

Artificial Intelligence in Crop Innovation

Crop Innovation & Business, April 15th 2019
Marcel van Verk, Team Leader Crop Data Science

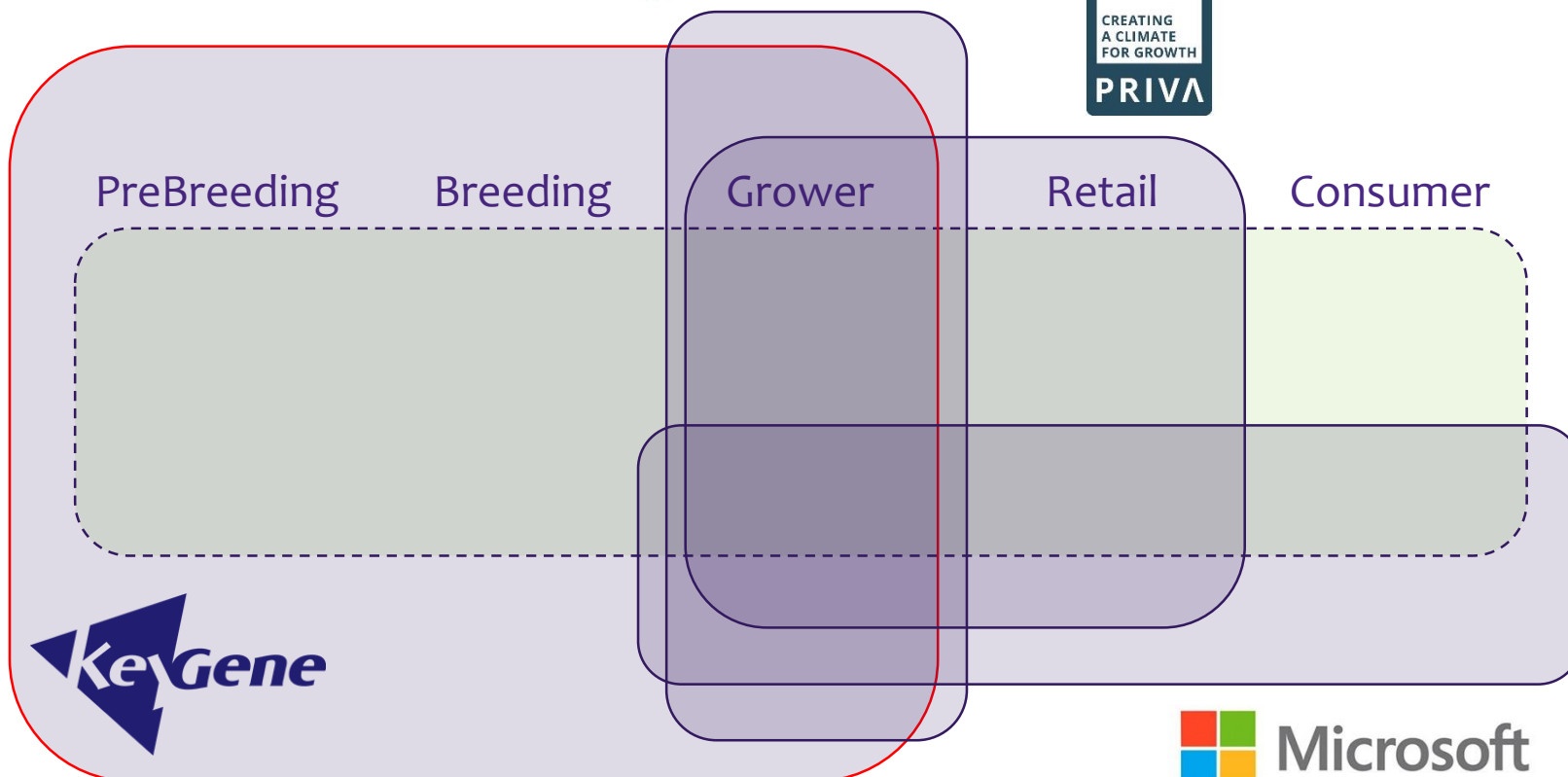


Crop Innovation

A black and white photograph of an old, wrinkled hand holding a young, smooth hand. The image is used as a background for the central text overlay.

Old craft
New technologies

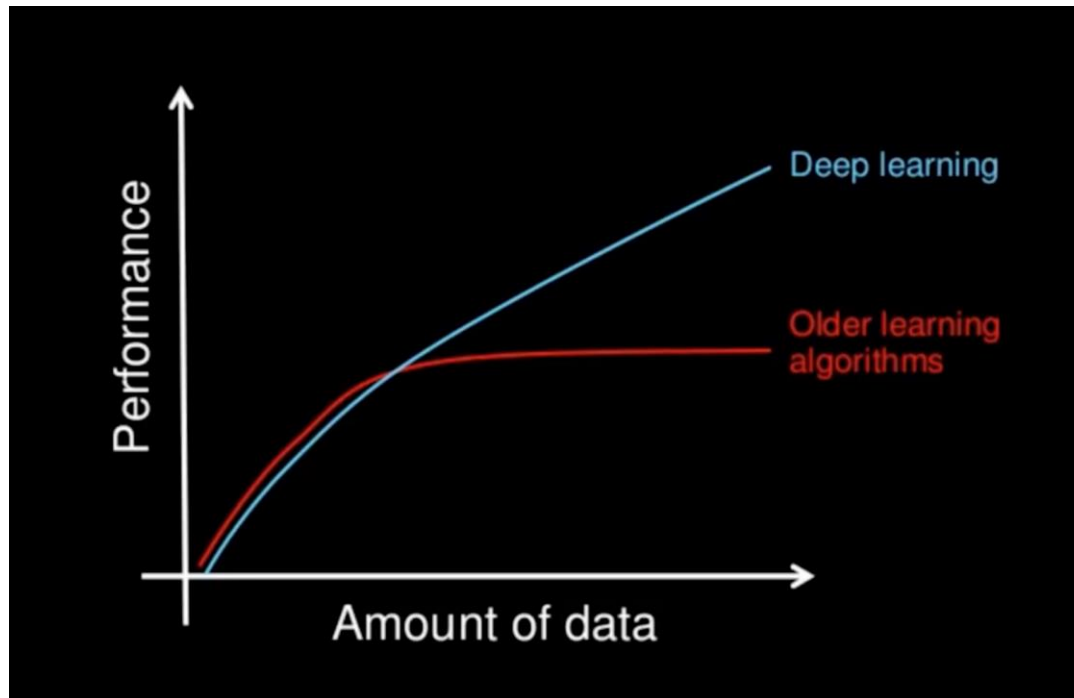
Breeding meets AI



Artificial Intelligence

The power

Unravel and predict complex relations and patterns in data

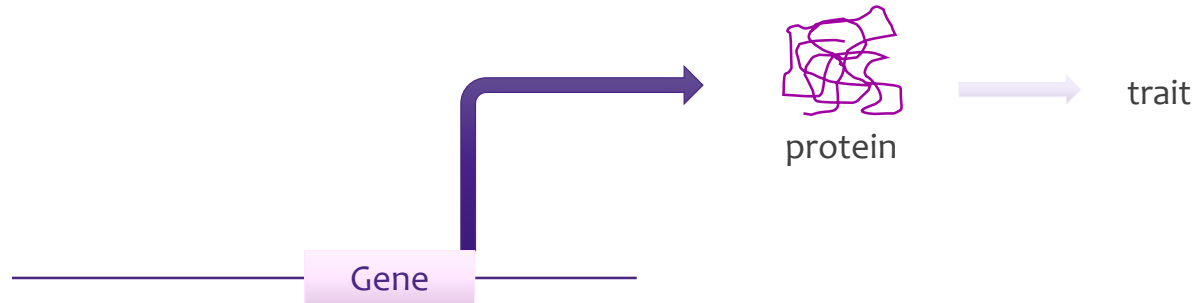


Enabled by compute power (GPUs, TPUs Googles processor optimized for deep learning) and Big Data

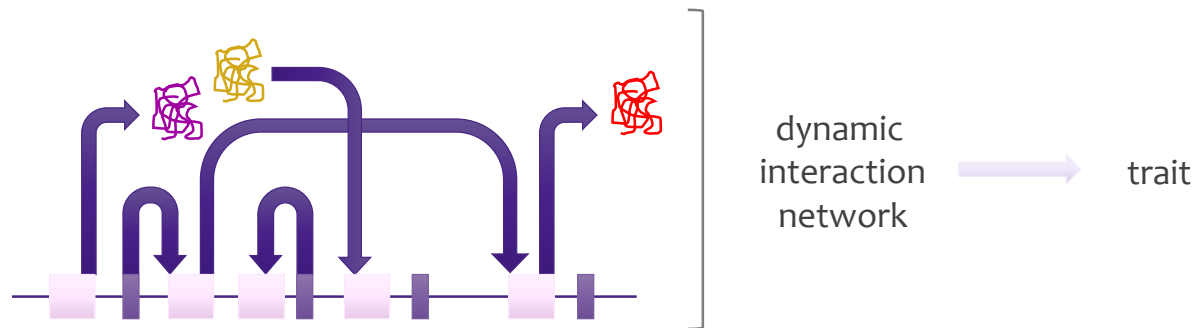
Trait complexity

The molecular genetic basis

1. Simple

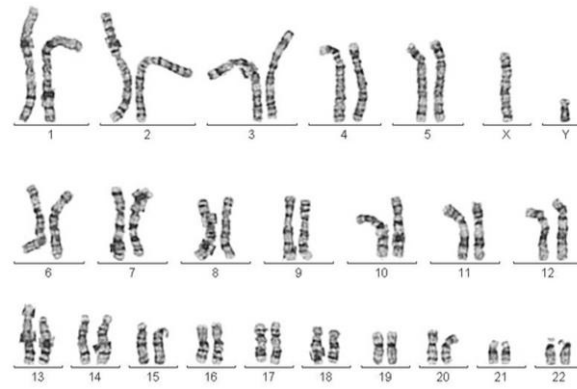
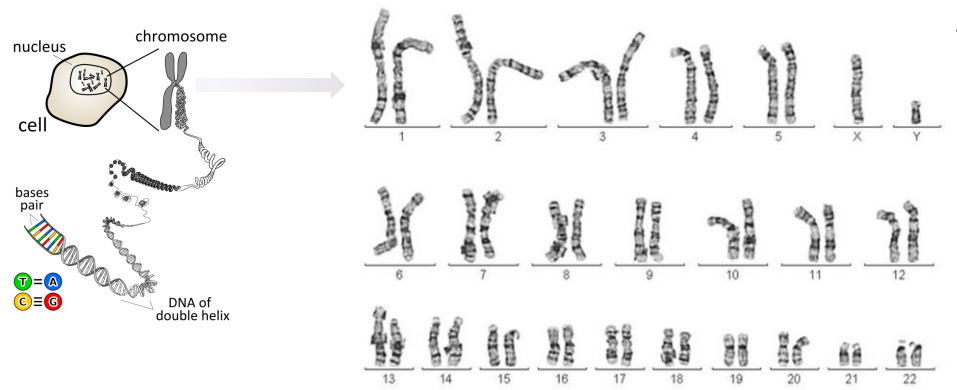


2. Complex



Genes and genomes

Human genome and a plant genome

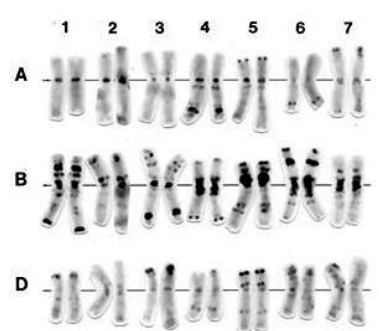


Human:

23 Chromosome pairs

3×10^9 base pairs

~20,000 genes



Bread Wheat:

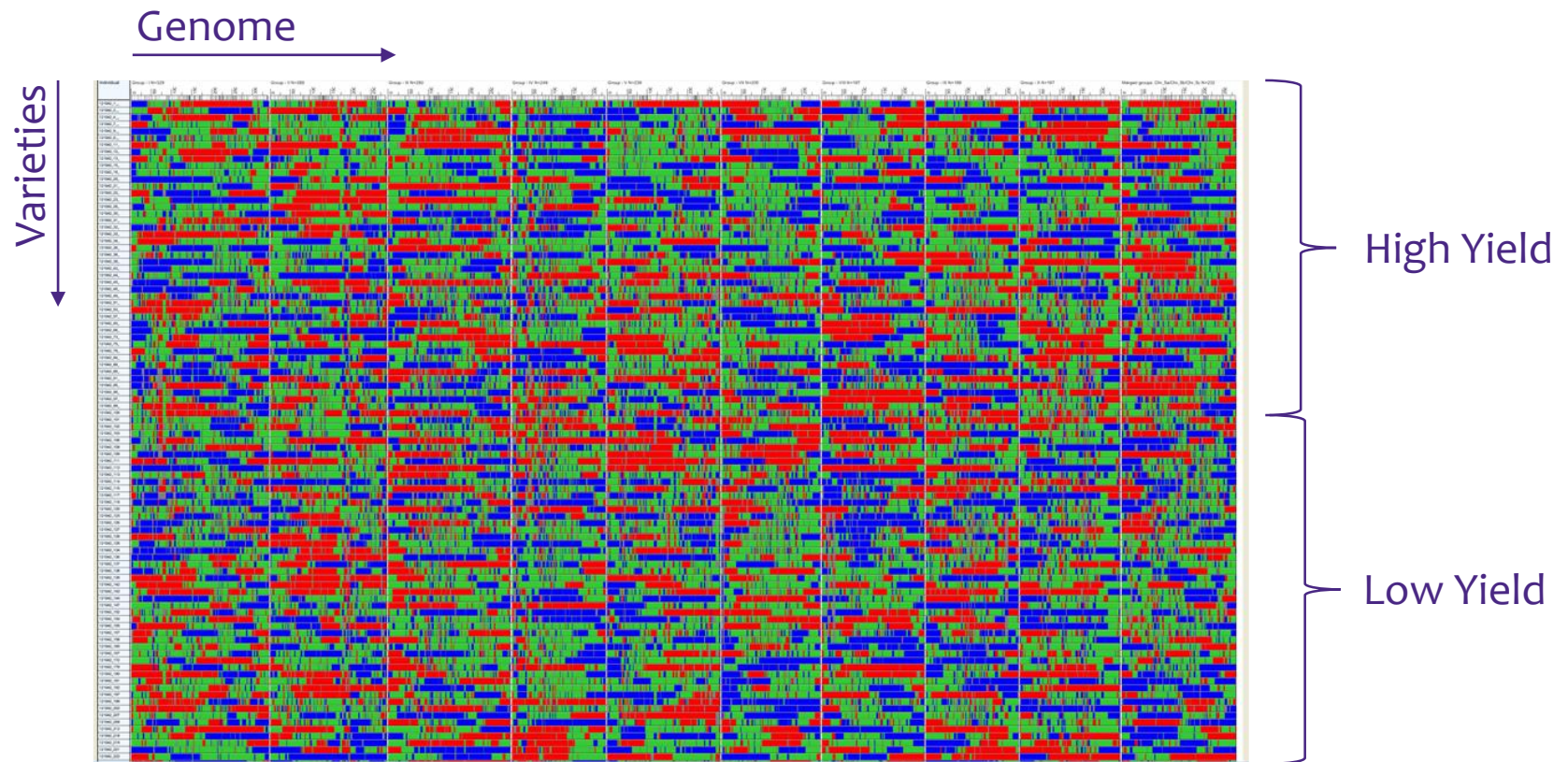
21 Chromosome pairs

17×10^9 base pairs

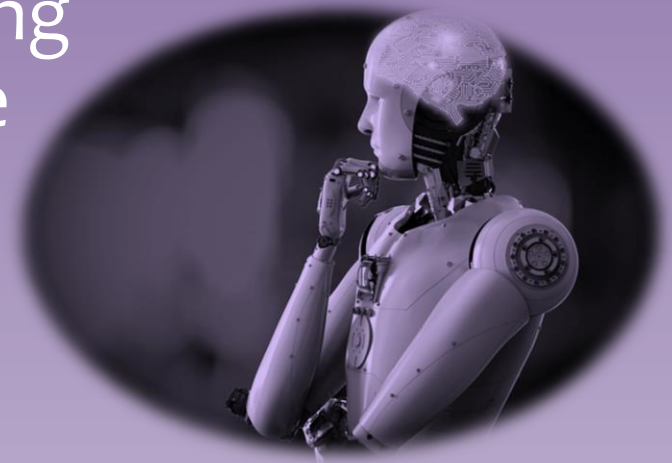
~95,000 genes

Trait prediction

What do I need?

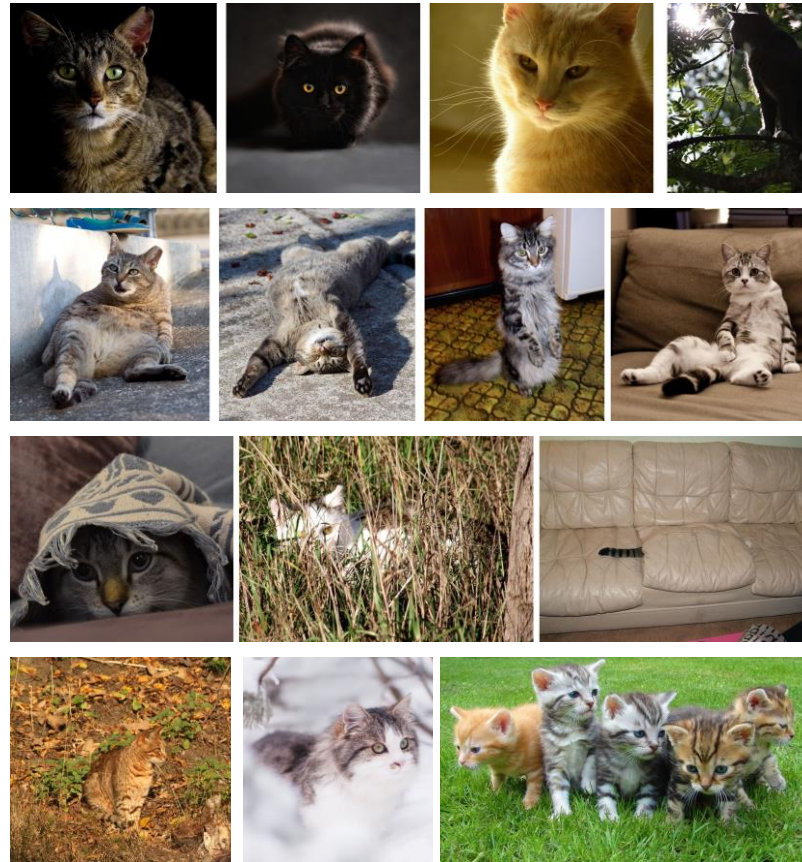


Deep Learning Machine Learning Artificial Intelligence



Deep Learning

Big data



Light

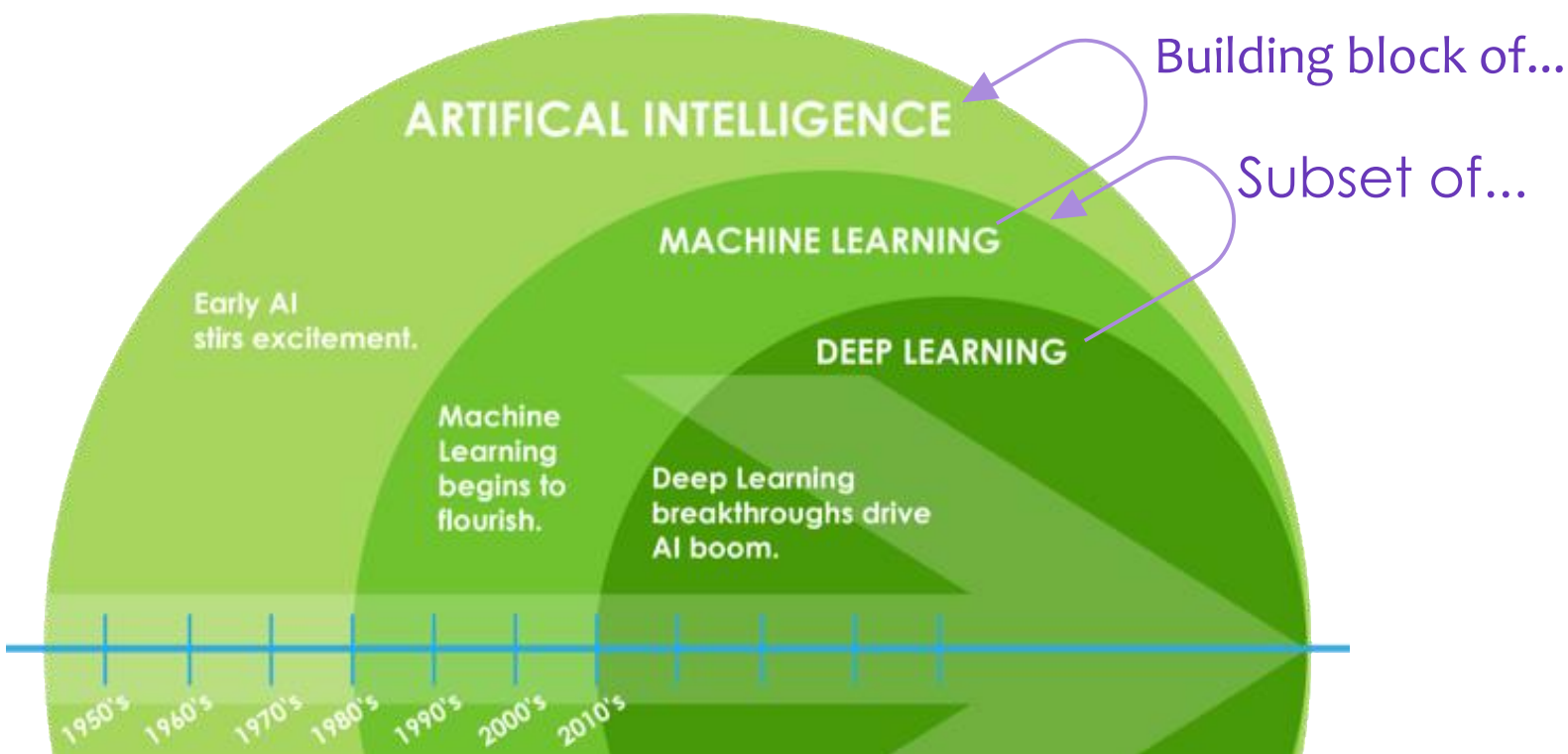
Distortion

Hiding

Variation

Artificial Intelligence

Connections



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



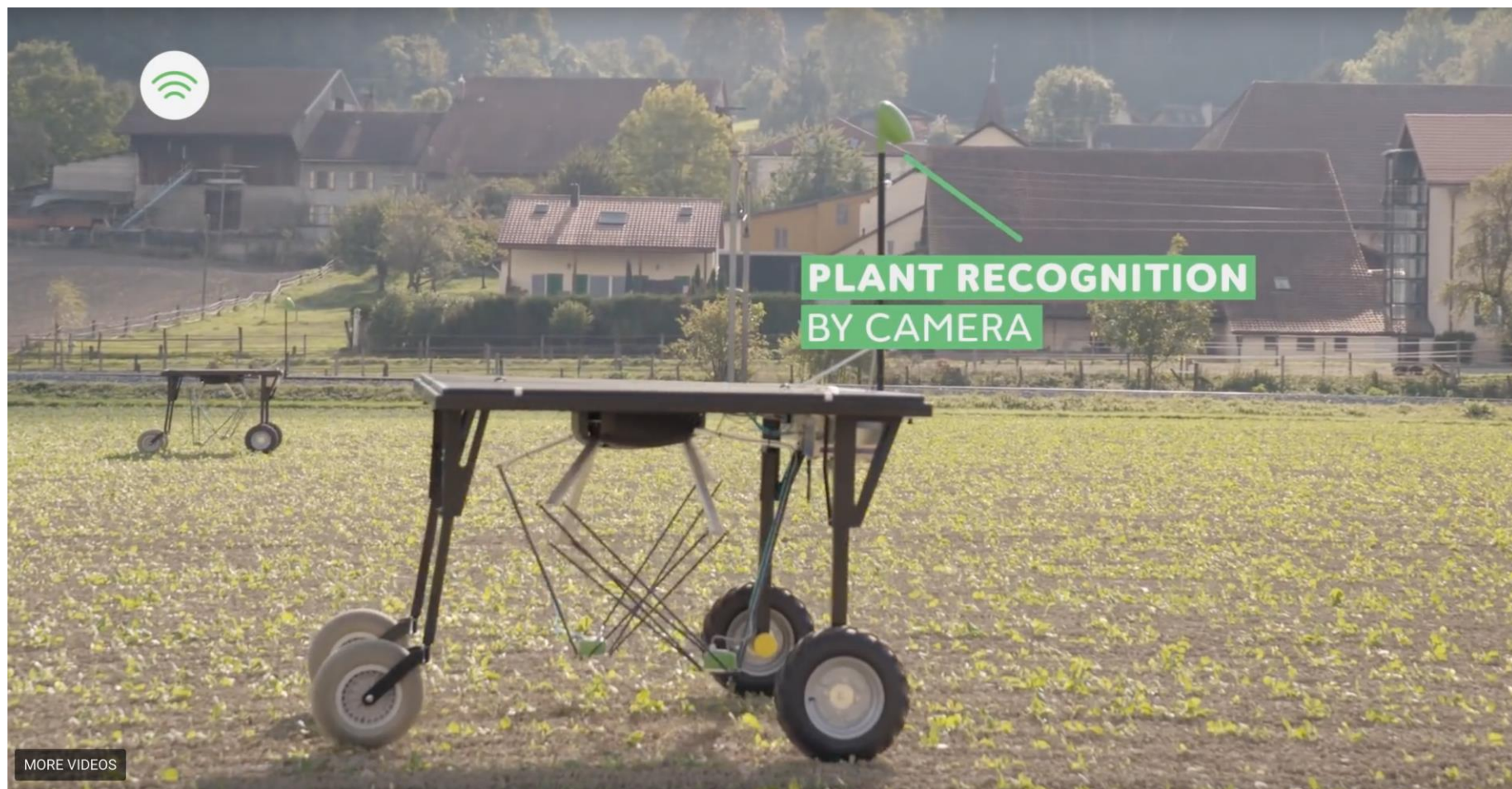
Nonlinear classification

Ambiguity



Deep learning

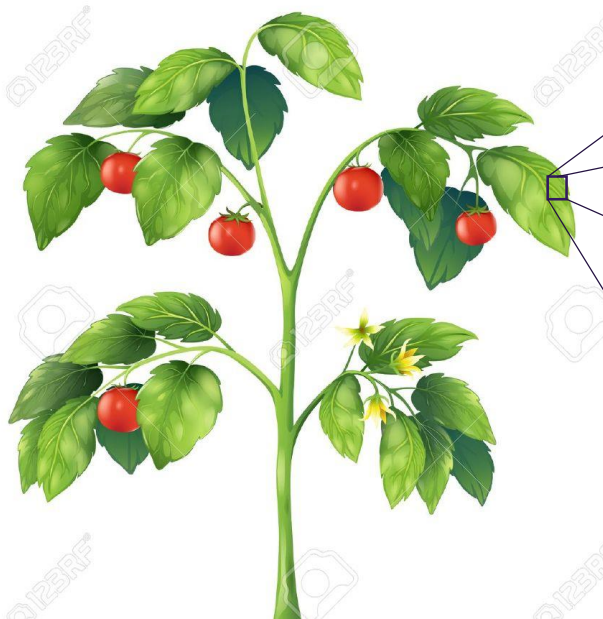
In the “field”



Digital phenotyping

Semantic gap

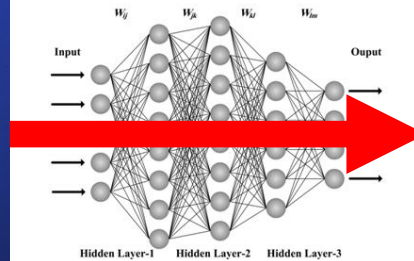
What we see



What the computer 'sees'

12	91	87	218	46	104	175	74	60	107	230	13
128	112	167	217	15	101	154	58	177	0	31	98
244	220	228	210	244	74	41	8	111	149	196	98
109	125	17	233	227	95	201	14	114	200	61	81
155	45	172	199	131	70	184	30	244	104	74	28
101	41	97	8	42	52	81	7	248	61	139	37
111	208	187	10	144	100	226	24	37	233	156	24
90	117	78	162	248	44	18	102	223	31	142	95
122	150	44	13	133	160	57	105	208	165	25	74
83	26	83	51	40	76	76	12	234	34	86	89
237	30	176	77	125	73	1	88	213	137	202	56
74	111	26	105	5	88	110	145	151	188	164	17
163	70	11	150	201	119	195	185	200	143	135	

Automatic image analysis



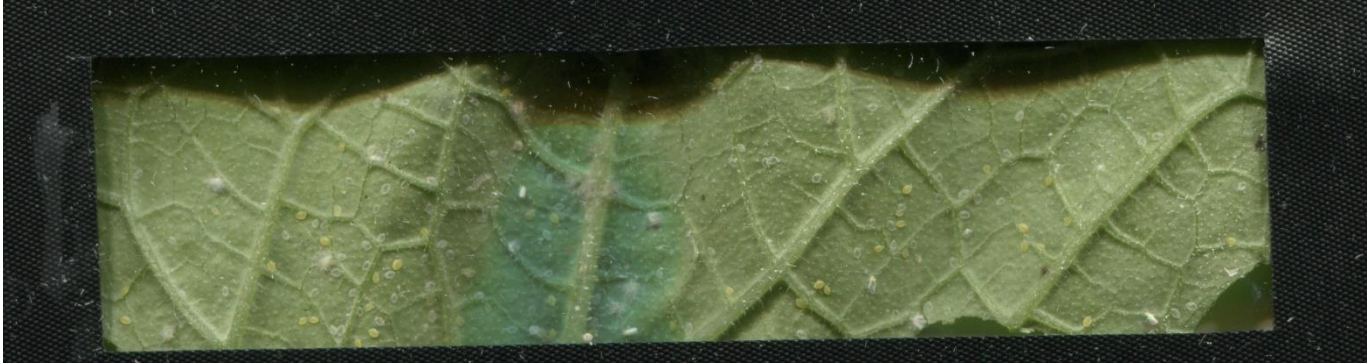
Automatic image analysis

Application

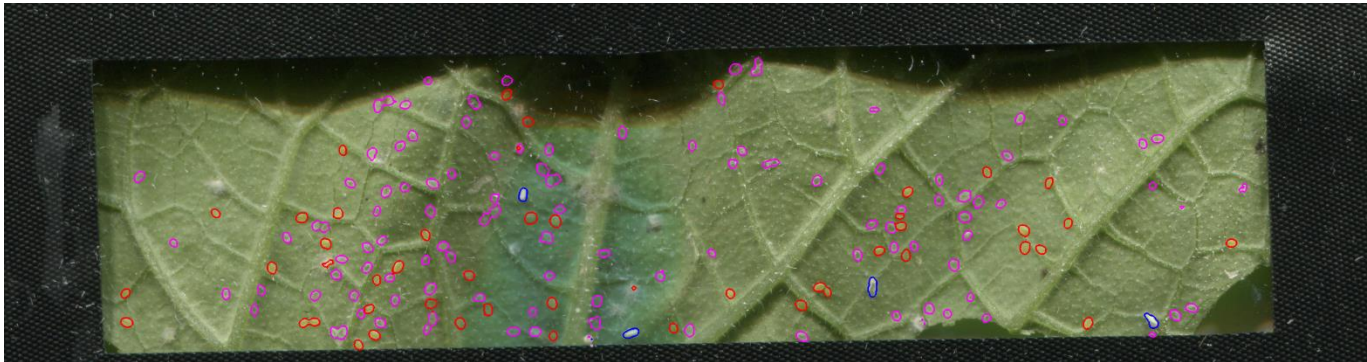


Insect detection

Whiteflies



Manual
Scoring



ALARM!
Apply
biological control

Machine Learning: 70% accurate
Deep Learning: Surpass human

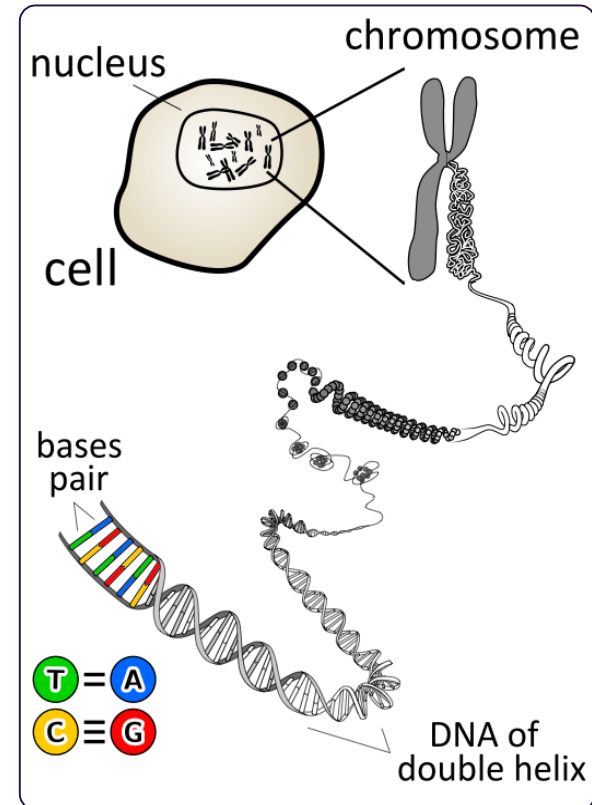
New, unseen applications



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

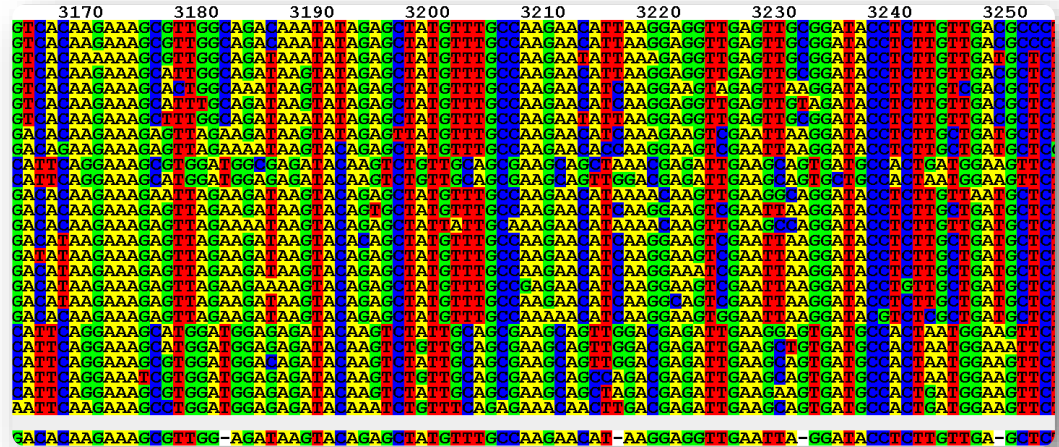
Variation is encoded in the DNA



Deep Learning

Variation recognition





Complex relations between genotype and phenotype

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

CROPPEDIA

search in 120 reference(s) [advanced search options](#)

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CROPEDIA

Sample Groups
New Group

RNAseq Analysis

Alphabetically
Cluster
Rank by Sum
Rank by Variance

Column Order
Alphabetically
Cluster
Rank by Sum
Rank by Variance

Row
Search

Opacity Slider

Top rows sum: all
Top rows variance: all

Matrix Values

CROPPEDIA

accession info
predicted localization
integrins results
blast annotations
go accessions
transcription factor binding sites
phylogenetic tree
protein clustering

BIGOSGAD3276Z
ASDHdSLV_937L_cnv10

genome parameters
update database
view annotation

accession info

accession	B07YGA02C76Z
name	
location	937L_cnv10.B07YGA02C76Z.B07J20T
taxonomy ID	39946
reference	ASDHdSLV (<i>Dryina sativa</i> Imbra Group cultivar IS-11) (price), assembly ASDHdSLV

Predicted localization

cytoplasmic	0.53
nucleus	0.07
peroxisomal	0.09
mitochondrial	0.01
extracellular	0
plasma membrane	0

Integrins results

Integrin accession	visualisation	contributing signature	contributing signature description	contributing signature library
PF00102A	<div style="width: 100%;"></div>	P510D95	PLAT	PRODIG_PROFILES
no IRS	<div style="width: 100%;"></div>	P1HE317B.SFG	SUBFAMILY NOT NAMED	PANTHER

[illegible]

25

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