Deep Learning

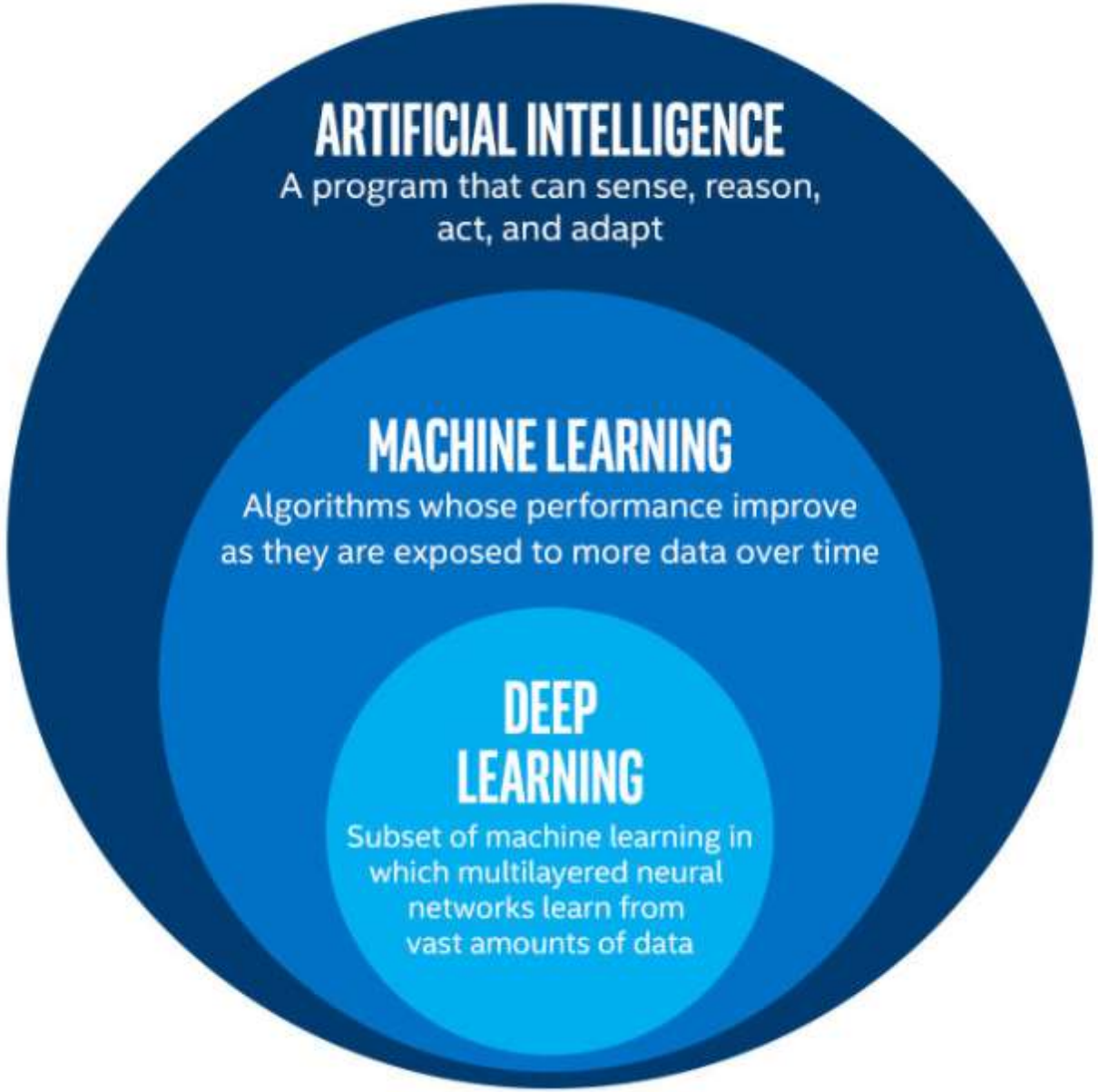
Methods to understand wheat (data)

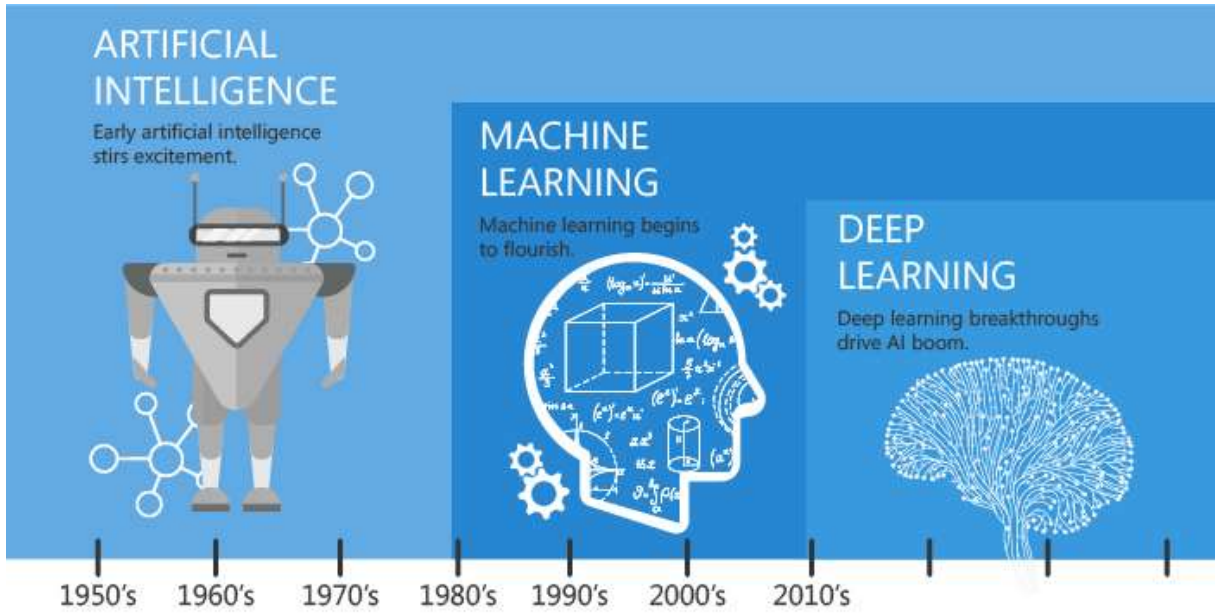
Fred Van Ex

Head of Trait Discovery Bayer Crop Science

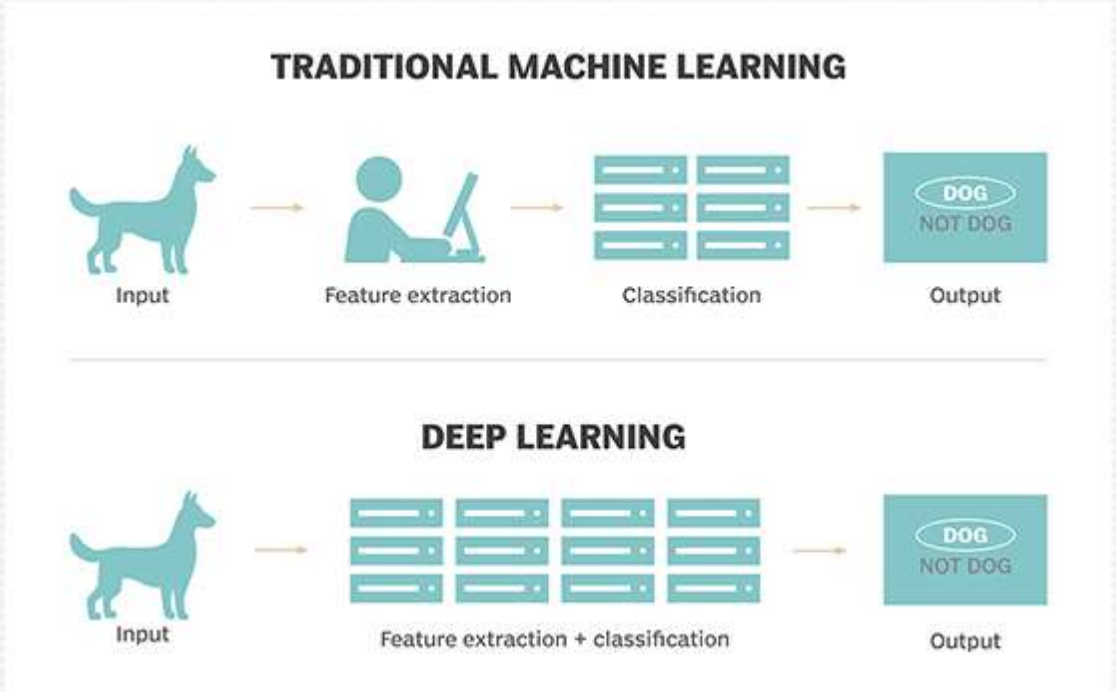
Agenda

- Deep Learning: What is it?
- Applications
  - Image Analysis
  - Genomics
- Bayer Innovation

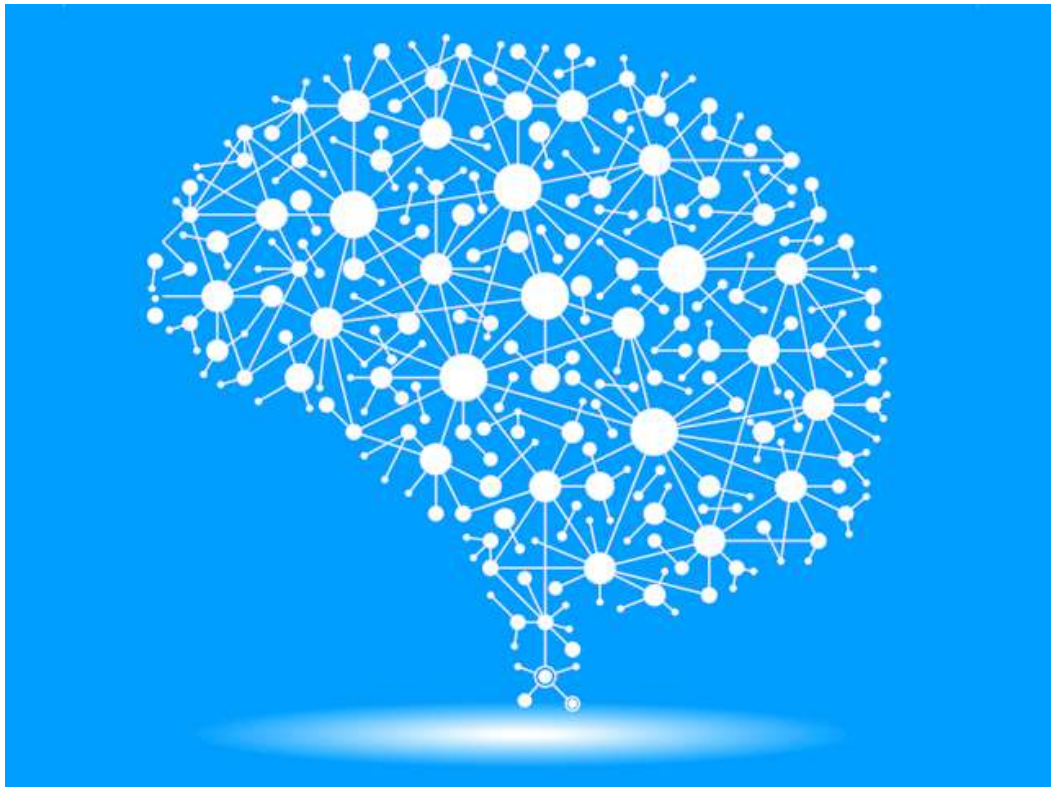

ARTIFICIAL INTELLIGENCE
A program that can sense, reason, act, and adapt
MACHINE LEARNING
Algorithms whose performance improve as they are exposed to more data over time
DEEP LEARNING
Subset of machine learning in which multilayered neural networks learn from vast amounts of data

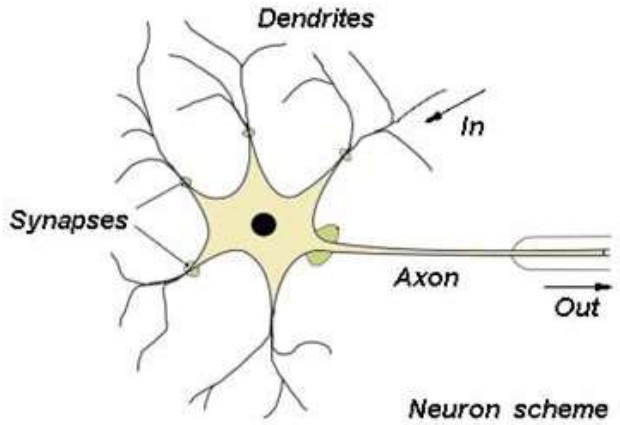

ARTIFICIAL INTELLIGENCE
Early artificial intelligence stirs excitement.
MACHINE LEARNING
Machine learning begins to flourish.
DEEP LEARNING
Deep learning breakthroughs drive AI boom.
1950's
1960's
1970's
1980's
1990's
2000's
2010's

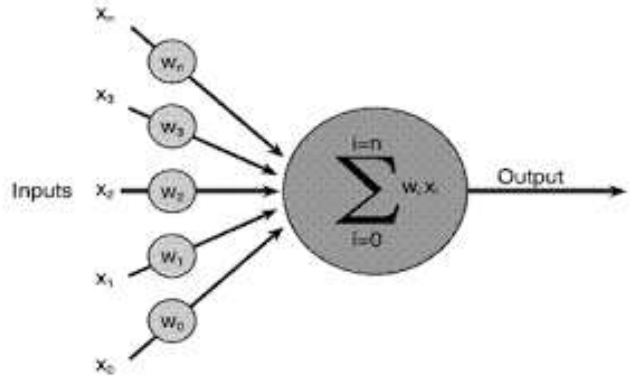
Deep Learning does not require supervision

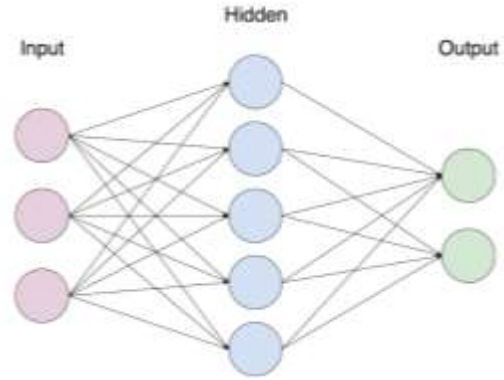


Deep Learning relies on Artificial Neural Networks



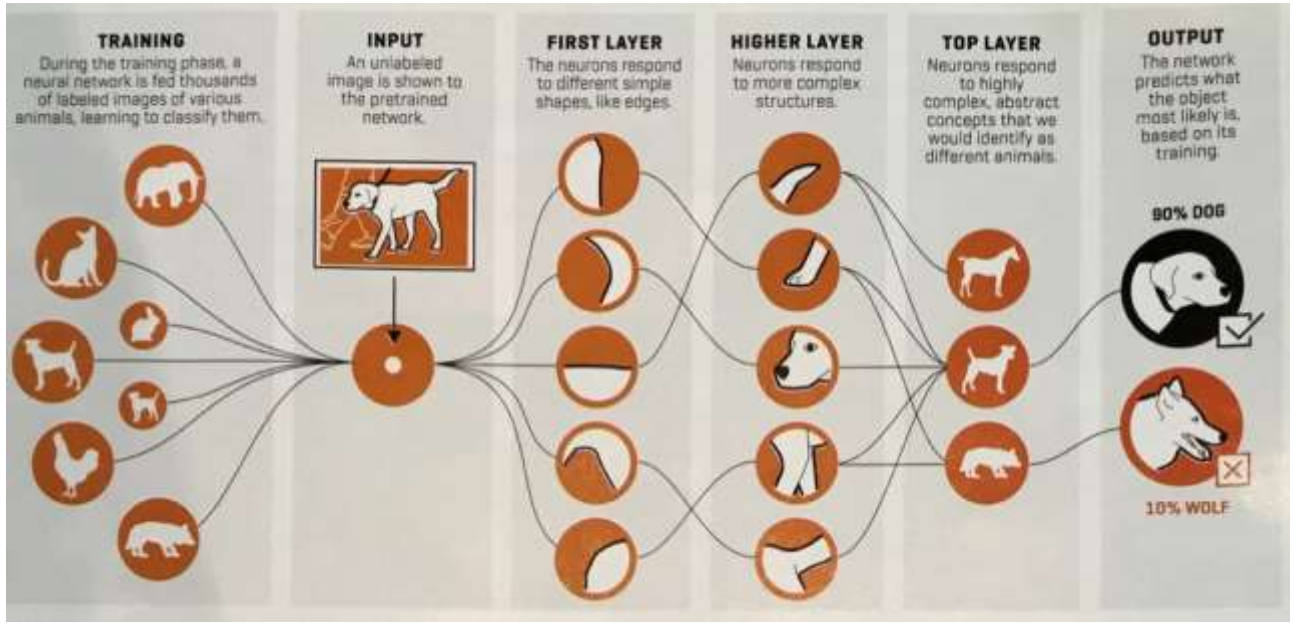






Deep Learning works by layering information

How does it work



Forbes, 2016

What do you need for it to work

- ✓ Large high quality data set
- ✓ Measurable and describable goals
- ✓ Computing power
- ✓ Best used in tasks where the basic unit (pixel, word, nucleotide) has very little meaning by itself but where the combination of those units become meaningful

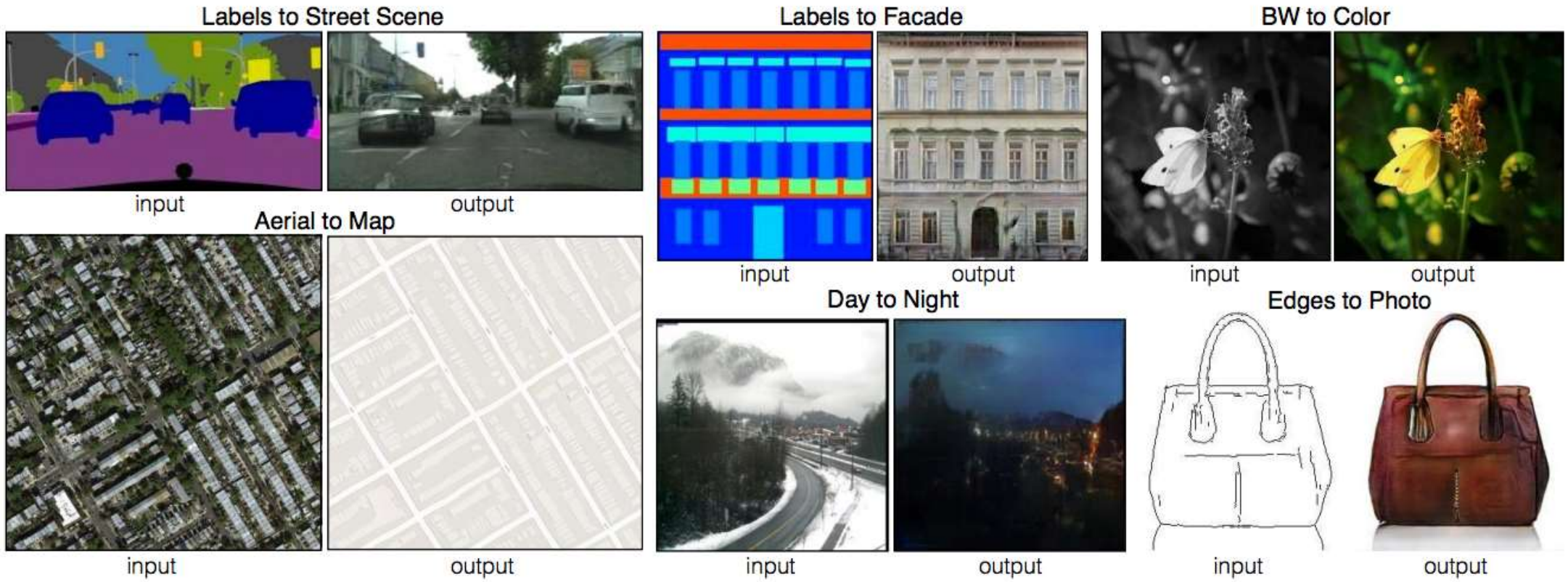
Real World Applications of Deep Learning

Self-driving cars

NVIDIA’s self-driving car in action

Real World Applications of Deep Learning

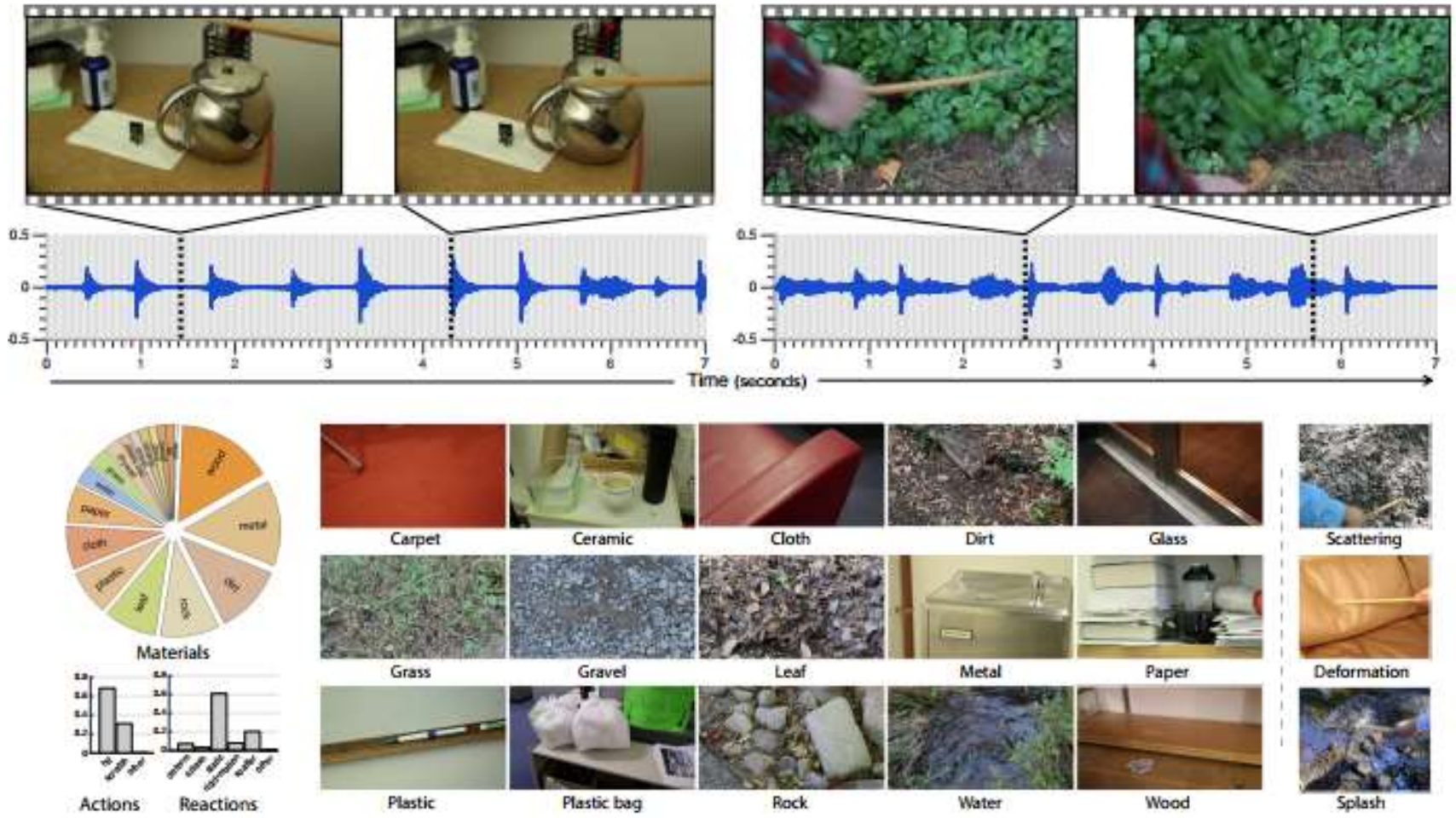
Image Restoration



Isola et al, CVPR 2017

Real World Applications of Deep Learning

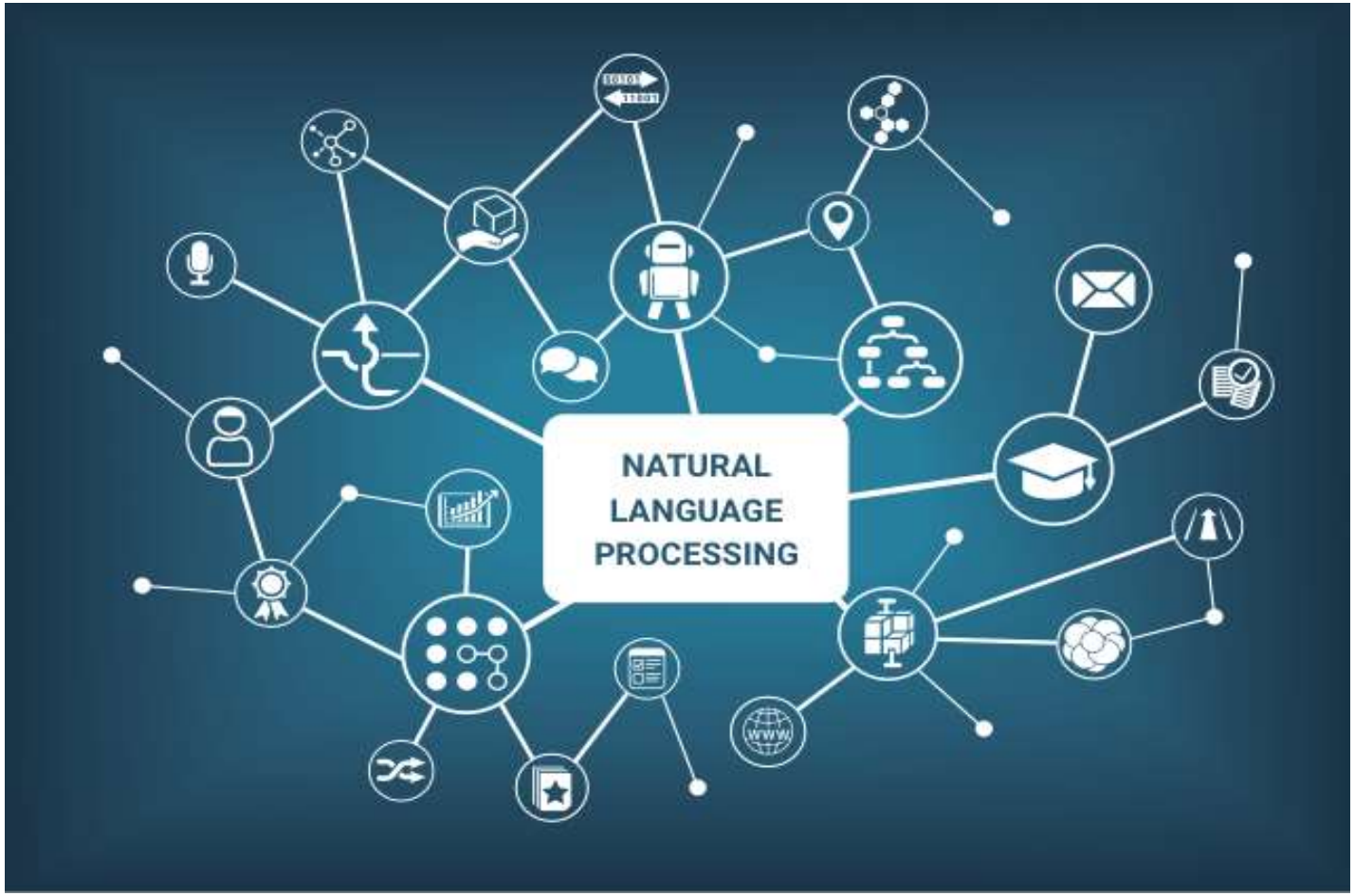
Restoring sound in videos



Owen et al,, arXiv:1512.08512 [

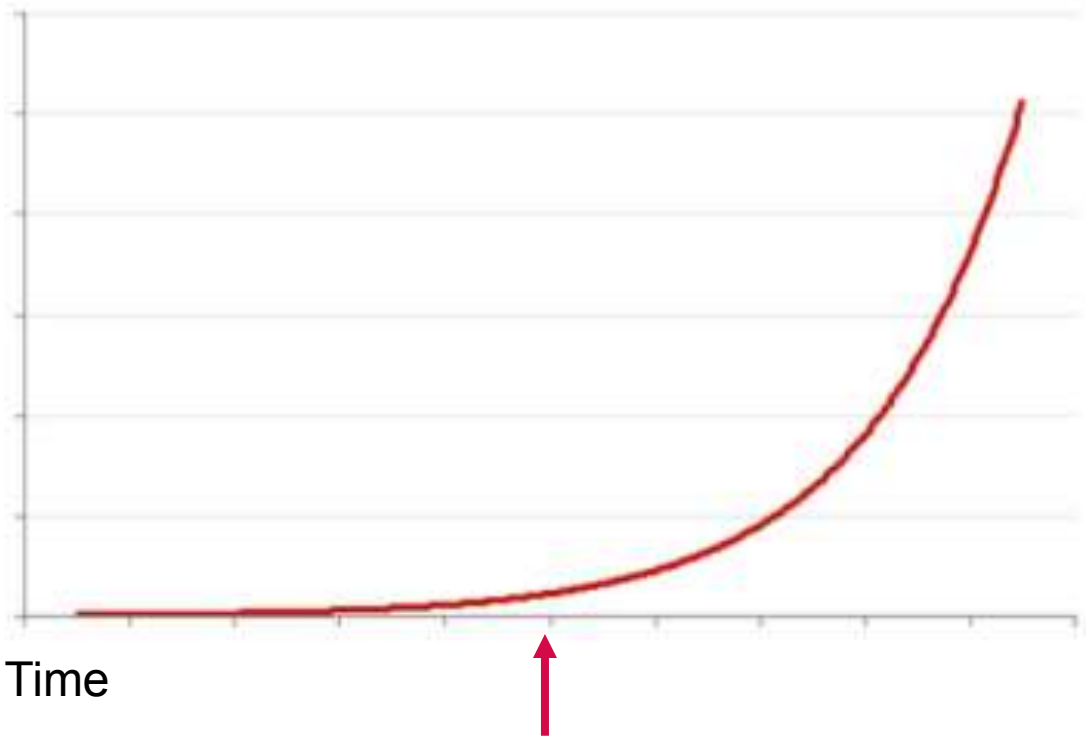
Real World Applications of Deep Learning

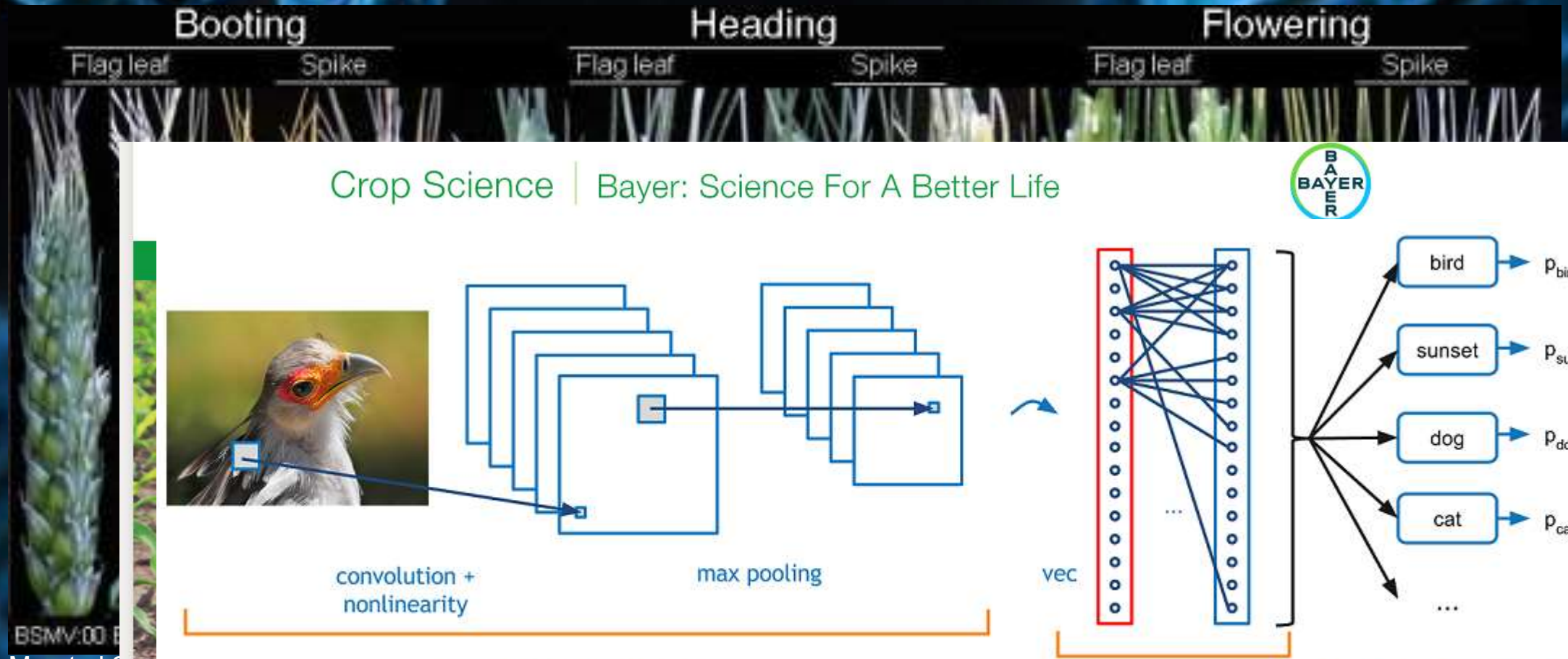
Natural Language Processing



- Text Classification
- Language Modeling
- Speech Recognition
- Caption Generation
- Machine Translation
- Document Summarization
- Question Answering
- ...

Data





Ma et al 2

Crop Science | Bayer: Science For A Better Life

Deep Learning and Biology

Genomics

Basset: Learning the regulatory code of the accessible genome with deep convolutional neural networks

David R Kelley[1], Jasper Snoek and John Rinn

NATURE METHODS | BRIEF COMMUNICATION

Predicting effects of noncoding variants with deep learning–based sequence model

Jian Zhou & Olga G Troyanskaya

NATURE BIOTECHNOLOGY | COMPUTATIONAL BIOLOGY | ANALYSIS

日本語要約

Predicting the sequence specificities of DNA- and RNA-binding proteins by deep learning

Babak Alipanahi, Andrew Delong, Matthew T Weirauch & Brendan J Frey

https://github.com/hussius/deeplearning-biology)

The human splicing code reveals new insights into the genetic determinants of disease

Hui Y. Xiong[1,2,3,*], Babak Alipanahi[1,2,3,*], Leo J. Lee[1,2,3,*], Hannes Bretschneider[1,3,4], Daniele Merico[5,6,7], Ryan K. C. Yuen[5,6,7], Yimin Hua[8], Serge Gueroussov[2,7], Hamed S. Najafabadi[1,2,3], Timothy R. Hughes[2,3,7], Quaid Morris[1,2,3,7], Yoseph Barash[1,2,9], Adrian R. Krainer[8], Nebojsa Jojic[10], Stephen W. Scherer[3,5,6,7], Benjamin J. Blencowe[2,5,7], Brendan J. Frey[1,2,3,4,5,7,10,†]

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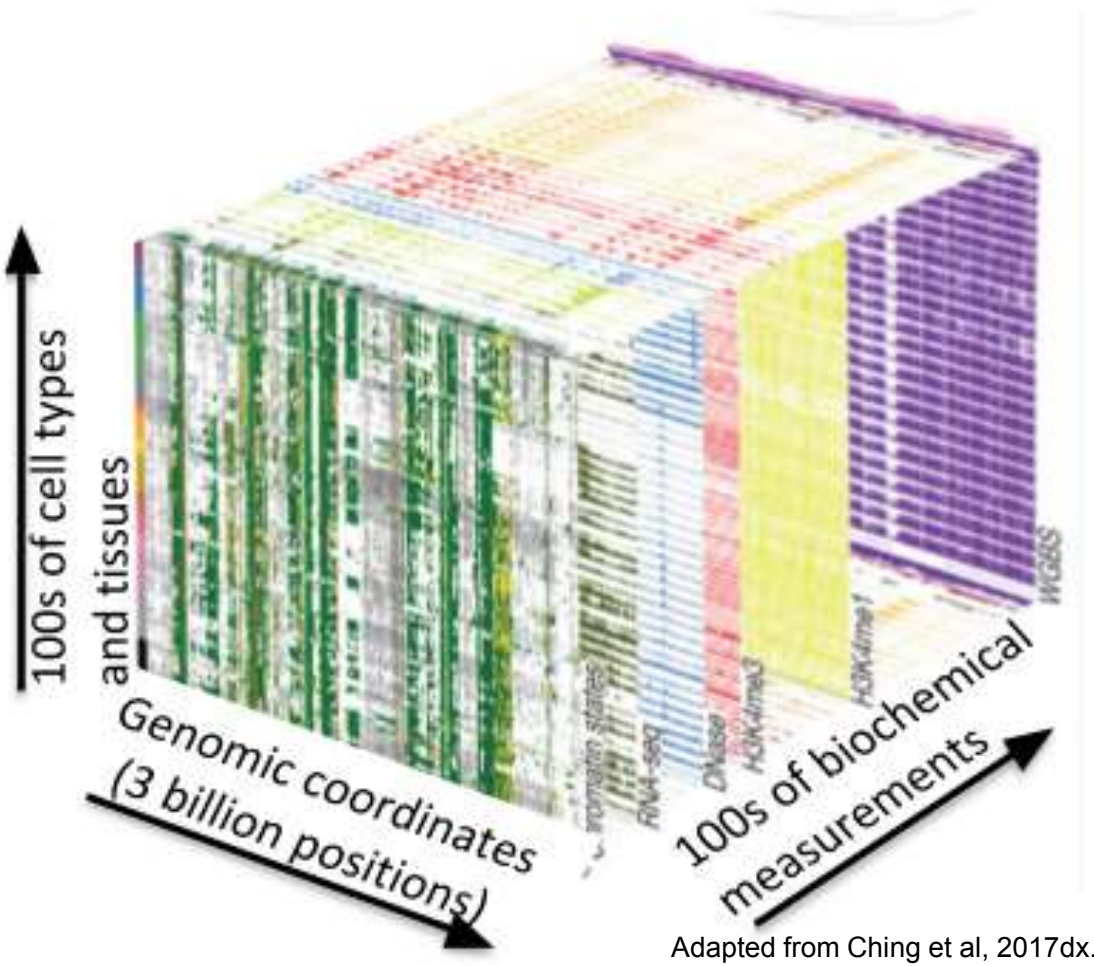
* These authors contributed equally to this work.

Science 09 Jan 2015:
Vol. 347, Issue 6218,
DOI: 10.1126/science.1254806

Opportunities for Deep Learning in Genomics



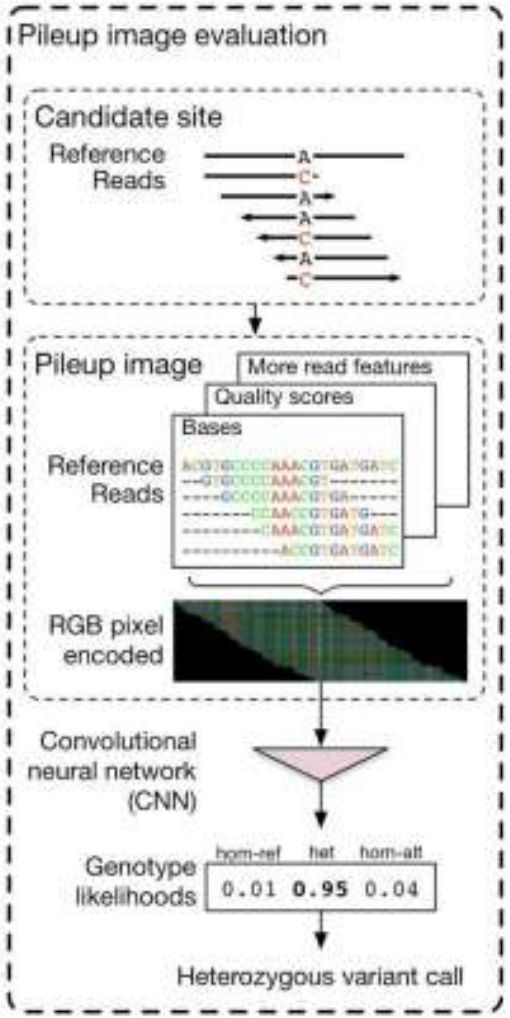
Deep Learning

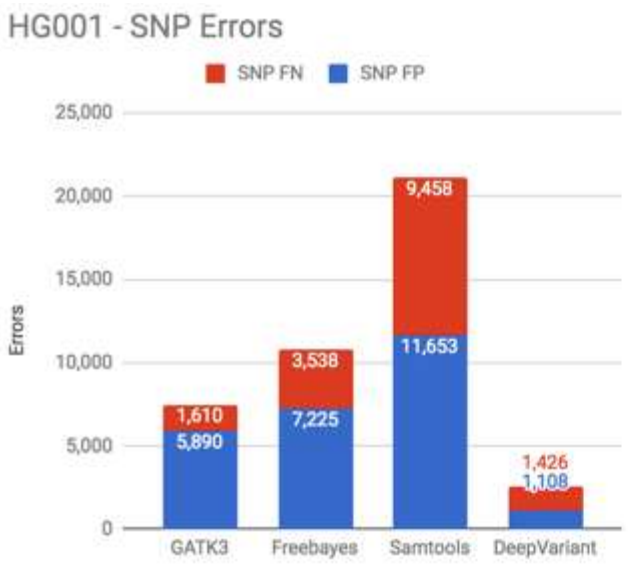
- Functional annotation genome
- Phenotype/trait prediction
- Plant modeling
- ...

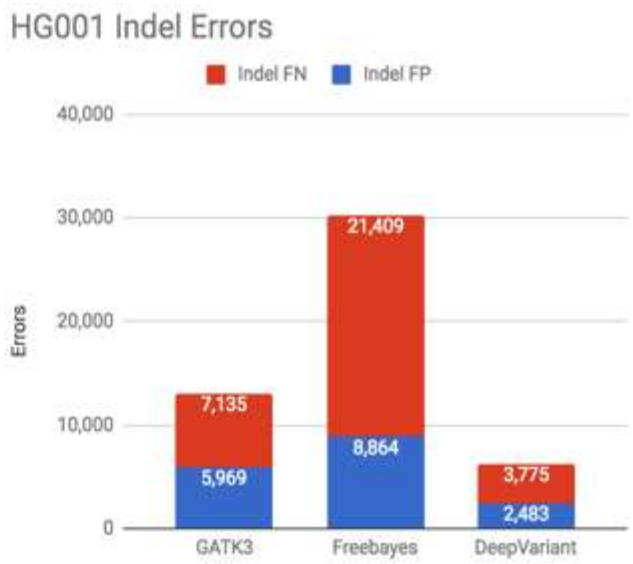
Adapted from Ching et al, 2017dx.doi.org/10.1101/142760

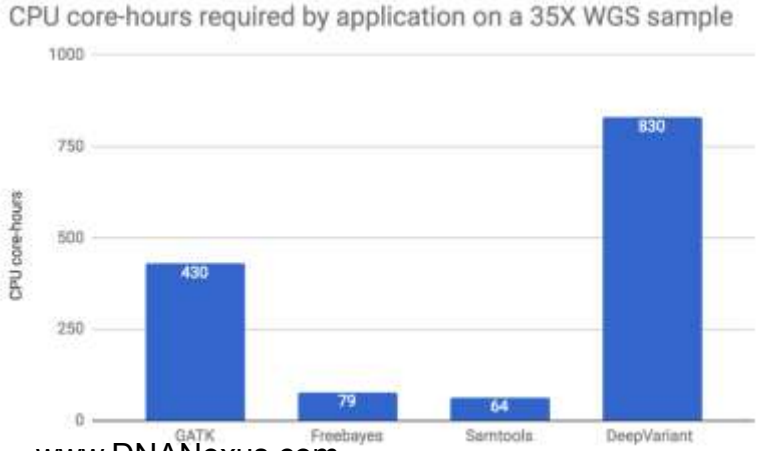
DeepVariant Google

A universal SNP and small indel variant caller with deep neural networks









DNAnexus

Poplin et al 2016, http://dx.doi.org/10.1101/092890.

www.DNANexus.com

Deep Learning @bayer

Deep Learning – Core Platform

Joren Retel

Clevert

Heyndrickx

Scope

Bayer is developing knowledge and expertise in Deep Learning techniques.

Building up up a central Deep Learning core platform containing:

(i) state-of-the-art GPU hardware,

(ii) a sustainable and scalable Deep Learning framework which is able to handle the large amount of data,

(iii) data management scheme

Results

- 1 GPU server is running
- 3 additional GPU server are about to be ordered
- powerful computational resource at Bayer
- scalable DL framework established
- fully integrated

The Deep Learning infrastructure is up and running!

Deep Learning for Phenotype-Genotype Analysis

Joren Retel
Joined August 2017

Clevert

Trucks

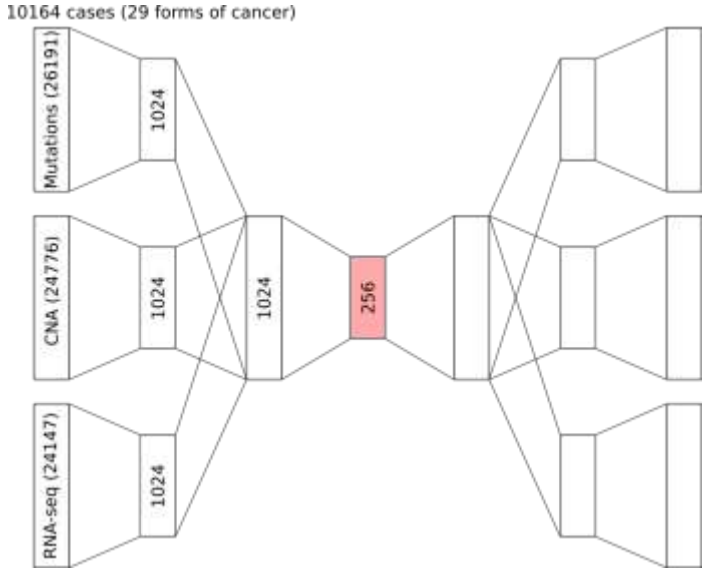
Scope

Develop new approaches for **analyzing complex phenotype data** sets

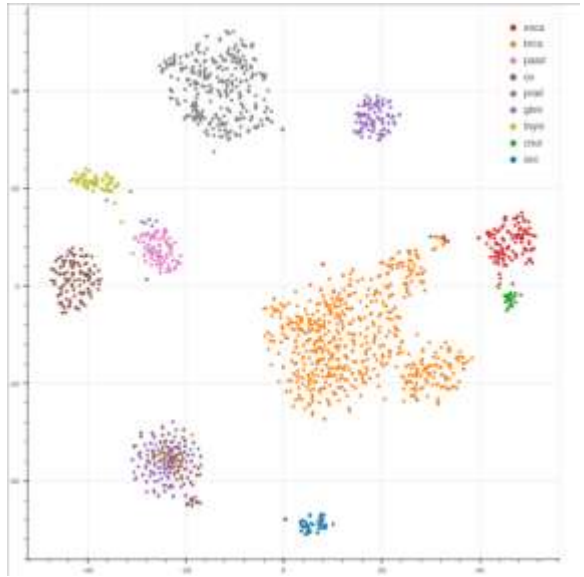
Purpose: Bridging phenotype-genotype gaps, improving the decision making for novel therapeutic targets, genetic biomarkers, drug discovery, patient selection and stratification, highly transferable to other genomic studies.

Results

Network for integrating multi-omics data



Clustered TCGA data



Successful clustered multi-omics data of 10k cancer cases. Right figure shows non-overlapping groups of clusters.

Phenotype-based Annotation of Genetic Variation

Thomas Janssens

Hollunder

Heyndrickx

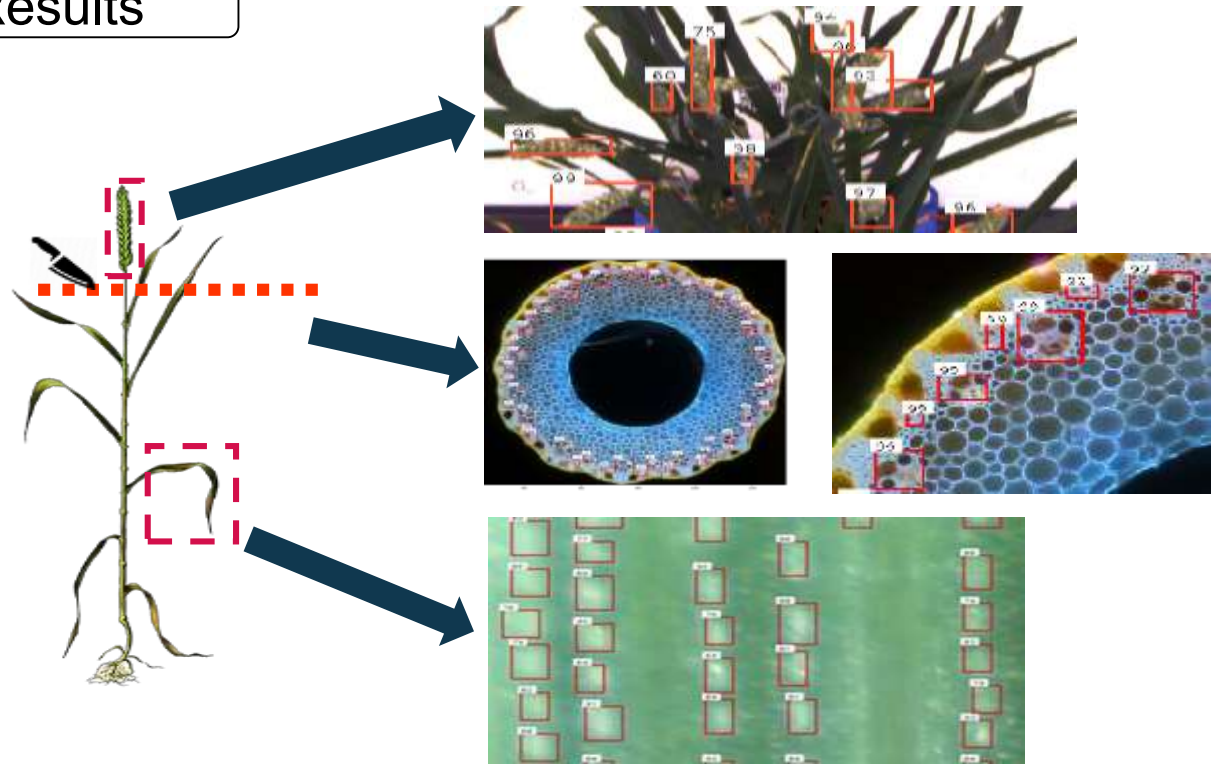
Scope

The functional annotation of genomic variation, and its effect on the phenotype is challenging.

Purpose

- extract plant features from phenotyping platforms
- utilize deep learning as an alternative to GWAS to link genetic variation to phenotypic variation

Results



Successful identification of multiple plant structures. Integration into genetic studies for traits of interest.

Gene Function Translation across Species

Sadegh Mohammadi

Hollunder

Heyndrickx

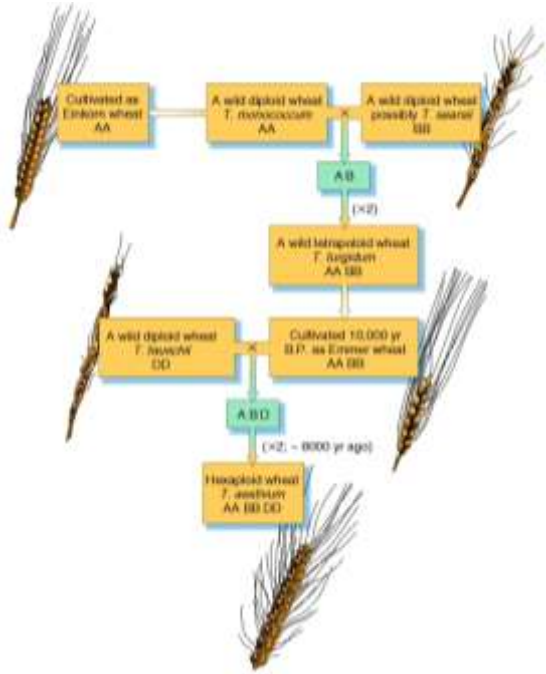
Scope

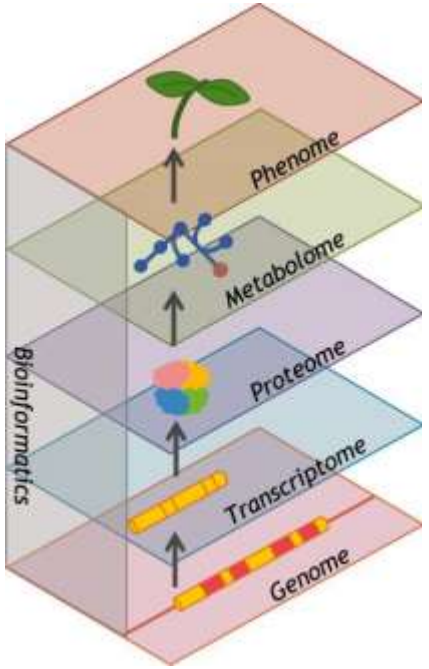
Genetic function has been translated via homology reasoning, but delineating correct homology is difficult

Purpose:

- create a holistic framework of genomics features to determine gene function
- determine which genomics features underlie function

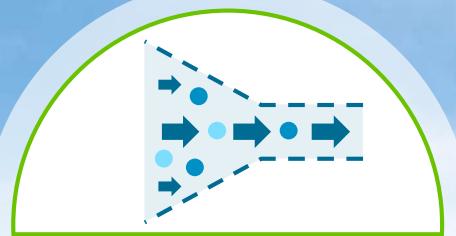
Results





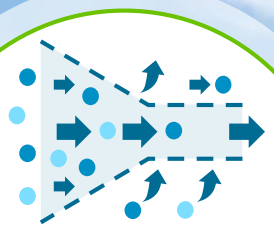
Working on it

Moving from closed Innovation towards Innovation Networks/Ecosystems



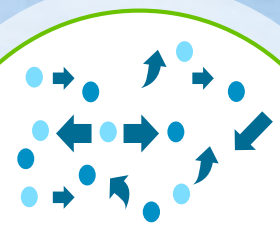
Centralised, Inward Looking Innovation

Closed Innovation



Externally Focused, Collaborative Innovation

Open Innovation



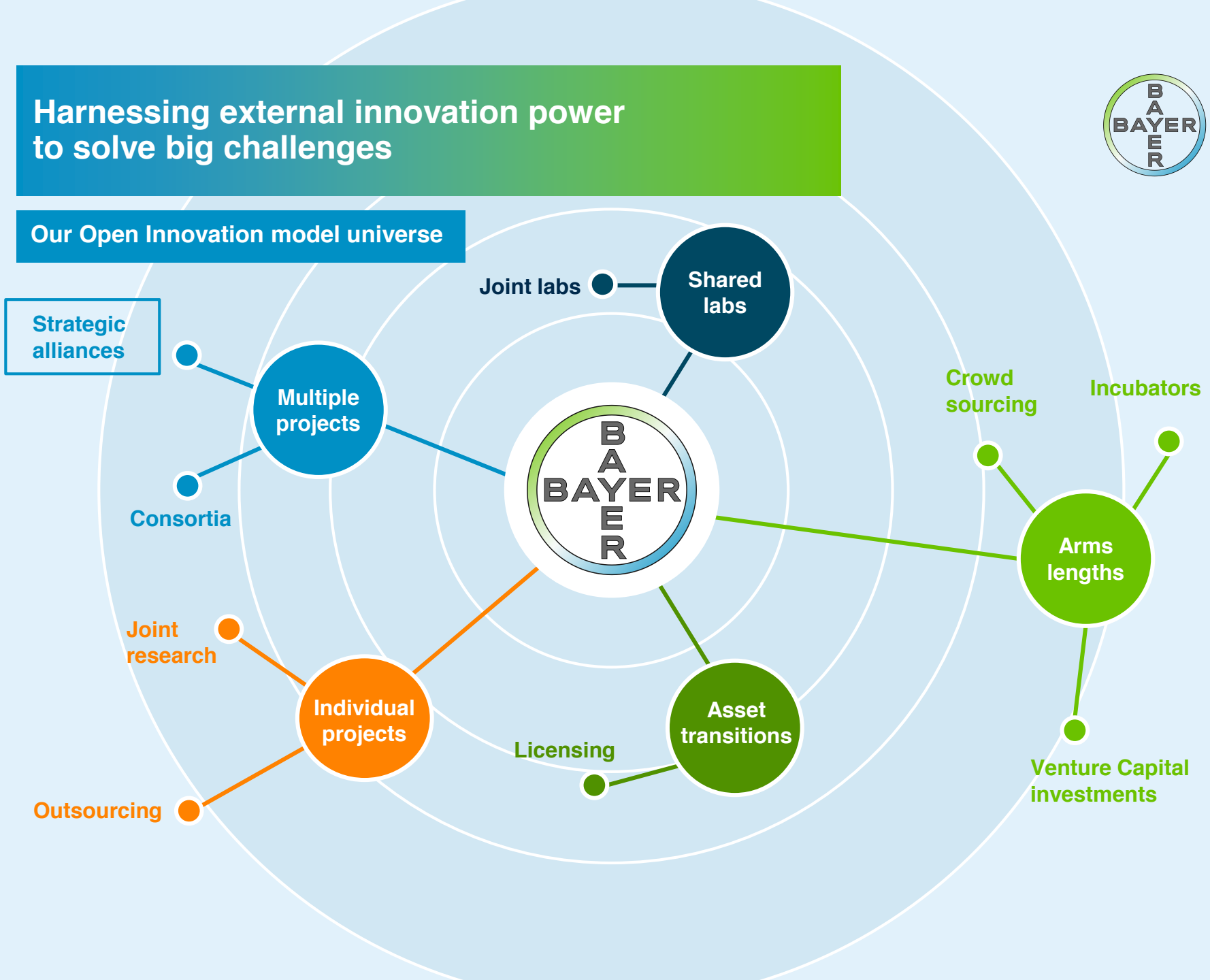
Ecosystem Centric, Cross-Organizational Innovation

Innovation Networks/ Ecosystems

"Increasingly, a large industrial company needs to think about itself as **a node in a much broader network**,and it needs "competition" not simply about **how we build market share** but about how we **capture innovation share from across a very broad ecosystem." – Gary Hamel**[1]

Harnessing external innovation power to solve big challenges

Our Open Innovation model universe



Thank you!