Artificial Intelligence in

Crop Innovation

Crop Innovation & Business, April 15th 2019

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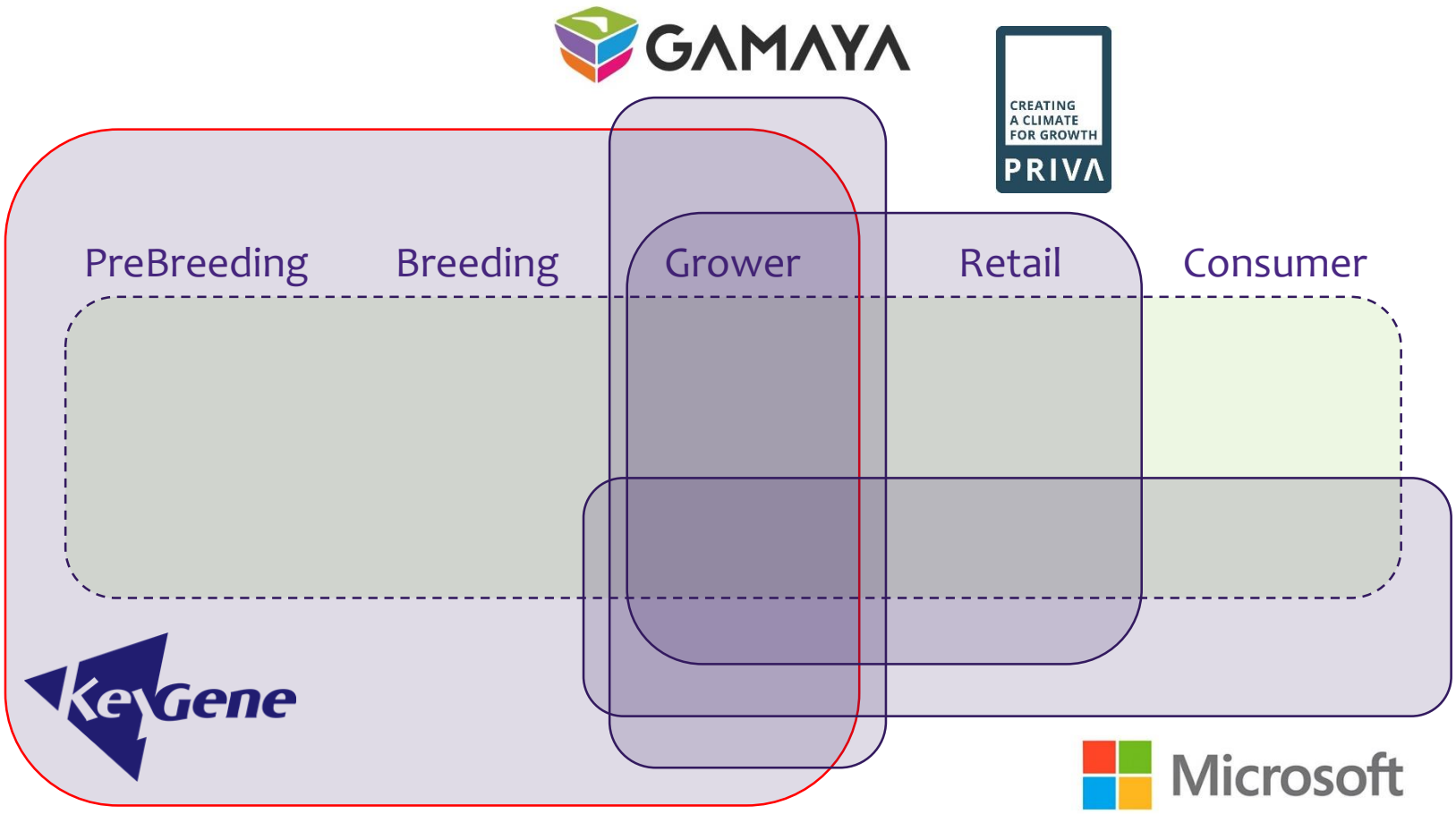
Crop Innovation

KeyGene

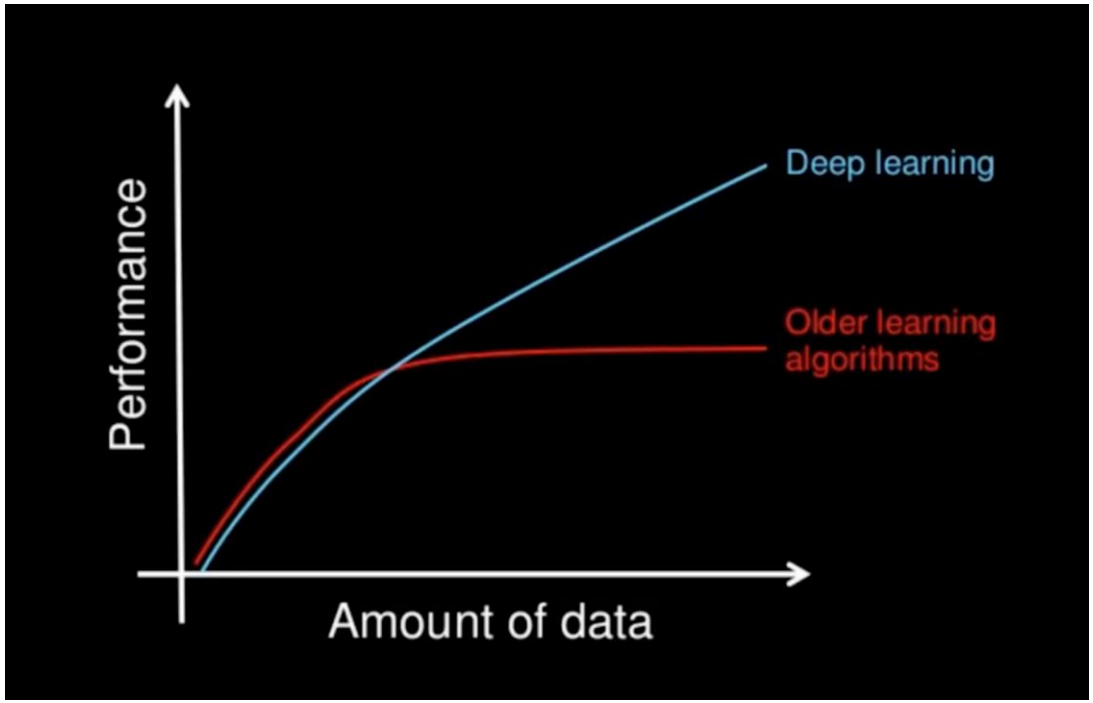
The Crop Innovation Company



Artificial Intelligence

The power

Unravel and predict complex relations and patterns in data

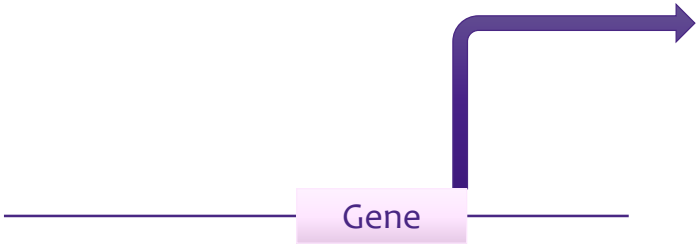


Enabled by compute power (GPUs, TPUs Googles processor optimized for deep learning) and Big Data

Trait complexity

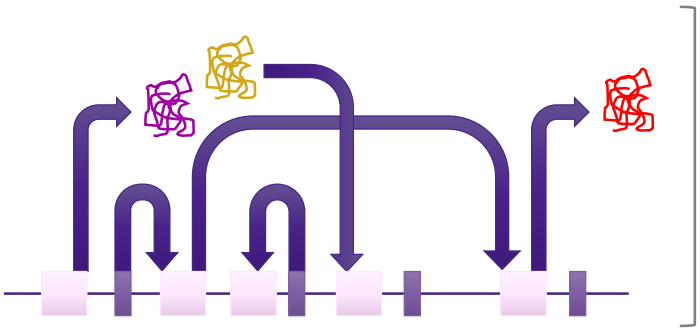
The molecular genetic basis

1. Simple



protein → trait

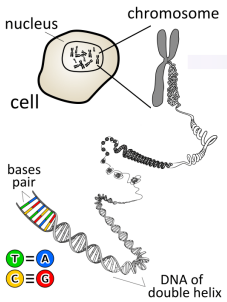
2. Complex

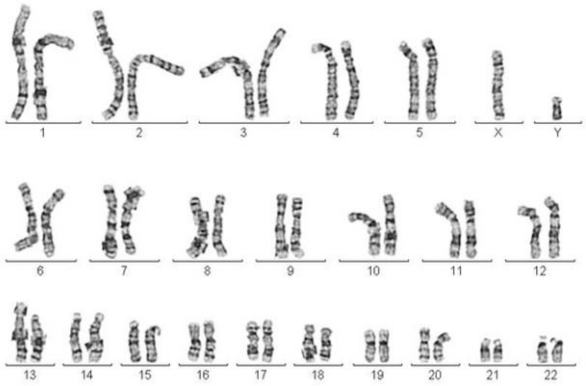


dynamic interaction network → trait

Genes and genomes

Human genome and a plant genome



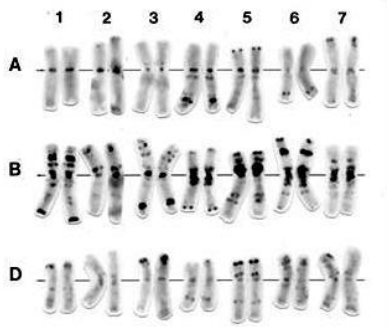


Human:

23 Chromosome pairs

3 x 10^9 base pairs

~20,000 genes



Bread Wheat:

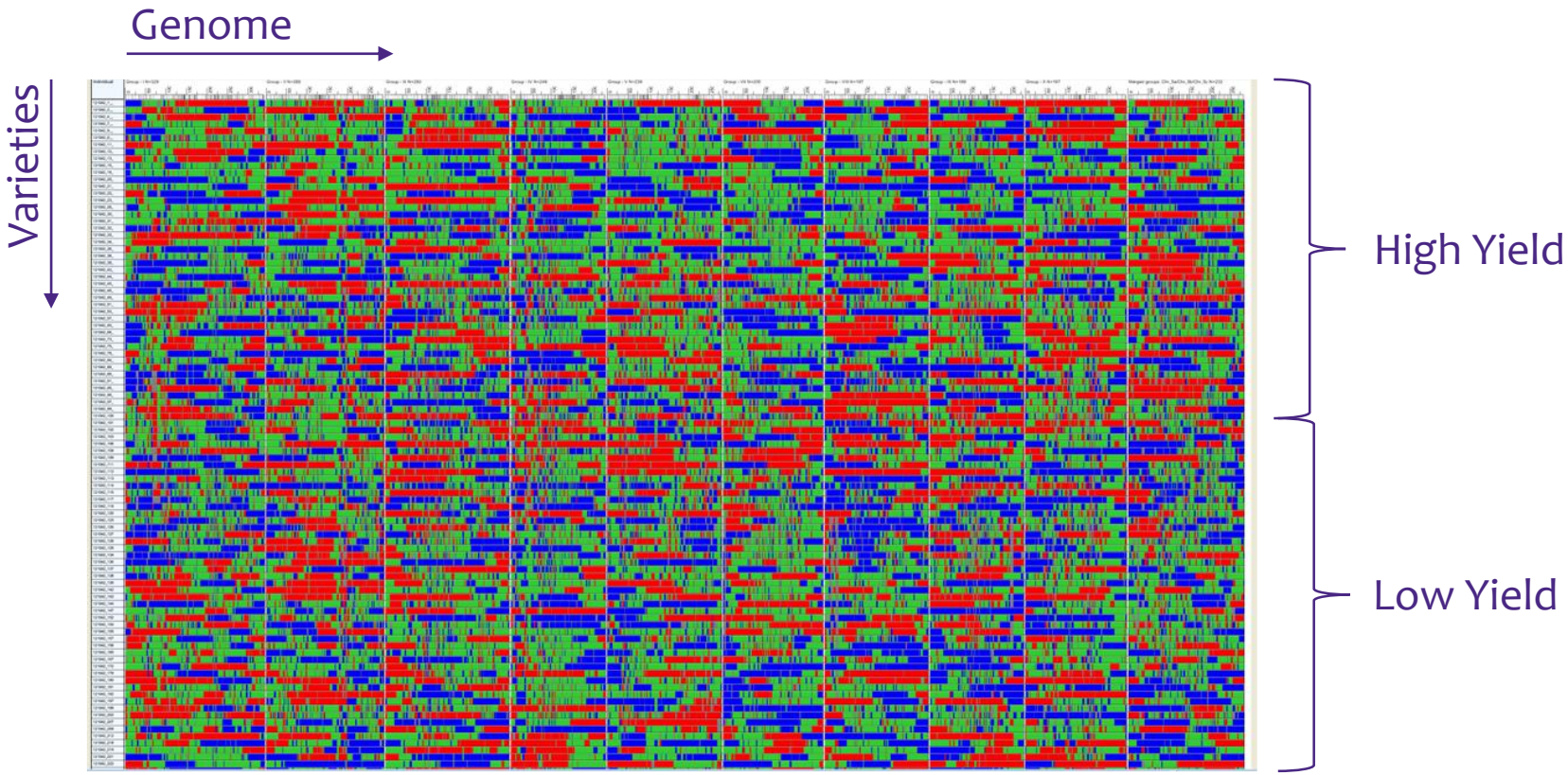
21 Chromosome pairs

17 x 10^9 base pairs

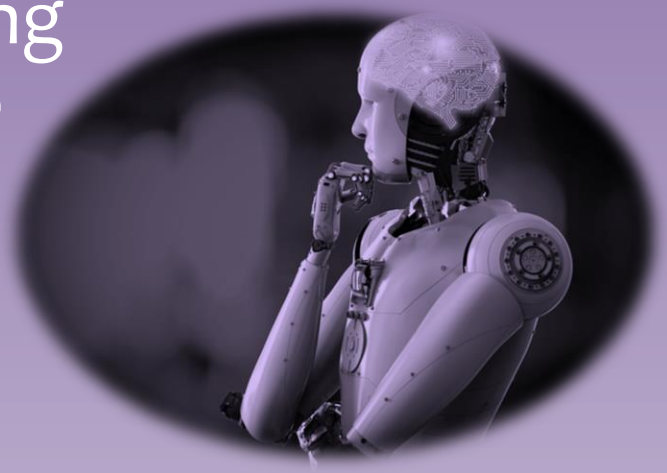
~95,000 genes

Trait prediction

What do I need?

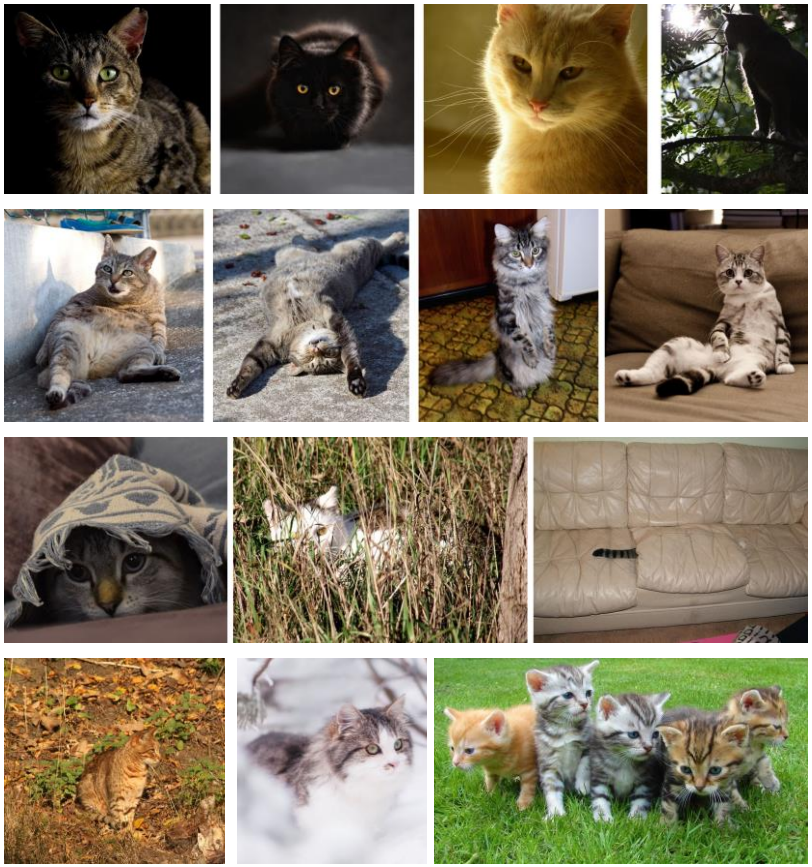


Deep Learning
Machine Learning
Artificial Intelligence



Deep Learning

Big data



Light

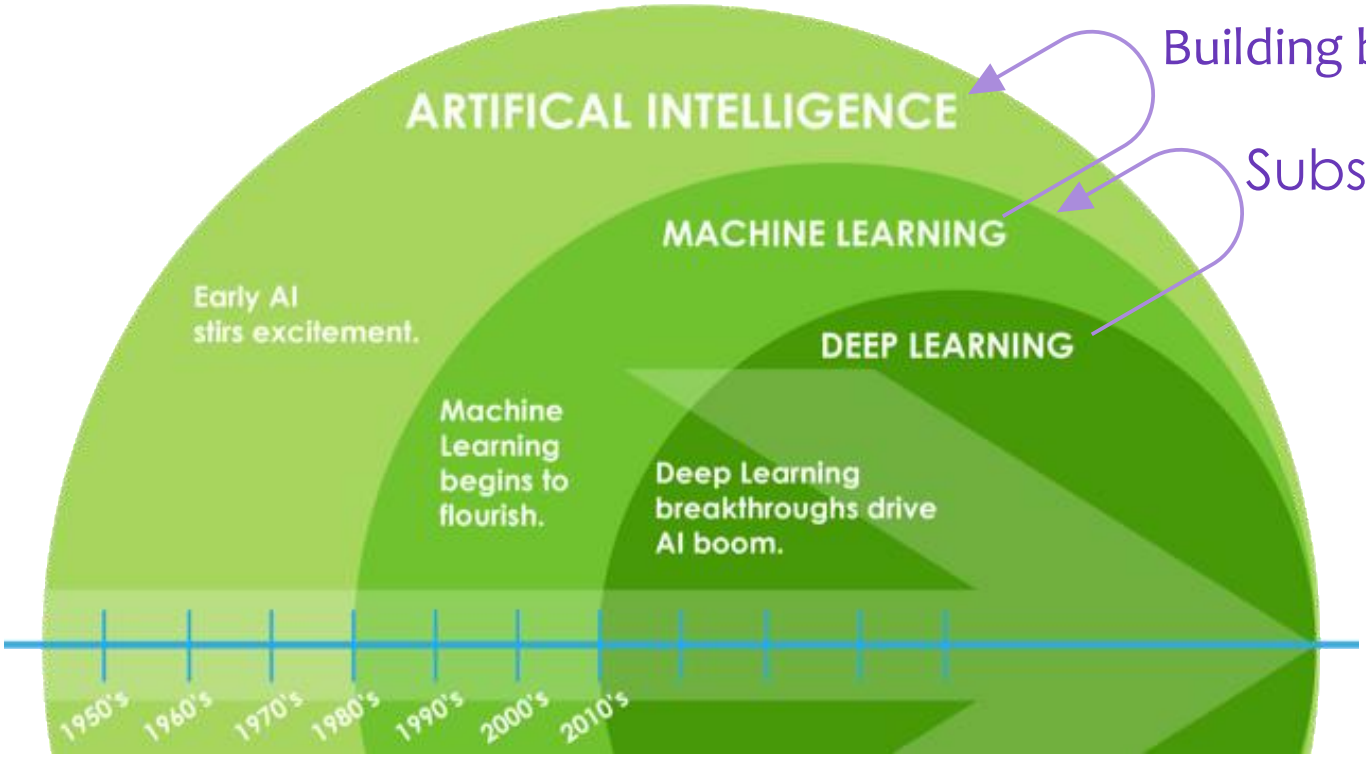
Distortion

Hiding

Variation

Artificial Intelligence

Connections



Building block of...

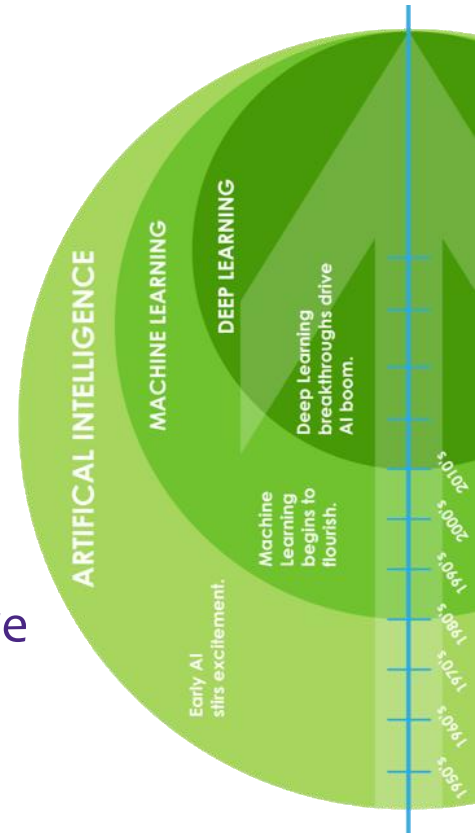
Subset of...

Data

Knowledge

What is what?

- Artificial Intelligence
  - "Artificial Intelligence is everything we cannot make a computer do *now*"
- Machine Learning
  - Define rules and learn patterns from existing data
  - Apply to new, unseen data
- Deep Learning
  - Skip defining rules and learn patterns directly from large collections of data
  - Apply to new, unseen data
  - Inspired by neural networks in the human brain



Use of Deep Learning

- Facebook: Classification of unstructured user data
- Google:
  - Image search engine
  - Strategic games, AlphaGo
- Amazon: product recommendation
- Tesla: self-driving car
- IBM: interpretation of human conversation:
  - Supercomputer "Watson"
  - Won American TV-quiz Jeopardy!
  - Now used in health care, disease diagnosis

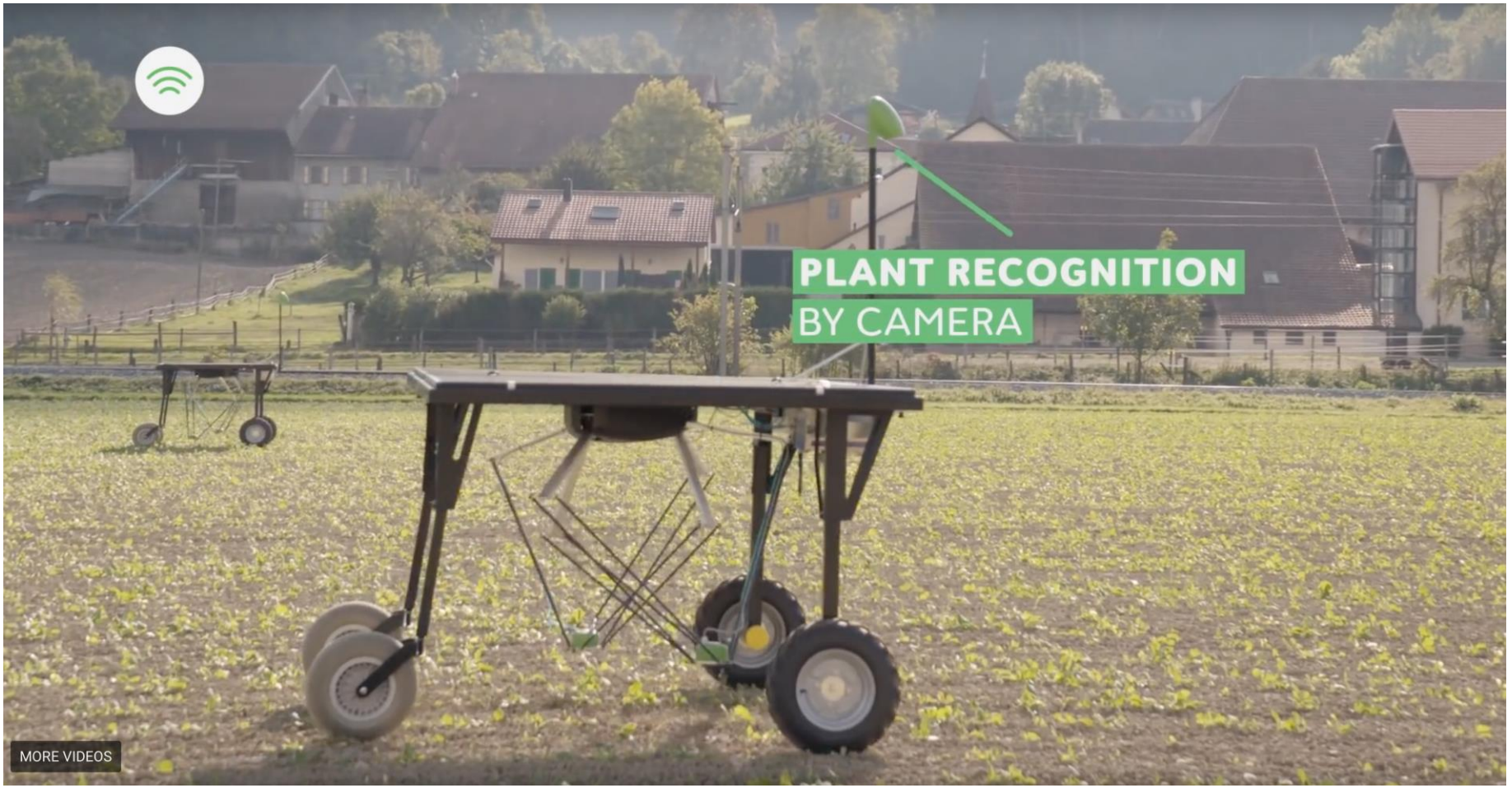
Applications in Breeding

Nonlinear classification

Ambiguity

Deep learning

In the "field"

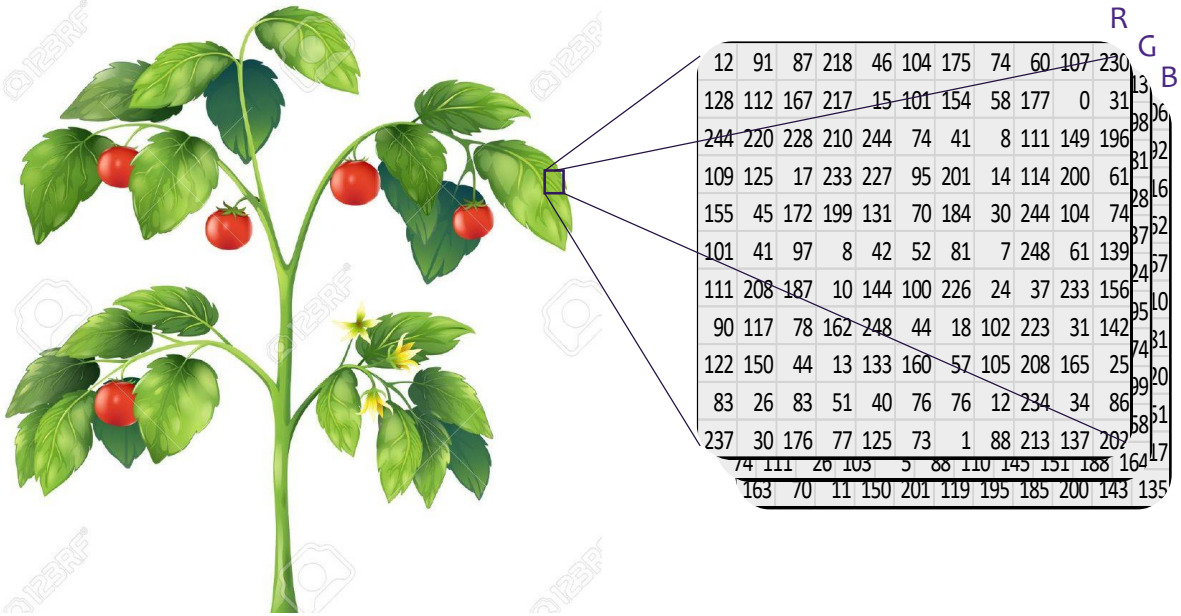


Digital phenotyping

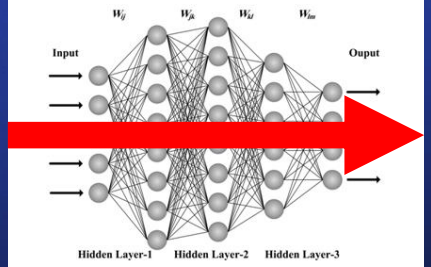
Semantic gap

What we see

What the computer ‘sees’



Automatic image analysis

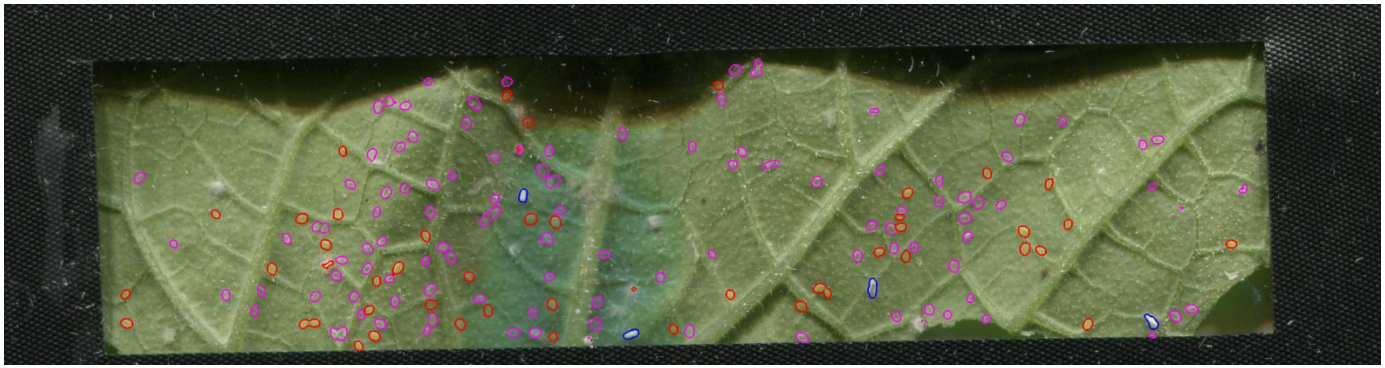


Automatic image analysis

Application

Insect detection

Whiteflies



Manual Scoring

ALARM!
Apply biological control

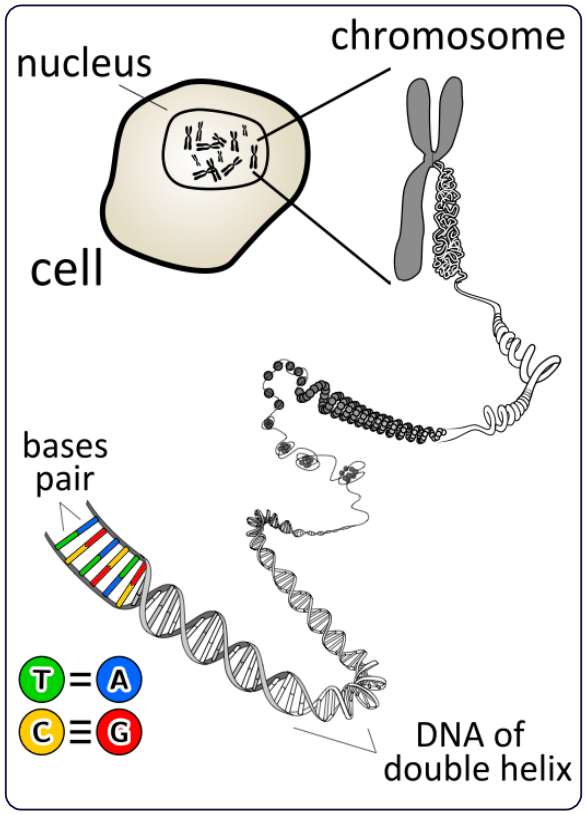
Machine Learning: 70% accurate
Deep Learning: Surpass human

New, unseen applications

New, unseen applications

- In the domain of genetics, genomics, breeding:
  - Analysis, automation, classification, prediction of:
    - Networks of collaborating bio-molecules in the cell
    - Complex features of plant DNA
    - Structure of proteins and genes
    - Predict highly complex traits directly from DNA

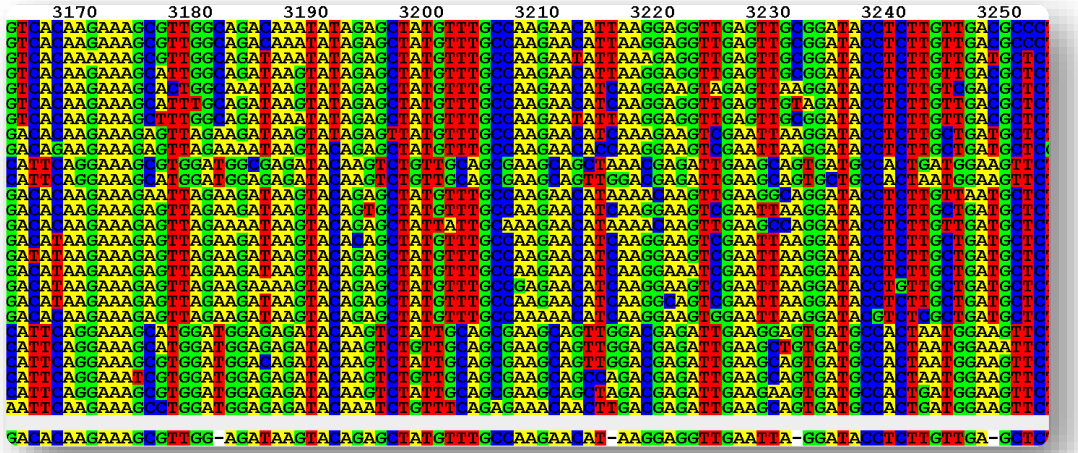
Variation is encoded in the DNA

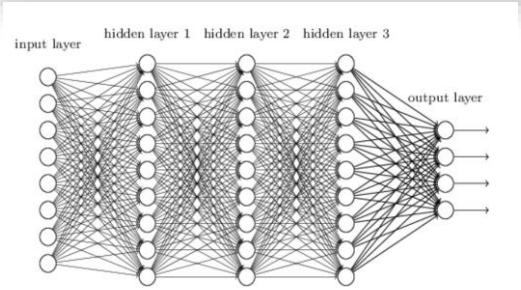


Deep Learning

Variation recognition

Genomic Prediction



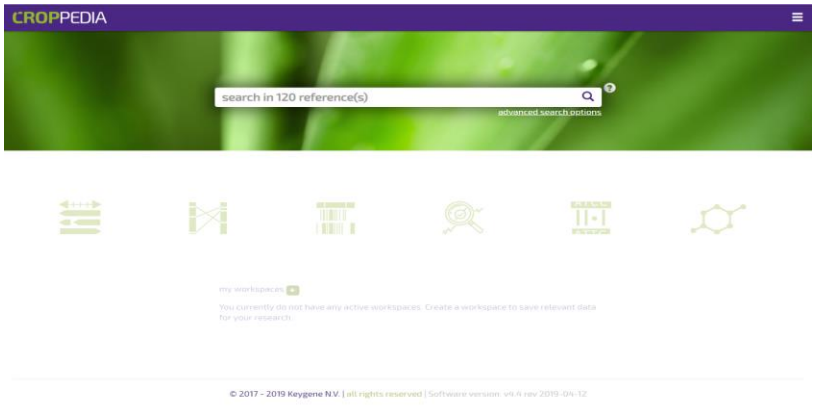


Complex relations between genotype and phenotype

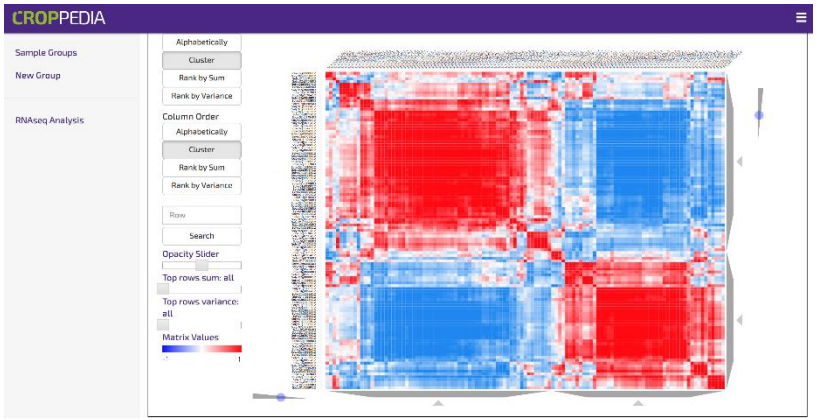
Deep learning models tell what DNA variation is needed for the best traits

CropPedia

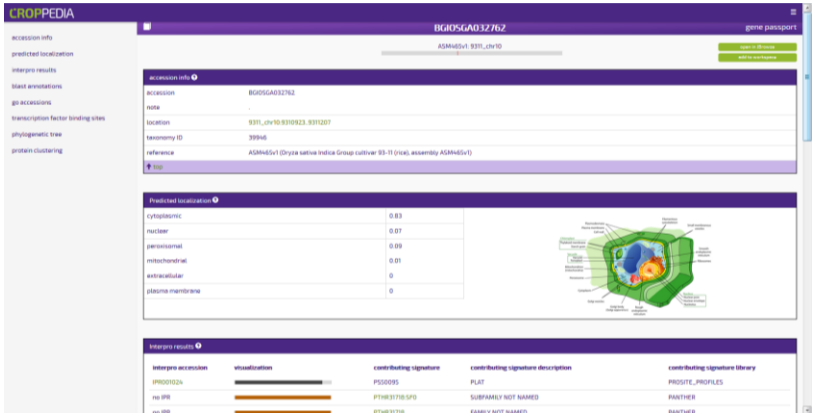
The data visualization and integration platform



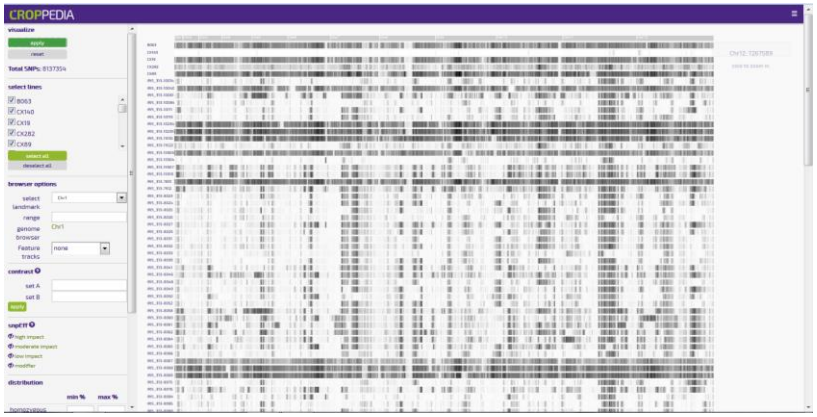
Landing page



Omics analysis



Gene Passports



Variome analysis

Take-home messages

- Deep Learning is coming close to human capabilities in pattern recognition
- The technology excels in revealing **complex relations** in data…
- KeyGene is at the forefront developing and applying these technologies in close collaboration with its partners
- Many promising and unseen applications in crop innovation