

Cognitive Computing and the Future of Science

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 **@Ale_Curioni**



IBM Research:

12 Labs on 6 Continents and 3,000 Scientists
IBM invests 6% of revenue in R&D annually



Six Nobel Laureates



Nine Medals of Technology



Five National Medals of Science



Three Kavli Prizes



2.5 quintillion
bytes of data
created
every day.

90% of the data
in the world today
has been created in
the last **two years**
alone.

Every minute,
1.7 megabytes
of data is created for
every person on
the planet.
All 7.3 billion of us.



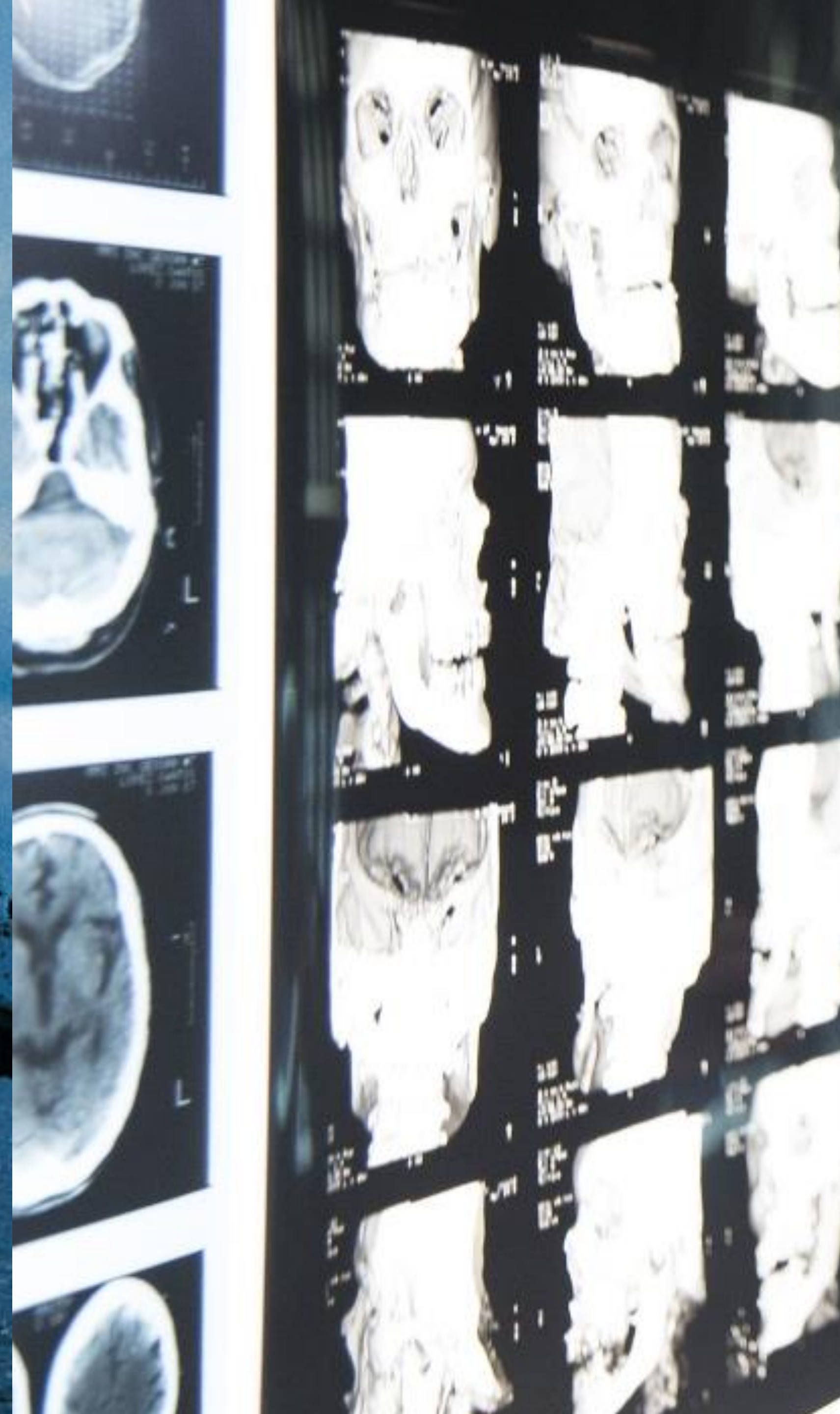
Unstructured data — “dark data” —
accounts for 80% of all data generated
today.

This is expect to grow
to 93% by 2020.





The price of not knowing.





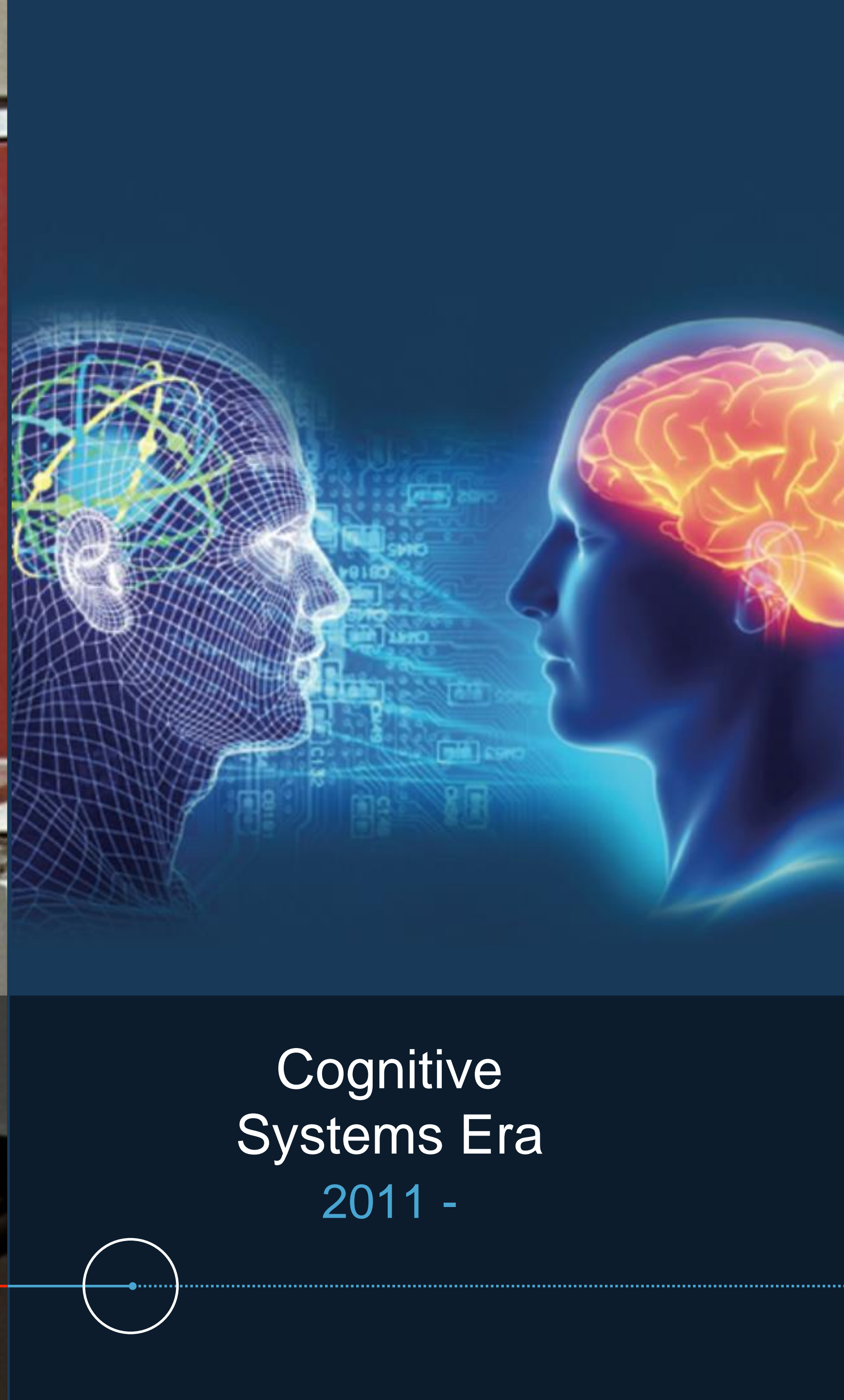
Welcome to
the dawn of the
Cognitive Era



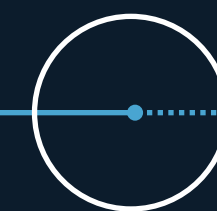
Tabulating
Systems Era
1900 - 1940s



Programmable
Systems Era
1950s - Present



Cognitive
Systems Era
2011 -





\$18,200



\$21,040

WATSON

\$5,600

BRAD

Watson in 2011

System Specifications



2880 Processing Cores



90 IBM P750 Servers



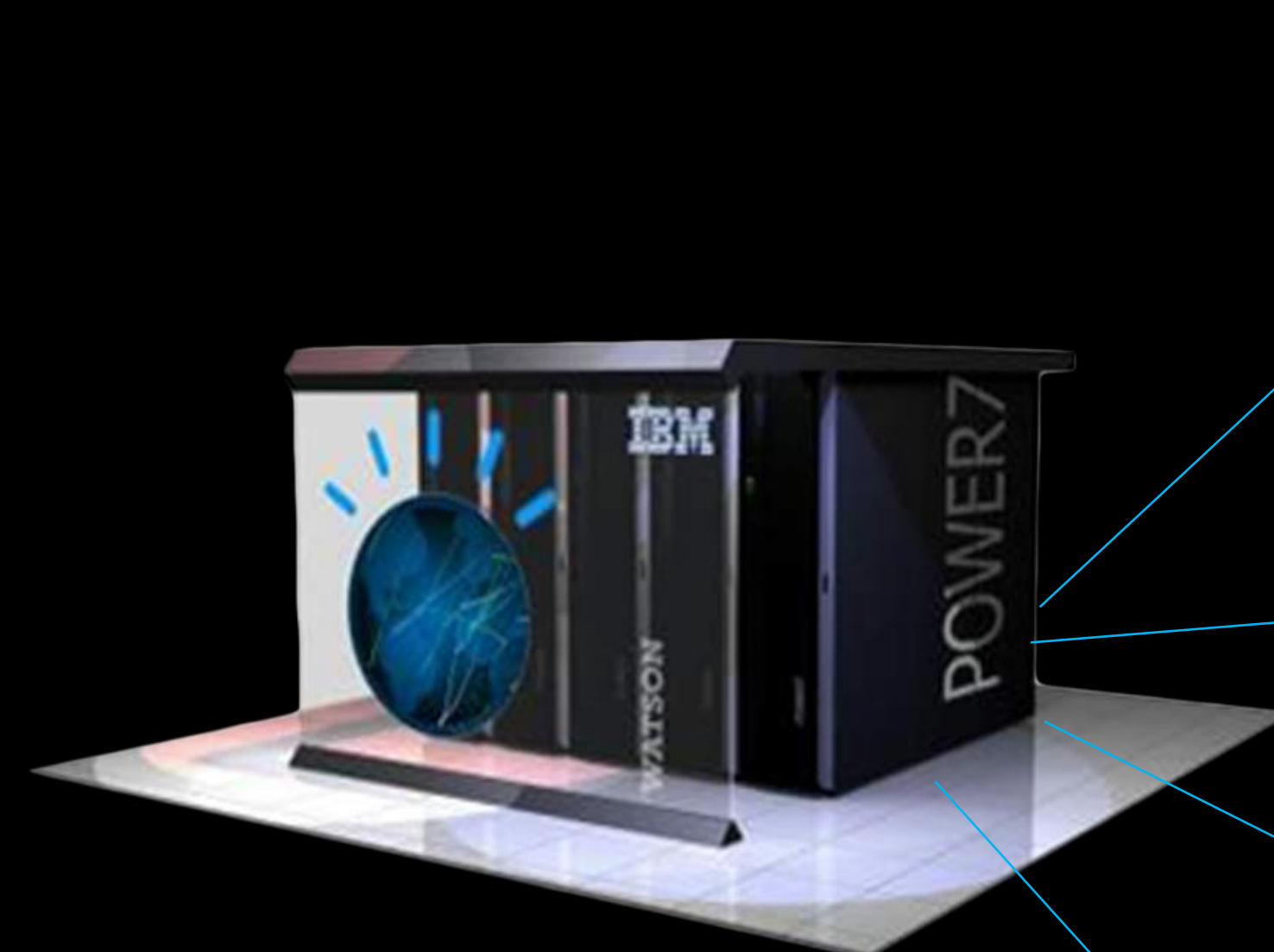
16 Terabytes Memory (RAM) – 20TB Disk



80 Teraflops (80 trillion operations per second)



Workload Optimized Systems



IBM Technology Depth



Content Analytics



Business Analytics



Big Data

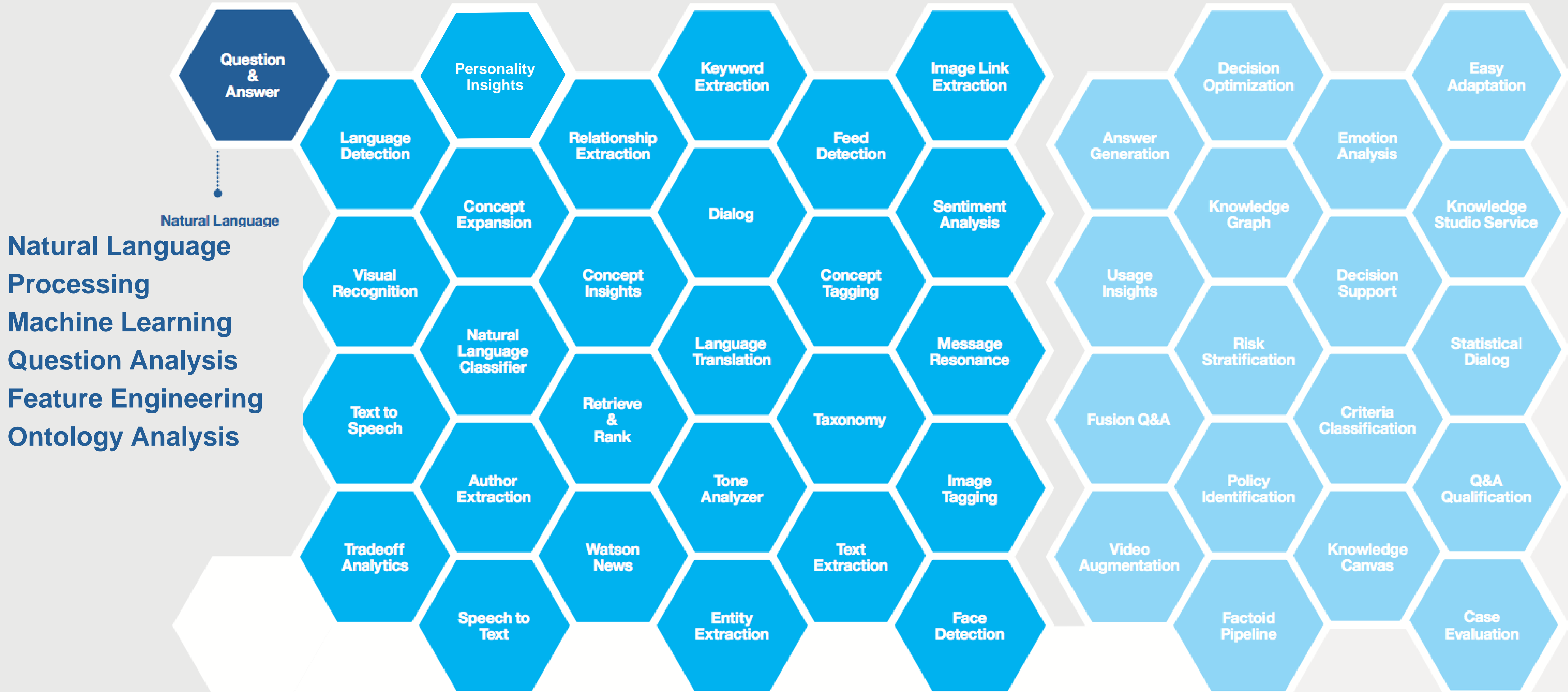


Databases / Data Warehouses

Watson in 2016

Since then, Watson has grown to a family of **28 APIs**.

By the end of 2016, there will be nearly **50 Watson APIs**—with more added every year.



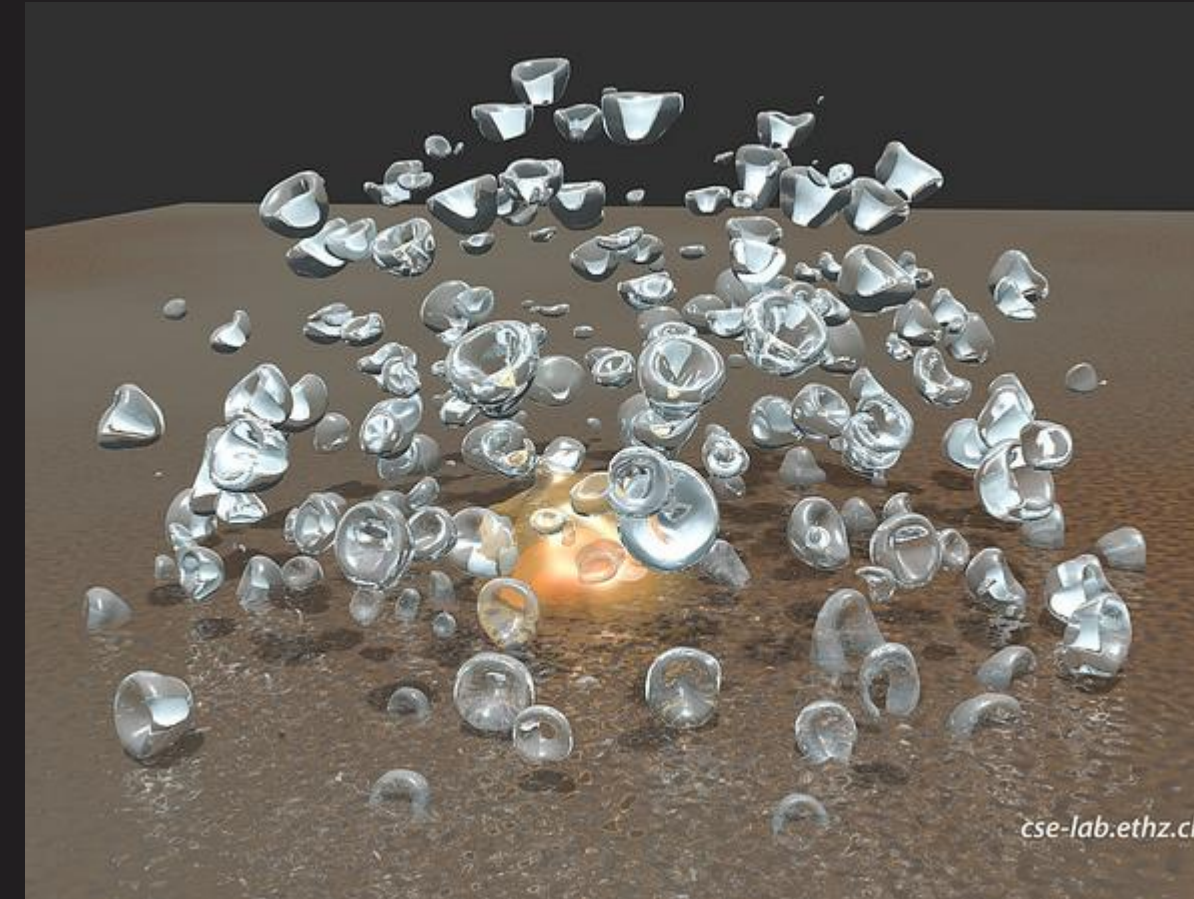
More Data + New Technologies = Scientific Discovery



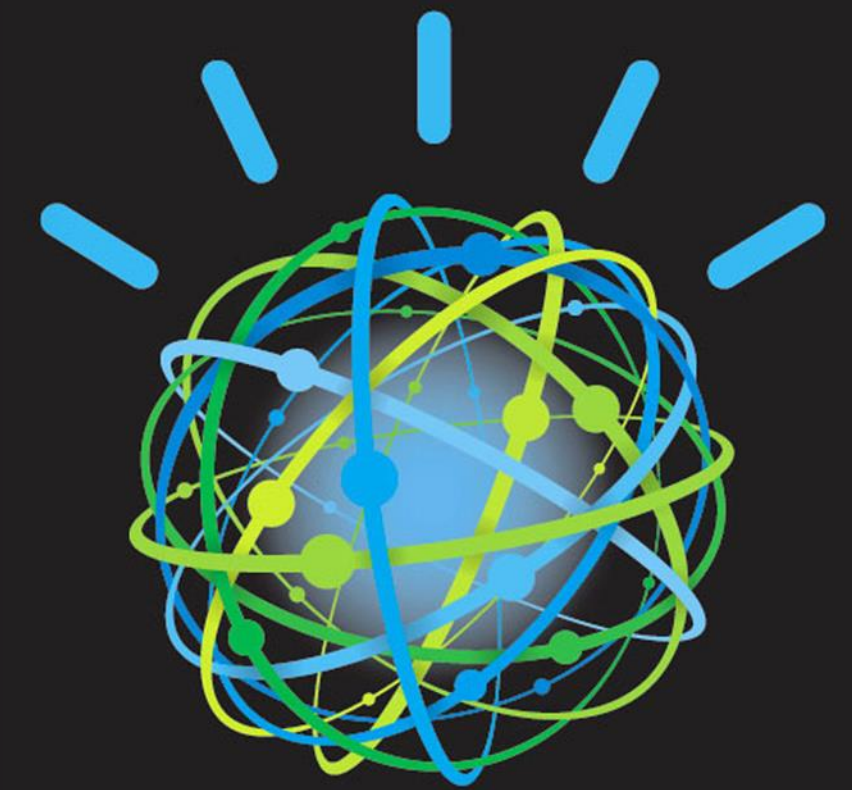
1000s Years Ago
Theory



Last 100s of Years
Experimentation



Recent Decades
Computer Simulation



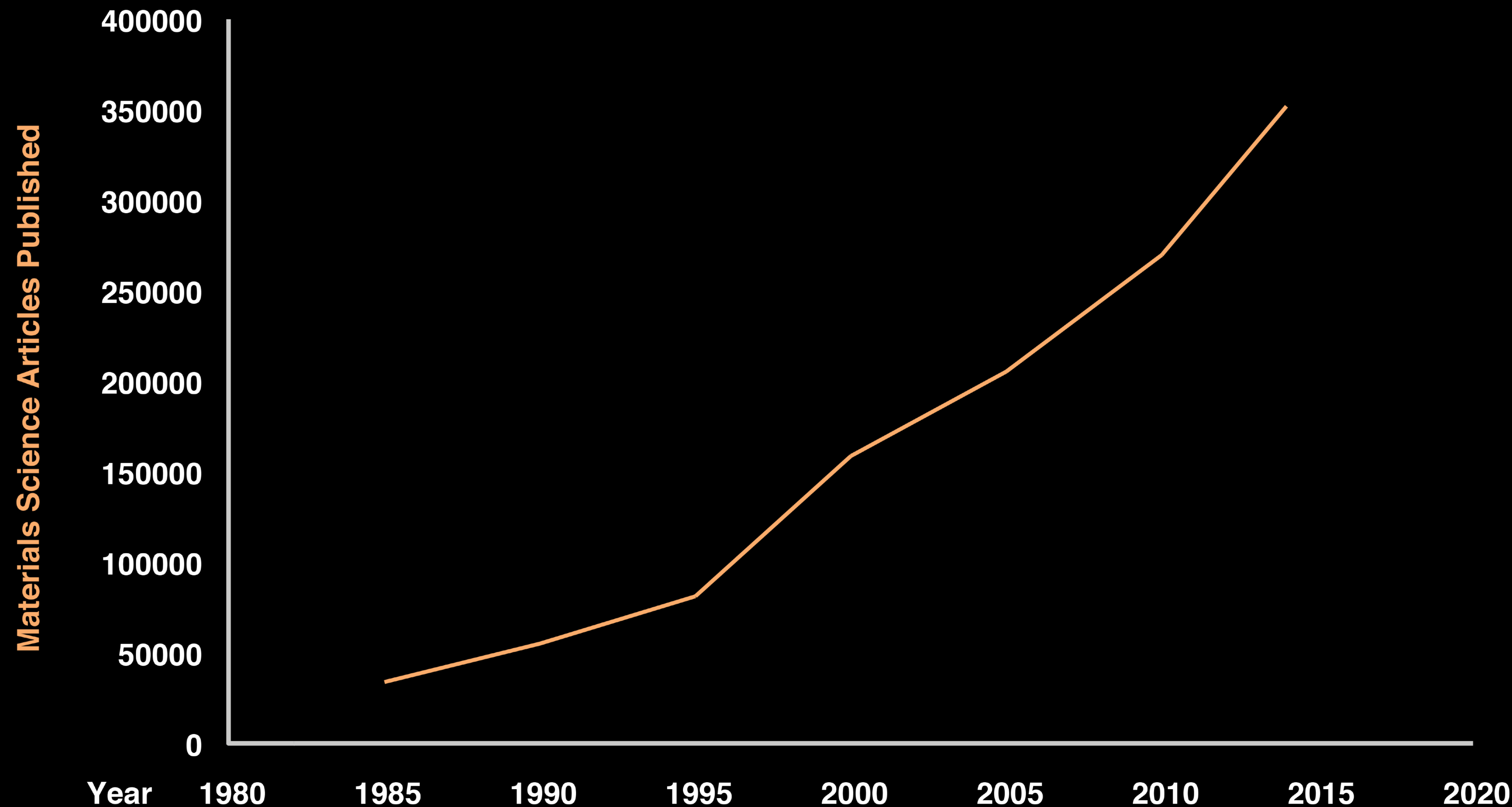
Today & Tomorrow
Cognitive Discovery

Our ability to discover is directly linked to the amount of data available

A top-down view of numerous petri dishes arranged on a blue surface. Each dish contains a bacterial culture, likely E. coli, which has formed a dense, dark, fuzzy mat. The dishes are labeled with white tape and black ink, showing various numbers and symbols such as '1', '11', '1-1', '1-2', '1-3', '1-4', '1-5', '1-6', '1-7', '1-8', '1-9', '1-10', '1-11', '1-12', '1-13', '1-14', '1-15', '1-16', '1-17', '1-18', '1-19', '1-20', '1-21', '1-22', '1-23', '1-24', '1-25', '1-26', '1-27', '1-28', '1-29', '1-30', '1-31', '1-32', '1-33', '1-34', '1-35', '1-36', '1-37', '1-38', '1-39', '1-40', '1-41', '1-42', '1-43', '1-44', '1-45', '1-46', '1-47', '1-48', '1-49', '1-50', '1-51', '1-52', '1-53', '1-54', '1-55', '1-56', '1-57', '1-58', '1-59', '1-60', '1-61', '1-62', '1-63', '1-64', '1-65', '1-66', '1-67', '1-68', '1-69', '1-70', '1-71', '1-72', '1-73', '1-74', '1-75', '1-76', '1-77', '1-78', '1-79', '1-80', '1-81', '1-82', '1-83', '1-84', '1-85', '1-86', '1-87', '1-88', '1-89', '1-90', '1-91', '1-92', '1-93', '1-94', '1-95', '1-96', '1-97', '1-98', '1-99', '1-100'.

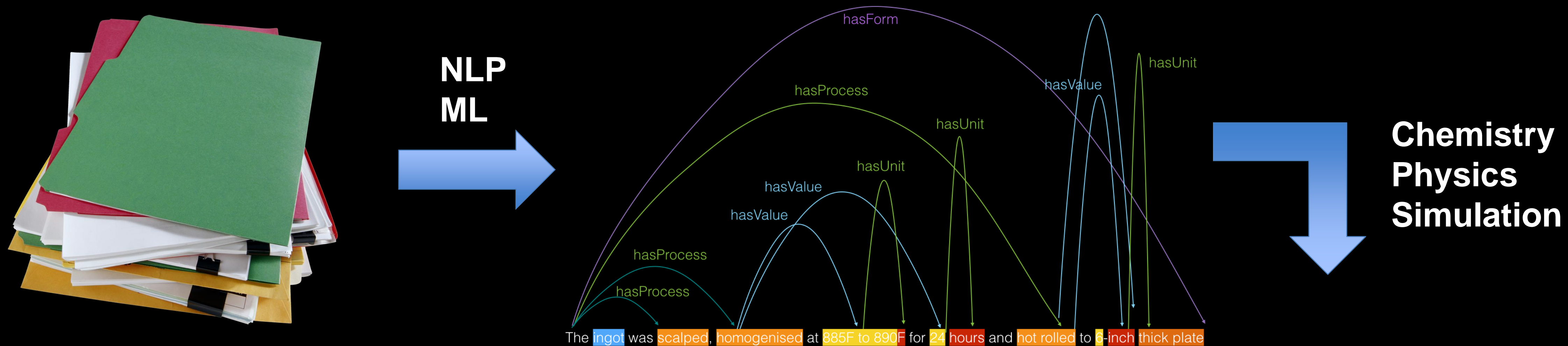
Cognitive Computing for Discovery

Unstructured Data Deluge in Peer Review Publications



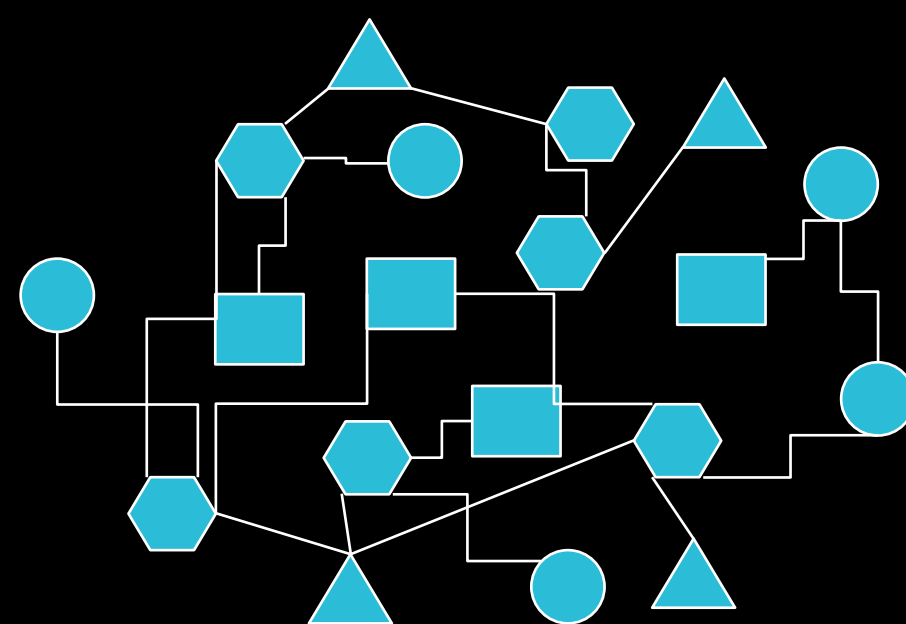
Transforming unstructured data into knowledge

Unstructured data is stored in a complex Knowledge Graph that captures all the knowledge in the text, in the practical experience & from physics/chemistry principles.

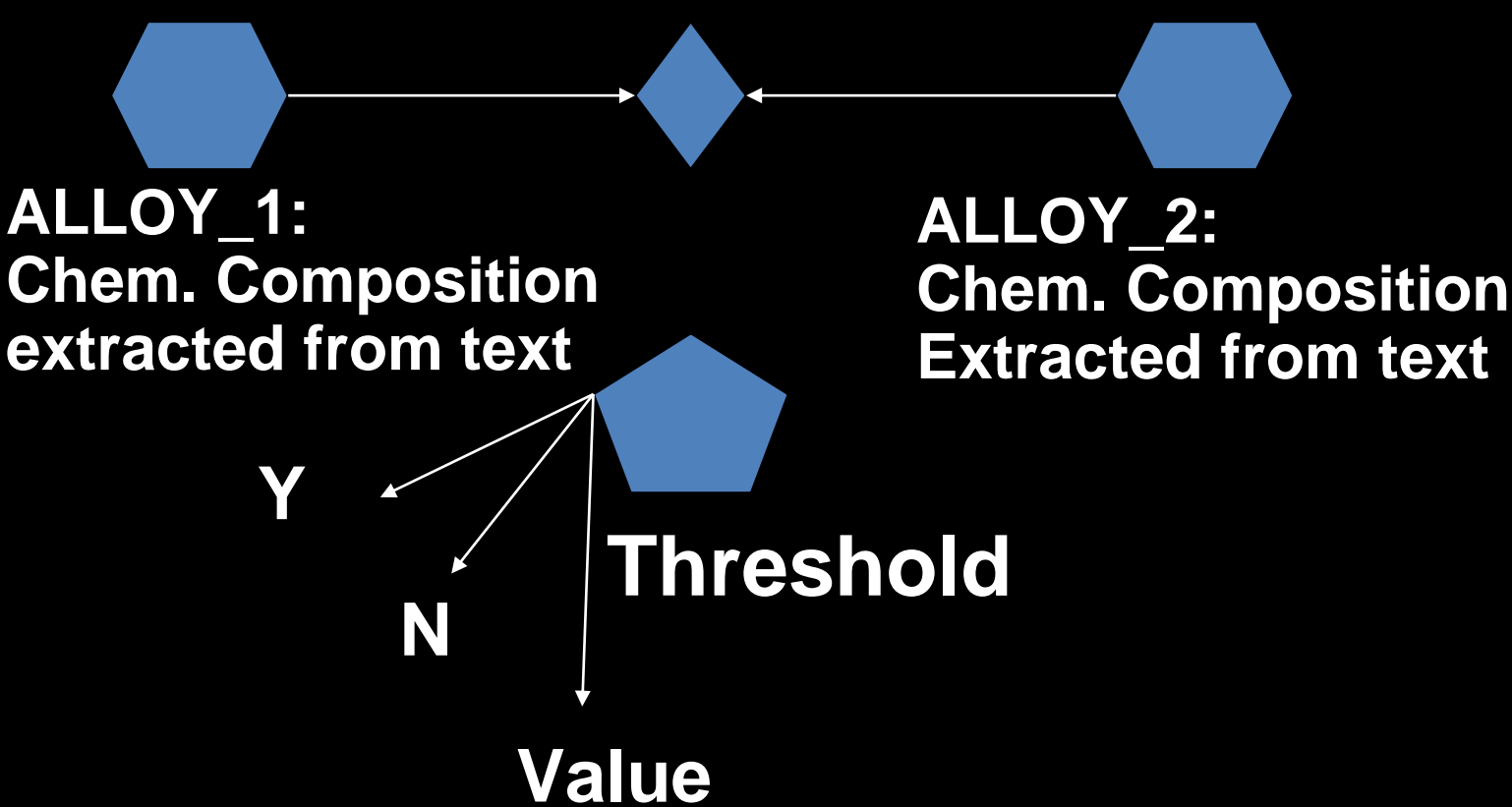


Knowledge Graph

- ALLOY NODE TYPE
- PROCESS NODE TYPE
- PRODUCT NODE TYPE
- ELEMENT NODE TYPE



SIMULATION





Enter some keywords separated by commas.



Ask



Advanced

Query

SELECT ELEMENTS ▾

SELECT PROPERTIES ▾

SELECT FORM ▾

KEYWORDS ▾

Query
(Unordered)

Query
(Ordered)

Prediction

Attribute distribution

Attribute correlation

Result in table

Result in Box Plots

Prediction

Document View

Review the distribution of an attribute as found in all documents (the corpus).

Select attribute to plot:

☐ If applicable, limit to range in last query.

Frequency

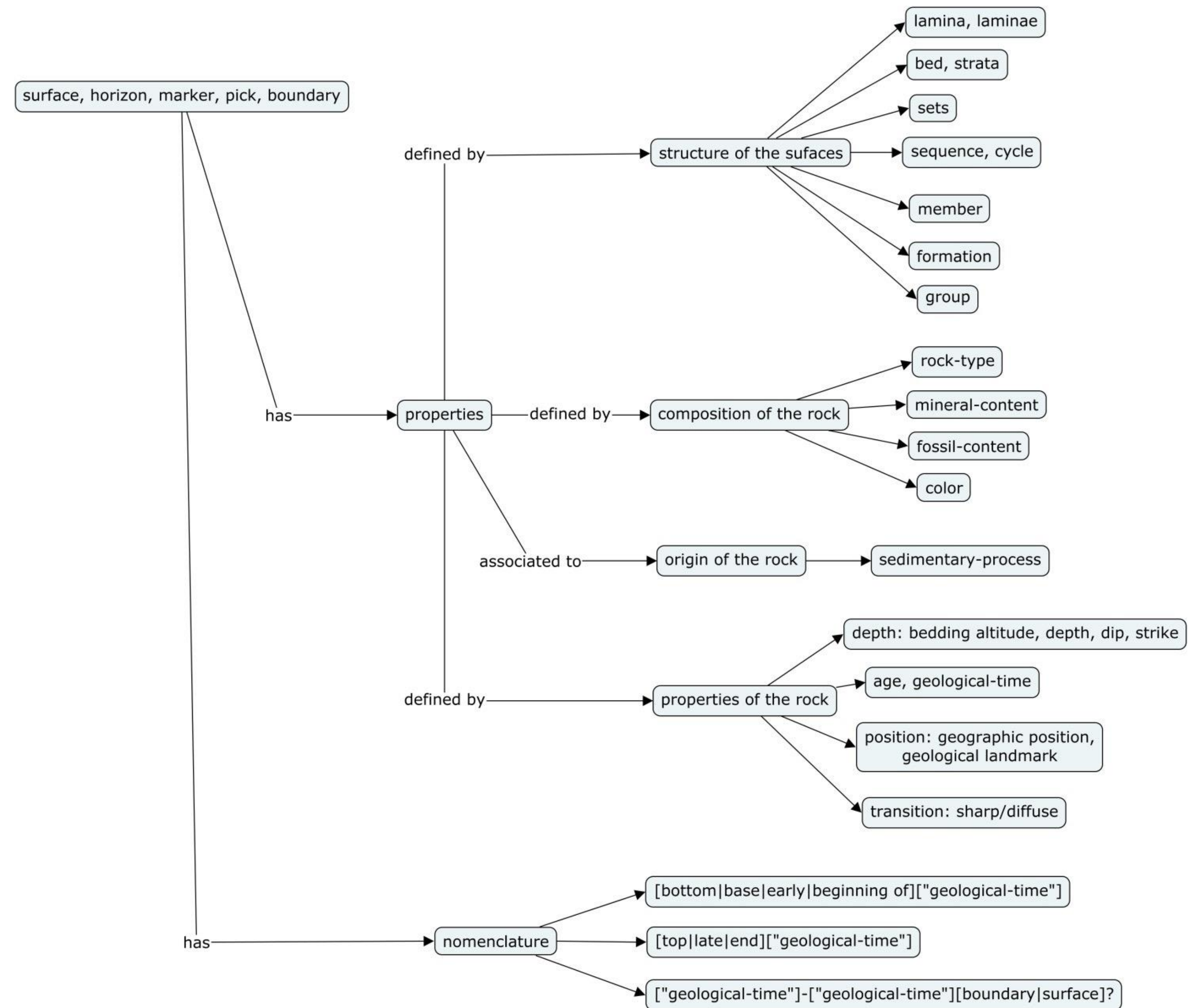
Teaching Geology to Watson

Currently working on the concept of identifying petroleum basin analogues. Complex decision process driven by

- Structure of rocks
- Composition of formations
- Origin
- Properties

Work based on:

- Advanced semantic extraction from PDF documents
- Cognitive representation of the decision processes of Oil & Gas geologists



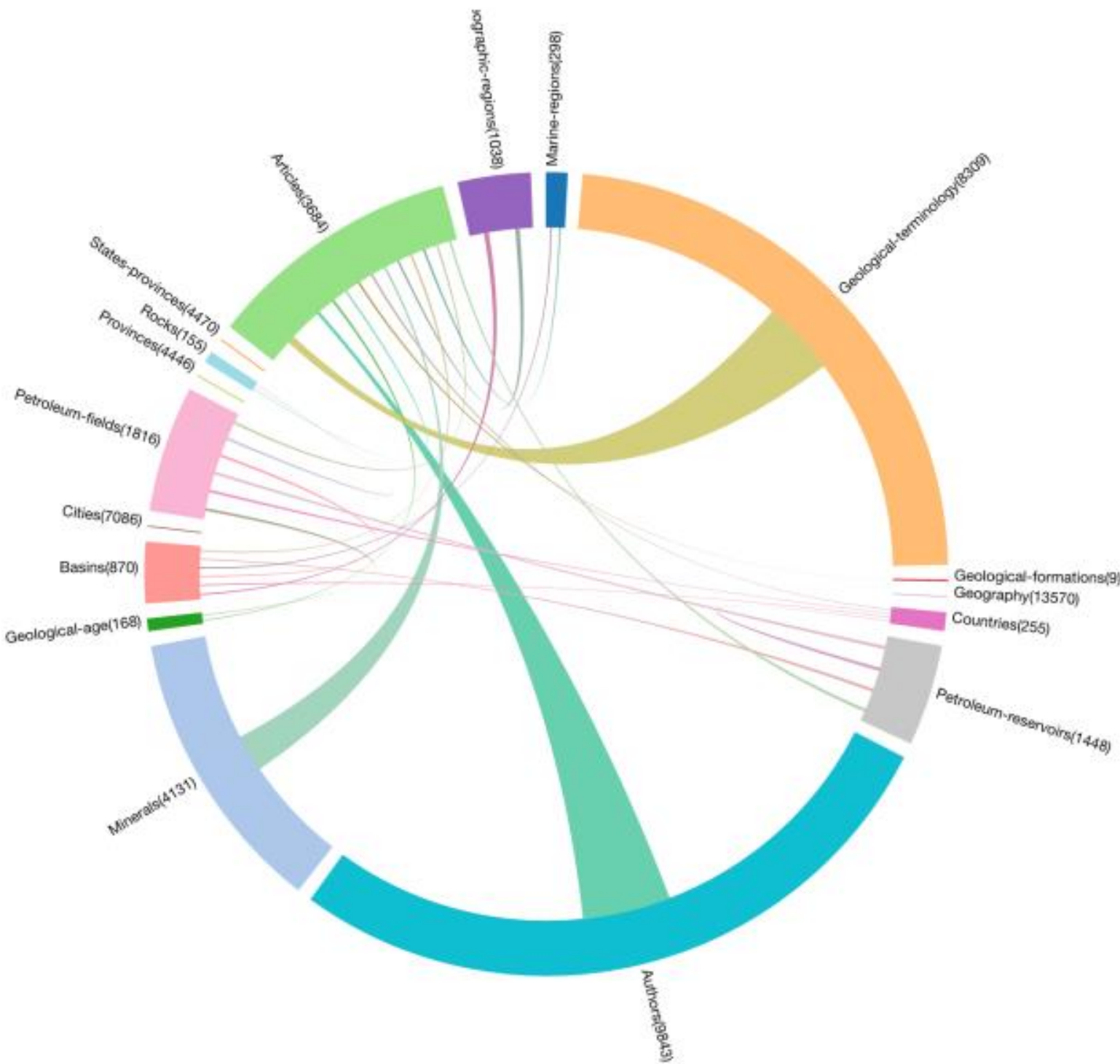
Teaching Geology to Watson

Geology Knowledge Graph

HomeCognitive SearchClear LS

Iraq

User Interface for exploring Knowledge Graph



Geology Knowledge Graph v0.1

Geology Knowledge Graph

Graph / geography, countries / Iraq

Iraq

Region Overlay

Basins (5)

Select all / Deselect all

☐ Euphrates - Sinjar Basin

☐ Southeast Turkey Foldbelt Basin

☐ Tabuk Basin

☐ Widyan - North Arabian Gulf Basin

☒ Zagros Foldbelt Basin

OverviewBasins (5)Petroleum-fields (40)Articles (17)Petroleum-reservoirs (34)Geography (5)

5 hits

Name

Categories

Euphrates - Sinjar Basin

geography, basins

Southeast Turkey Foldbelt Basin

geography, basins

Tabuk Basin

geography, basins

Widyan - North Arabian Gulf Basin

geography, basins

Zagros Foldbelt Basin

geography, basins

Advanced Exploration

Geology Knowledge Graph

Graph / articles / High_resolution_cathodoluminescence_spectroscopy_of_carbonate_cementation_in_Khurmala_Formation_Paleocene_L_Eocene_from_Iraqi_Kurdistan_Region_Norther

OverviewGeological-terminology (20)Geological-formations (1)Geography (1)Countries (1)Rocks (2)Authors (3)Minerals (3)

High resolution cathodoluminescence spectroscopy of carbonate cementation in Khurmala Formation (Paleocene-L. Eocene) from Iraqi Kurdistan Region, Northern Iraq

Abstract

A combination of high resolution cathodoluminescence-spectroscopy (HRS-CL) with spatial electron microprobe analysis and optical microscopy is used to determine paragenesis and history of cementation in the limestones and dolostones of Khurmala Formation which is exposed in many parts of Northern Iraq. Khurmala Formation was subjected to different diagenetic processes such as micritization, compaction, dissolution, neomorphism, pyritization and cementation that occurred during marine to shallow burial stages and culminated during intermediate to deep burial later stages. Five dolomite textures are recognized and classified according to crystal size distribution and crystal-boundary shape. Dolomitization is closely associated with the development of secondary porosity that pre-and postdates dissolution and corrosion; meanwhile such porosity was not noticed in the associated limestones. Microprobe analysis revealed three types of cement, calcite, dolomite and ankerite which range in their luminescence from dull to bright. Cathodoluminescence study indicated four main texture generations. These are (1) unzoned microdolomite of planar and subhedral shape, with syntaxial rim cement of echinoderm that show dull to red luminescence, (2) equant calcite cements filling interparticle pores which shows dull luminescence and weak zonal growth, (3.1) homogenous intrinsic blue stoichiometric calcite with dull luminescence and without activators, (3.2) coarse blocky calcite cement with strong oscillatory zoning and bright orange luminescence which postdates other calcite cements, (4) ankerite cement with red to orange, non-luminescence growth zonation which is the last formed cement.

Authors

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date

2014-07-05T16:31:16Z

Publisher

Elsevier BV

Journal

Journal of African Earth Sciences

DOI

10.1016/j.jafrearsci.2014.06.016

Text

High resolution cathodoluminescence spectroscopy of carbonate cementation in Khurmala Formation (Paleocene-L. Eocene) from Iraqi Kurdistan Region, Northern Iraq

Muhammed F. Omer [†], Dilshad Omer, Bahroz Gh. Zebari article info

1. Introduction

Data Driven Knowledge Discovery Pipeline

Gather Data



Analytics

Connect

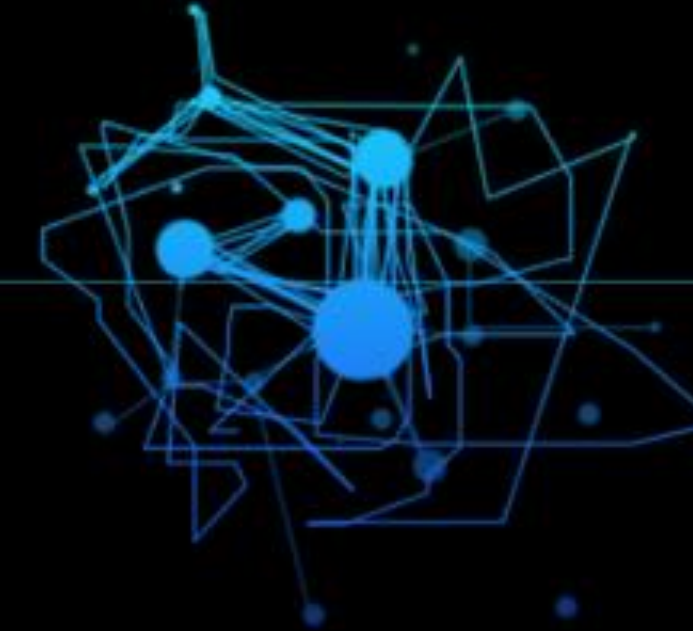


Reason



Cognitive

Knowledge



Adapt



Learn



Cognitive Computing for Healthcare

Healthcare Industry is dealing with data overload

Exogenous data

(Behavior, Socio-economic, Environmental, ...)

60% of determinants of health
Volume, Variety, Velocity, Veracity

1100 Terabytes
Generated per lifetime

Genomics data

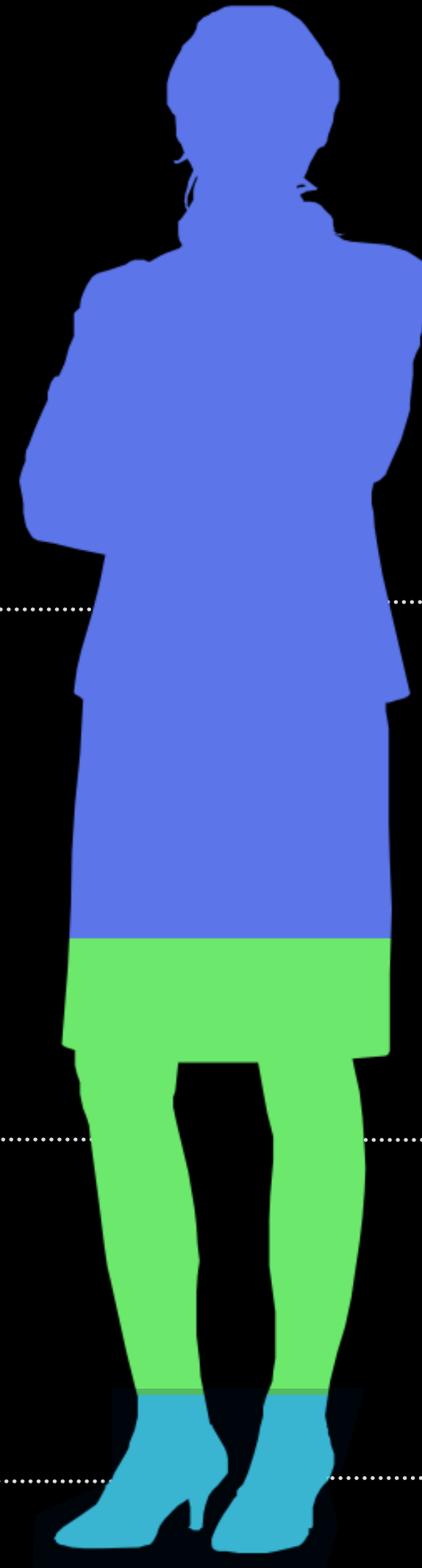
30% of determinants of health
Volume

6 TB
Per lifetime

Clinical data

10% of determinants of health
Variety

0.4 TB
Per lifetime





New Patient

Sample Patient Cases for Evaluation

Filter

Sort by: ▾

Range: 1-10 Total: 49

◀ 1 2 3 ... 5 ▶

10 | 25 | 50 | All +

Bryan, Mr. Eric

Diagnosis: Colon Cancer, Gender: M, Age: 73, Patient ID#: Example 91505762-75fb-4a13-a336-25d641db57a6
Last Updated: 1/22/2015, 1:46:45 PM



Brown, Mrs. Christine

Diagnosis: Breast Cancer, Gender: F, Age: 64, Patient ID#: Example-gh36q7-g45h-ahe1-4562sk7a
Last Updated: 1/22/2015, 1:46:37 PM



Cary, Mrs. Olivia

Diagnosis: Breast Cancer, Gender: F, Age: 67, Patient ID#: Example-gf56f5-hy67-a45b-aeh1-cvgw89a
Last Updated: 1/22/2015, 1:46:18 PM



Jackson, Mr. Larry

Diagnosis: Colon Cancer, Gender: M, Age: 47, Patient ID#: Example fc8bf916-3486-4d81-9af8-dc411e898f47
Last Updated: 1/21/2015, 7:53:16 AM



Lewis, Mrs. Samantha

Diagnosis: Rectal Cancer, Gender: F, Age: 68, Patient ID#: Example c10833e4-f4de-45ed-ae3a-941b36c93df9
Last Updated: 1/21/2015, 7:52:29 AM



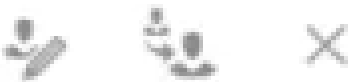
Wu, Mrs. Alice

Diagnosis: Breast Cancer, Gender: F, Age: 66, Patient ID#: Example d04b4081-c268-43fb-9d69-c77e7d20daad
Last Updated: 1/20/2015, 1:40:41 PM



Bryan, Mr. Eric

Diagnosis: Colon Cancer, Gender: M, Age: 73, Patient ID#: Example 91505762-75fb-4a13-a336-25d641db57a6
Last Updated: 1/20/2015, 1:40:27 PM



Range: 1-10 Total: 49

◀ 1 2 3 ... 5 ▶

10 | 25 | 50 | All +

POLITICS

DOMANI SERA ORE 21.10

Rai 3 HD

PRESA DIRETTA

POLITICS

DOMANI SERA ORE 21.10

Rai 3 HD

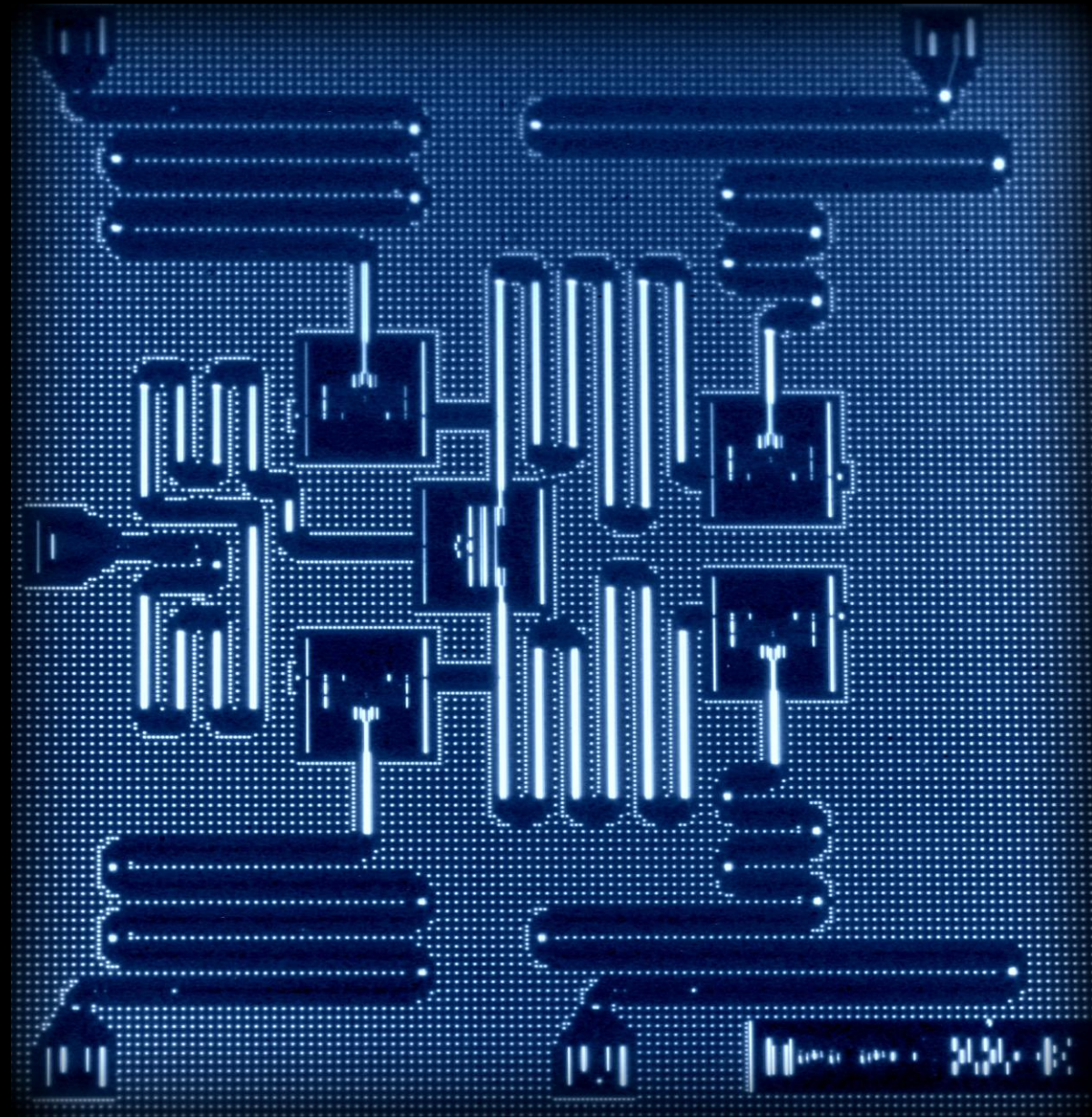
IBM Research

Melanoma Image Analysis

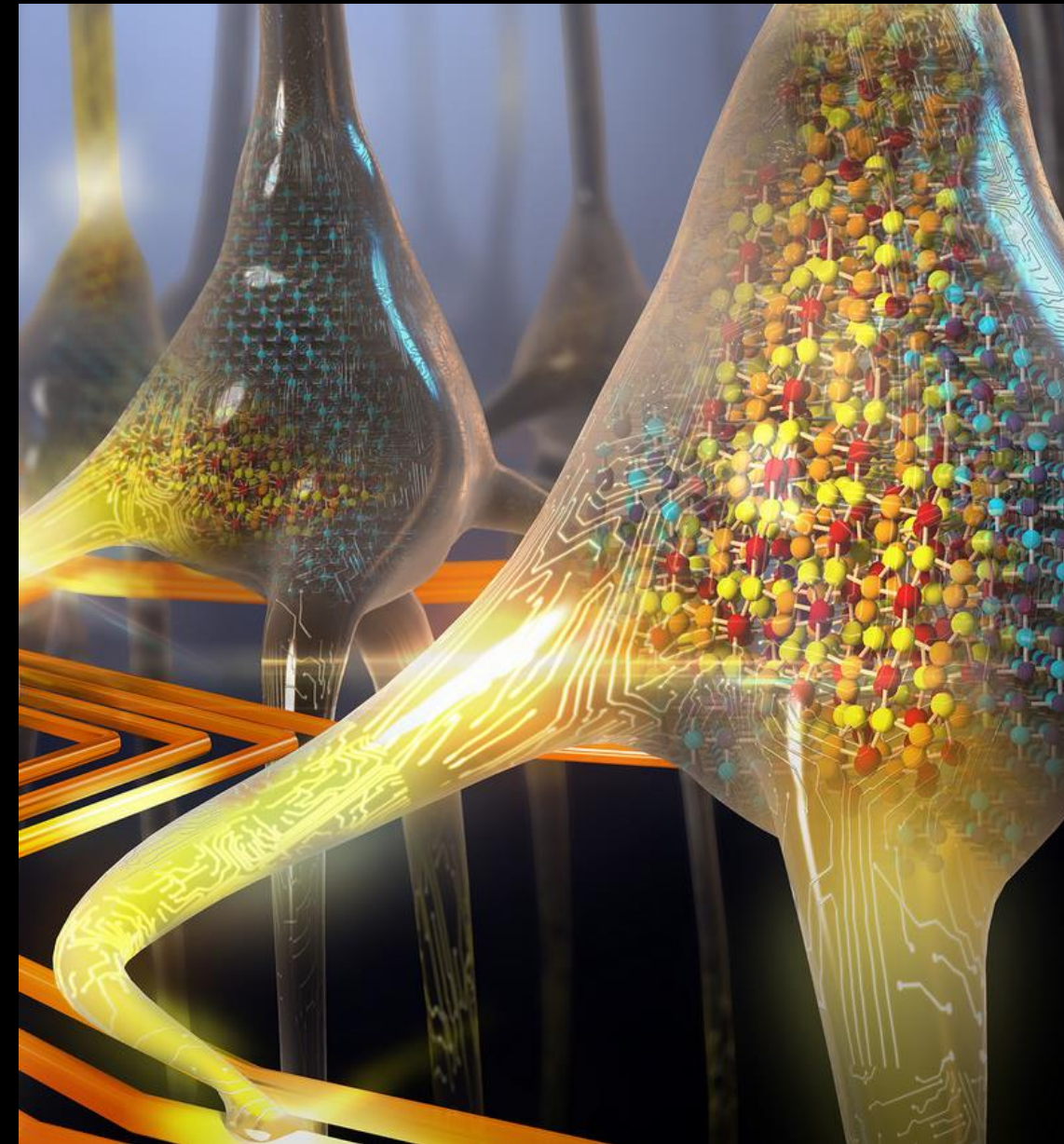


PRESA DIRETTA

Watson in the Future: Non-Von Neuman for Next Generation Cognitive Applications



Quantum Computing



Neuromorphic Computing

Classic vs Quantum Computer

- A classical computer makes use of bits to process information, where each bit represents either a 1 or a 0.

A quantum bit (qubit) can represent a 1, a 0, or both at once, which is known as superposition.

This property along with other quantum effects enable quantum computers to perform certain calculations vastly faster than is possible with classical computers.

● 0

● 1

Classic Bit



Qubit

User Guide

Composer

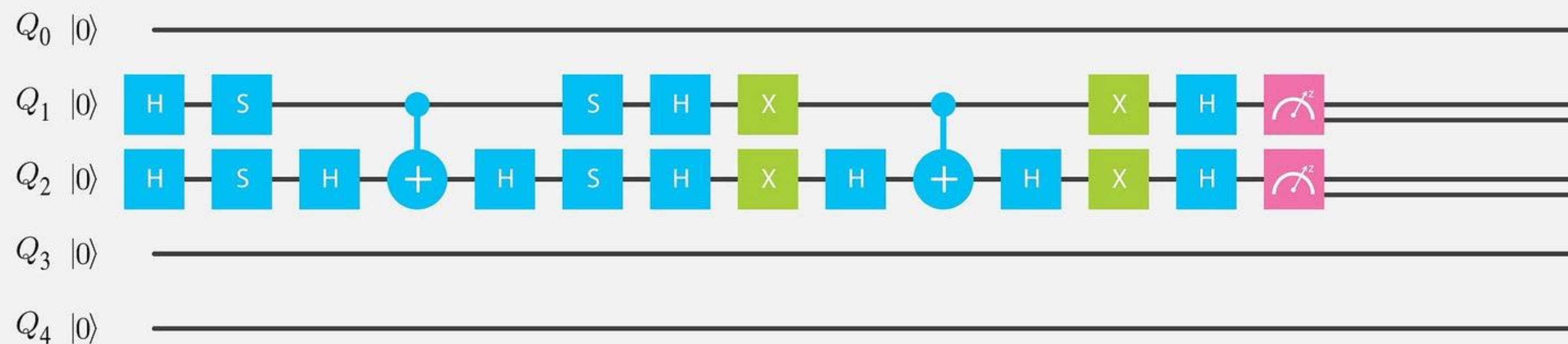
My Scores

[← Back to the User Guide](#)

Standard User, QCoins: 0/15

Name: 'Grover N=2 A=00'

Real Quantum Processor



Simulate

Run

New

Save

Save as

Results

Help



Program a Qubit in the IBM Cloud Today!
<https://quantumexperience.mybluemix.net>

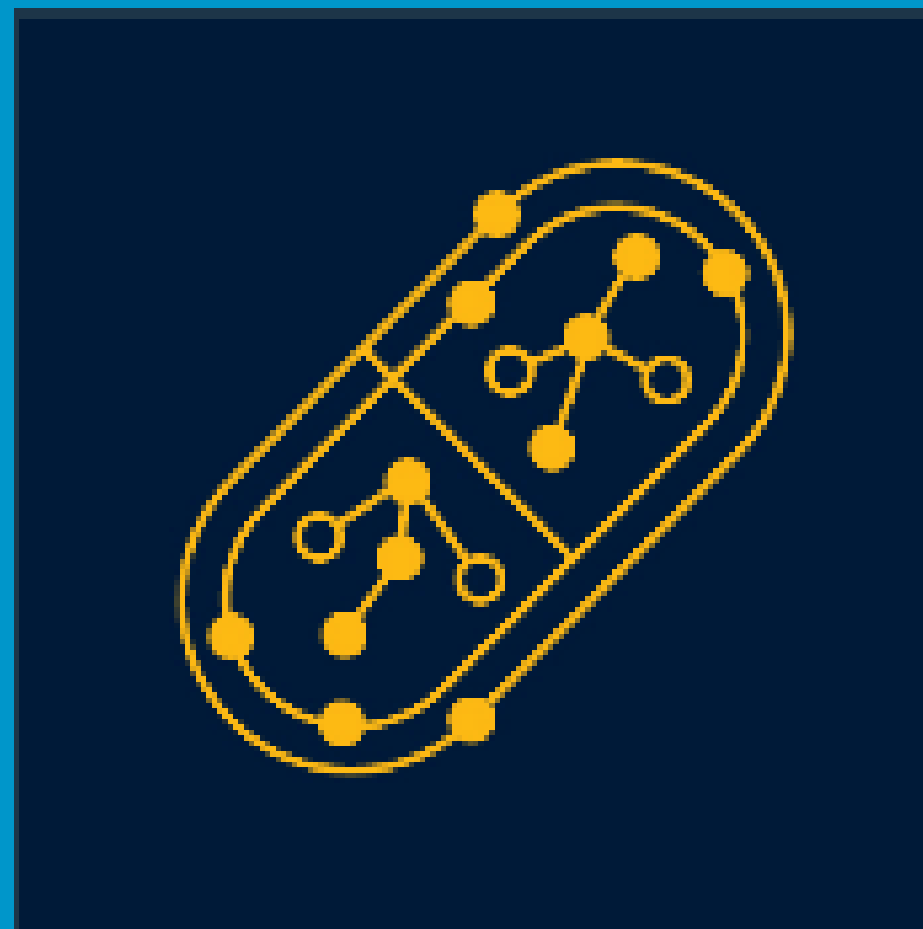


Applications for Quantum

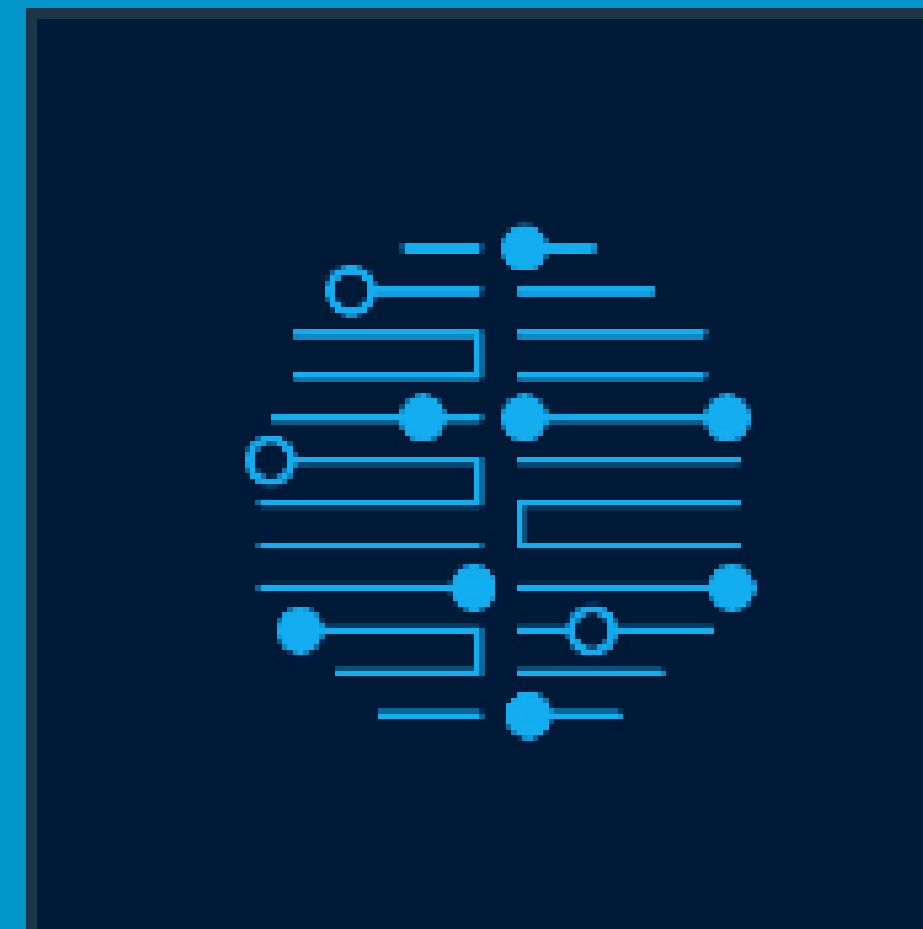
- With Moore's Law running out of steam, quantum computing will be among the technologies that IBM believes will usher in a new era of innovation across industries.
- This leap forward in computing could revolutionize:



Cryptography



Medicine &
Materials

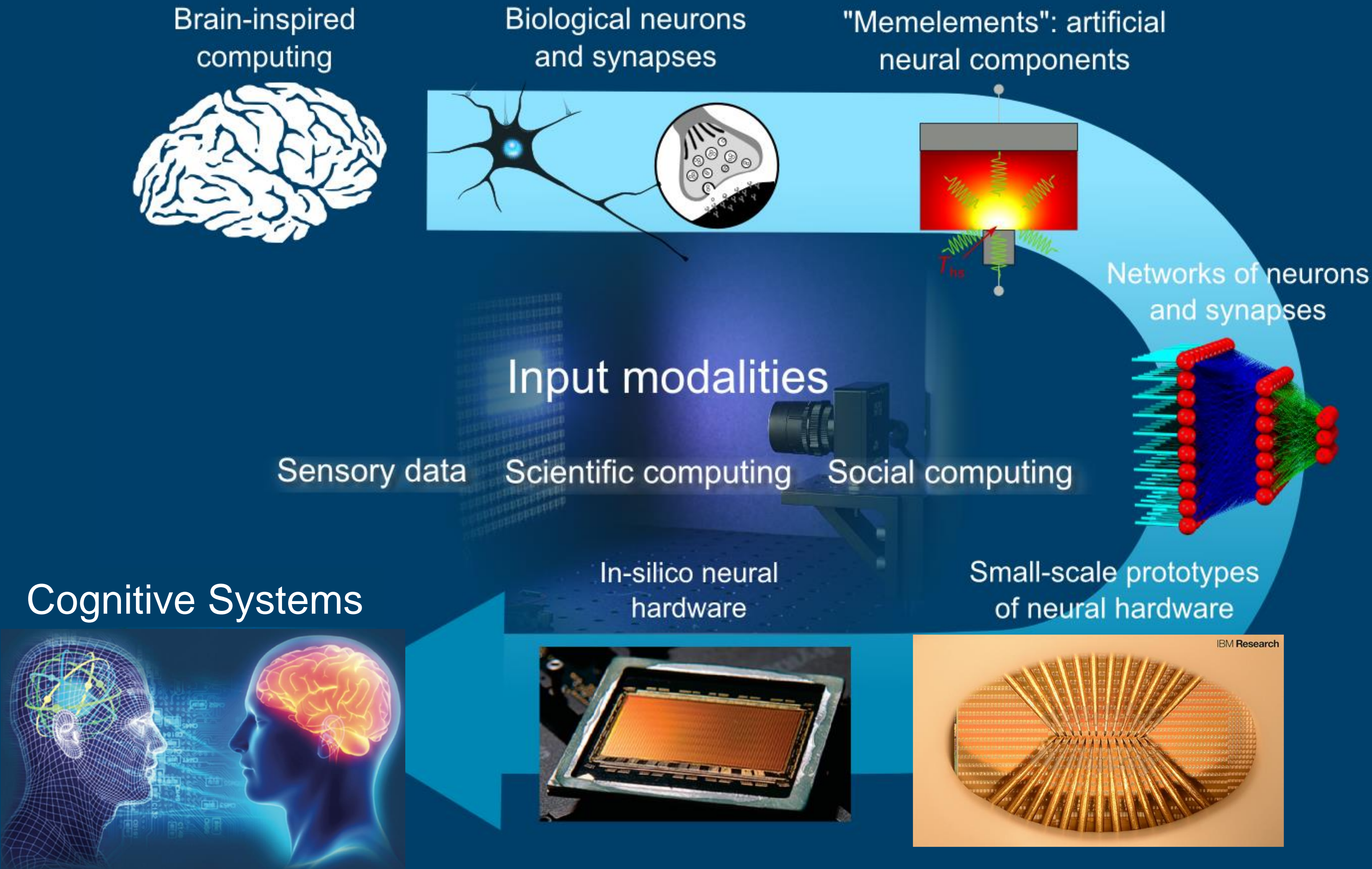


Machine Learning



Searching Big
Data, Pattern
Recognition, IoT

Neuromorphic Computing



TrueNorth Chip (SyNAPSE)



2011

Now

Programmable
Neurons

256

1 million

Programmable
Synapses

262,144

256 million

Neurosynaptic
Cores

1

4096

Saliency



Saliency + Classification



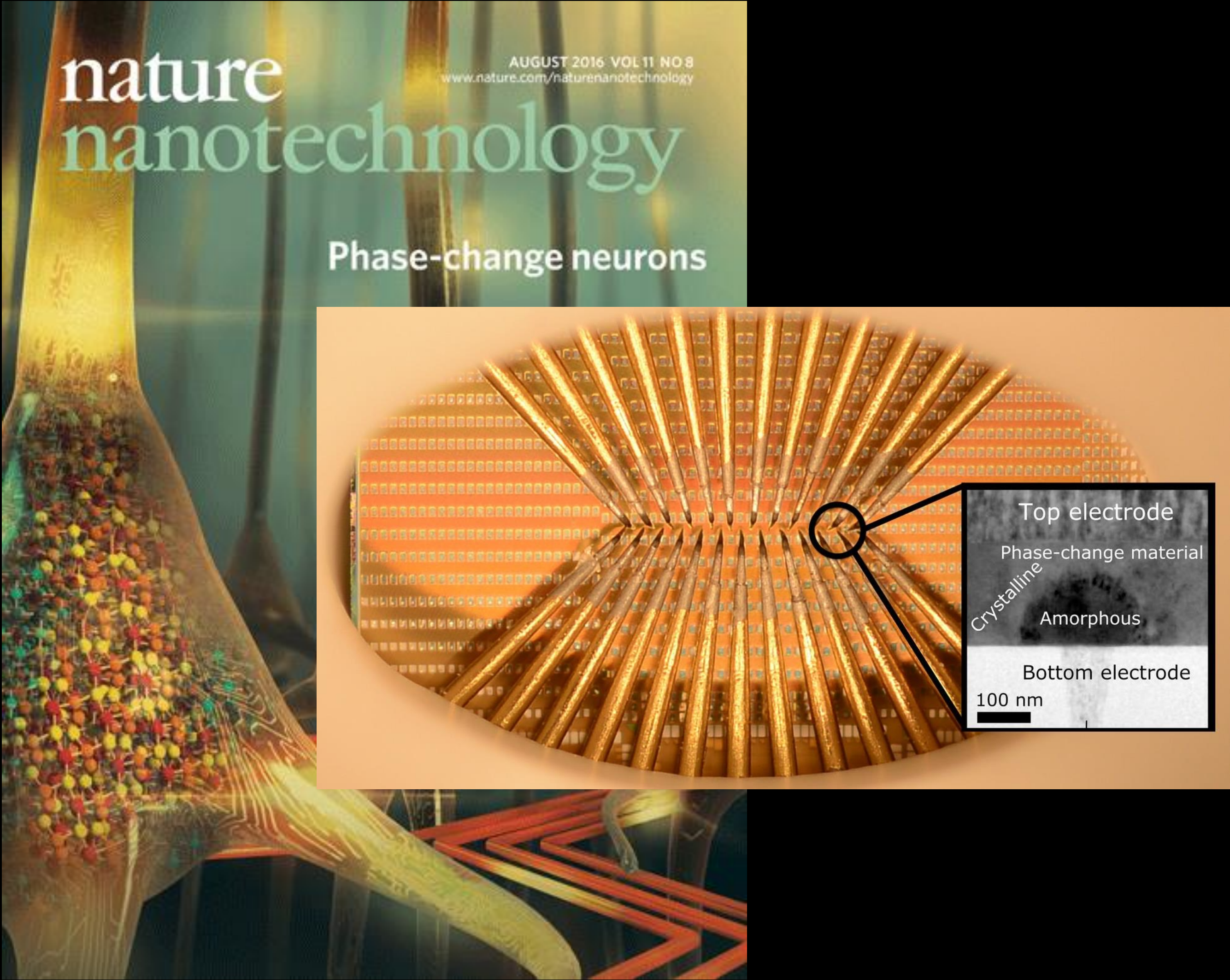
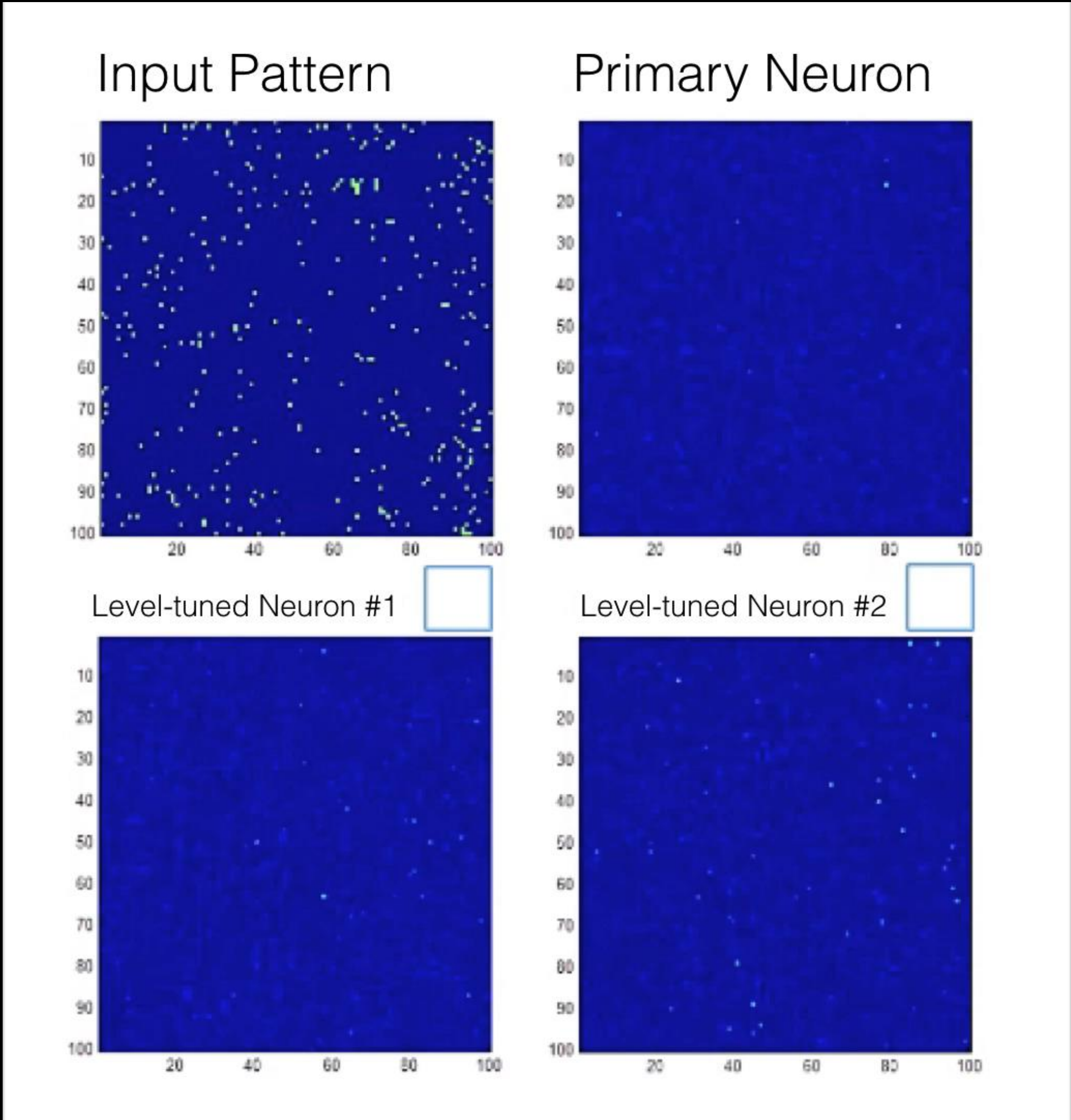
Object Centers



Output

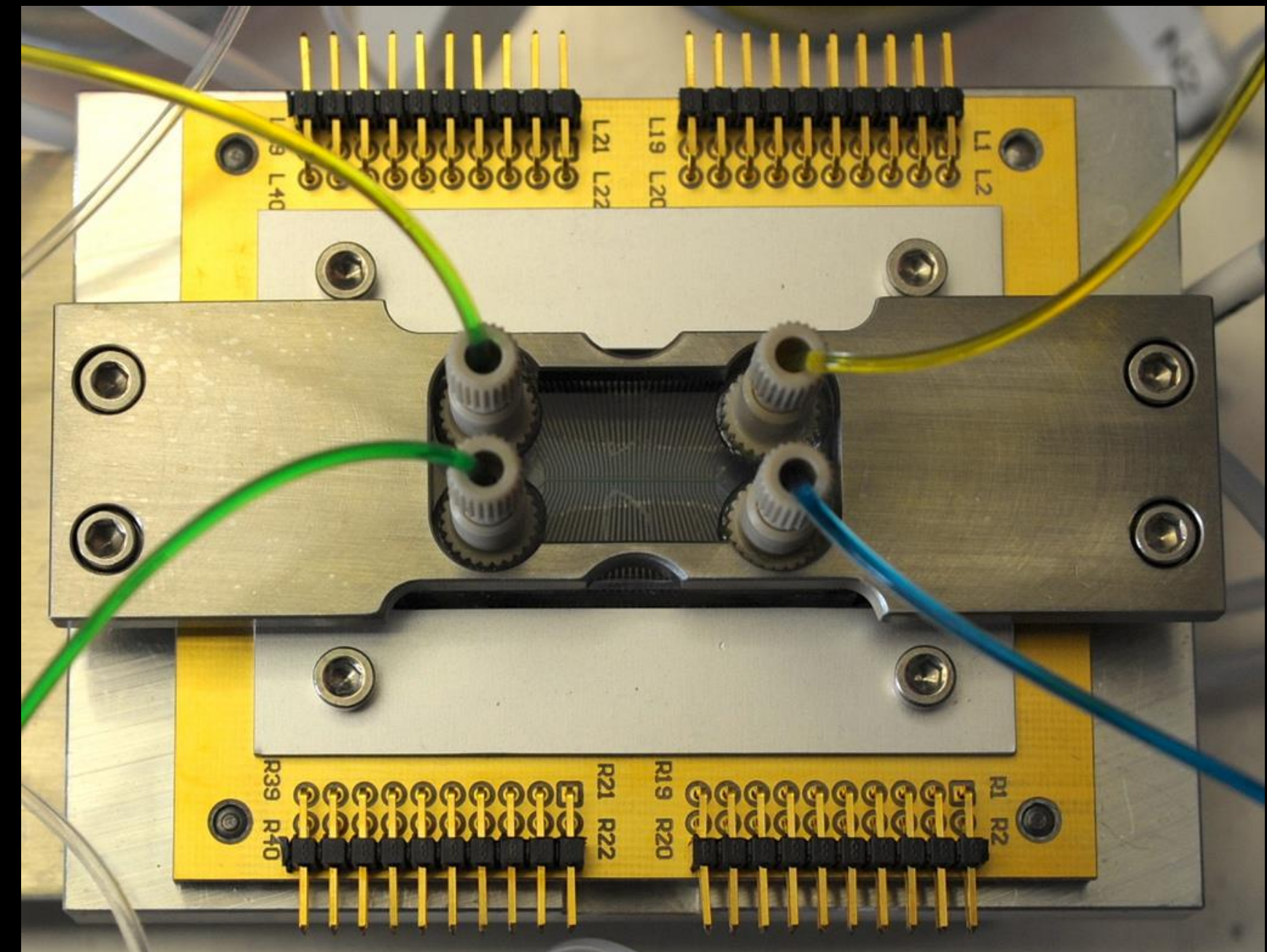
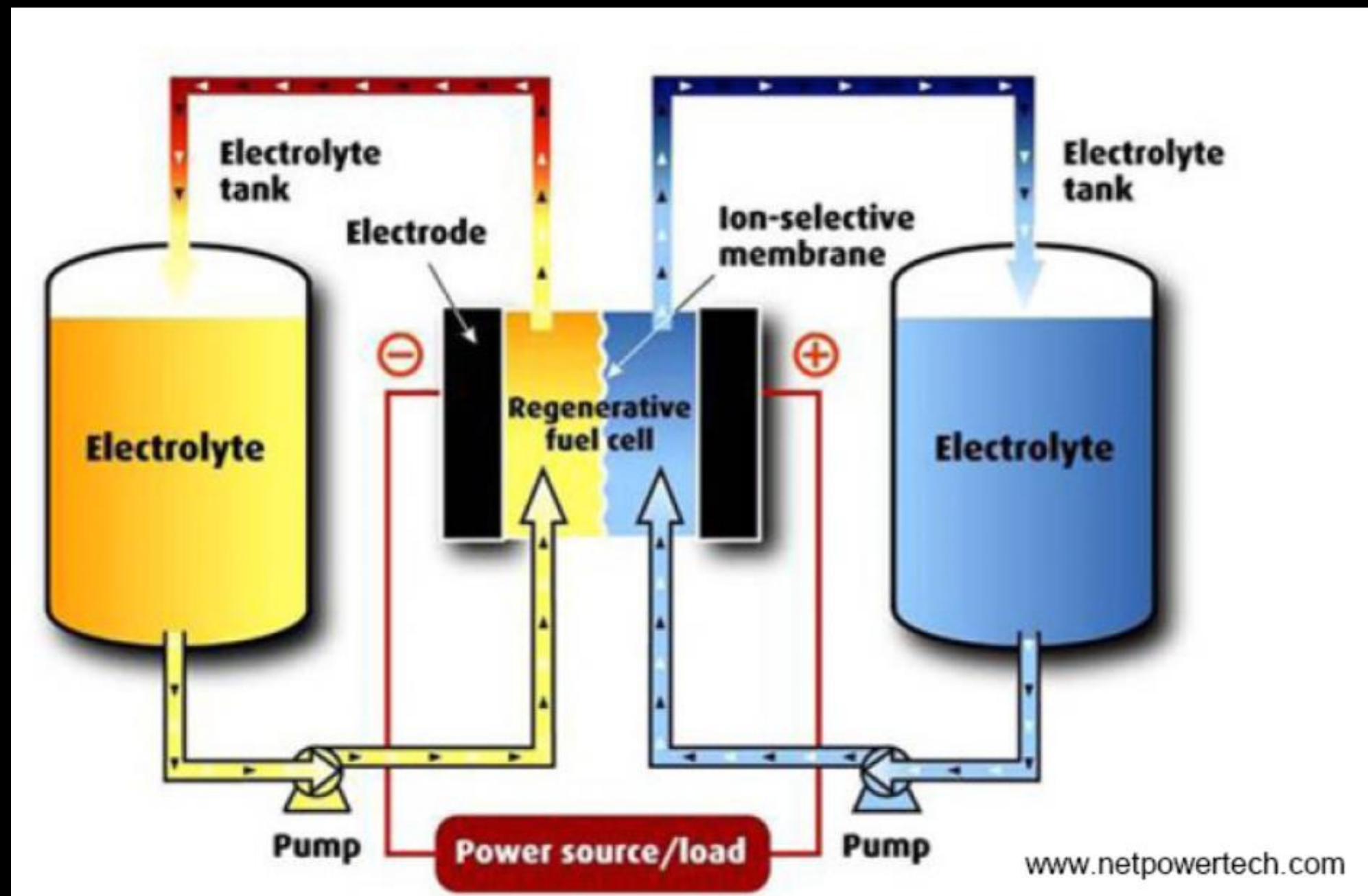


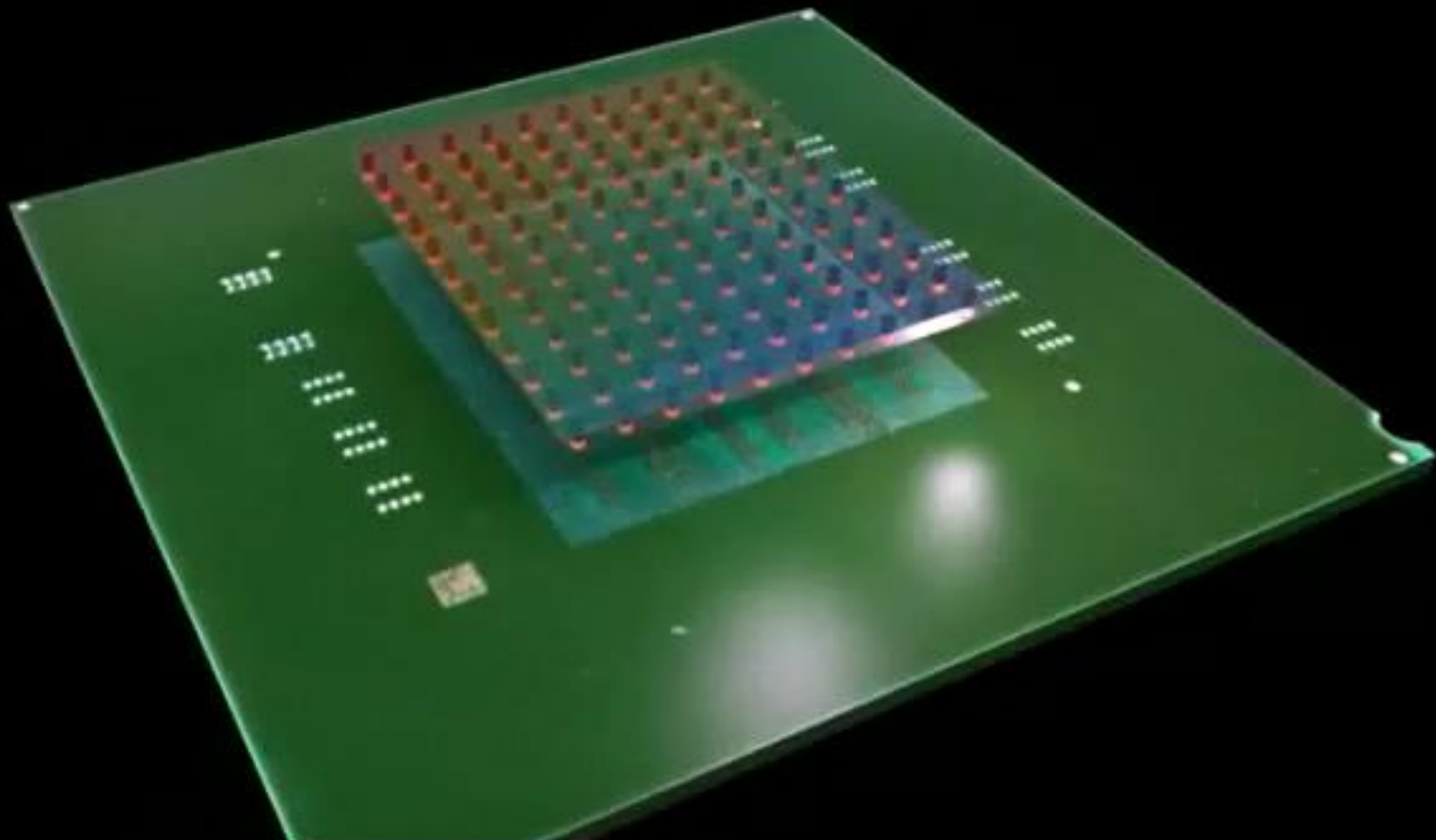
Detecting Correlations with a Spiking Neural Network



Brain Inspired Computing: Electronic Blood

- 98% of the energy of a computer is for cooling
- Liquid removes heat 4000x more efficiently than air
- The brain is powered & cooled using liquid, can we do the same for computers?
- The result: a 1 PetaFlop supercomputer in 10 liters







Compassion

Intuition

Design

Value judgements

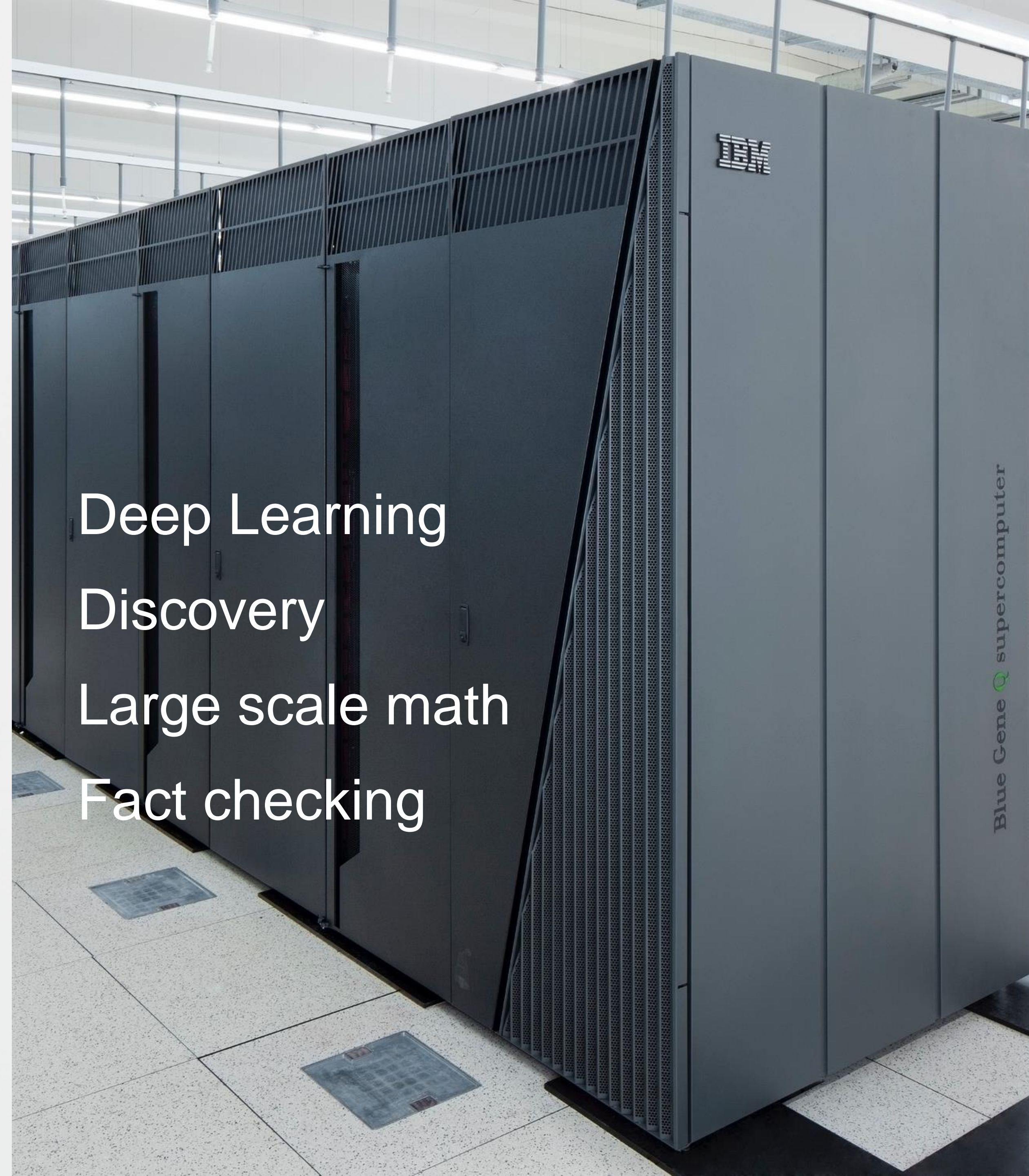
Common sense

Deep Learning

Discovery

Large scale math

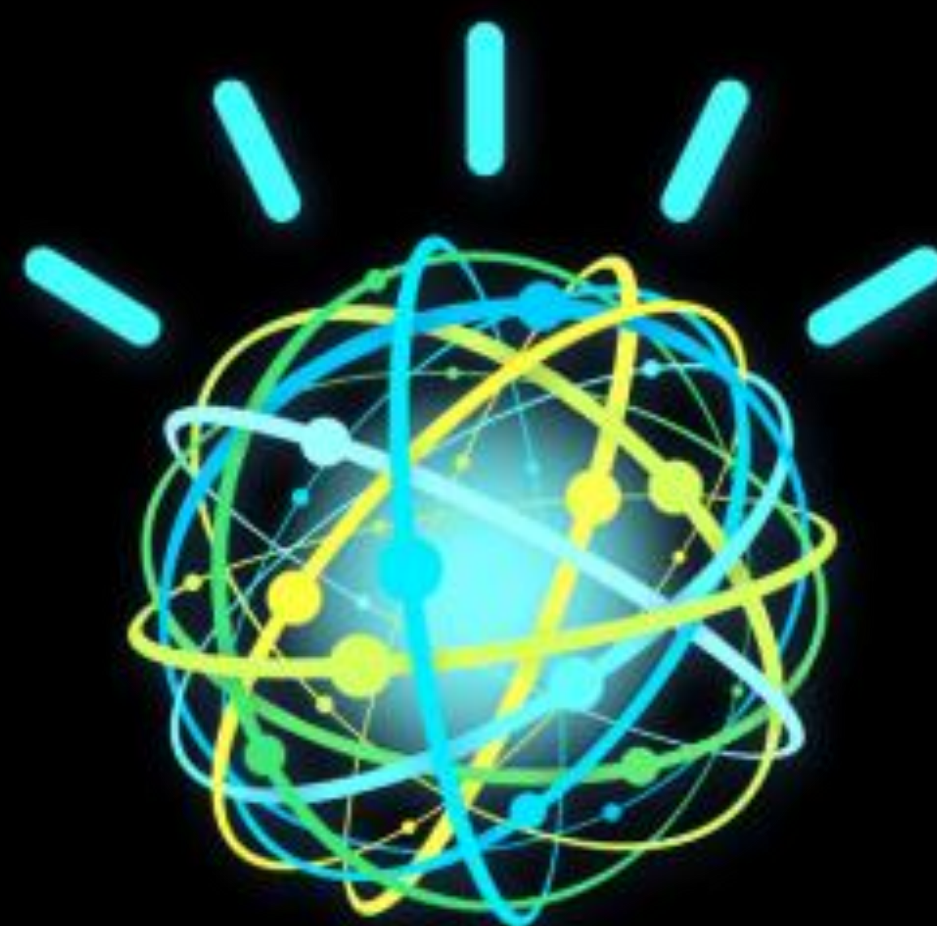
Fact checking





Human + Machine





Questions?