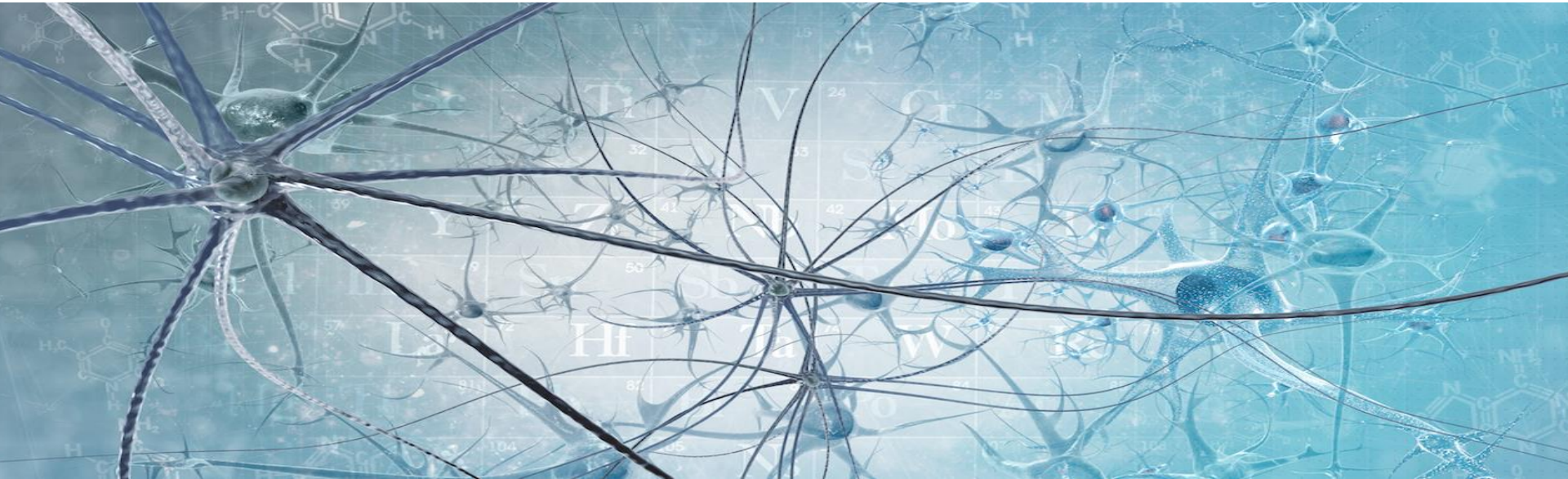
European Biotech Week
Pavia, Sept 25th 2019

Artificial Intelligence in Healthcare and Life Science

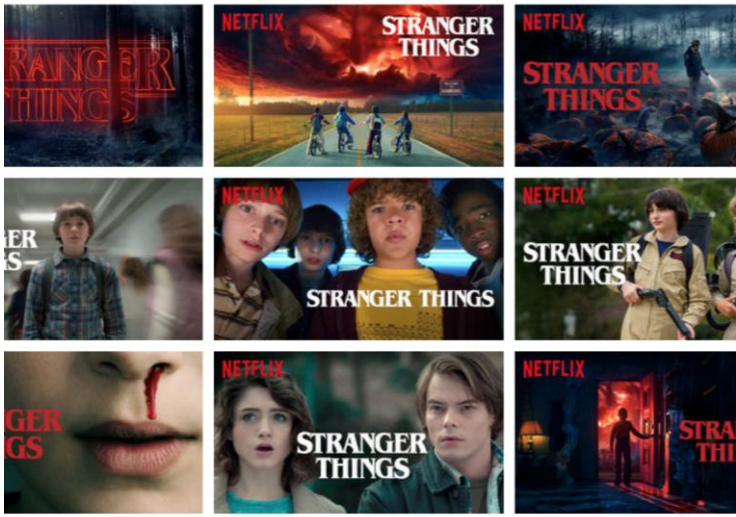
Antonio Pelliccia | Healthcare & Life Sciences, IBM



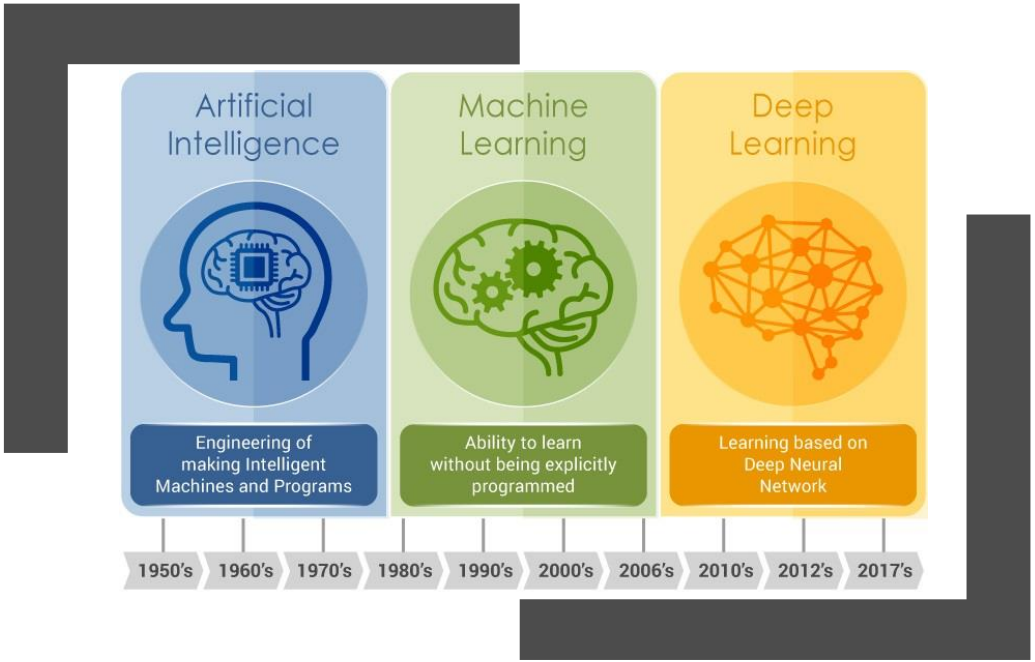
The official birth of AI

- 1956: Darmouth Summer Research Project on Artificial Intelligence

McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon



What is AI?



"**Machine learning** is a field of computer science that gives computer systems the ability to "learn" from data, **without being explicitly programmed**"

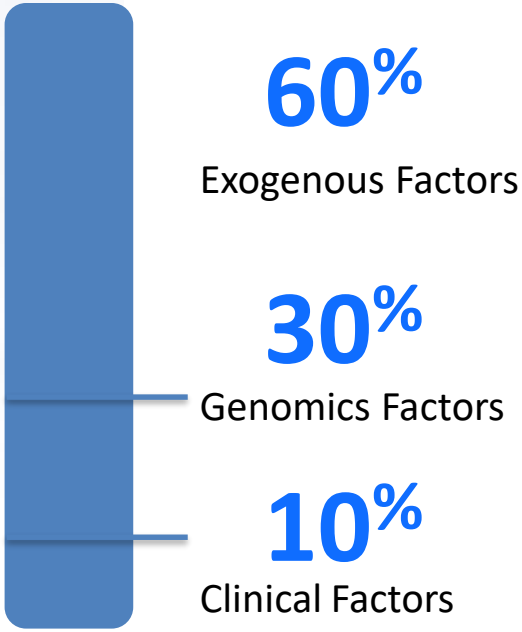
Samuel, Arthur L. (1959). "Some Studies in Machine Learning Using the Game of Checkers". *IBM Journal of Research and Development*

Image source:
https://www.slideshare.net/linagora/deep-learning-in-practice-speech-recognition-and-beyond-meetup


Why is Deep
Learning stepping
in the limelight?

Healthcare Data are exploding

(from 153 Exabytes in 2013 to 2.314 Exabytes in 2020 - IDC)



Source: Health Policy Brief: The Relative Contribution of Multiple Determinants to Health Outcomes," Health Affairs, August 21, 2014

If it walks/swims/quacks like a Duck… then it must be a Duck

Swims

Walks

Quacks

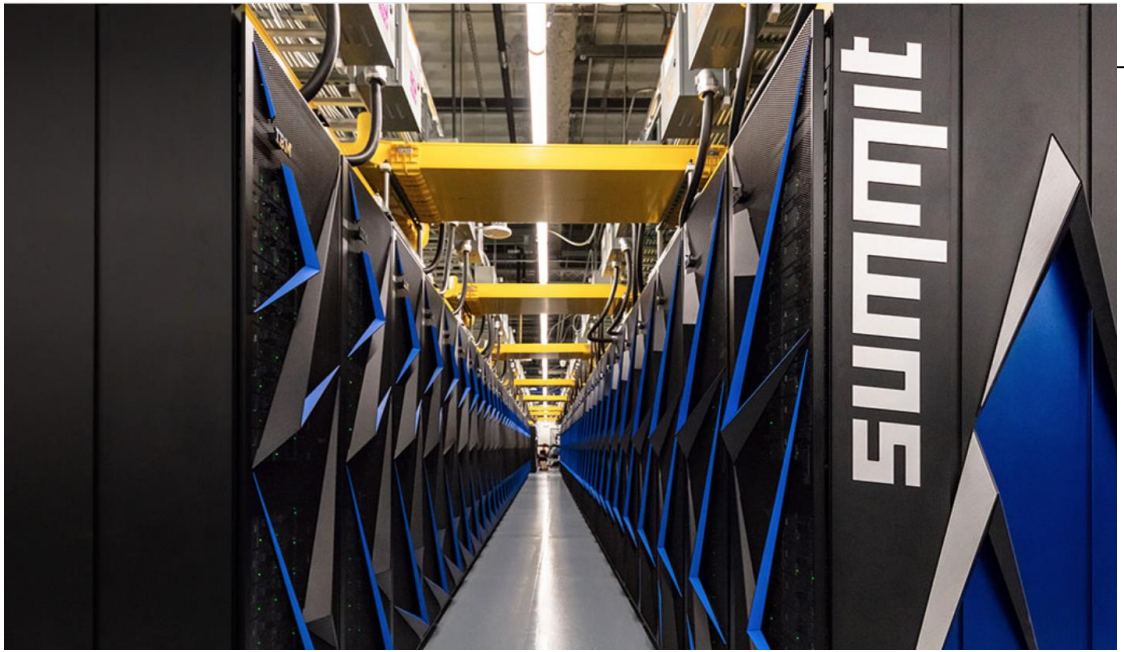
Duck

Walks

Swims

Quacks

Not a Duck

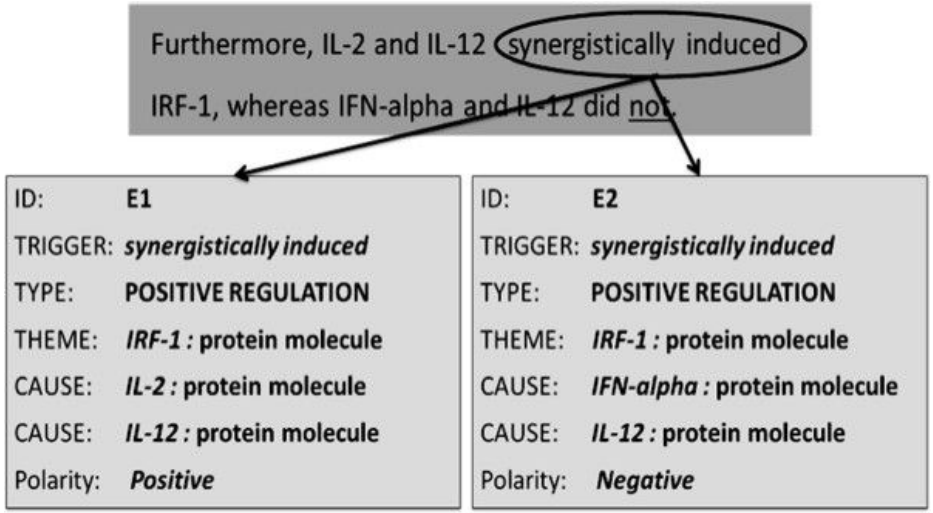


IBM builds the world's fastest supercomputers
What will we do with 200 petaflops?

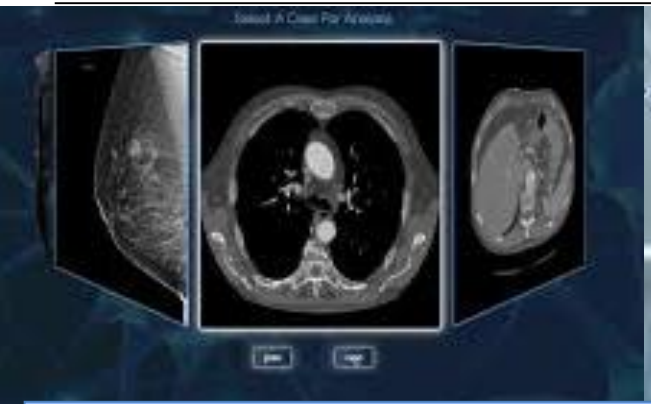
- Machine learning algorithms scaled on Summit will help medical researchers with a comprehensive view of the cancer population
- Using a mix of AI techniques, researchers will be able to identify patterns in the function, cooperation, and evolution of human proteins and cellular systems

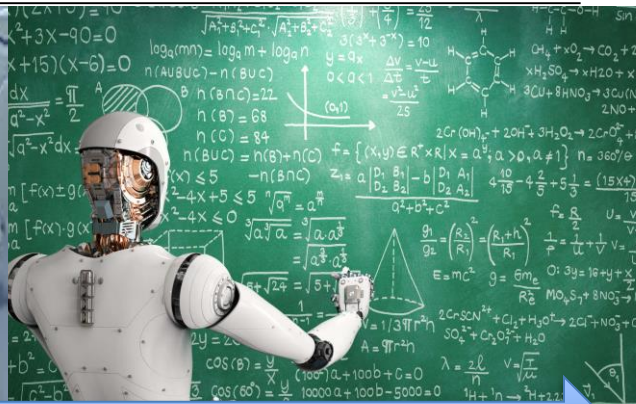
Negation disambiguation in medical text is still a challenge

A 12-year old girl with known hyperagglutinability, presented to the emergency department with a 2-week history of headeaches and facial weakness. Neurologic examination indicated sensorineural hearing loss on the right side with Weber's test lateralizing to the left, and the Rinne's test demonstrating bone conduction greater than air conduction on the right. Magnetic resonance imaging of the head revealed severe structural defects of the right petrous temporal bone. No indication of cerebral infarction.



It is hard to train AI for Image recognition (!?)





2010 and earlier | 2015 | 2019 | 2050 and beyond

Narrow AI

Single Task, Single Domain

Superhuman accuracy and speed for certain tasks

Broad AI

Multi Task, Multi Domain

Multi modal, explainable, Distributed

General AI

Cross Domain learning and reasoning

Broad autonomy

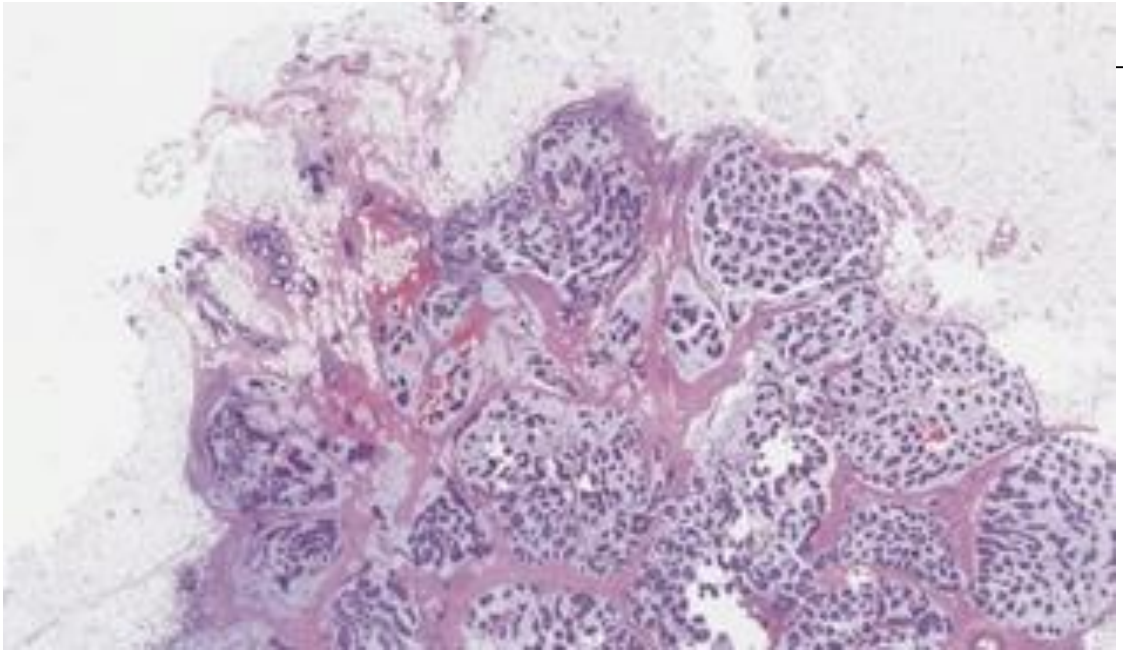
Where we are nowadays?

The evolution of AI


What can Artificial Intelligence do?

AI can understand and extract data from Natural Language:
- Literature
- PDTA and guidelines
- Medical data
- Patient generated data

- At Baylor College, Watson analysed 70.000 publications on p53 in few minutes and predicted proteins that turn on/off p53's activity
- 6 potential proteins were identified for new research targets



AI can understand Images

Project to help anatomy pathologists to early identify precancerous lesions of breast tumours (UDH, ADH FEA, DCIS)

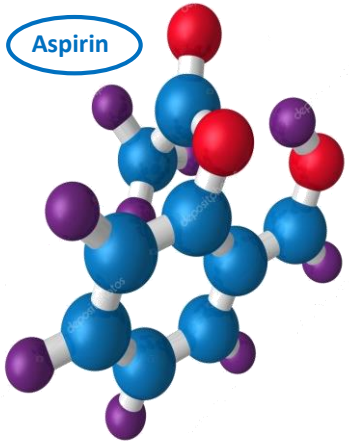
ISTITUTO NAZIONALE TUMORI
IRCCS - Fondazione Pascale

ICAR CNR

IBM Research | Zurich

A future quantum processor could simulate a drug molecule

This would require a conventional computer larger than 10 percent of the size of the earth



Type of Scaling	Time to Solve Problem				
Classical algorithm with exponential runtime	10 secs	2 mins	330 years	3300 years	Age of the Universe
Quantum algorithm with polynomial runtime	1 min	2 mins	10 mins	11 mins	~24 mins

Use case of Artificial Intelligence for Biotech industry

AI for drug target identification and validation

AI for target based and phenotypic drug discovery

AI for dealing with biomedical, clinical and patient data

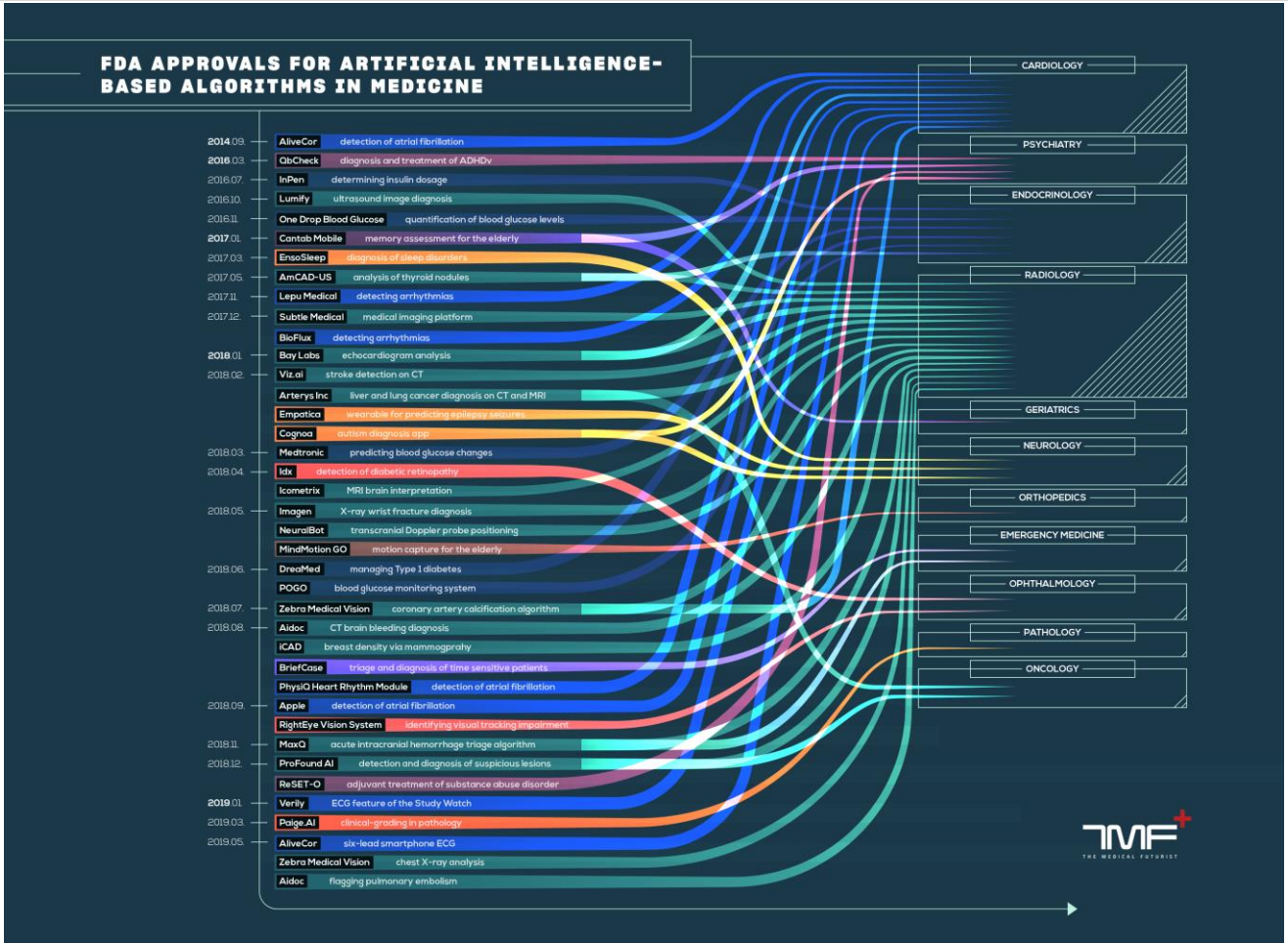
AI for polypharmacology discovery

AI for drug repurposing programs

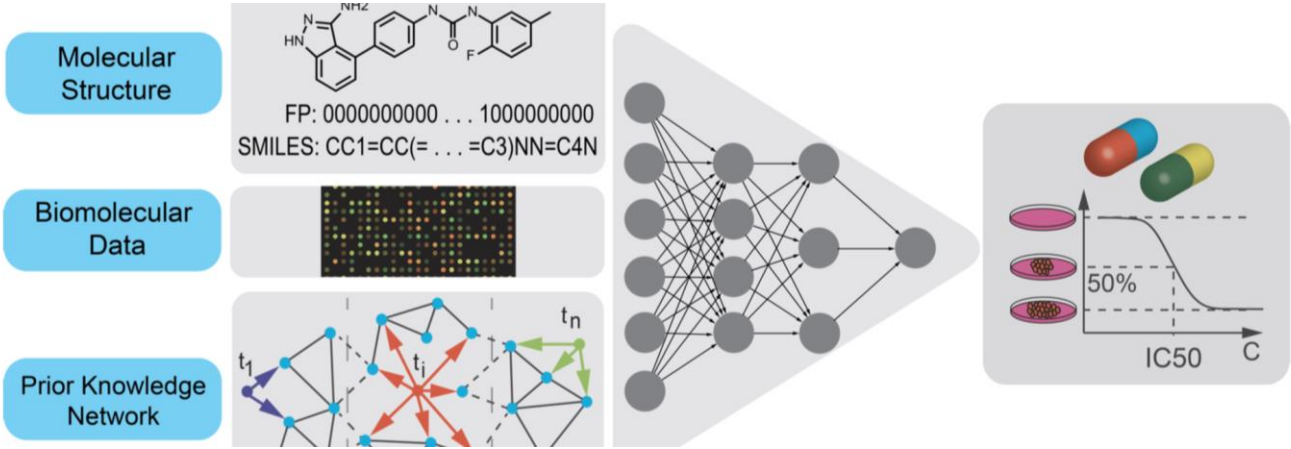
AI for biomarkers development

AI for analyzing research literature, publications, and patents

Bioconvergence - Bio & Software toward the Smart Health



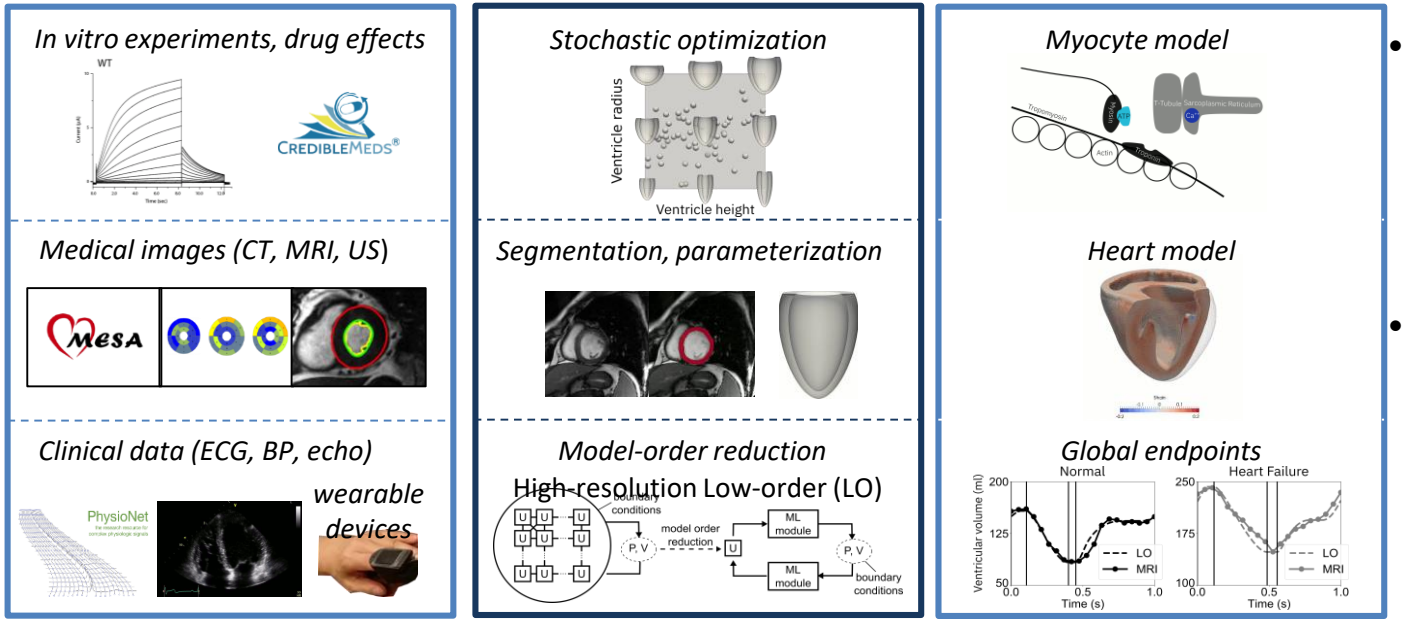
Multi-modal prediction of IC50 drug sensitivity (PaccMann)



Drug	Cell line	Cancer type	Top-5 attended genes	IC50	
				Predicted	Measured
Afatinib	UMC-11	lung (NSCLC)	F13A1, MYH4, ATOH8, SEMA4A, NES	0.505	0.493
BX-912	YH-13	glioma	RNASE2, HOXA13, CBR3, FABP1, HDC	0.532	0.5
GSK319347A	EW-12	bone	CD300A, RHBDL2, NES, TFF3, SOCS1	0.597	0.7
JW-7-24-1	OVTOKO	ovary	HDC, EIF2A, RNASE2, ANGPTL6, CBR3	0.502	0.49
PI-103	MV-4-11	leukemia	TFF3, ATOH8, RBP2, ITIH3, GRIP1	0.362	0.33
TGX221	SW962	urogenital system	CBR3, RNASE2, FABP1, HDC, SH3D21	0.621	0.66
S-Trityl-L-cysteine	NCI-H187	lung (SCLC)	RHBDL2, NR1H4, MYH4, NES, APCS	0.535	0.502
Fedratinib	BL-41	lymphoma	TFF3, ATOH8, RBP2, MAPK7, ARHGEF33	0.382	0.428
Tipifarnib	RCC10RGB	kidney	EIF2A, HDC, CBR3, PIK3R5, HOXA13	0.542	0.544
Midostaurin	GAK	skin	SVOP, FABP1, HDC, F13A1, FGFR3	0.507	0.477

PaccMann: Prediction of anticancer compound sensitivity with multi-modal attention-based neural networks
IBM Research https://arxiv.org/pdf/1811.06802.pdf

Multiscale heart modelling for diagnosis, patient monitoring and system pharmacology



- Allow comprehensive exploration of cardiac drug action from cell to whole-organ and systemic levels
- Allow synthesizing virtual patient populations to better design and analyze early stage clinical trials (accounting for confounding factors)

Gurev, V. et al. BMMB (2015) Di Achille et al. Frontiers in Physiology (2018)

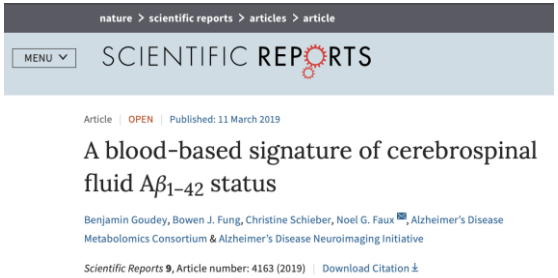
Healthcare

Using Machine Learning to Develop Blood Test For Key Alzheimer's Biomarker

It is recognized that Alzheimer's disease (AD) exists before dementia is present and that shifts in amyloid beta occur long before clinical symptoms can be detected.

IBM Research developed a blood-based signature that can provide a cheap and minimally invasive estimation of an individual's CSF amyloid status using a machine learning approach.

This is the first study to show that a machine learning approach, using plasma protein levels, age and APOEε4 carrier status, is able to predict CSF Aβ1−42 status, the earliest risk indicator for AD, with high accuracy.



https://www.nature.com/articles/s41598-018-37149-7

Watson for Clinical Trials Matching matches patients to open clinical trials

MAYO CLINIC

HOG HIGHLANDS ONCOLOGY GROUP

BARROW
Neurological Institute

AI is helping Barrow Neurological Institute narrow research scope and uncover new pathways of interest for drug therapies in the fight against ALS:

- ***5 new proteins identified in months***
- ***80% of top-ranked targets were proven to be linked to ALS***
- ***Identifies new pathways of interest for drug therapies*** *that scientists may not have considered otherwise*

Predict the best second level therapy to type-2 diabetic patients using RWE

Estimating the effects of second-line therapy for type 2 diabetes mellitus: retrospective cohort study

Gottlieb A, Yanover C, Cahan A, Goldschmidt Y. *BMJ Open Diab Res Care* 2017;5:e000435.

Causal inference methods applied to observational data aligned with current evidence

Predicted reduction in glycosylated hemoglobin (HbA1c) levels for sulfonylureas, the most commonly prescribed second-line drugs, was smaller than for other tested classes (TZDs, GLP-1 agonists, DPP-4 inhibitors)

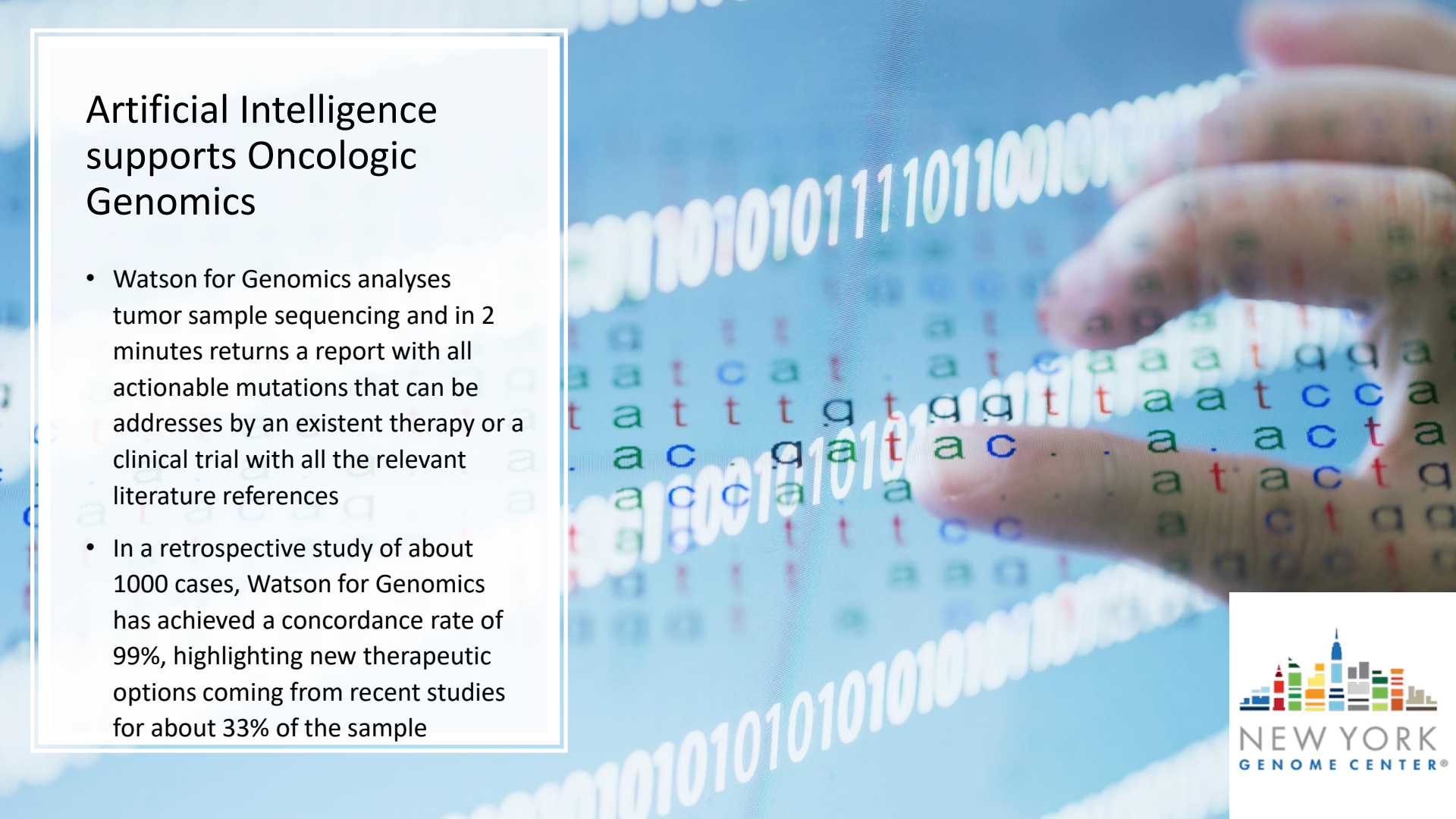
Predicted significant reduction of body mass index with DPP-4 inhibitors compared to sulfonylureas and TZDs

*TZDs = thiazolidinediones, GLP-1 = glucagon-like peptide-1, DPP-4 = dipeptidyl peptidase 4

"EHR data can support causal inference and allow replication of clinical trial results. The advantages of this approach in terms of the labor and costs required to expand evidence-based medicine are clear."

Artificial Intelligence supports Oncologic Genomics

- Watson for Genomics analyses tumor sample sequencing and in 2 minutes returns a report with all actionable mutations that can be addresses by an existent therapy or a clinical trial with all the relevant literature references
- In a retrospective study of about 1000 cases, Watson for Genomics has achieved a concordance rate of 99%, highlighting new therapeutic options coming from recent studies for about 33% of the sample



NEW YORK GENOME CENTER®

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With Watson you can transform personal healthcare

415 million adults with diabetes in the world – a number that could grow to 642 million by 2040

Cost of diabetes and prediabetes in US at $322 billion

Sugar.IQ with Watson app features real-time, continuous glucose monitoring (CGM) to predict hypoglycemia 2 to 3 hours in advance, with an accuracy of 85-89%

With Watson, insights drive positive behavior changes among app users to control blood sugar levels

Medtronic

aimac

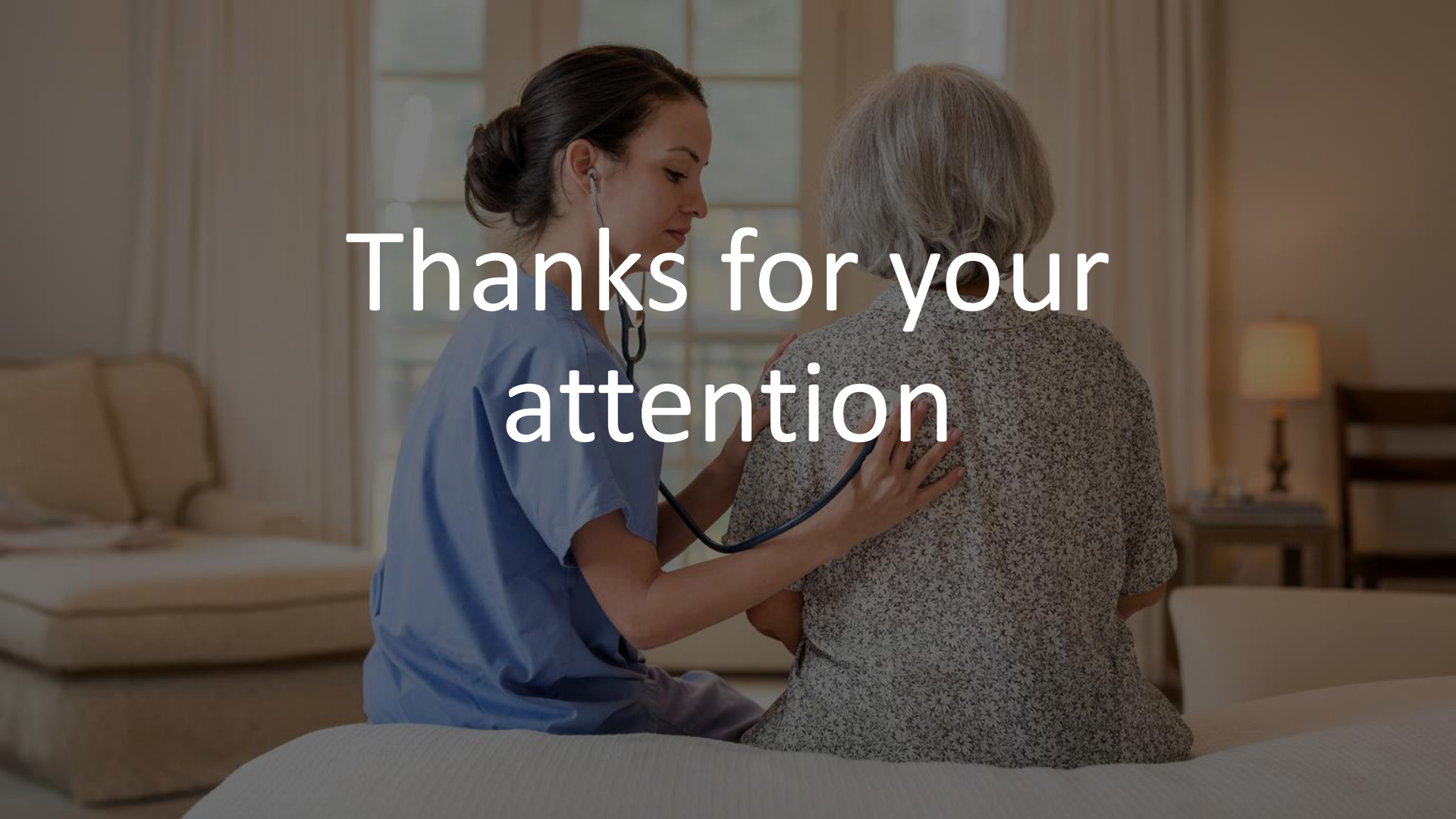
informa per aiutare
a vivere con il cancro

IBM has developed a virtual assistant that helps the citizens and caregivers to ask questions about oncologic patient rights

IBM collaborated with Cooperativa Sole to develop new technologies for innovative care models

sole.
persone per le persone

The best technology… is the invisible one


Thanks for your attention