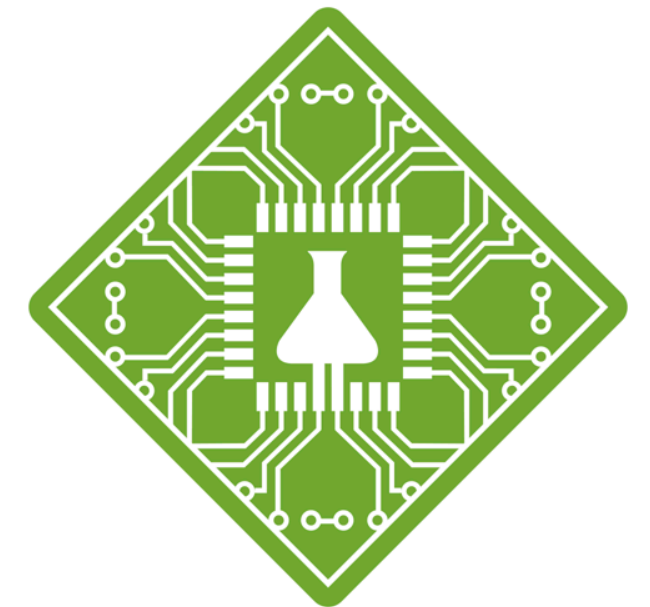




# TRANSFORMING THE FUTURE OF HEALTHCARE AND AGING WITH ARTIFICIAL INTELLIGENCE AND AI-POWERED AGING RESEARCH

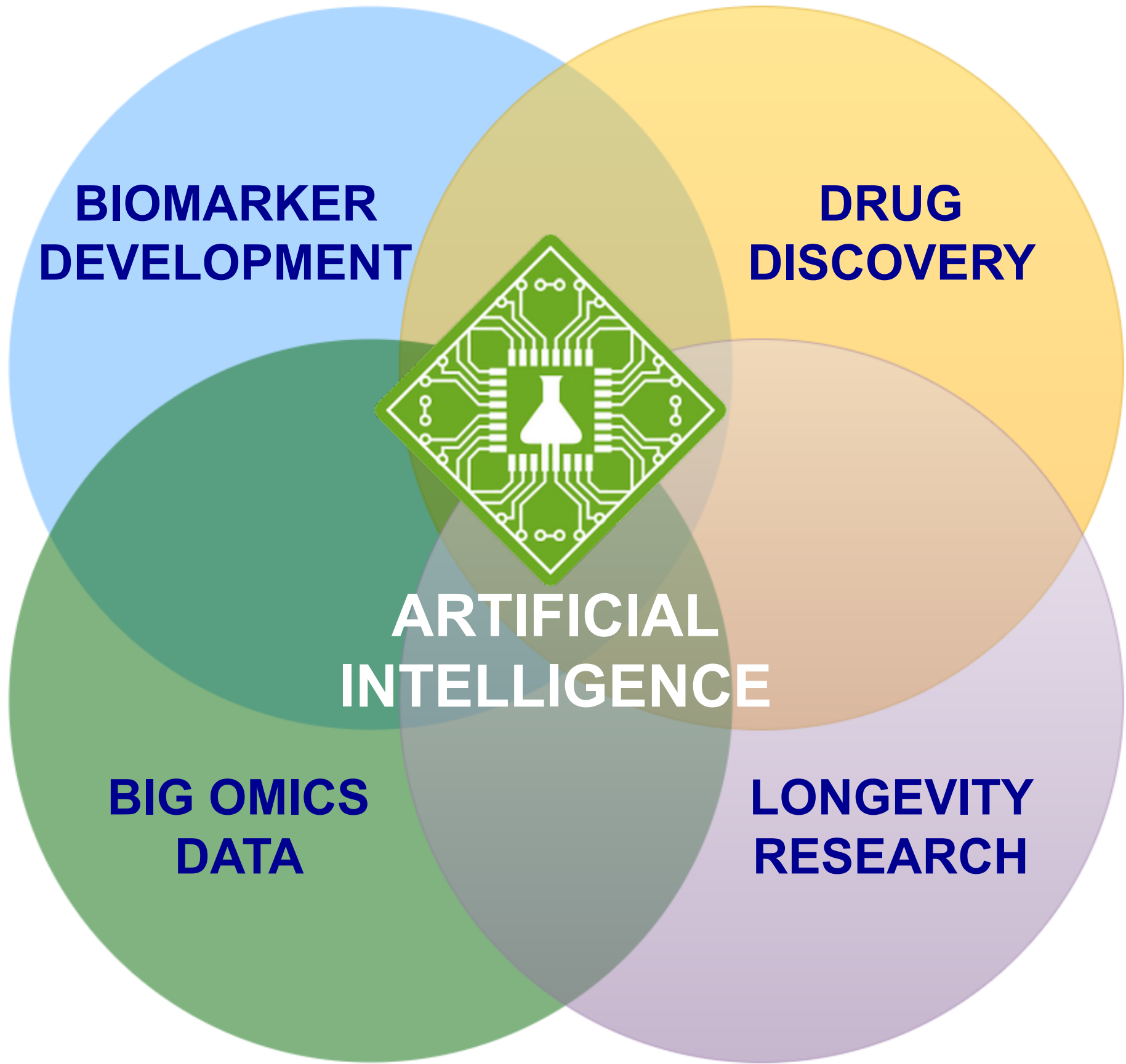
**Insilico Medicine, Inc**  
**Emerging Technology Centers**  
Johns Hopkins University  
**B301, 1101 33<sup>rd</sup> Street**  
**Baltimore, MD, 21218**

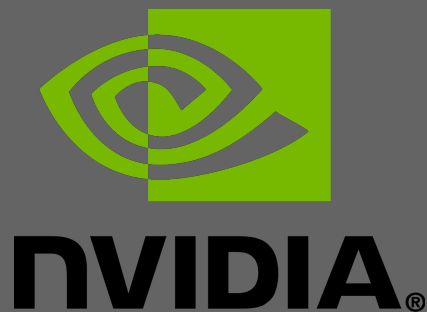


**INSILICO MEDICINE**

**ALEX ZHAVORONKOV, PHD**  
**[alex@insilicomedicine.com](mailto:alex@insilicomedicine.com)**

# ARTIFICIAL INTELLIGENCE MEETS LONGEVITY RESEARCH, DRUG DISCOVERY AND BIOMARKER DEVELOPMENT

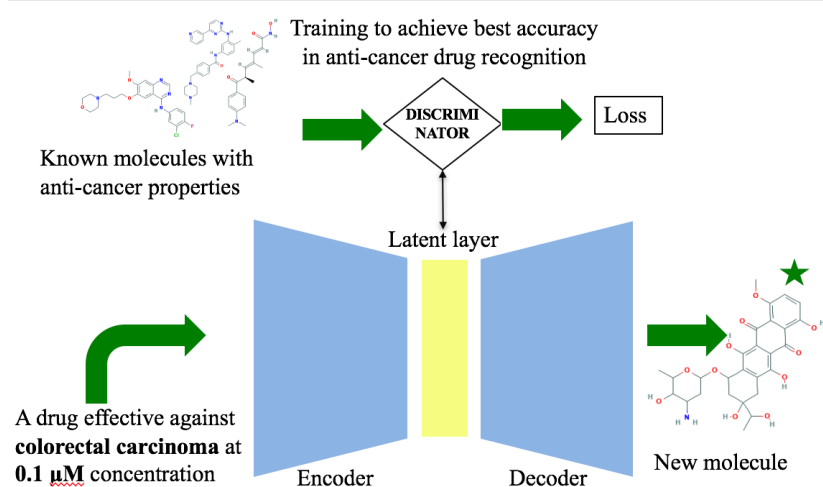




# INSILICO MEDICINE

19 PEER-REVIEWED RESEARCH PAPERS IN 2016

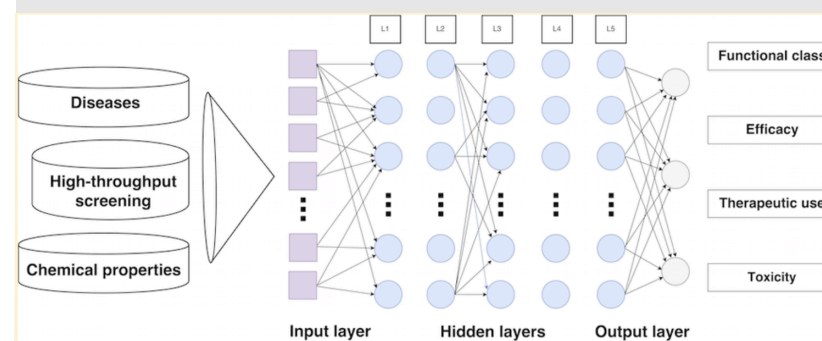
First application of Adversarial Autoencoder (AAE) generating new molecular structures with desired properties



Published: Oncotarget, Dec. 22, 2016

Generative Adversarial Networks (GANs) "imagine" new cancer drugs on demand

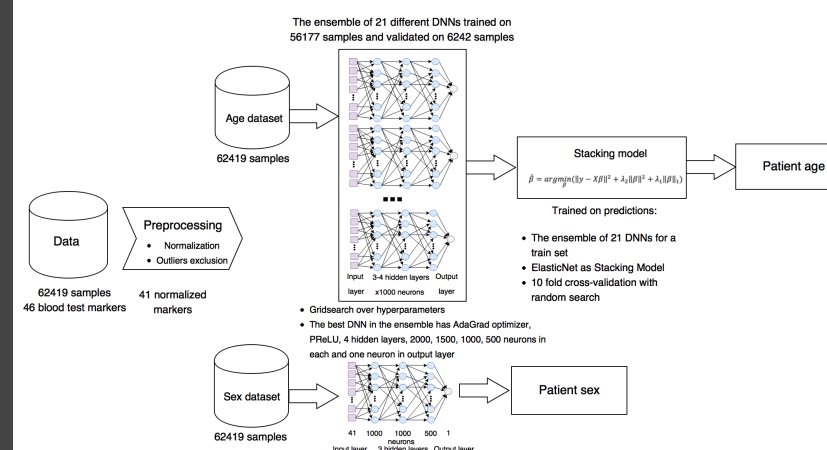
First transcriptomic and structural DNN ensemble predictors of therapeutic class, side effects and Phase I/II clinical trials outcomes



Publications: Molecular Pharmaceutics, May 20, 2016 (American Chemical Society Editors' Choice Award), Nature Communications, Nov 16, 2016, bioRxiv Dec 29, 2016

Pharma.AI  
A Set of Predictors of Toxicity and Efficacy

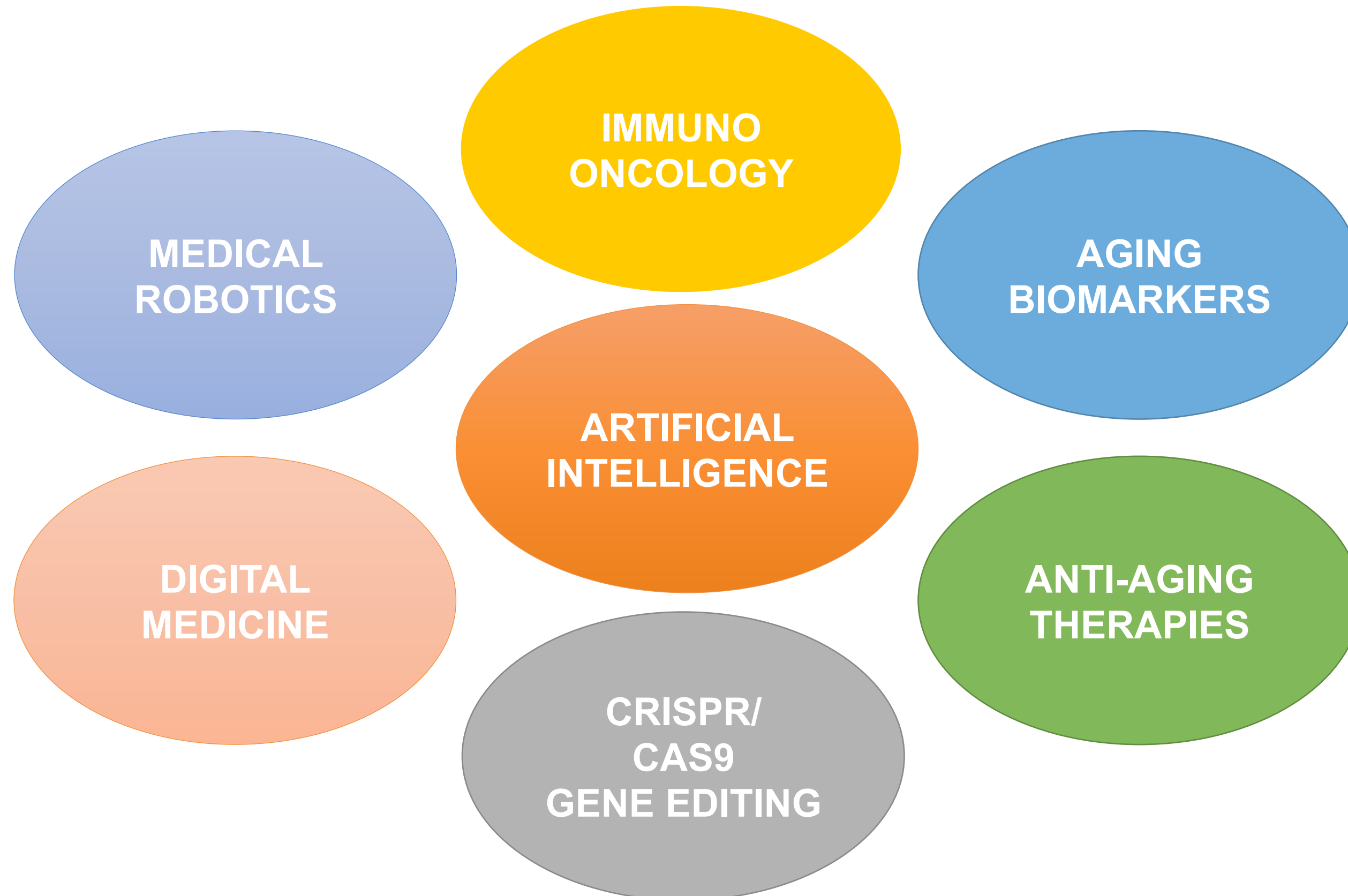
First deep learned biomarkers of aging using DNN ensembles; multimodal one-shot learning disease markers; navigator of differentiation state; First nutraceuticals to be launched in 2017

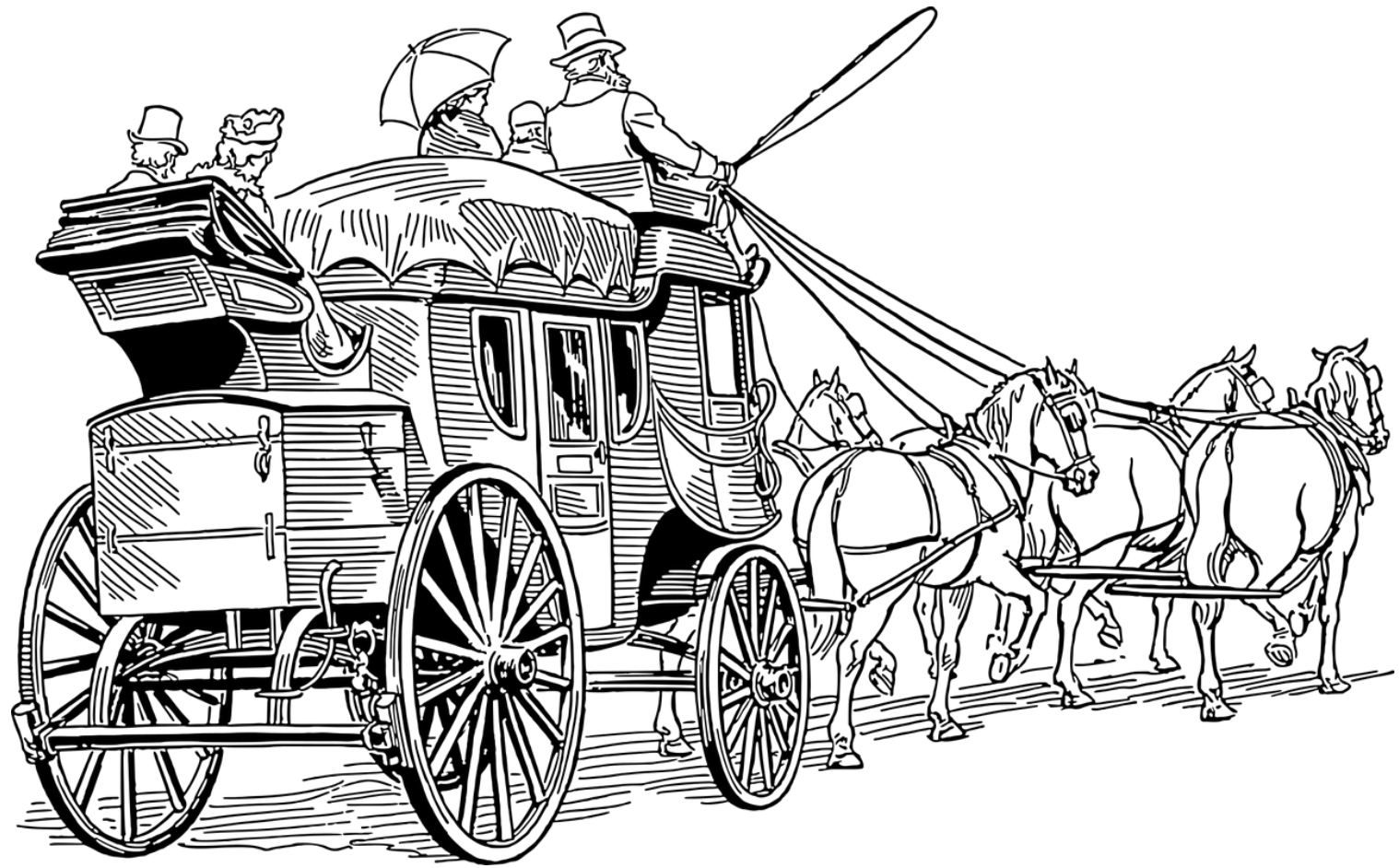


Publications: Aging, May 18, 2016, Aging, Sep. 24, 2016, many submitted

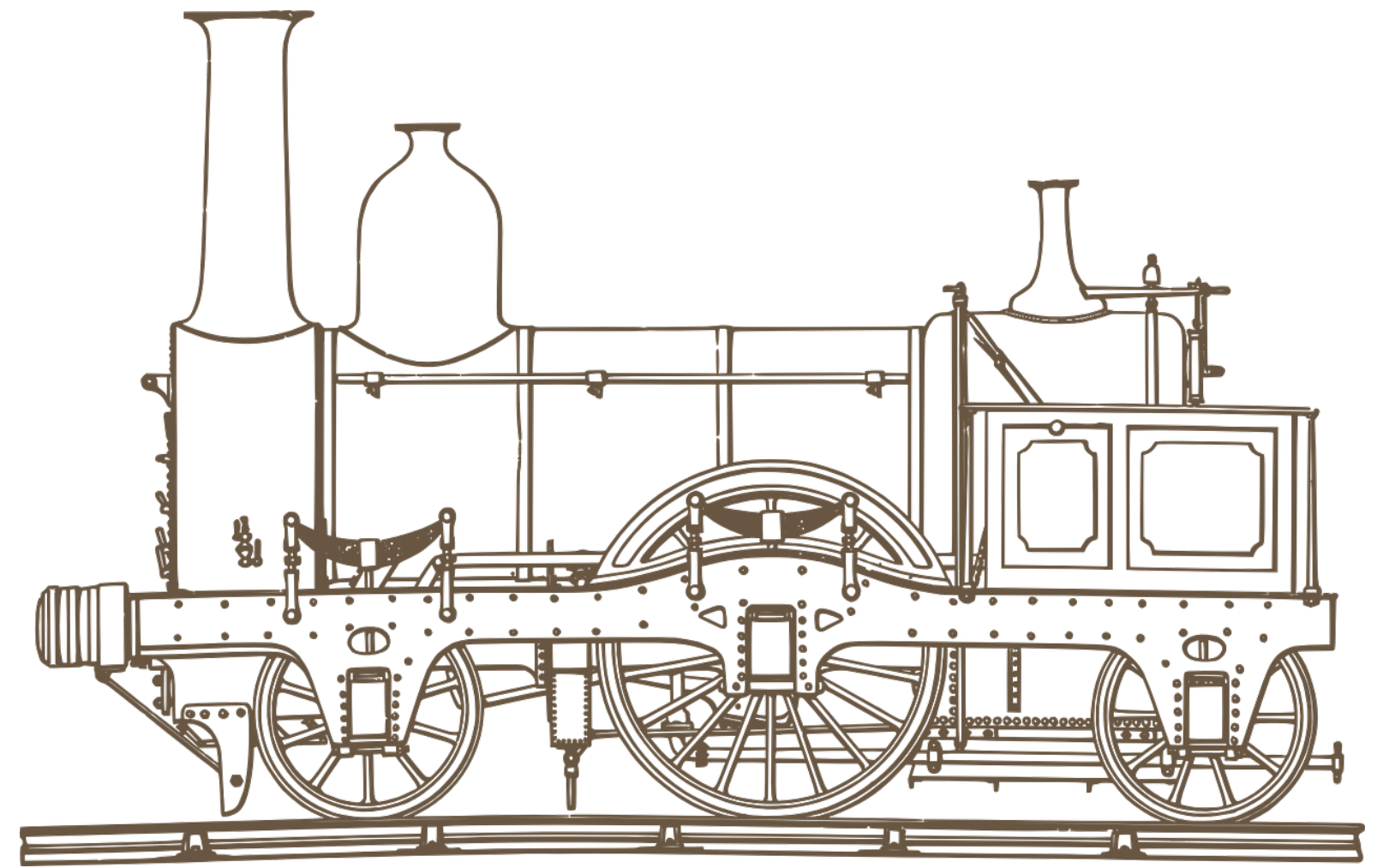
Embryonic.AI  
Aging.AI  
Geroprotectors.AI

# BREAKTHROUGHS IN BIOMEDICINE 2012-2017





**VS**



**DATA IS THE NEW OIL**

**AI IS THE NEW COMBUSTION ENGINE**

# CAN DNNs PREDICT HUMAN AGE BETTER THAN HUMANS?

How-Old.net  
How old do I look? #HowOldRobot

Search Faces...

Use this photo

Use your own photo

Microsoft

P.S. We don't keep the photo

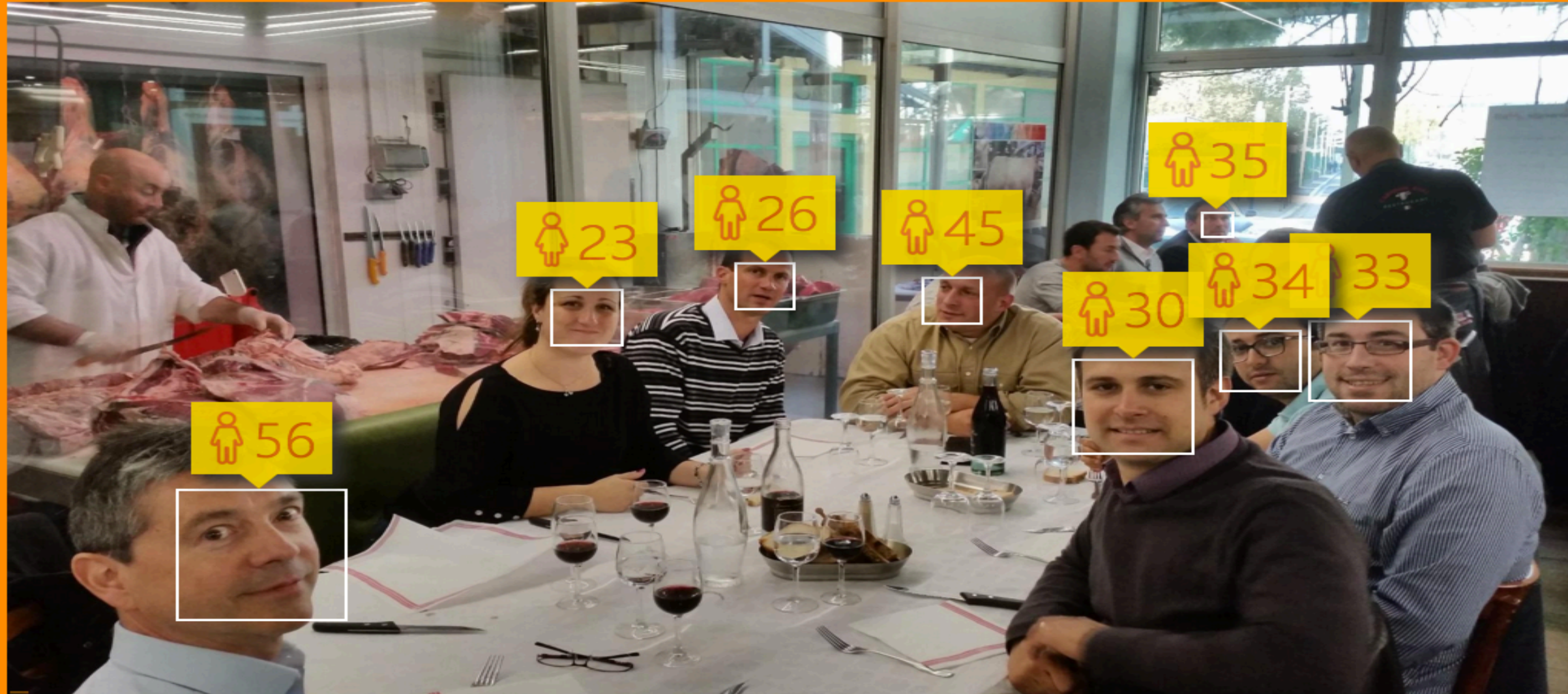
Share 2.3M Tweet

The magic behind How-Old.net  
Privacy & Cookies | Terms of Use



# How-Old.net

How old do I look? #HowOldRobot



Sorry if we didn't quite get it right - [we are still improving this feature.](#)

[Get a human opinion](#)

or

[Try Another Photo!](#)



P.S. We don't keep the photo

[Share](#) [2.3M](#) [Tweet](#)

# DEEP BLOOD BIOCHEMISTRY PREDICTOR OF HUMAN CHRONOLOGICAL AGE



## Deep Biomarkers Of Human Aging

How old by basic blood test

### Aging.AI <sup>1.0</sup>

- 41 input parameters
- $r = 0.91$
- $Rsq = 0.82$
- $MAE = 5.5$  years

Test your samples

### Aging.AI <sup>2.0</sup>

- 33 input parameters
- $r = 0.79$
- $Rsq = 0.63$
- $MAE = 6.2$  years

Test your samples

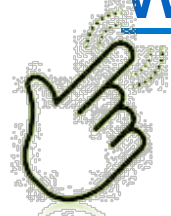
### Idea:

Take a very large number of very common features from basic blood draws of reasonably healthy people linked to age and gender and build a deep predictor of chronological age and gender

### Hidden agenda:

Reduce animal experimentation when testing anti-aging interventions

[www.Aging.AI](http://www.Aging.AI)





# WHY AGING RESEARCH IS ESSENTIAL FOR DRUG DISCOVERY, BIOMARKER DEVELOPMENT?

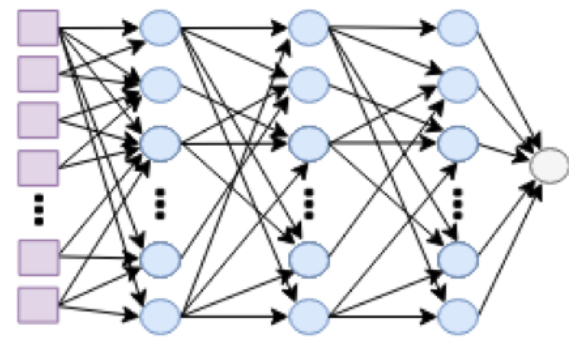
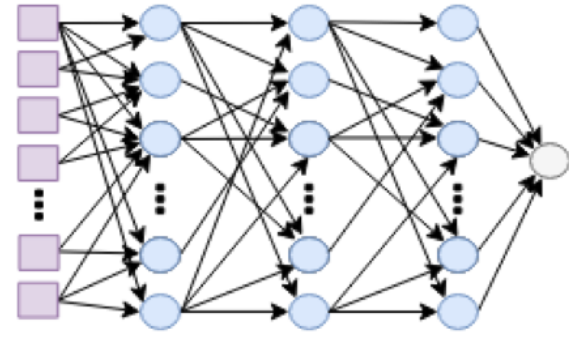
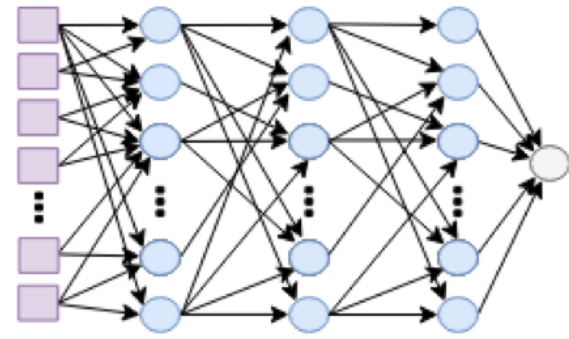
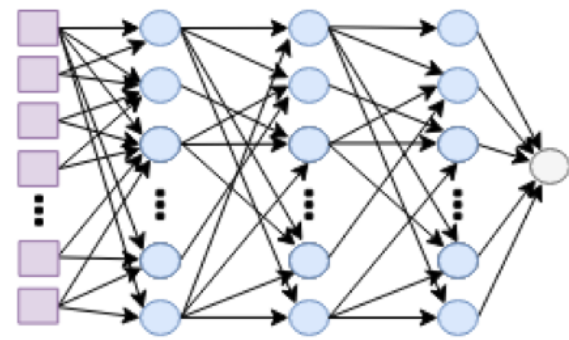


In this crowd very few people have cancer, but everyone has:

- Sex
- Eyes
- Eye color
- Skin color
- Hair color
- Race
- Height
- Weight
- **Age**

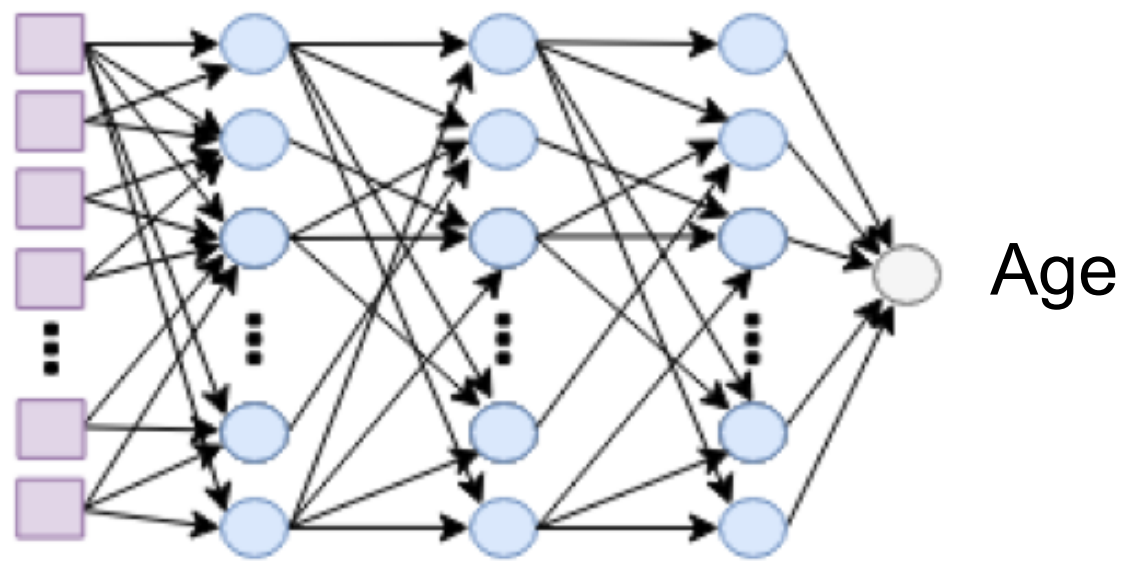
**IF I CAN NOT PREDICT YOUR AGE, HOW CAN I  
CLAIM THAT I CAN PREDICT YOUR HEALTH STATUS?**

- Features from simple blood tests (biochem.)
- Features from simple urine tests (biochem.)
- Blood Transcriptome/proteome
- Tissue-specific Transcriptome/proteome
- Urine Transcriptome/proteome
- Genome
- Metabolome
- Imaging Data (MRI/CT)
- Pictures
- Hair/Nail/Skin composition



Individual DNNs  
& Feature Importance Analysis

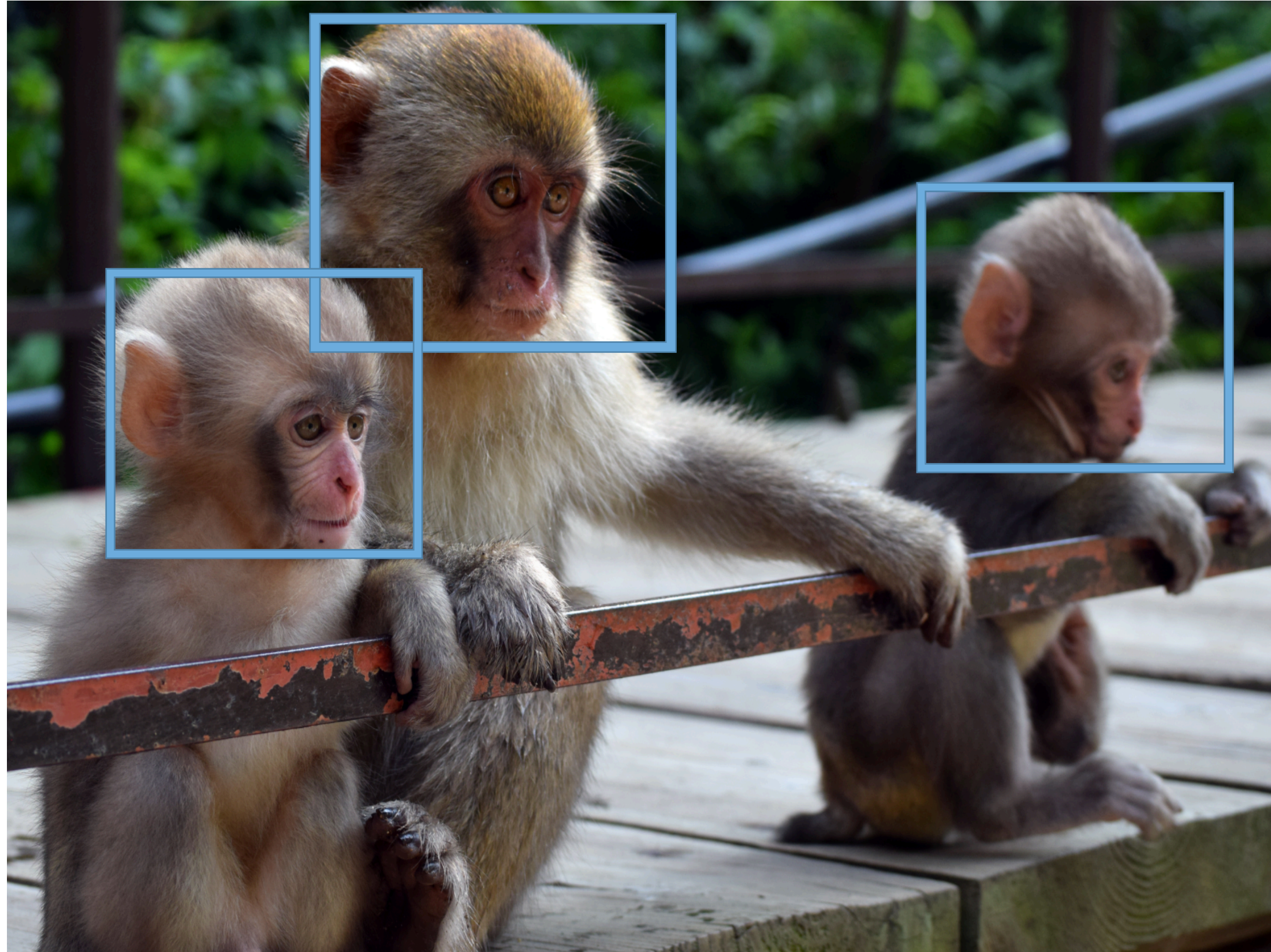
**BIG IDEA: USE AGE FOR MULTI-OMICS DATA INTEGRATION**



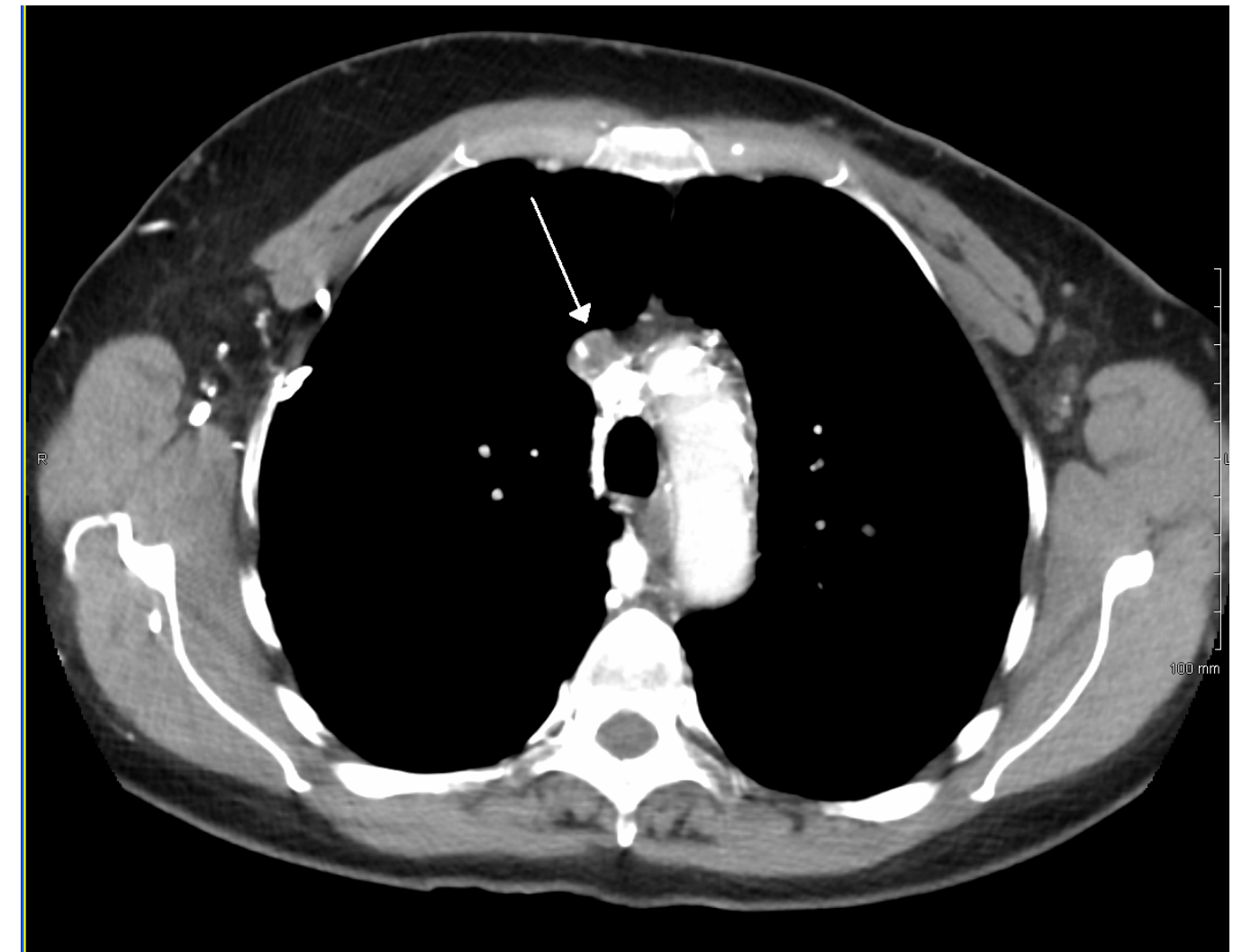
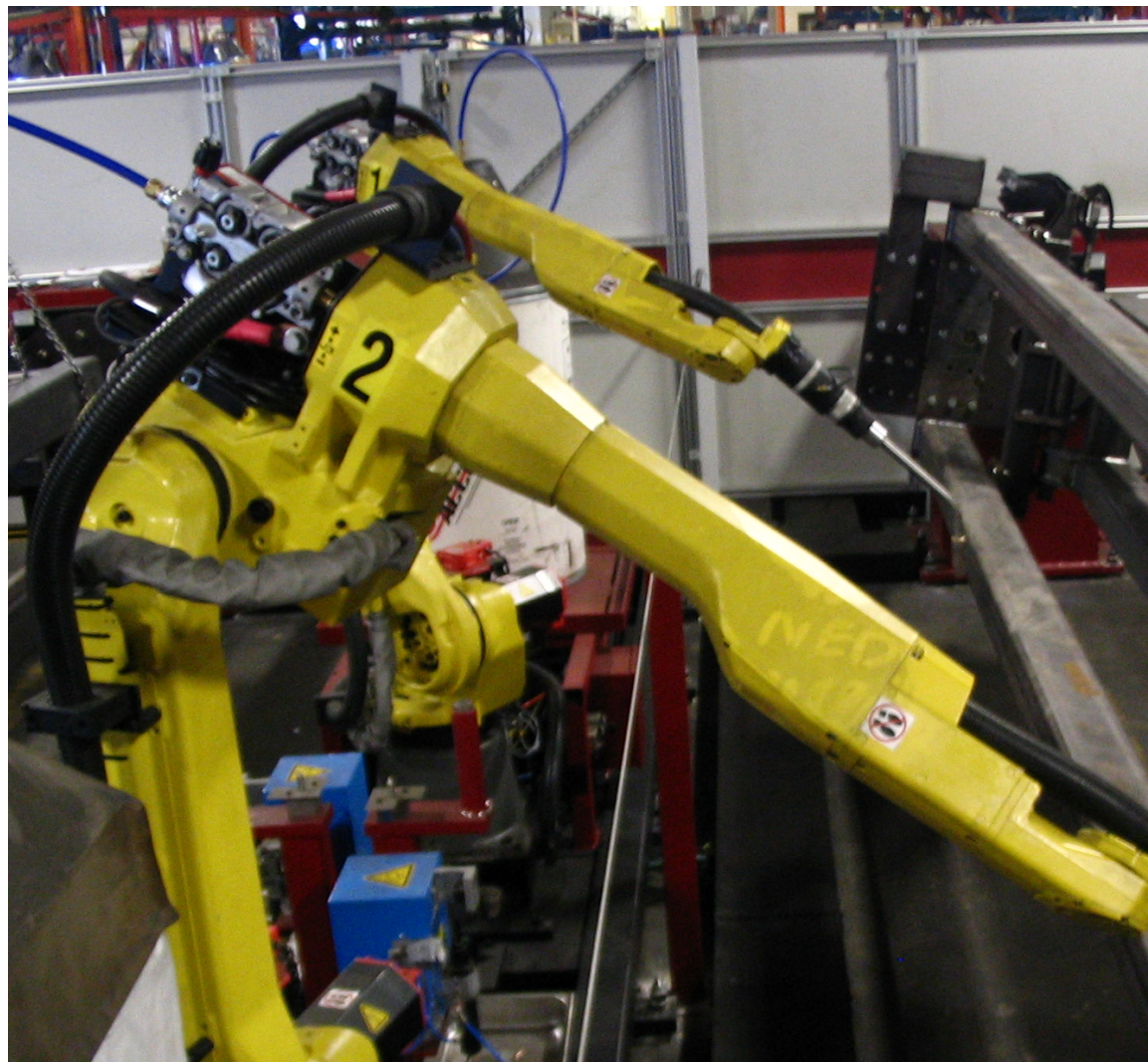
Multi-modal one-shot learning DNNs  
& Feature Importance Analysis

**I CAN ACCURATELY PREDICT YOUR AGE  
USING THE VARIOUS DIFFERENT DATA  
TYPES BUT HOW DOES IT CHANGE  
ANYTHING?**

**WHAT IS THE AGE OF EACH MONKEY?  
LIFESPAN: 25**

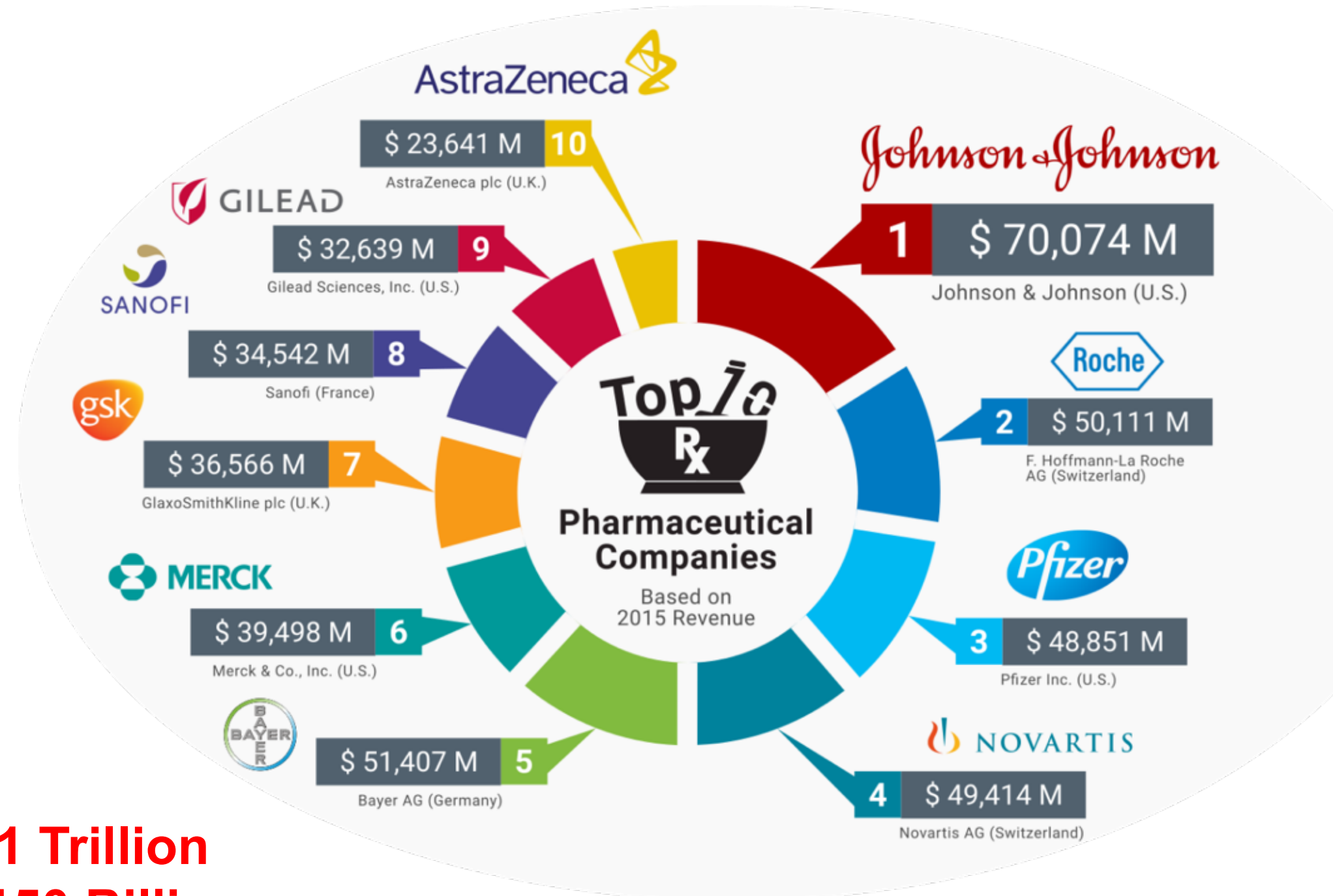


# EVERY INDUSTRY WILL BE TOUCHED OR TRANSFORMED BY AI BEFORE 2020



**WHAT IS THE MOST INEFFICIENT  
INDUSTRY TO BE TRANSFORMED BY AI?**

# ARTIFICIAL INTELLIGENCE TO TRANSFORM THE PHARMACEUTICAL INDUSTRY



Global sales: **>\$1 Trillion**

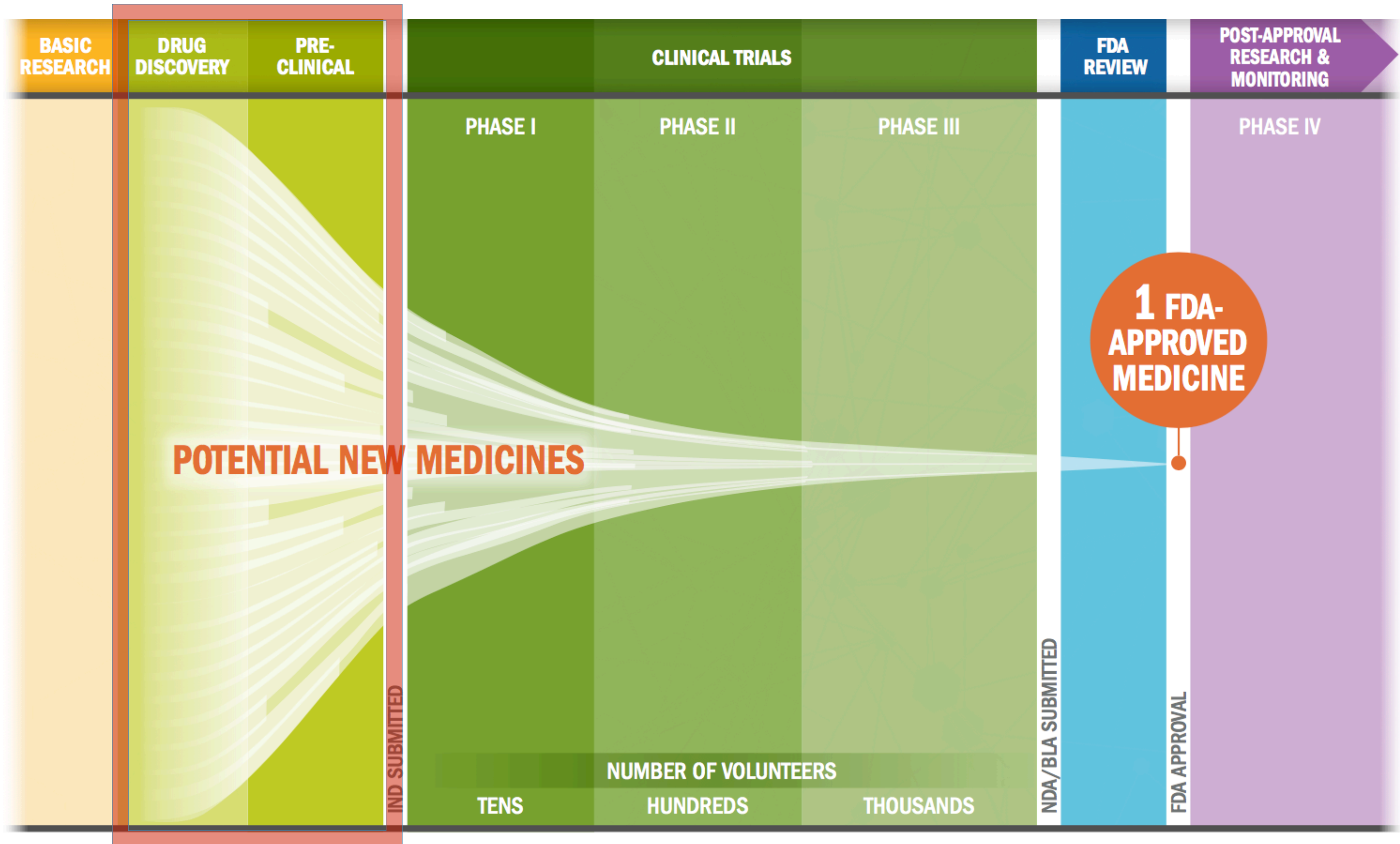
Global R&D: **>\$150 Billion**

**46 new drugs** launched in 2014

**>\$2.5B** to develop a drug

**92% failure rate in clinical trials**

# THE BIOPHARMACEUTICAL RESEARCH AND DEVELOPMENT PROCESS

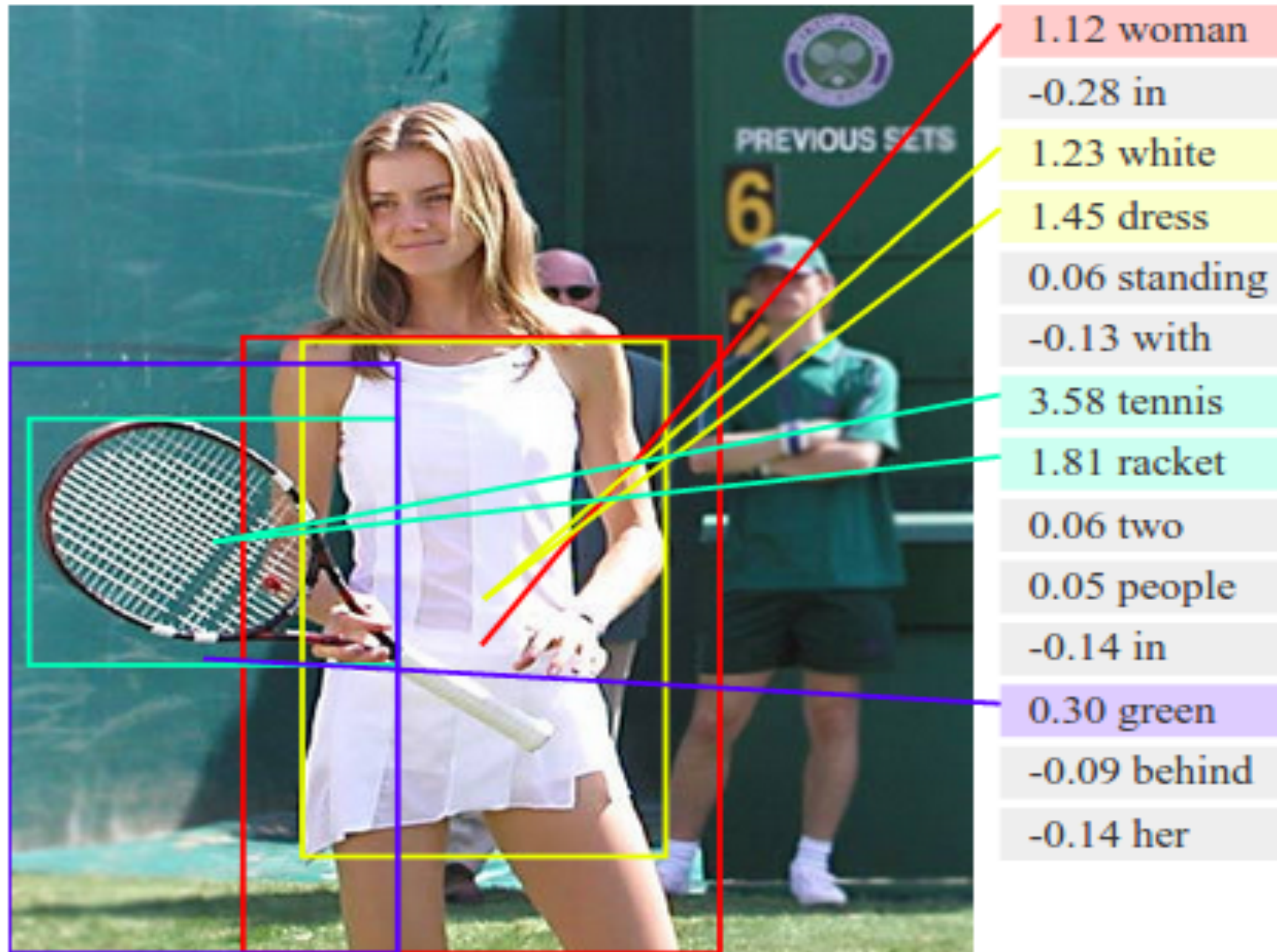


Key: IND: Investigational New Drug Application, NDA: New Drug Application, BLA: Biologics License Application

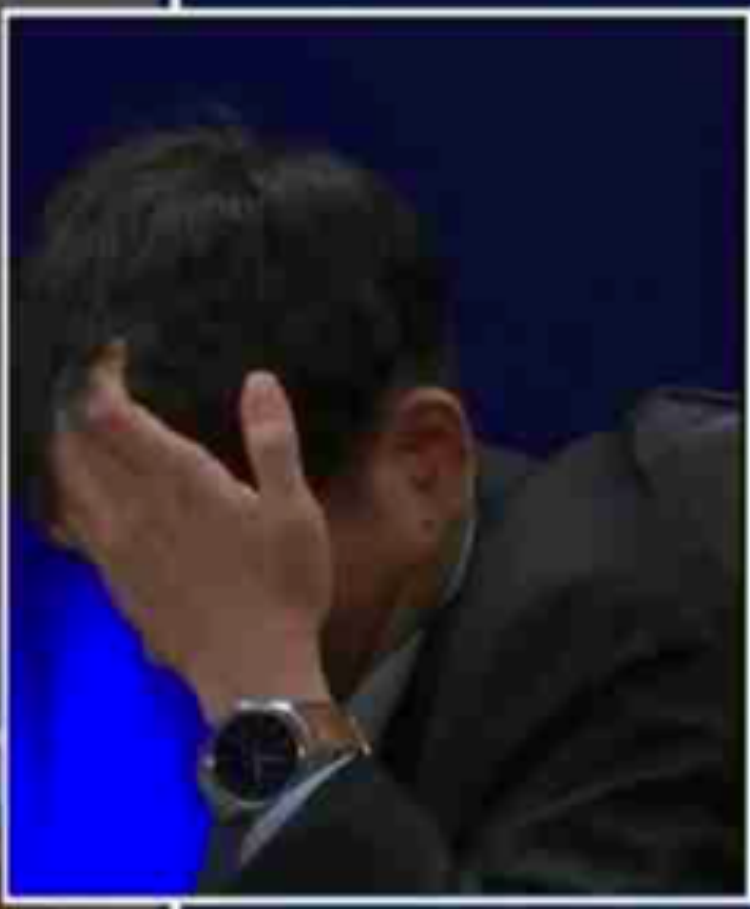
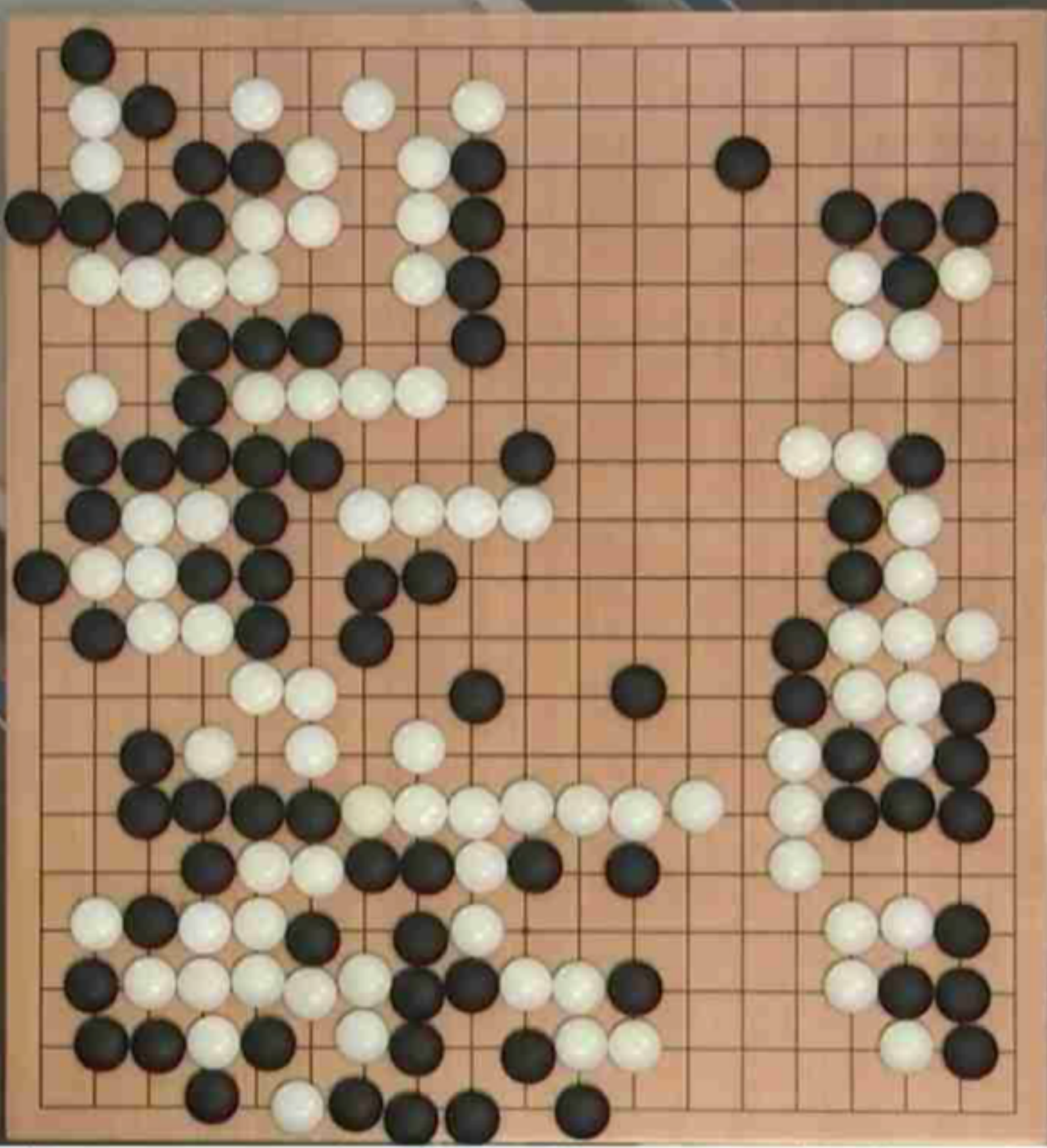
Source: Biopharmaceutical Research & Development, PRMA [http://phrma-docs.phrma.org/sites/default/files/pdf/rd\\_brochure\\_022307.pdf](http://phrma-docs.phrma.org/sites/default/files/pdf/rd_brochure_022307.pdf)



# DEEP LEARNING: HUMAN LEVEL



● ALPHAGO  
00:10:29



● LEE SEDOL  
00:01:00

# **GENERATIVE ADVERSARIAL NETWORKS**

# GENERATIVE ADVERSARIAL NETWORKS (GANs)

this small bird has a pink breast and crown, and black primaries and secondaries.



this magnificent fellow is almost all black with a red crest, and white cheek patch.



the flower has petals that are bright pinkish purple with white stigma



this white and yellow flower have thin white petals and a round yellow stamen



*Figure 1.* Examples of generated images from text descriptions. Left: captions are from zero-shot (held out) categories, unseen text. Right: captions are from the training set.

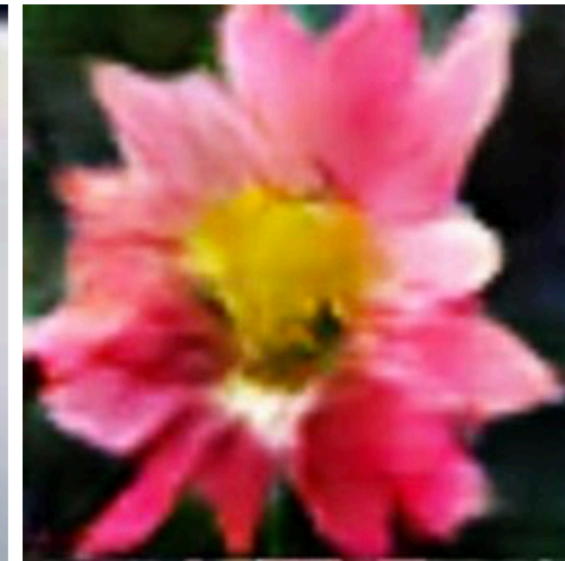
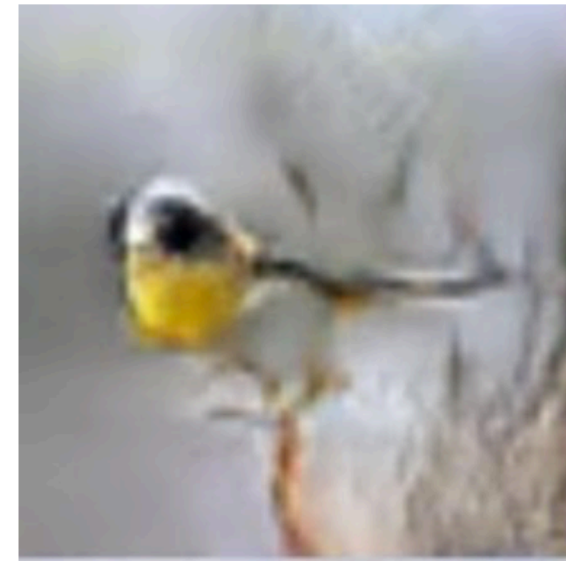
# ACHIEVING PHOTOREALISM WITH GANs

This bird has a yellow belly and tarsus, grey back, wings, and brown throat, nape with a black face

This bird is white with some black on its head and wings, and has a long orange beak

This flower has overlapping pink pointed petals surrounding a ring of short yellow filaments

(a) Stage-I images

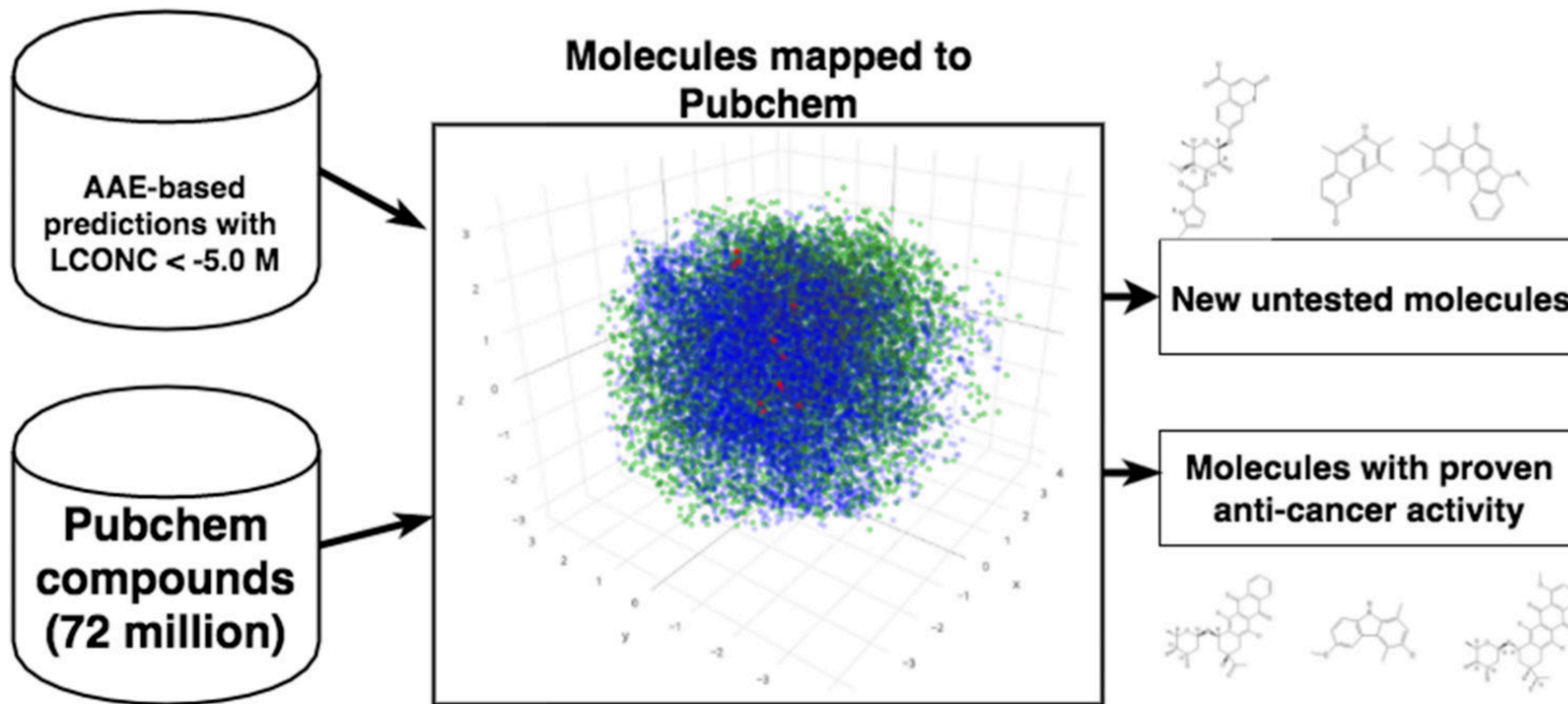


(b) Stage-II images



Zhang et al, StackGAN: Text to Photo-realistic Image Synthesis with Stacked Generative Adversarial Networks

# AT INSILICO WE ARE MAKING DRUGS USING GANs



# NOTICED BY THE MASTERS

Yann LeCun liked this.



**Yoshua Bengio**

2 hrs ·



Auto-encoders with a GAN objective in the latent layer for cancer drug discovery:

**Oncotarget | The cornucopia of meaningful leads: Applying...**  
doi:10.18632/oncotarget.14073. Artu...  
impactjournals.com



Yann LeCun and 340 others

64 Shares

Like

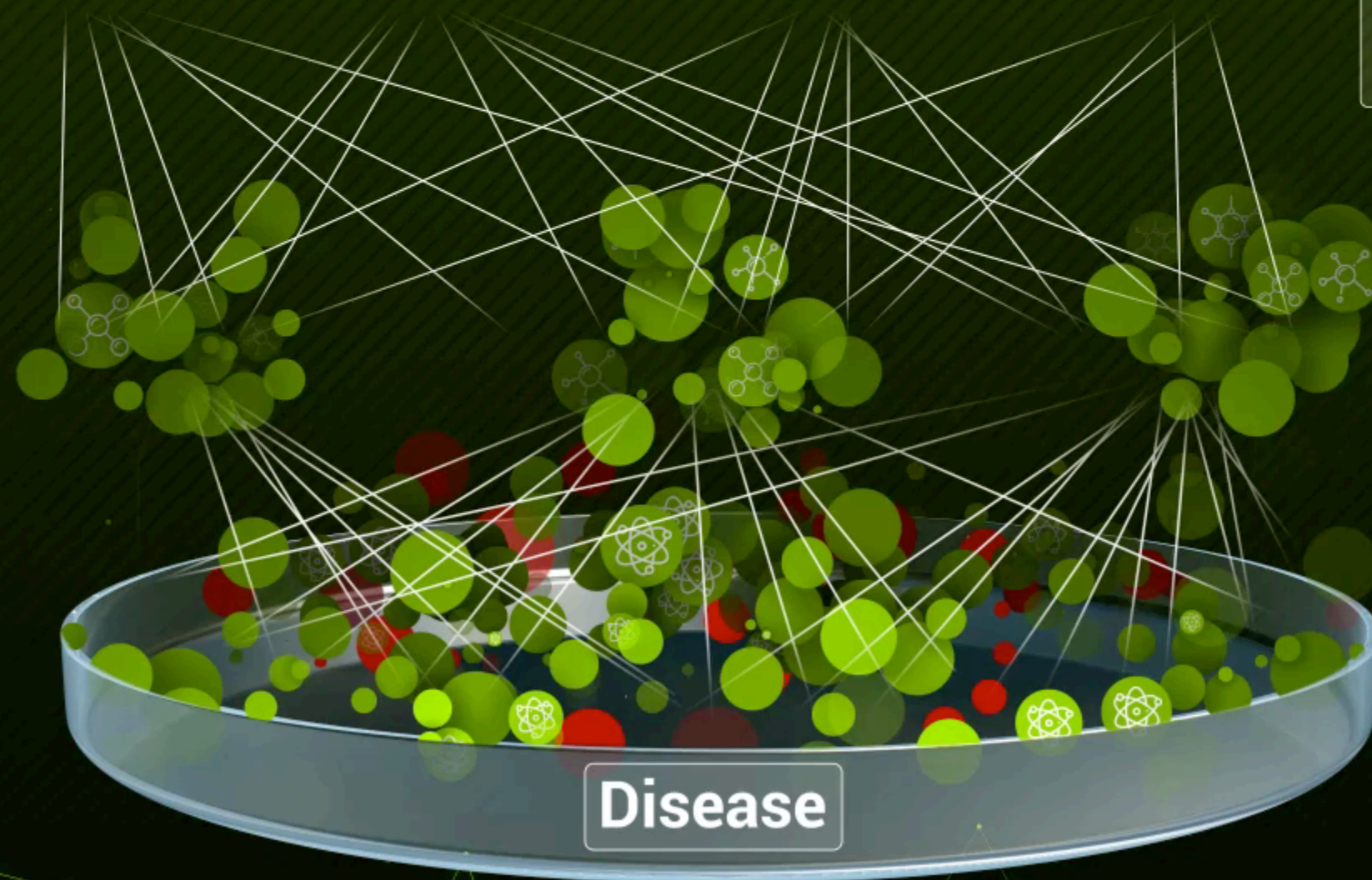
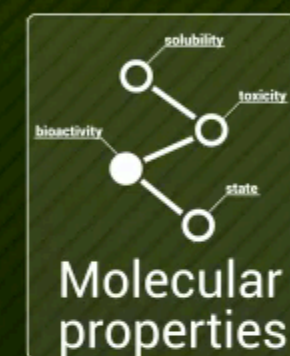
Share

# Drug Database

Drug candidates



discriminator



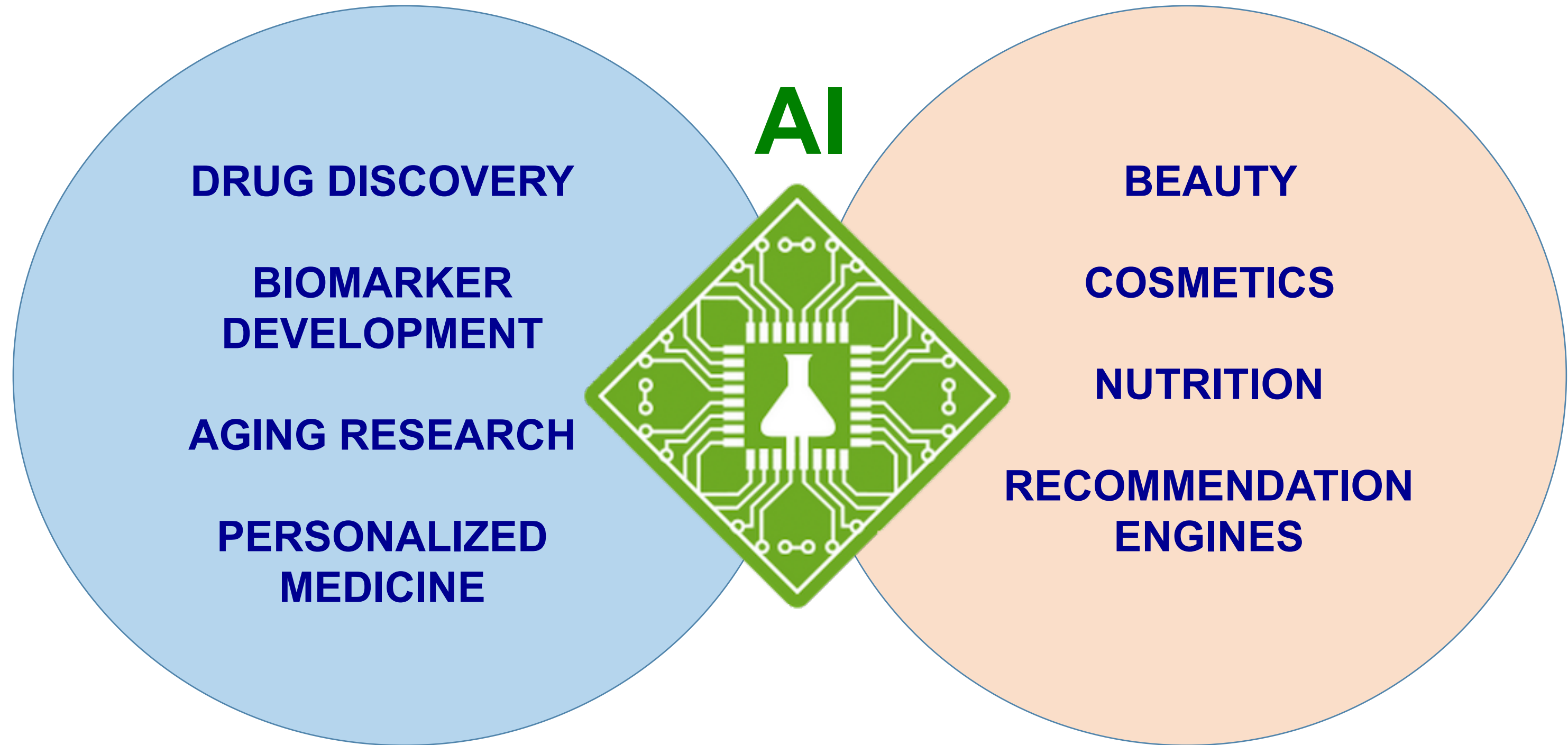
# Generative Adversarial Networks





**WE NEED NEW STRATEGIES FOR  
RAPID VALIDATION**

# WE ARE BRIDGING THE PHARMACEUTICAL AND CONSUMER INDUSTRIES



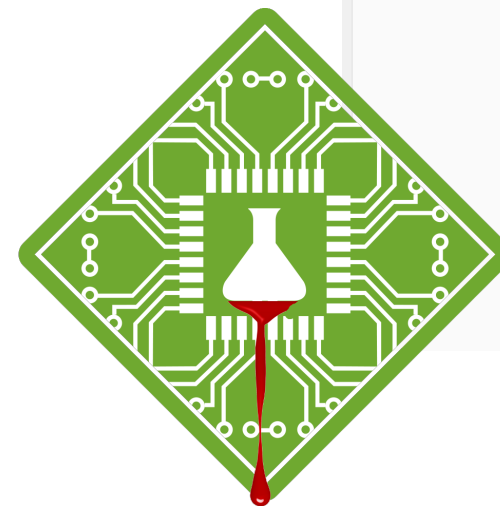
**HEALTH & MEDICINE**

**CONSUMER INDUSTRY**

# EXAMPLE: NATURAL COMPOUNDS WITH SUBSEQUENT BLOOD TESTING



[www.geroprotector.com](http://www.geroprotector.com)



[www.Aging.AI](http://www.Aging.AI)

Highest Quality Supplements Since 1980

LifeExtension®  
Stay Healthy, Live Better

Keyword or Item#

Sign In/Join | Contact Us

**BLOOD TEST SALE**

PRODUCTS | MAGAZINE | HEALTH | NEWS | ABOUT US | REWARDS | SUPPLEMENT GUIDE

My Cart

Shop Health Concerns | Vitamins & Minerals | Supplements | Herbs & Botanicals | Hormones | Skin & Personal Care | Diet & Lifestyle | Blood Testing

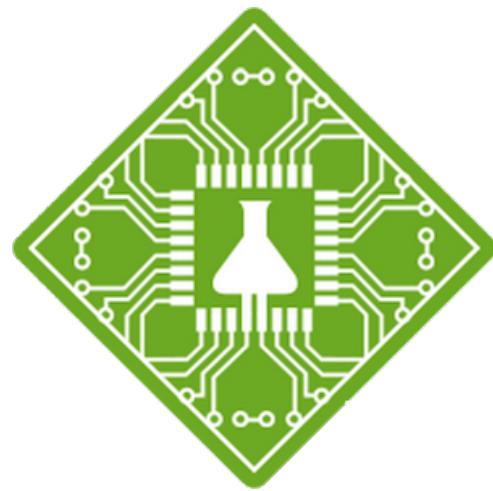
**ANNUAL  
BLOOD TEST  
SUPER SALE**

SAVE UP TO **50%** OFF RETAIL

A rack of test tubes and a pipette with a drop of red liquid on a slide.

[www.lifeextension.org](http://www.lifeextension.org)

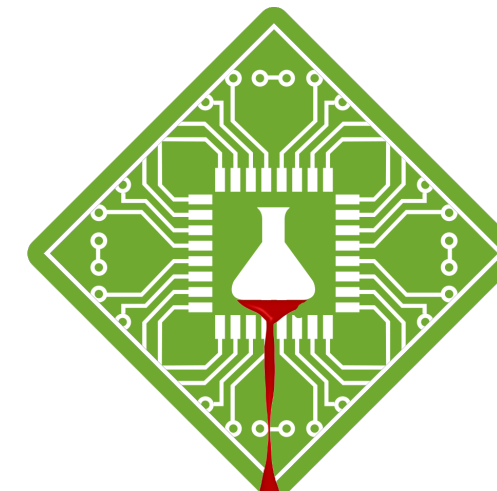
# EXAMPLE: NATURAL COMPOUNDS WITH SUBSEQUENT BLOOD TESTING



25 weeks



25 weeks



**PREDICT**  
4 weeks

**MARKET**

**TEST &  
ANALYZE**  
4 weeks

**ONE ORGAN, WHERE WE CAN VALIDATE  
QUICKLY IS  
SKIN**

**HAPPY TO ANNOUNCE THAT  
INSILICO KOREA  
WILL BE FOCUSED ON  
SKINCARE**

# CAN WE FORCAST BEYOND 5 YEAR HORIZON?



**. HOW WILL THE FUTURE LOOK LIKE IN 5 YEARS?**



# AI PHARMA INNOVATION

JULY 25 – 27, 2017 BOSTON, MA

www.ai-pharma.com

The first industry specific conference committed to helping large pharma, biotech, leading research institutes and technology pioneers overcome key challenges in the adoption and application of AI along the R&D pipeline

to optimize the discovery and development of novel therapies with better outcomes, faster and more cost effectively.

## Other Companies include:



RECURSION  
pharmaceuticals

SANOFI



NOVARTIS

AMGEN



Bristol-Myers Squibb  
Together we can prevail.®

Genentech



astellas

**DISCOUNT CODE: INSILICO10**

Apply AI to De-Risk  
Drug Discovery  
and Development

Deliver Better Medicines  
with Better Outcomes  
Faster & More  
Cost Effectively

## Confirmed Speakers Include:



**Alex Zhavoronkov**  
CEO  
Insilico Medicine



**Brandon Allgood**  
CTO  
Numerate



**Jason Raines**  
Head, Biometrics Data  
Sciences & Operations  
Biogen



**Guido Lanza**  
CEO  
Numerate



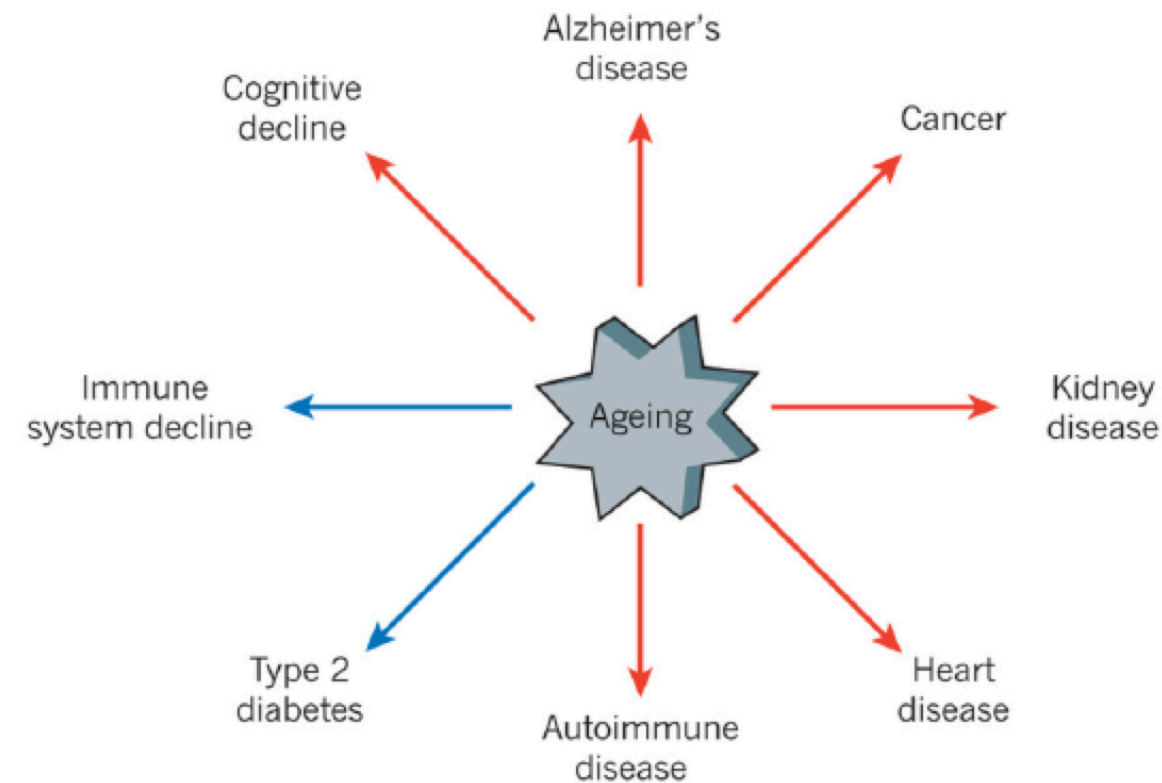
**Ranga Sarangarajan**  
Senior Vice  
President & CSO  
BERG



**Shahar Keinan**  
CSO  
Cloud  
Pharmaceuticals

# 4<sup>th</sup> ANNUAL AGING FORUM 1<sup>st</sup> AI & BLOCKCHAIN FOR DRUG DISCOVERY FORUM AT BASEL LIFE

Better understanding of mechanisms involved in ageing will help to address many different diseases



Source: *Nature* 493,17 January 2013

16 | MipTec | J Reinhardt | 23 September 2014

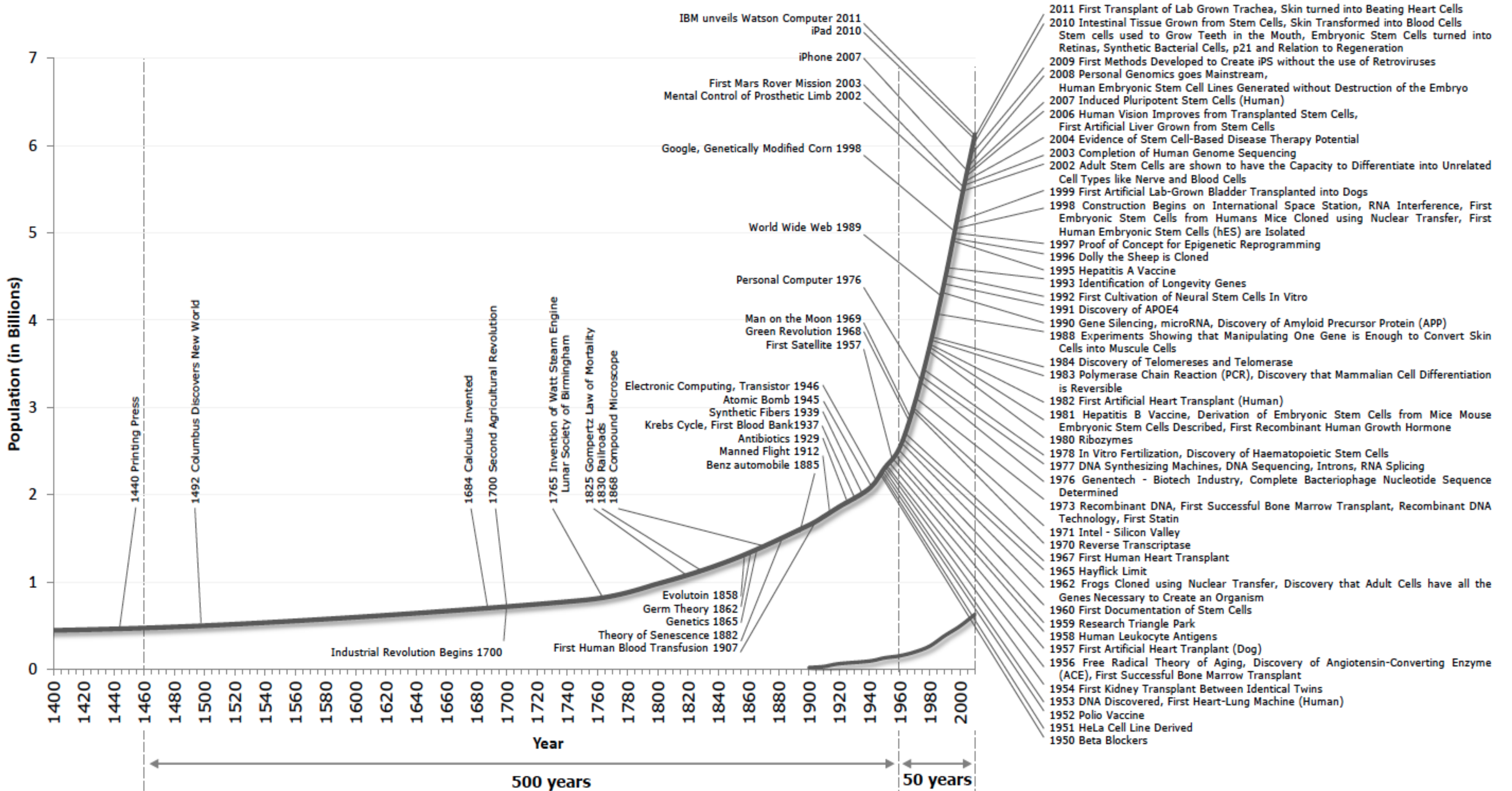
 NOVARTIS

- 4<sup>th</sup> Annual International Aging Research for Drug Discovery Forum, Basel, Basel Congress Center, **September 12-13 (with GSK)**
- 1<sup>st</sup> Artificial Intelligence & BlockChain for Drug Discovery Forum, Basel, Basel Congress Center, **September 13-14 (with NVIDIA)**

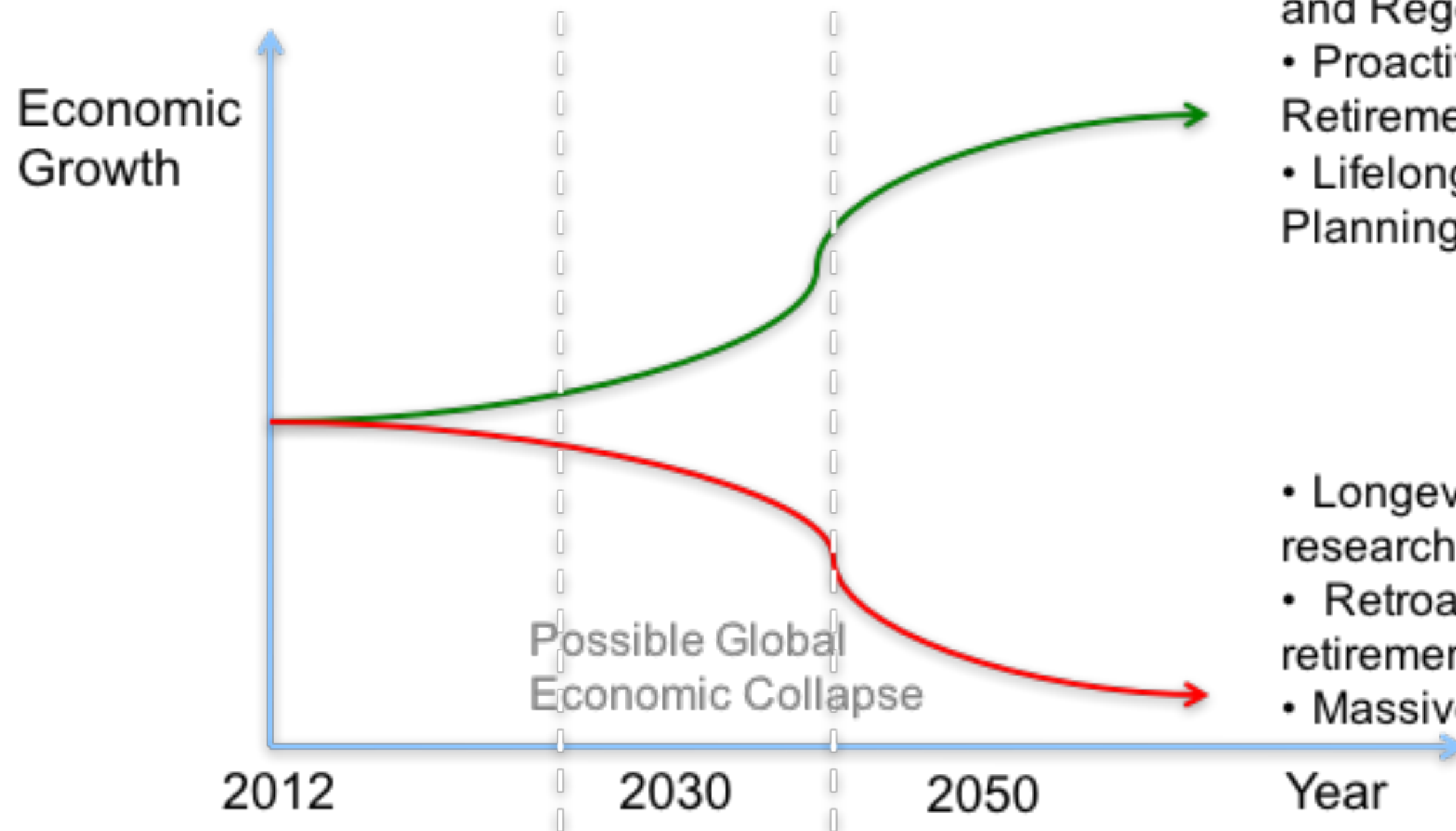
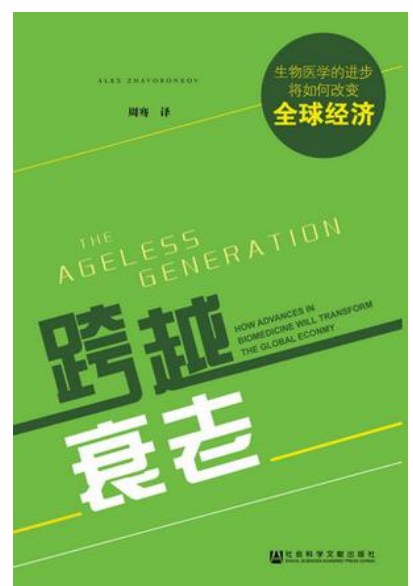
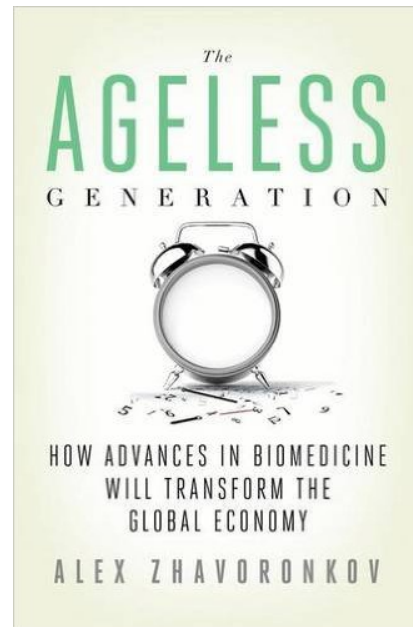
[www.BaselLife.Org](http://www.BaselLife.Org)

# **SUPPORT SLIDES**

# World population and Elderly population (>65)



# AGING IS WORLD'S MOST IMPORTANT AND PRESSING ECONOMIC CHALLENGE



- Accelerate Aging Research & Mass Adoption of Preventative and Regenerative Strategies
- Proactive Increase of Retirement Age
- Lifelong Learning & Career Planning

- Longevity gains from prior research
- Retroactive adjustments in retirement age
- Massive austerity measures