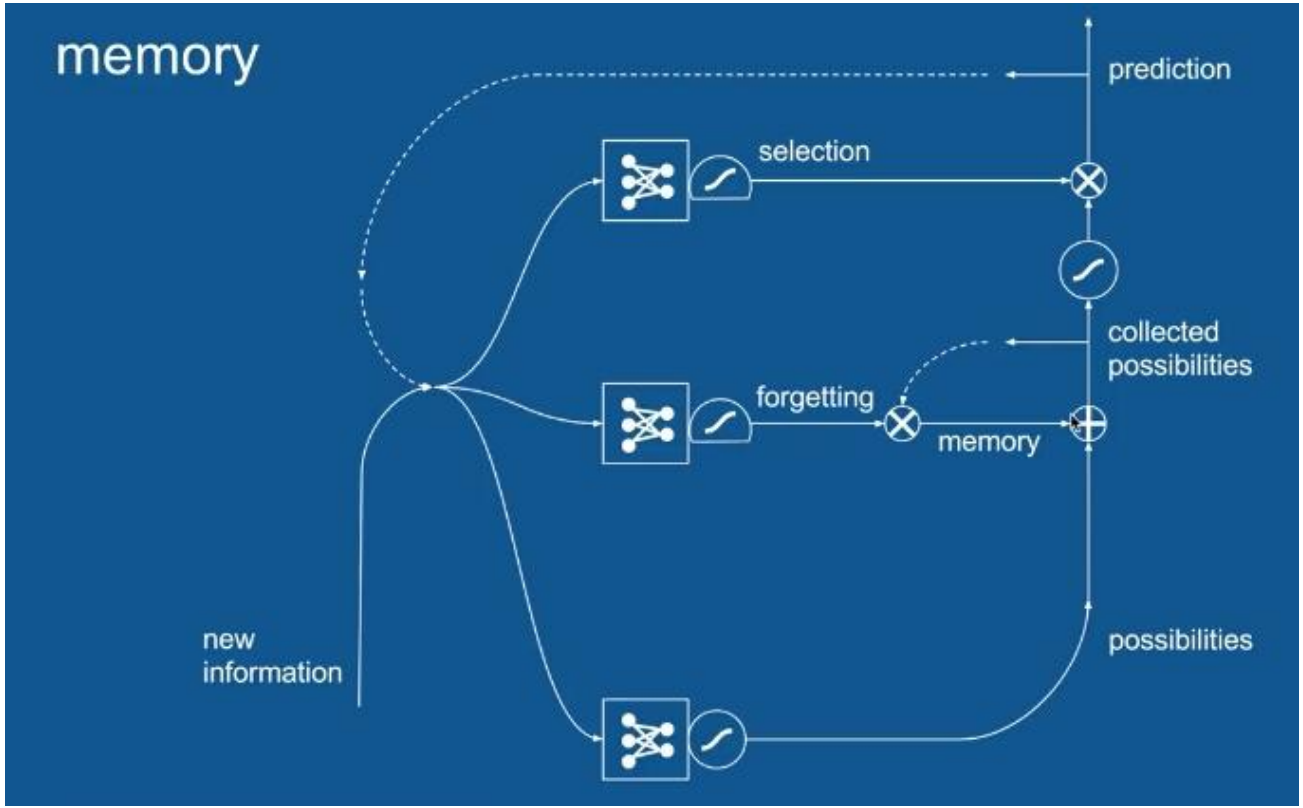
Jane saw Spot.

Spot saw Doug.

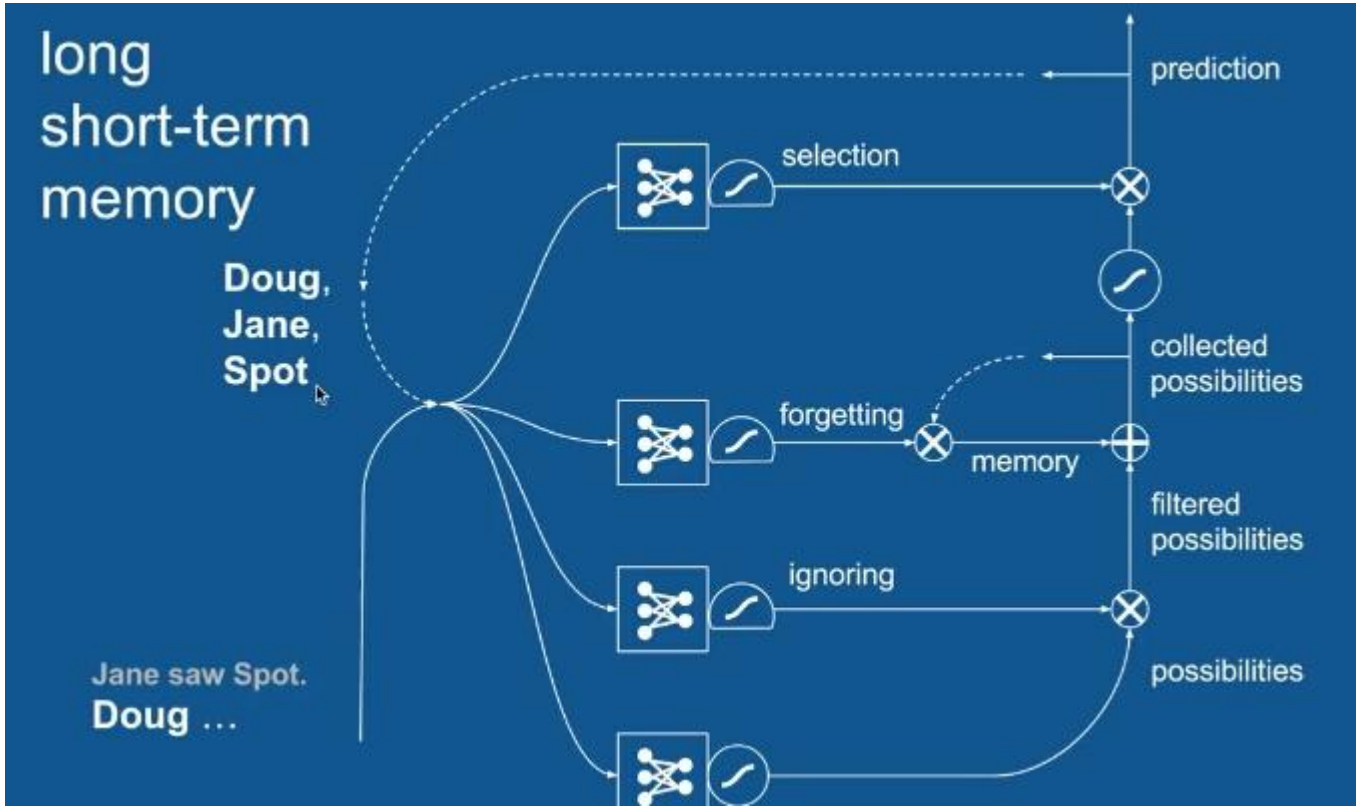
...



LSTM


memory
prediction
selection
collected
possibilities
forgetting
memory
new
information
possibilities

LSTM


long
short-term
memory
Doug,
Jane,
Spot
Jane saw Spot.
Doug …
prediction
selection
collected
possibilities
forgetting
memory
filtered
possibilities
ignoring
possibilities

Differentiable Neural Computer (DNC)

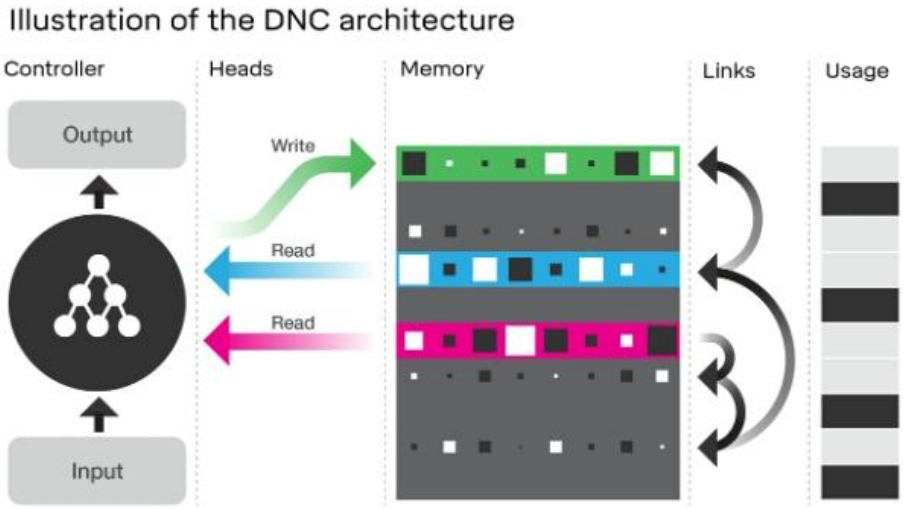
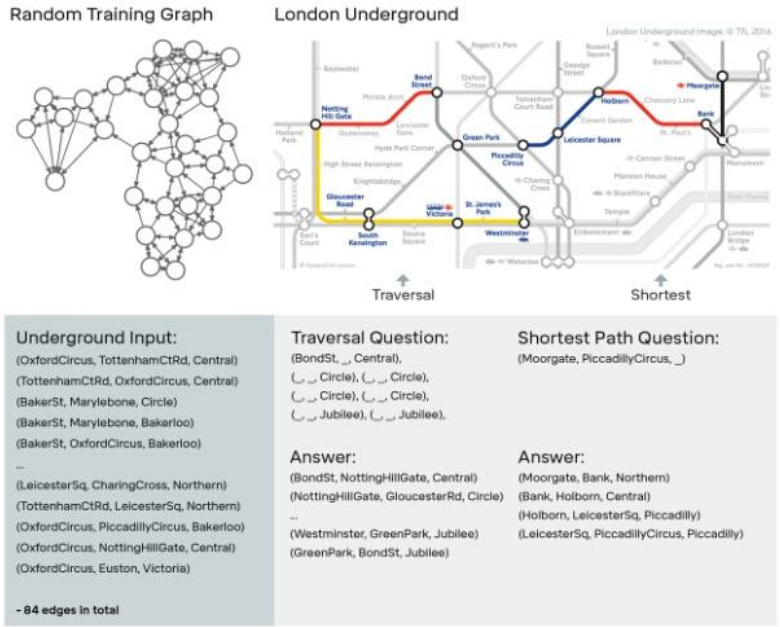


Illustration of the DNC architecture. The neural network controller receives external inputs and, based on these, interacts with the memory using read and write operations known as 'heads'. To help the controller navigate the memory, DNC stores 'temporal links' to keep track of the order things were written in, and records the current 'usage' level of each memory location.

Deciphering London Metro with DNC

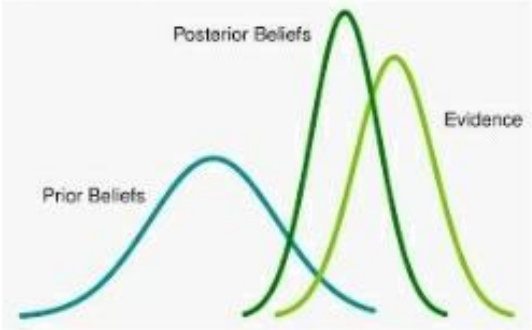


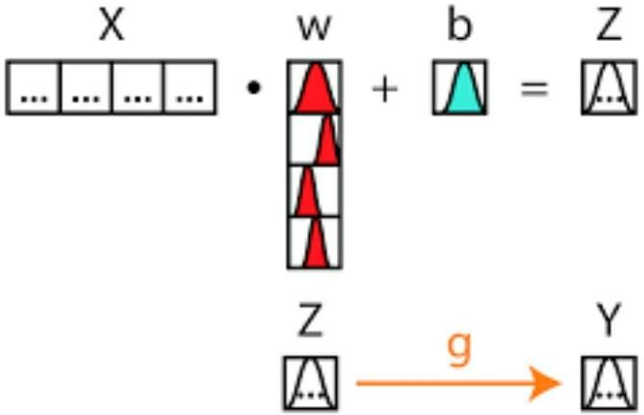
DNC was trained using randomly generated graphs (left). After training it was tested to see if it could navigate the London Underground (right). The (from, to, edge) triples used to define the graph for the network are shown below, along with examples of two kinds of task: 'traversal', where it is asked to start at a station and follow a sequence of lines; and 'shortest path' where it is asked to find the quickest route between two stations.

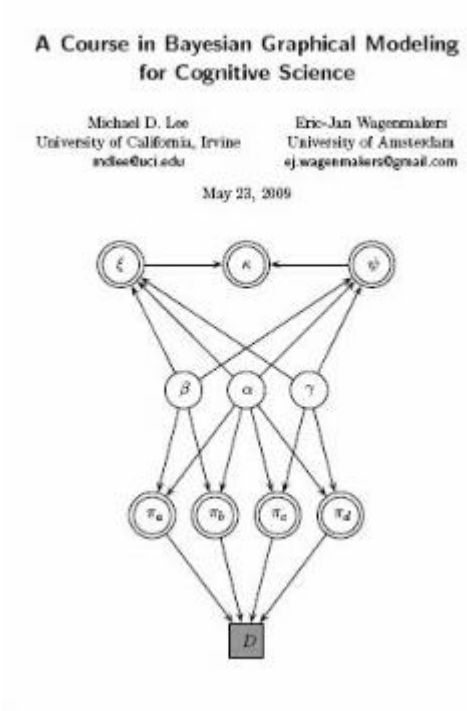
Starting at Bond street, and taking the Central line in a direction one stop, the Circle line in a direction for four stops, and the Jubilee line in a direction for two stops, at what stop do you wind up?

How do you get from Moorgate to Piccadilly Circus?

Bayesian Deep Learning





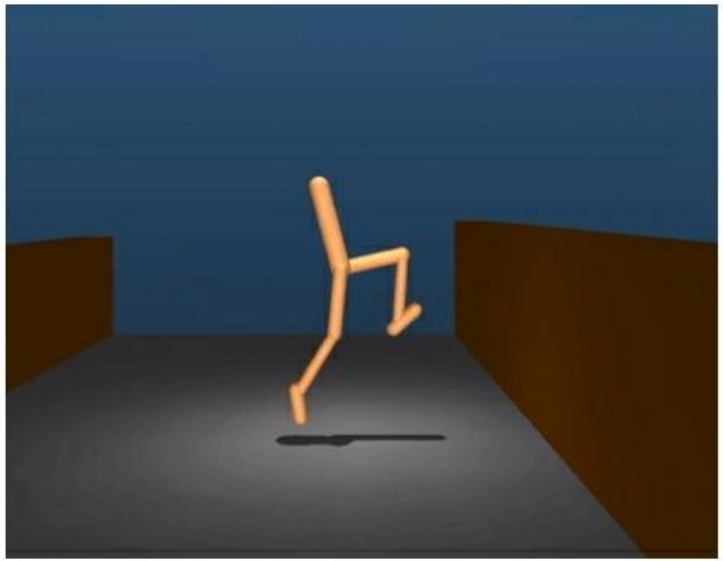

A Course in Bayesian Graphical Modeling for Cognitive Science

Michael D. Lee
University of California, Irvine
mdlee@uci.edu

Eric-Jan Wagenmakers
University of Amsterdam
ej.wagenmakers@gmail.com

May 23, 2009

Meta Learning or Genetic Algorithm

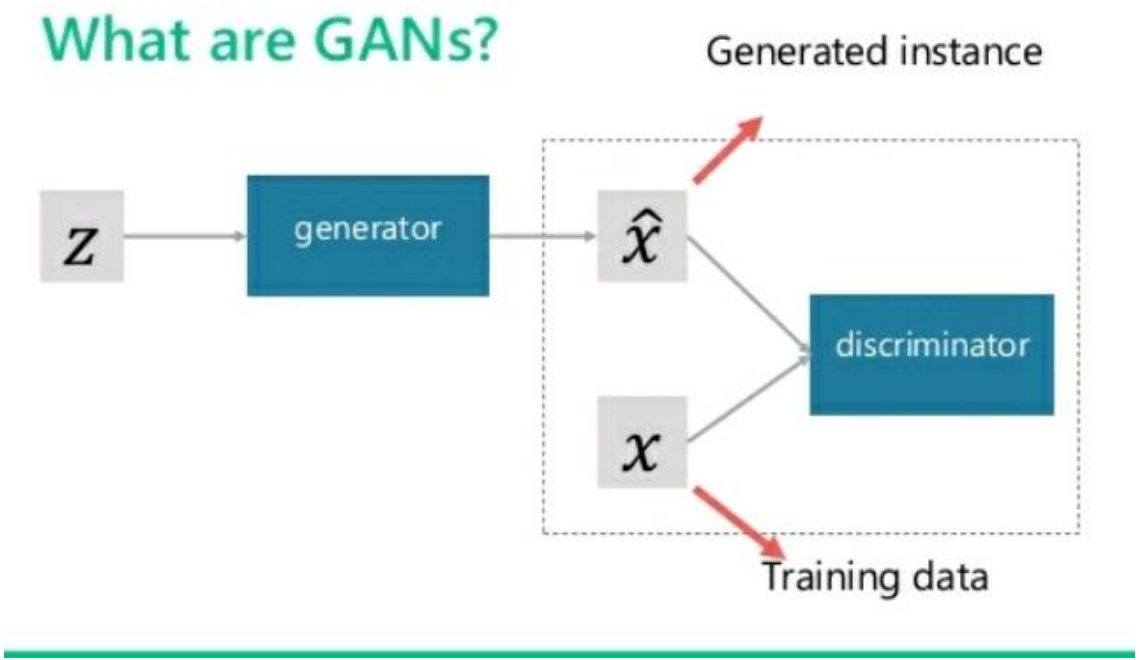


A Genetic Algorithm of an Agent learning to walk and powered by the principles of Evolution.

Generative Adversarial Network

First, an intuition

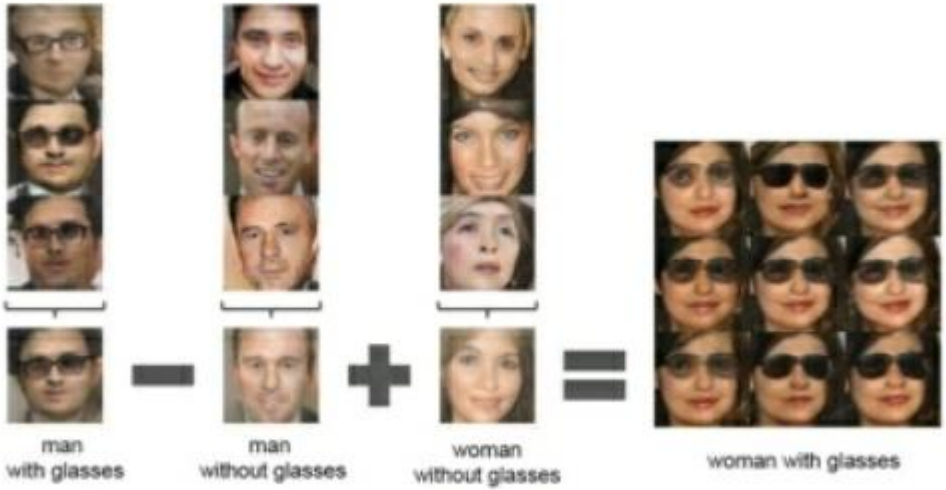
GAN architecture



Deep Convolutional GAN

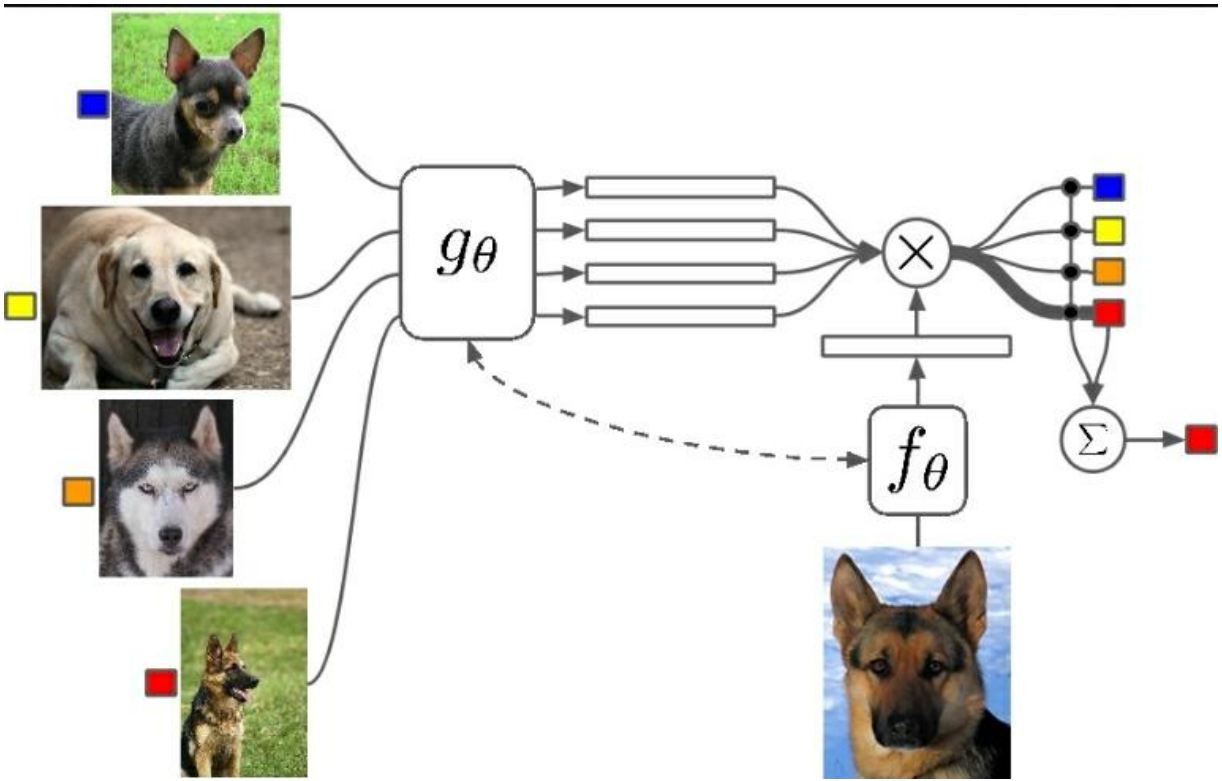
DCGAN – Vector Arithmetic

Deep Convolutional GAN – Alec Radford et al. (2016)

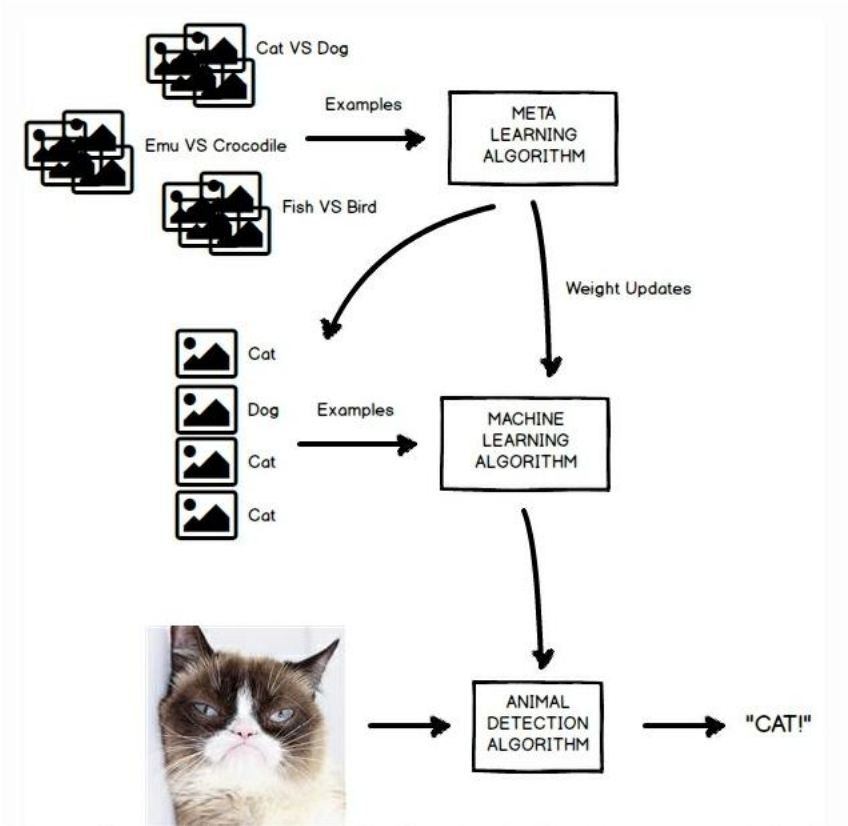


Source: Radford, Alec, Luke Metz, and Soumith Chintala. "Unsupervised representation learning with deep convolutional generative adversarial networks." arXiv preprint arXiv:1511.06434 (2015).

One Shot Learning



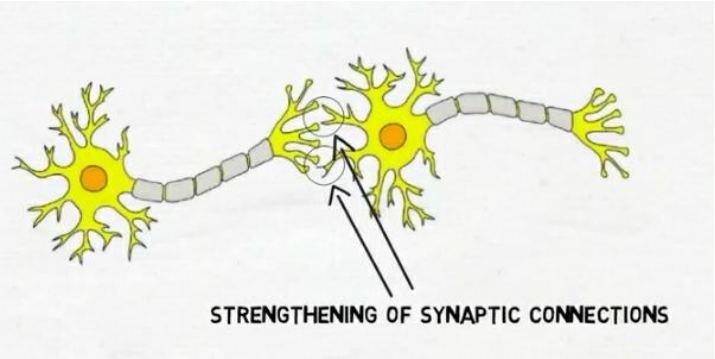
Machine that Learns how to Learn (Meta Leanring)



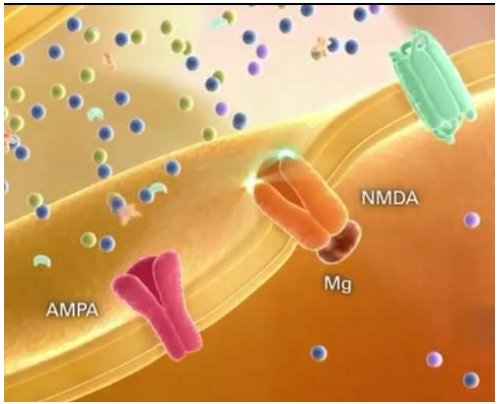
we want a ‘master’ machine learning algorithm to generate machine learning algorithm specifically tuned to one specific task

Modular Learning - PathNet

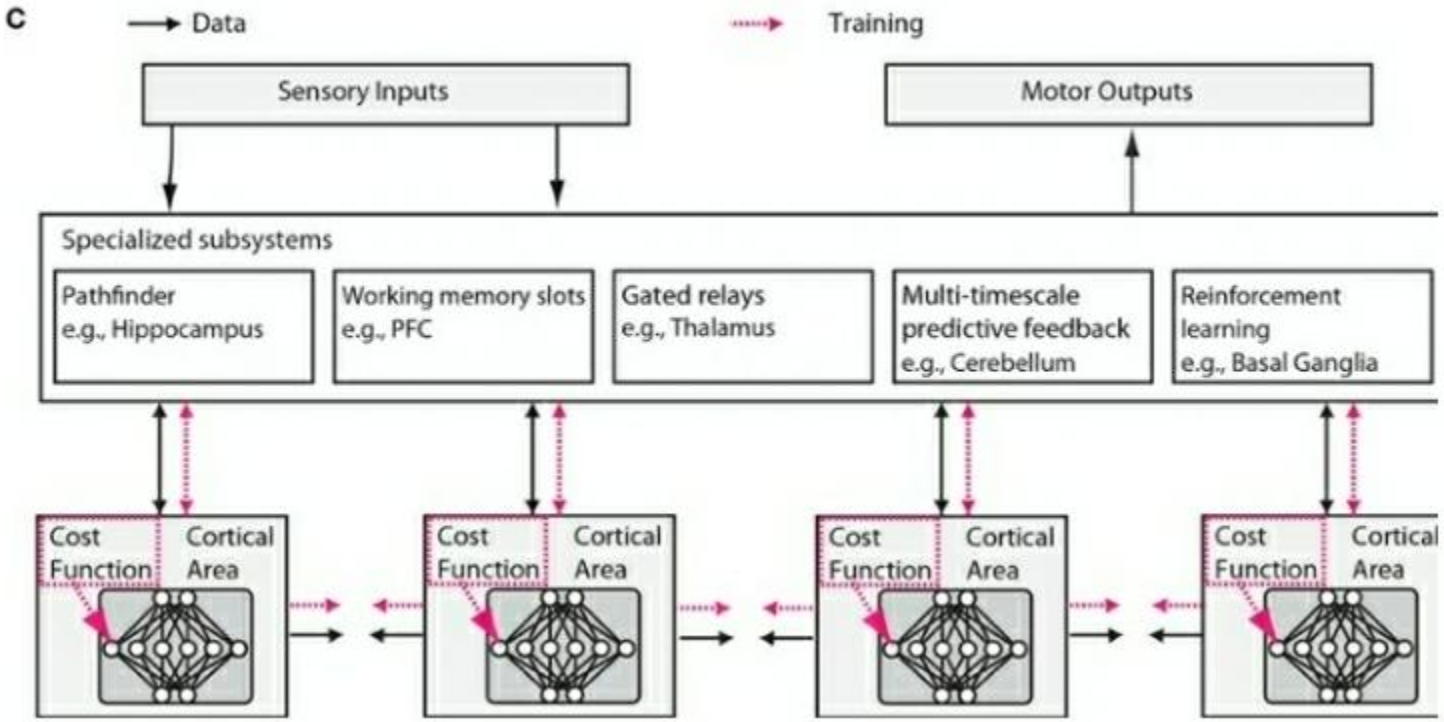
Biological Based for Cost Function Optimization



Spike
Time
Dependent
Plasticity



Cost Function based model of Brain

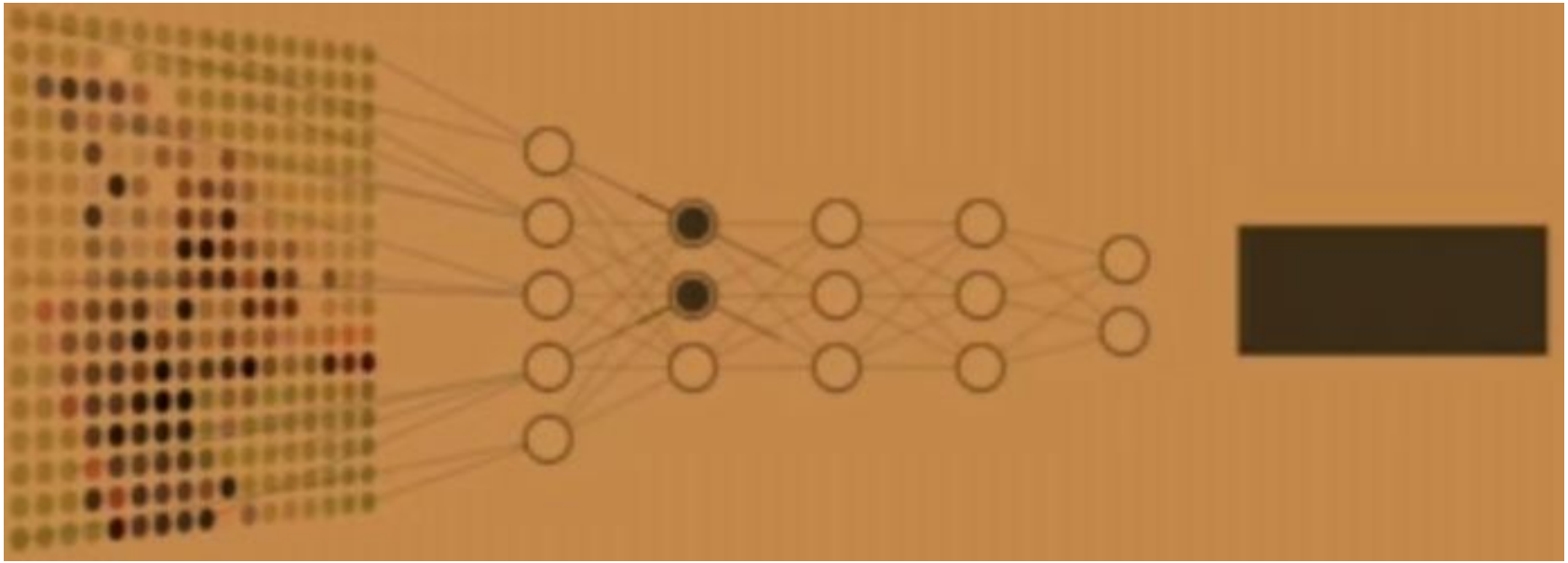


Scratch Notes

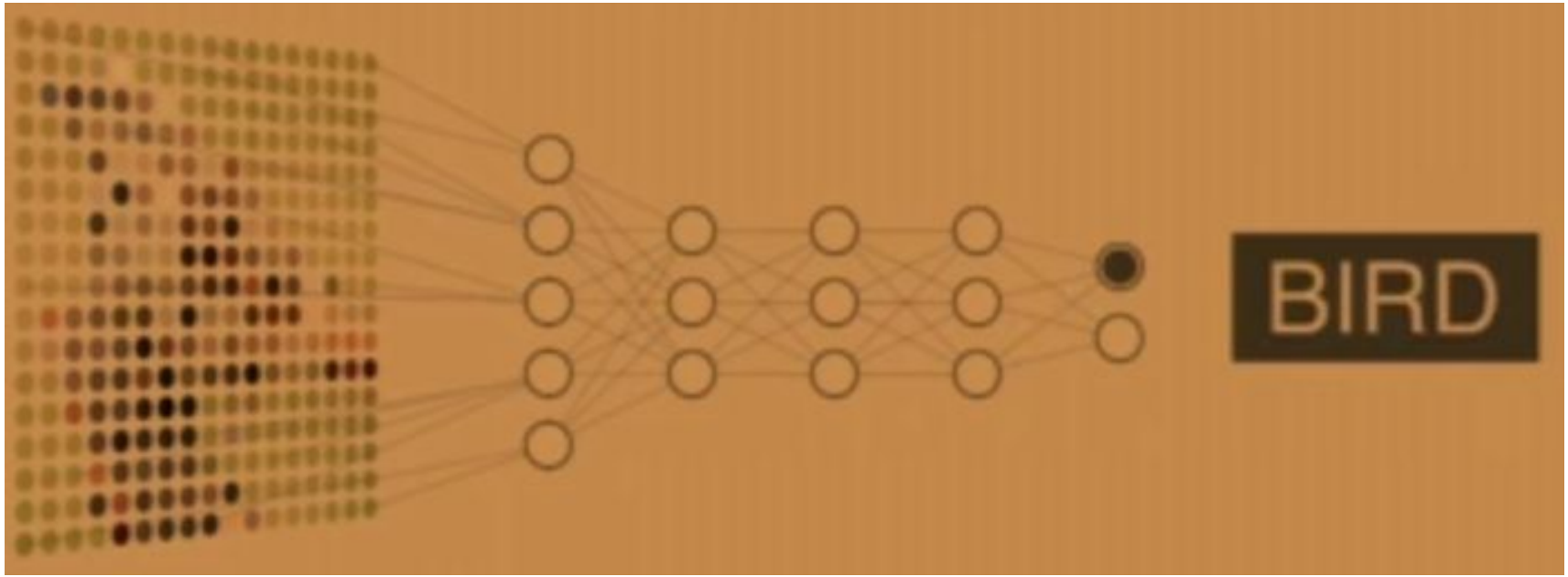
What is Deep Learning

What is Deep Learning

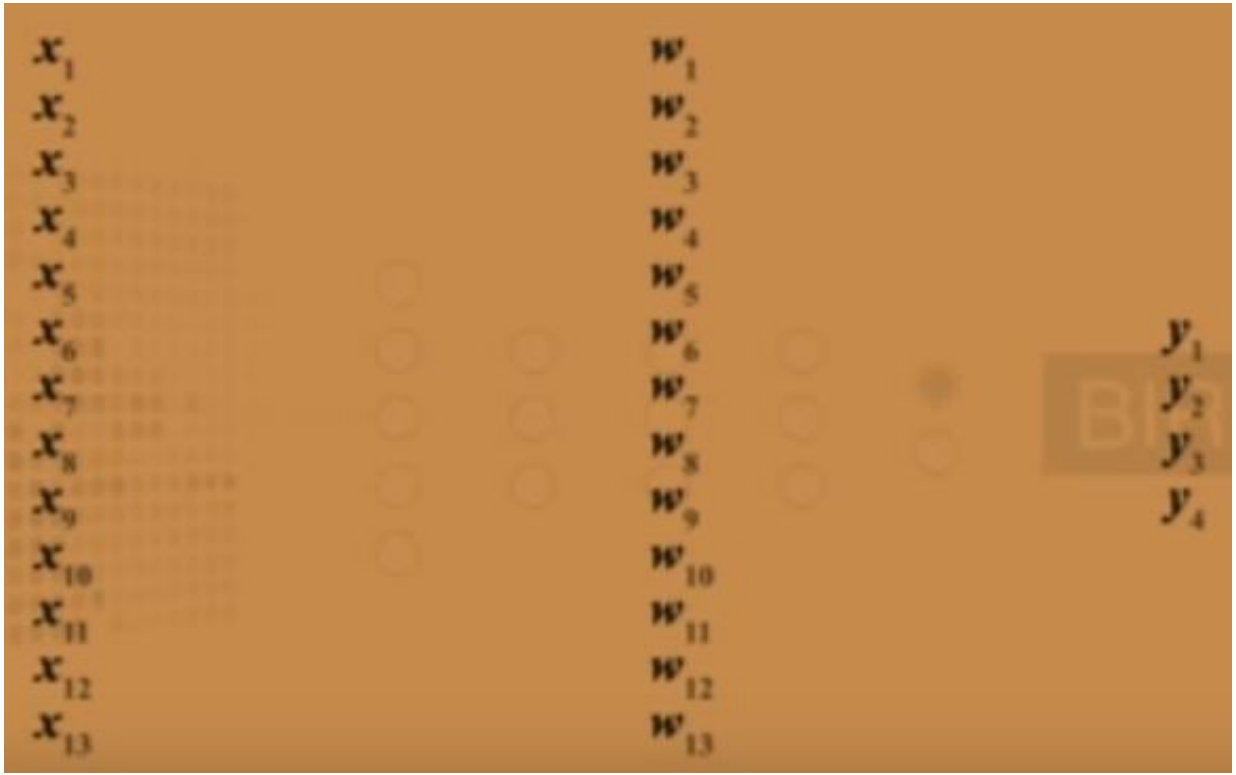
What is Deep Learning



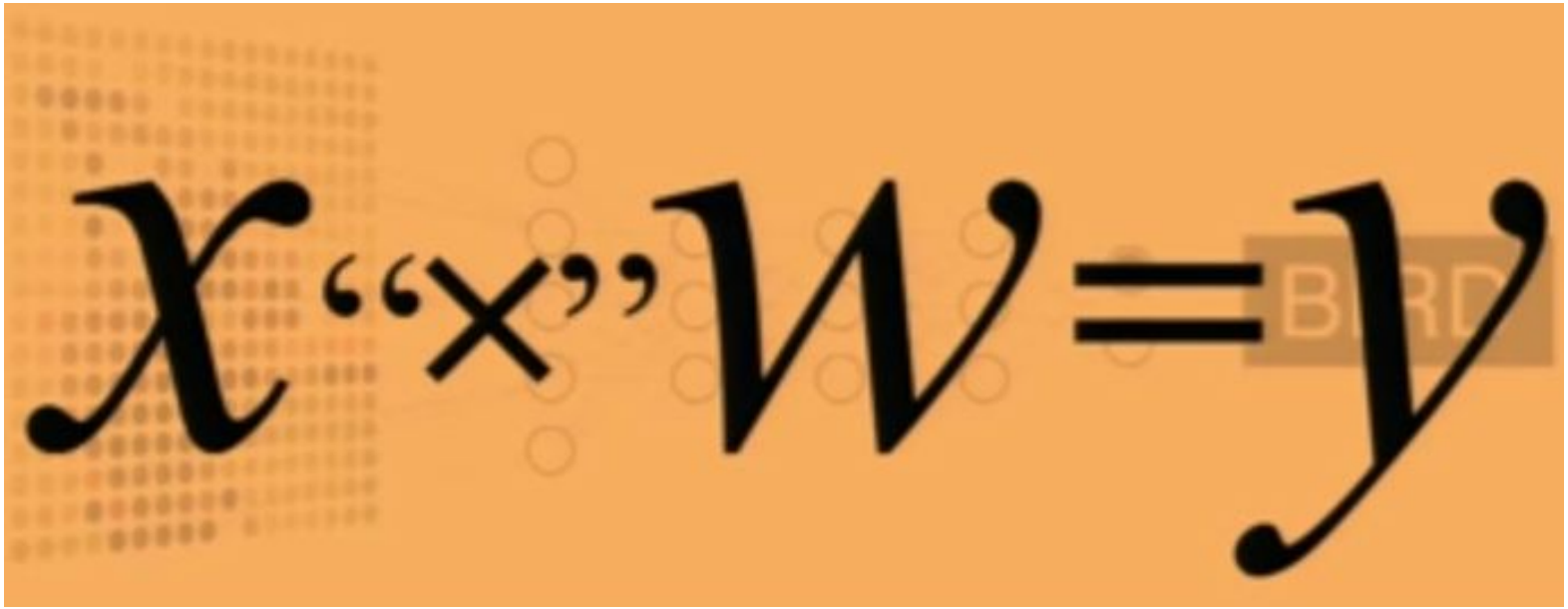
What is Deep Learning



What is Deep Learning



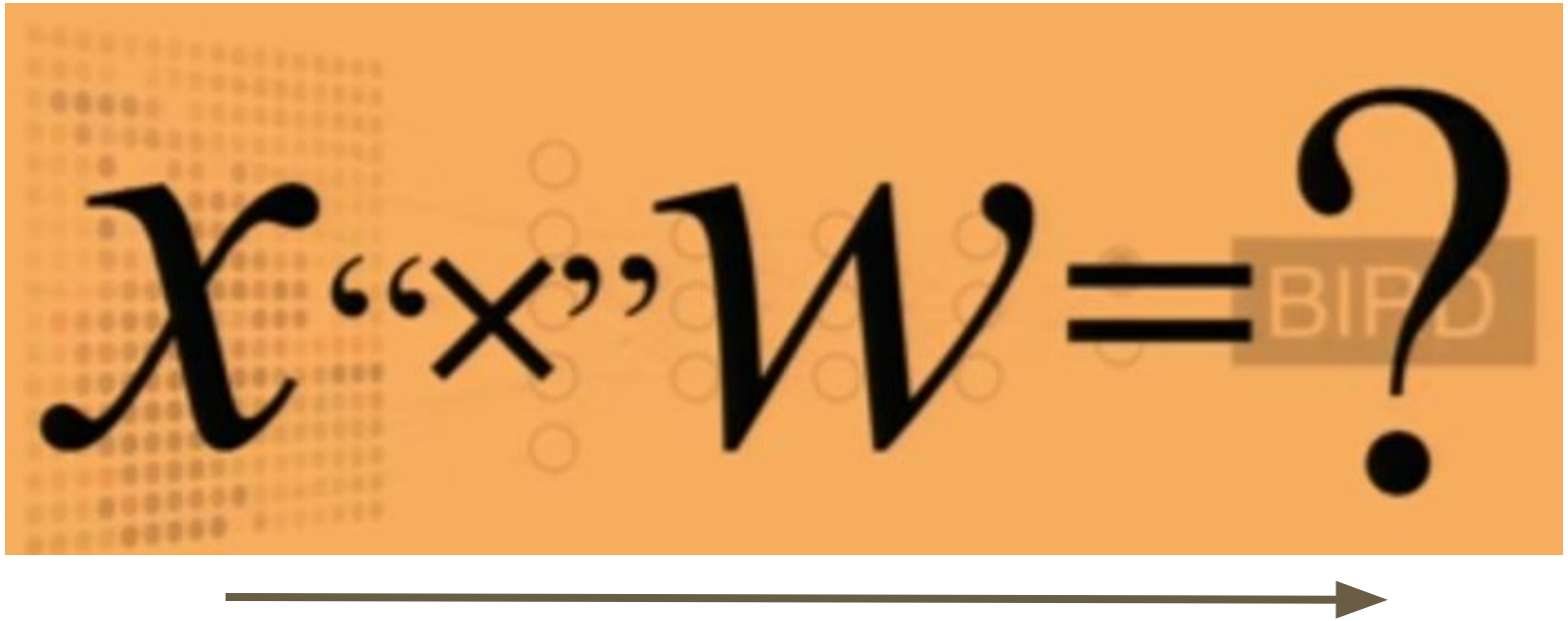
What is Deep Learning



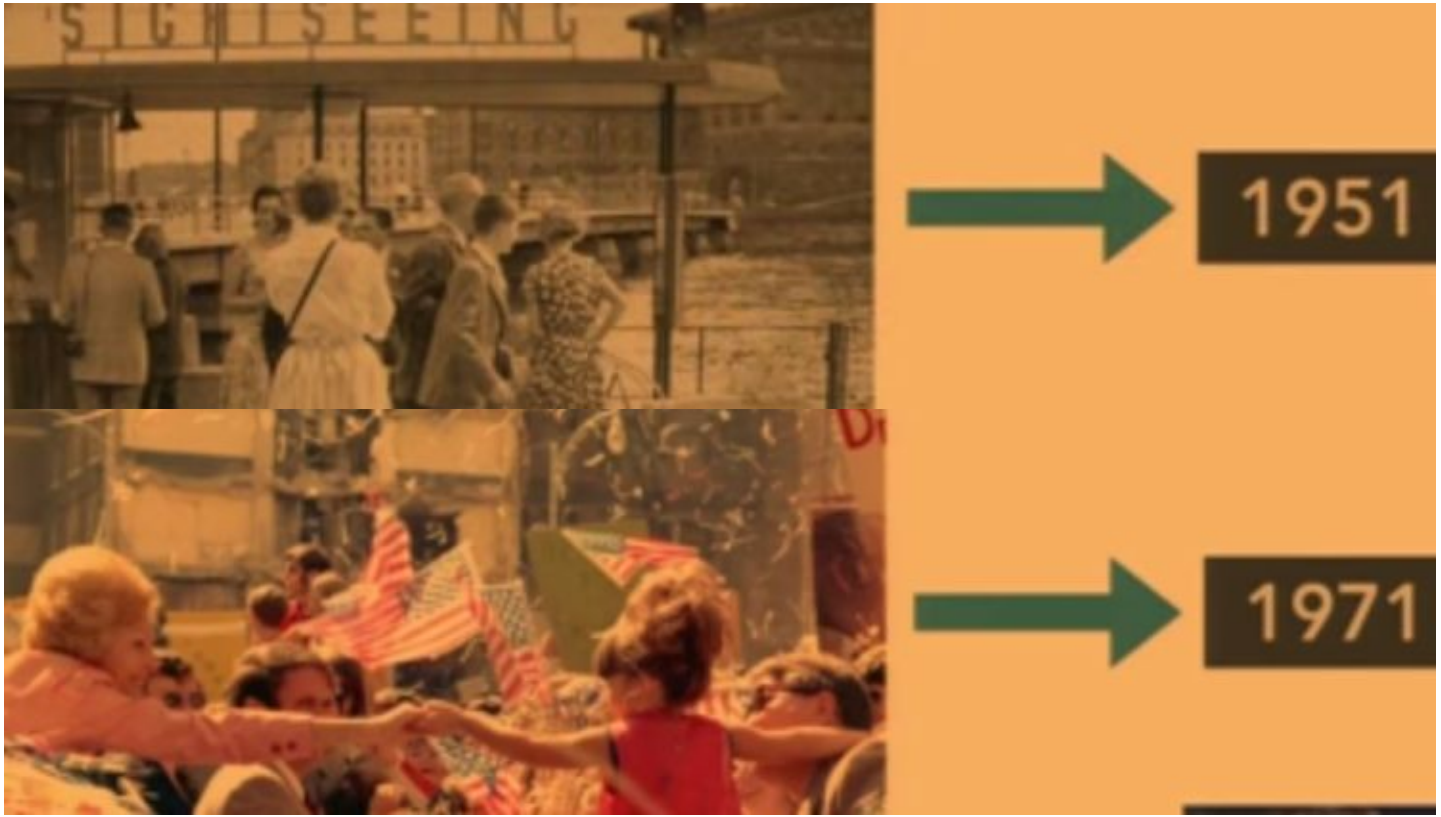
What is Deep Learning - Inference

Brain

What is Deep Learning - Perception



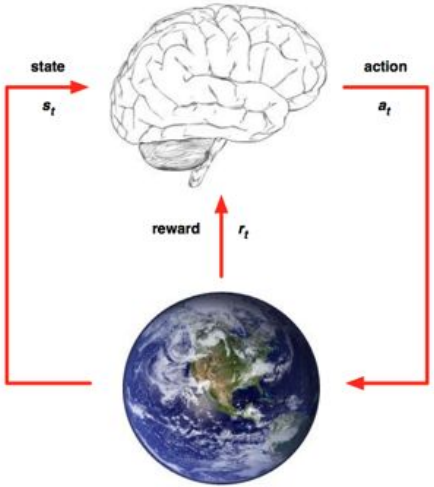
What is Deep Learning - Black box



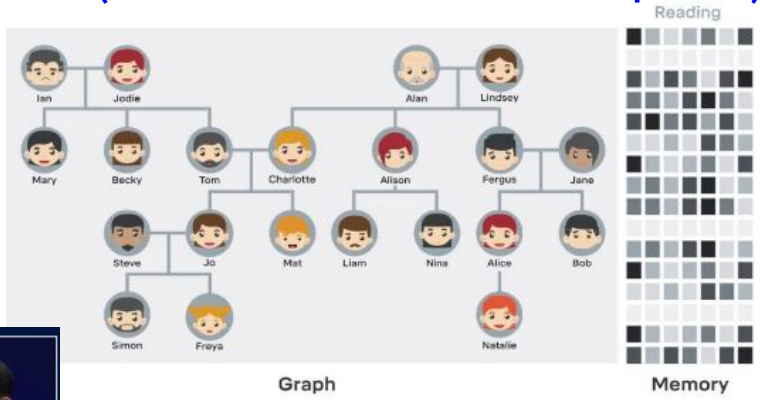
Leader in AI

Google DeepMind

DQN (Deep Reinforcement Learning)



DNC (Differential Neural Computer)



ASSAY DEVELOPERS

Clinical

LabCorp · Personalis · Foundation Medicine · Invitae · Quest Diagnostics · color · Roche · Sequenom · 华大基因 BGI · natera · Guardant Health · Myriad

Applied

Monsanto · DuPont · Syngenta · Pioneer A DuPont Business · PerkinElmer · Strand Life Sciences · Agilent Technologies · Sorenson Forensics

Research

Stanford University · Broad Institute · Human Longevity, Inc. · Harvard University · HudsonAlpha Institute for Biotechnology · National Institutes of Health · The Scripps Research Institute · Whitehead Institute · Wellcome Trust Sanger Institute

Consumer

23andMe · ancestryDNA · Wisdom Panel · µBiome · Counsyl · Pathway Genomics

DNA SEQUENCING

Analysisin the CLOUD

Google Genomics

Microsoft Azure

BaseSpace

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Consumer

23andMe · ancestryDNA · Wisdom Panel · µBiome · Counsyl · Pathway Genomics

Data mining insights

Expanse Bioinformatics · Appistry · CuroVerse

ASSAY DEVELOPERS → DNA SEQUENCING → Analysis CLOUD → ALGORITHM DEVELOPERS

Primary internal areas of focus

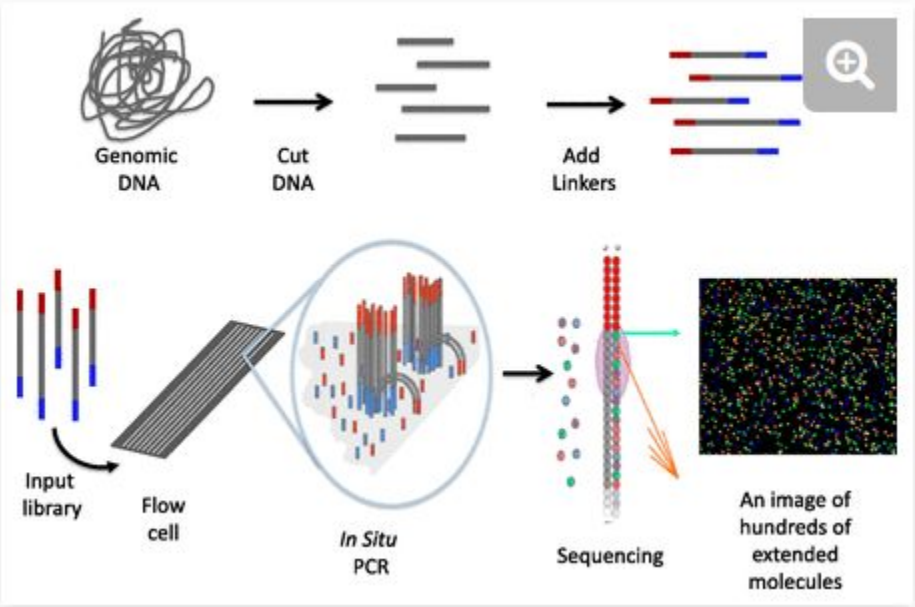
Enabled by partners

Enabled by partners

SAMPLE

ANSWER

Primary Analysis - Base Calling



Mohsen Hejrati

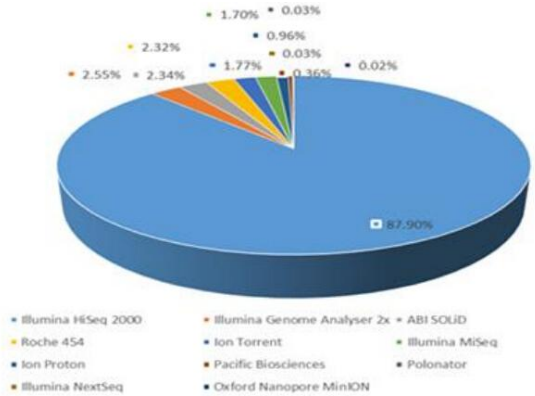
Founder at Computational Biology Technologies

San Francisco Bay Area | Internet

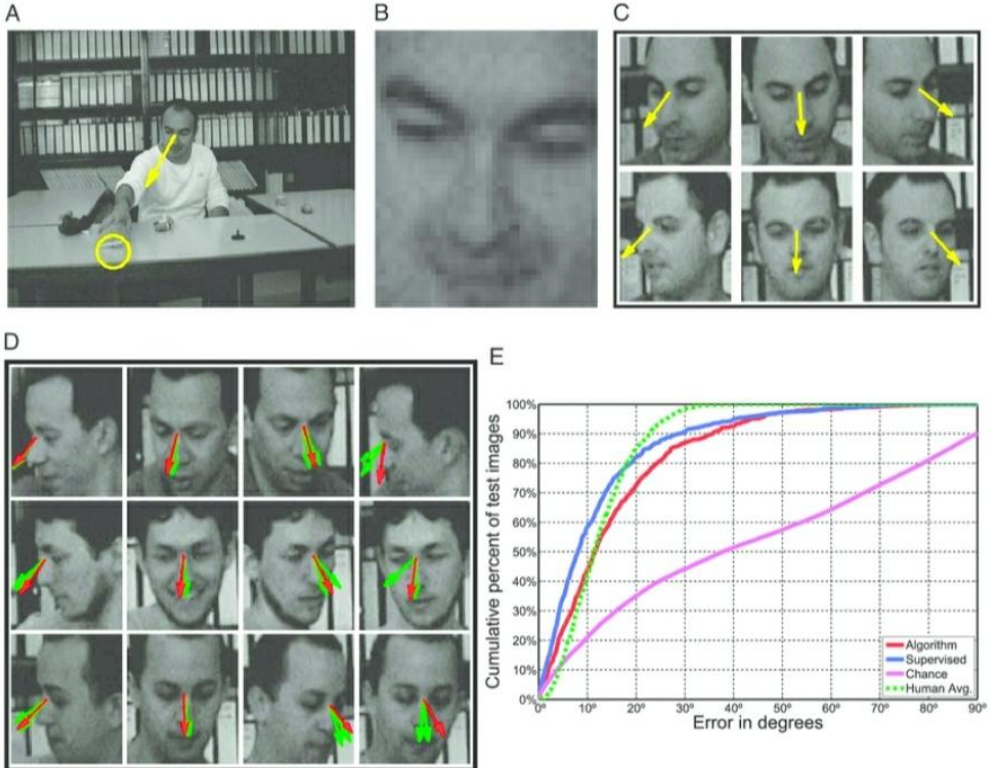
Current	Computational Biology Technologies, Polyup
Previous	Google, Vicarious.com, UC Irvine
Education	University of California, Irvine

C G A C G G A T T A C A T

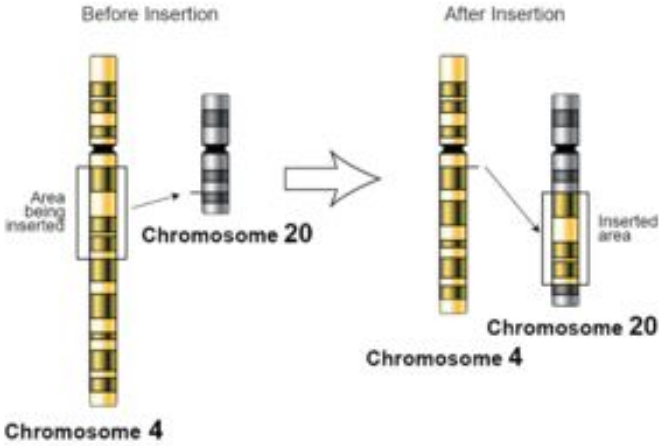
C G A C G G A T T A C A T



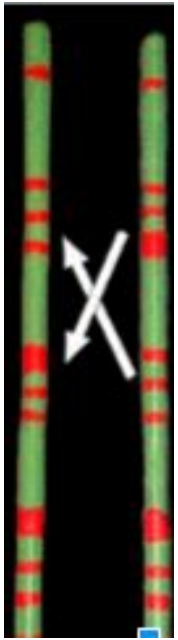
Bootstrap Learning in Humans



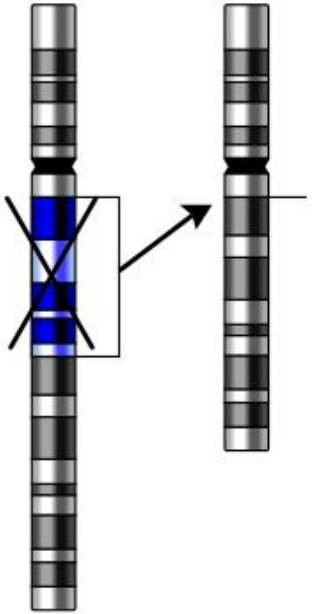
Structural Variation



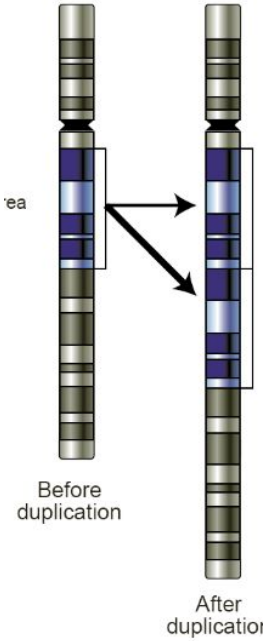
Insertion



Inversion

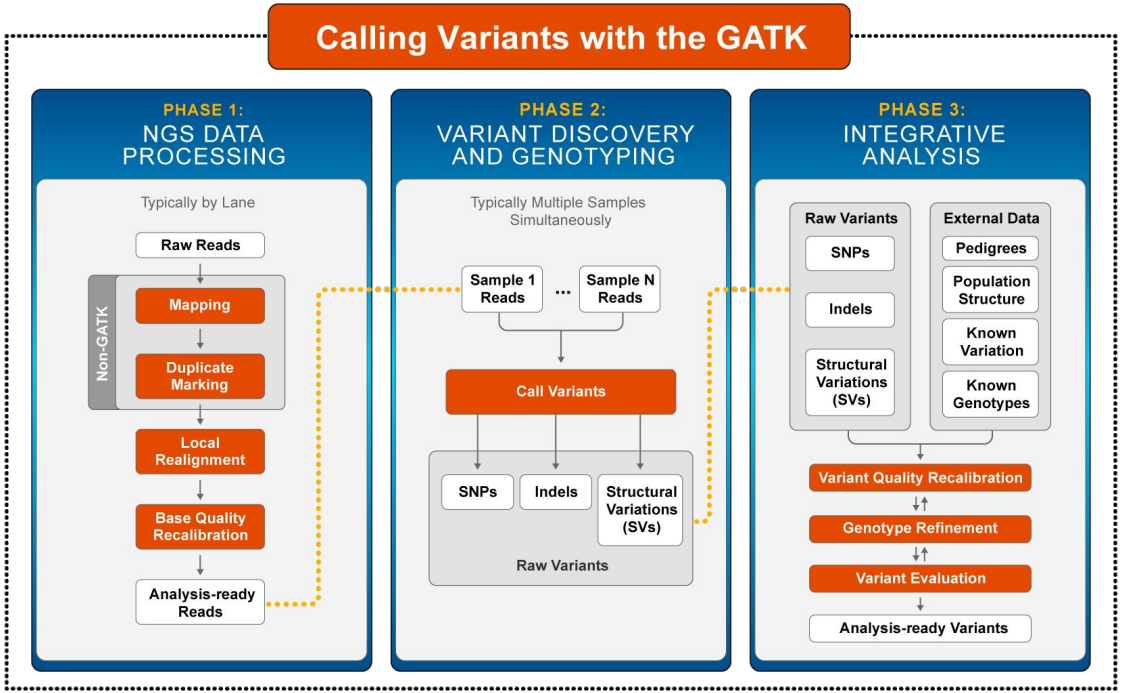


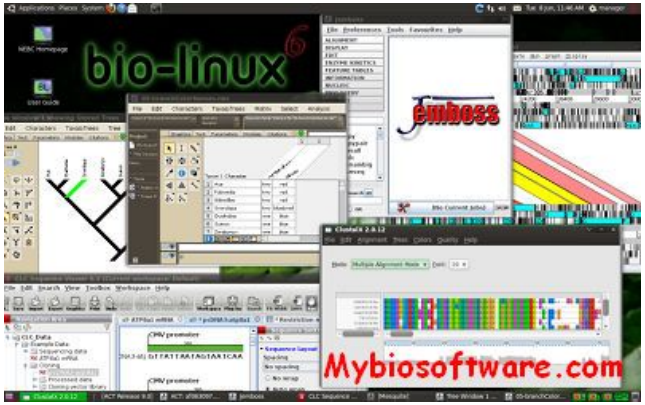
Deletion



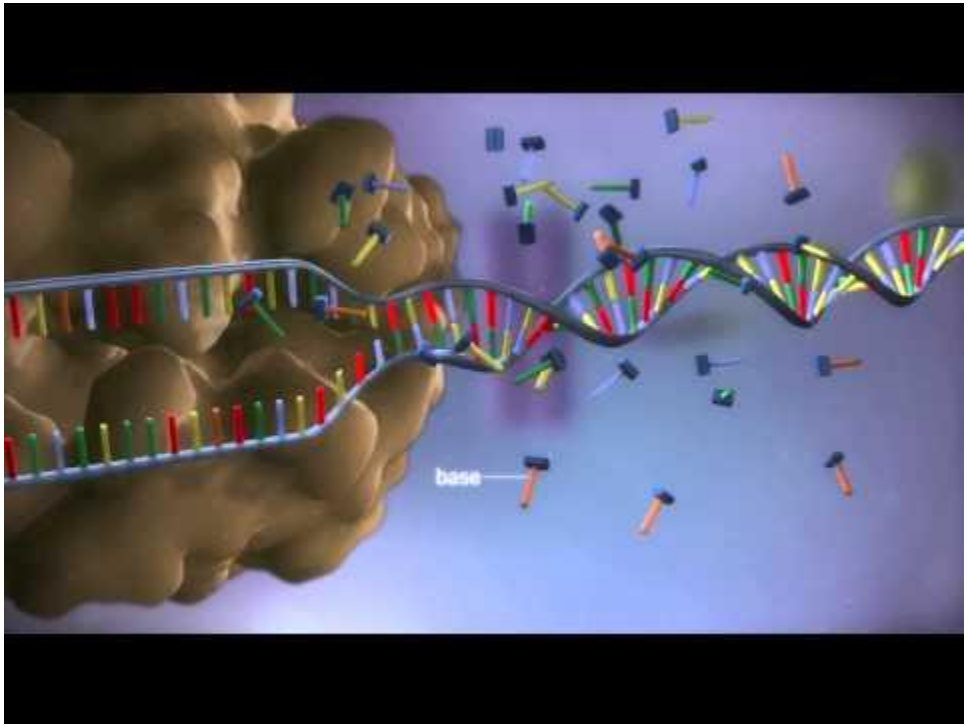
Duplication

Secondary Analysis





More than Just DNA

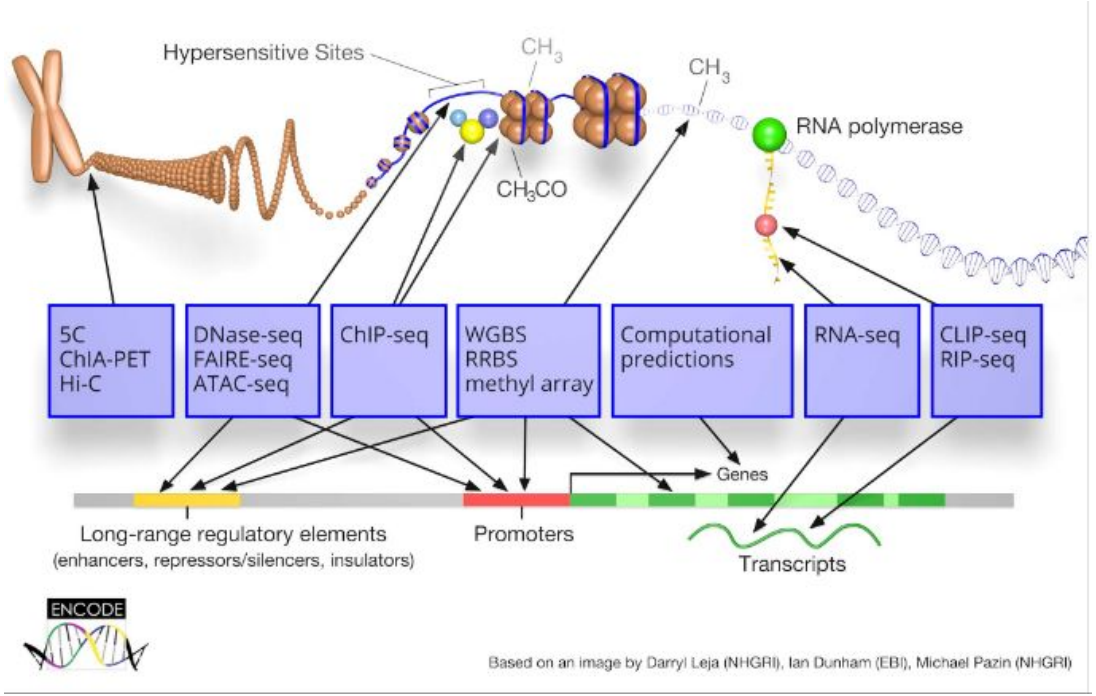


Deep Learning on Genomics Regulatory

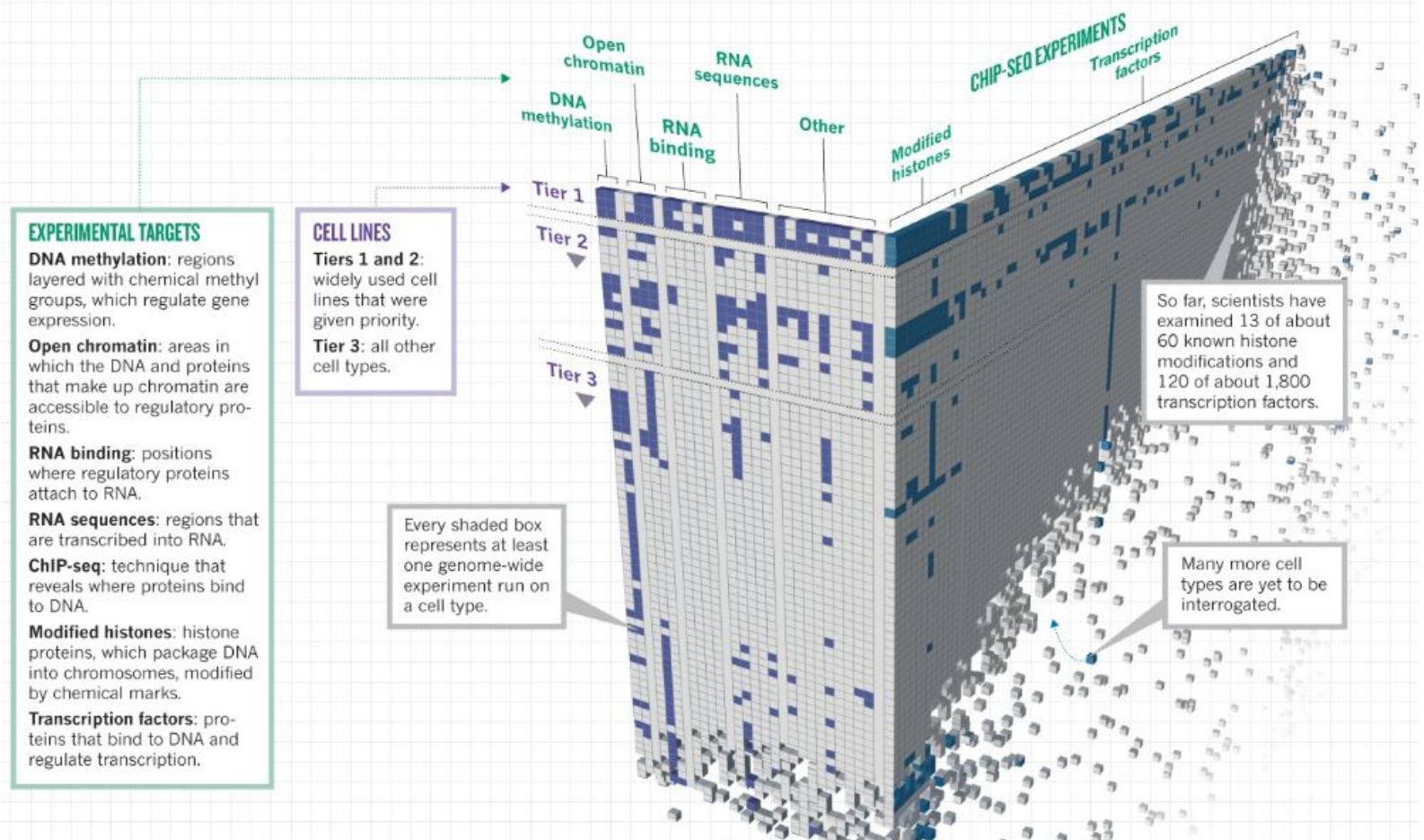
DragoNN

The dragonn package implements deep neural networks (DNNs) for regulatory genomics, methods for DNN interpretation, and provides tutorials showcasing dragonn models using sequence simulations.

Anshul Kundaje



ENCODE - The Human Encyclopedia

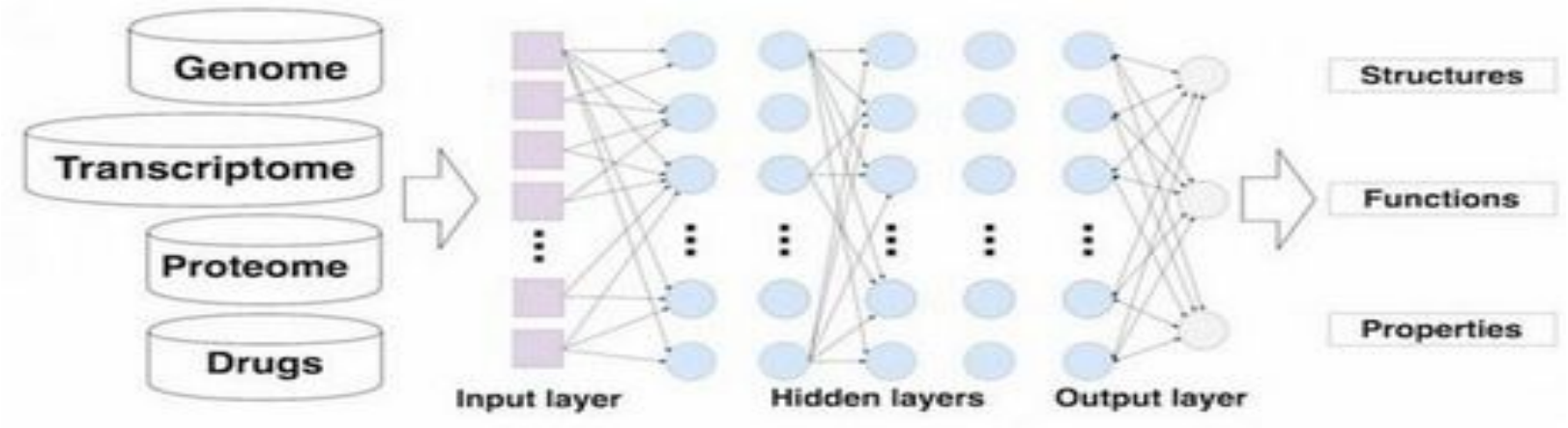


Use of Deep Learning on Drug Discovery

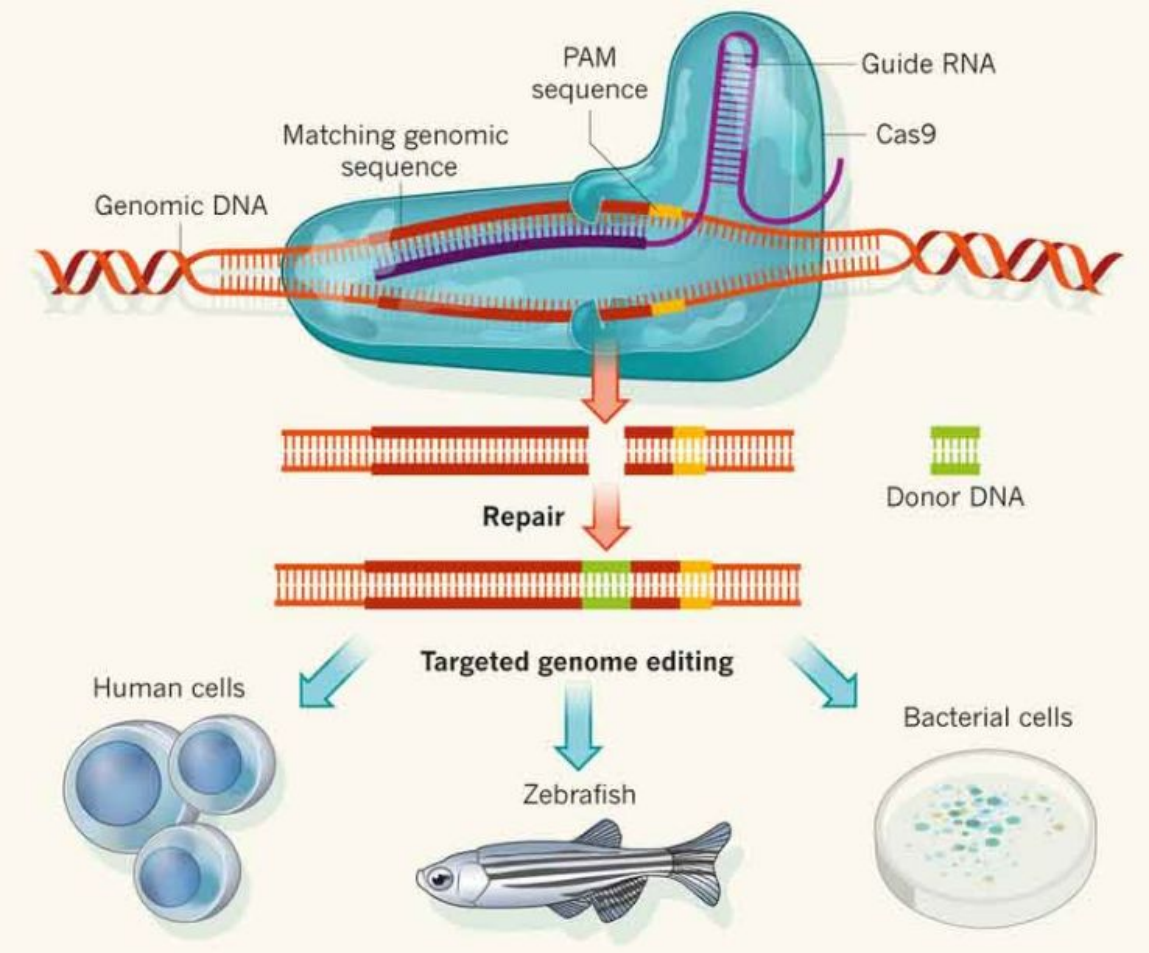
DeepSEA

deep genomics

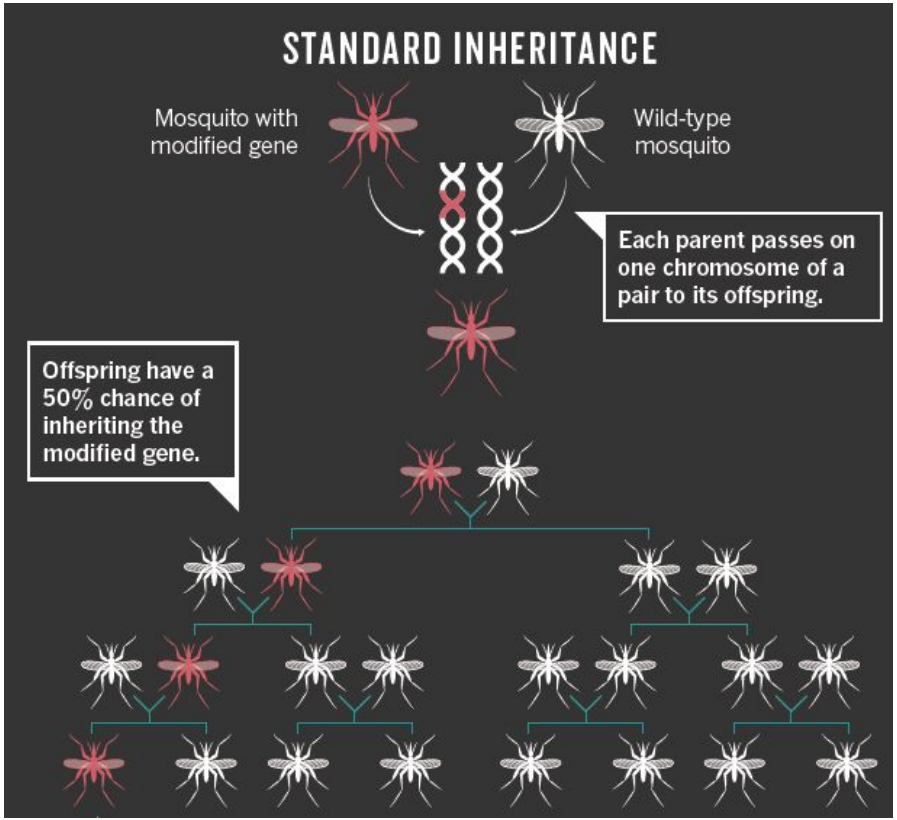
Scientists from Insilico Medicine, Inc. have trained deep neural networks (DNNs) to predict the potential therapeutic uses of 678 drugs

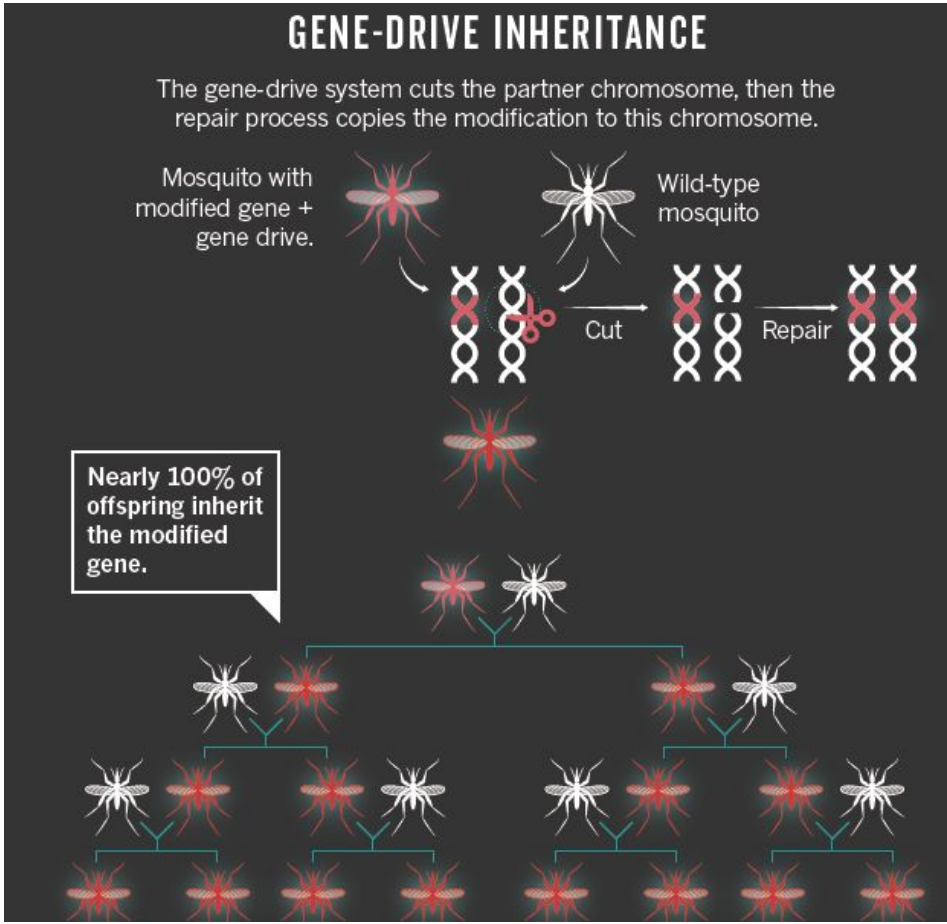


CRISPR - Cas9

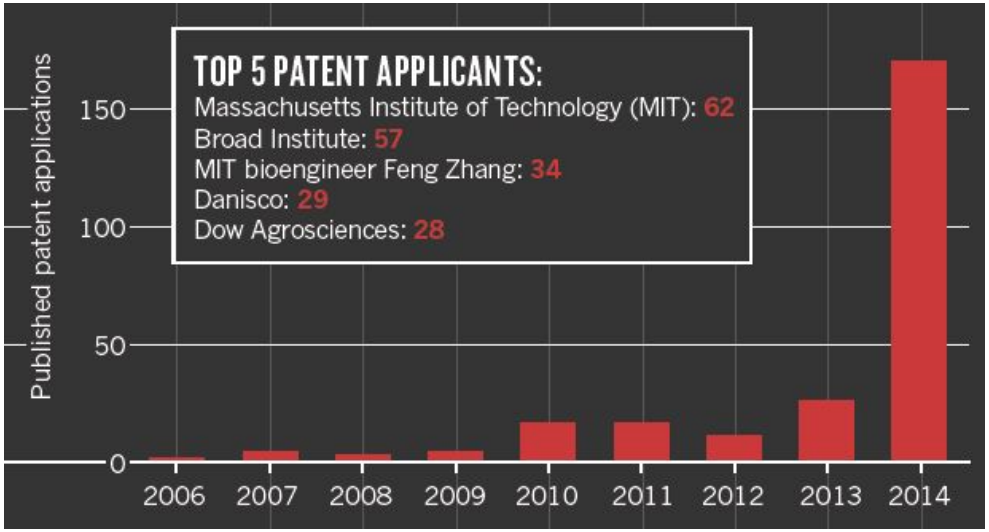

PAM
sequence
Guide RNA
Cas9
Matching genomic
sequence
Genomic DNA
Donor DNA
Repair
Targeted genome editing
Human cells
Zebrafish
Bacterial cells

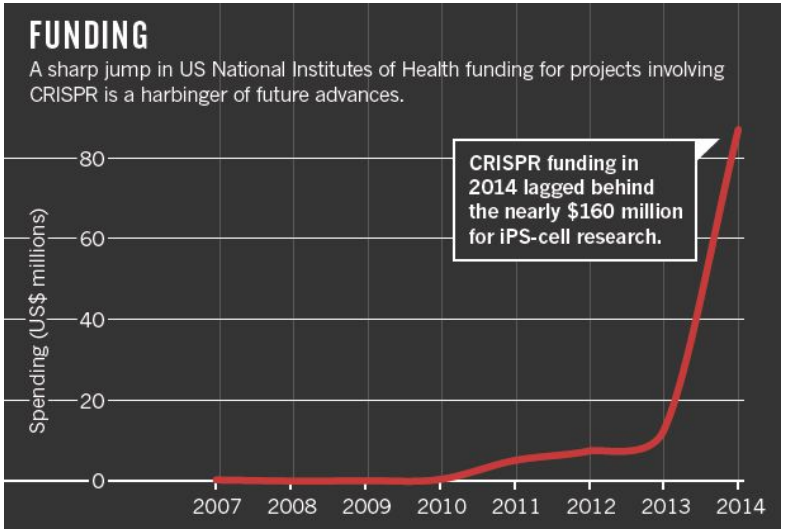
CRISPR - Gene Drive



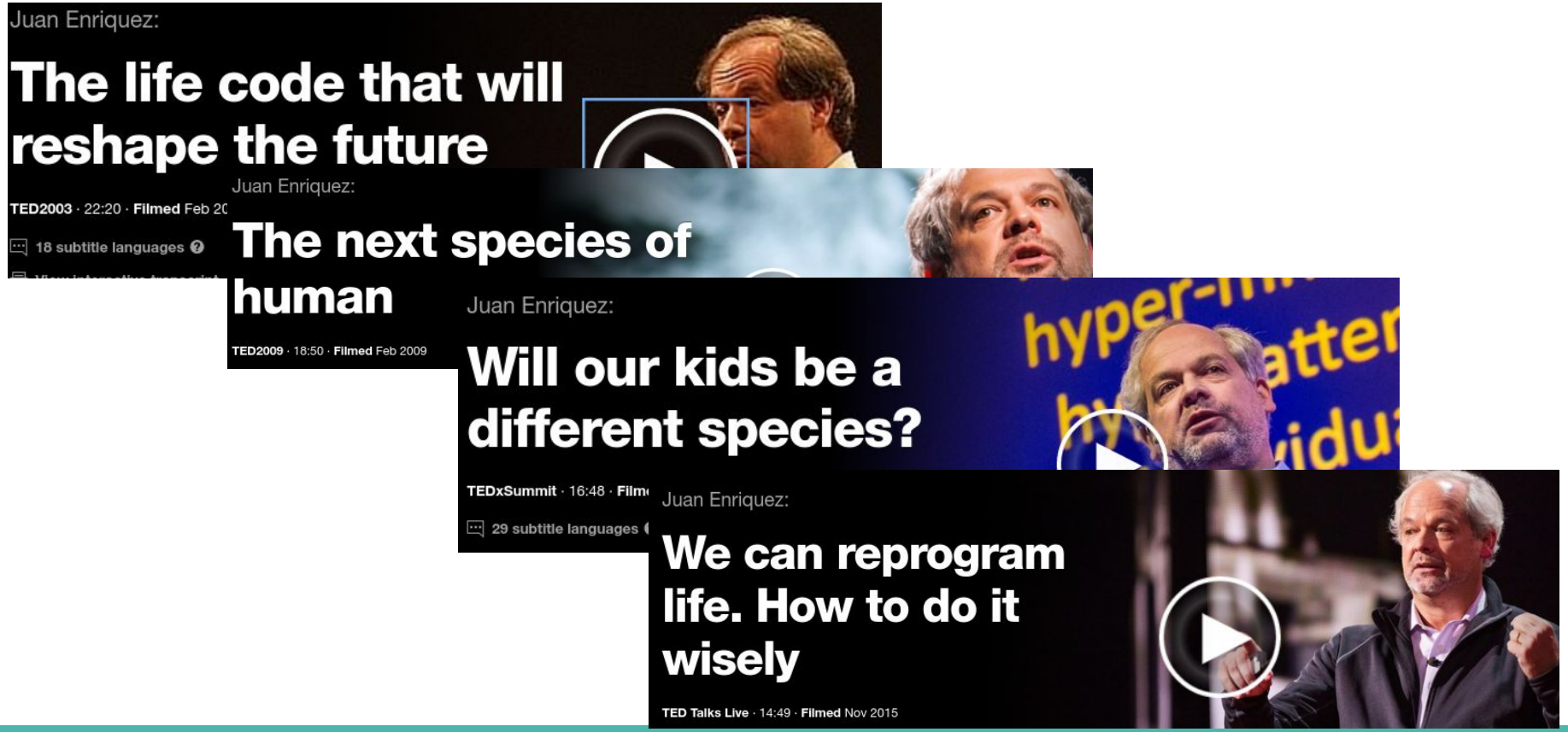


CRISPR on the rise





Futurist


Juan Enriquez:
The life code that will reshape the future
TED2003 · 22:20 · Filmed Feb 20
18 subtitle languages
Juan Enriquez:
The next species of human
TED2009 · 18:50 · Filmed Feb 2009
Juan Enriquez:
Will our kids be a different species?
TEDxSummit · 16:48 · Filme
29 subtitle languages
Juan Enriquez:
We can reprogram life. How to do it wisely
TED Talks Live · 14:49 · Filmed Nov 2015

Superhuman

Brain Coprocessor

is it ethical to evolve the human body?