# A.I. Based Modeling in Seed Imaging Applications

*ISTA Annual Meeting 2023,*
*Mathematical Modeling in Seed Testing*
*Verona, Italy*

***Kyle T. Peterson, Ph.D.***
Bayer Crop Science, Innovation Science & Engineering


**May 31, 2023**

# Agenda

- Introduction
- Background
- Imaging technology for seed applications
- Image analysis
- How AI is used to automate image analysis
- Overview of AI methods for image analysis
- How Bayer is approaching imaging and AI to create more robust assays etc..
- Benefits of AI compared to traditional Imaging applications
- Q & A

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# Kyle T. Peterson, Ph.D.

***Technologist | Researcher | AI and Imaging Expert***

## Professional Experience

- *Senior Imaging Data Scientist - Bayer*
  - 2019 - present
- *Sr. Imaging Engineer - Monsanto*
  - 2018-2019

Bayer CropScience

## Ph.D. in Integrated & Applied Sciences

- Saint Louis University
- Imaging Science and Artificial Intelligence

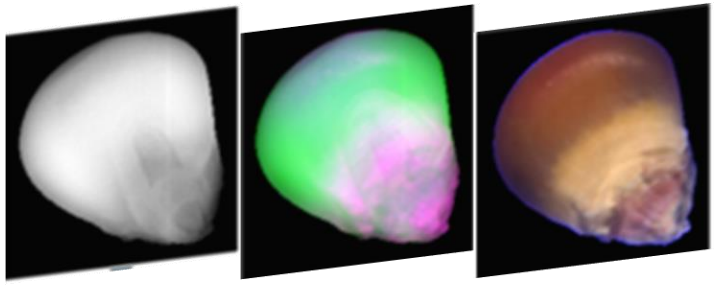
SAINT LOUIS UNIVERSITY. EST. 1818

## Professional Memberships

- *Visiting Science Fellow*, Saint Louis University
- *Executive Advisory Board Member*, University of Missouri, Institute for Data Science & Informatics
- *Venture Innovation Team*, Imaging and AI Expert, Bayer

## Technical Expertise

- *Imaging*
  - *Optical, Hyperspectral, Fluorescence, Thermal*
  - *X-ray, CT and MRI*
- *Artificial Intelligence*
  - *Computer Vision, Deep learning, Neural Networks*
  - *Data fusion*
  - *Chemometrics*



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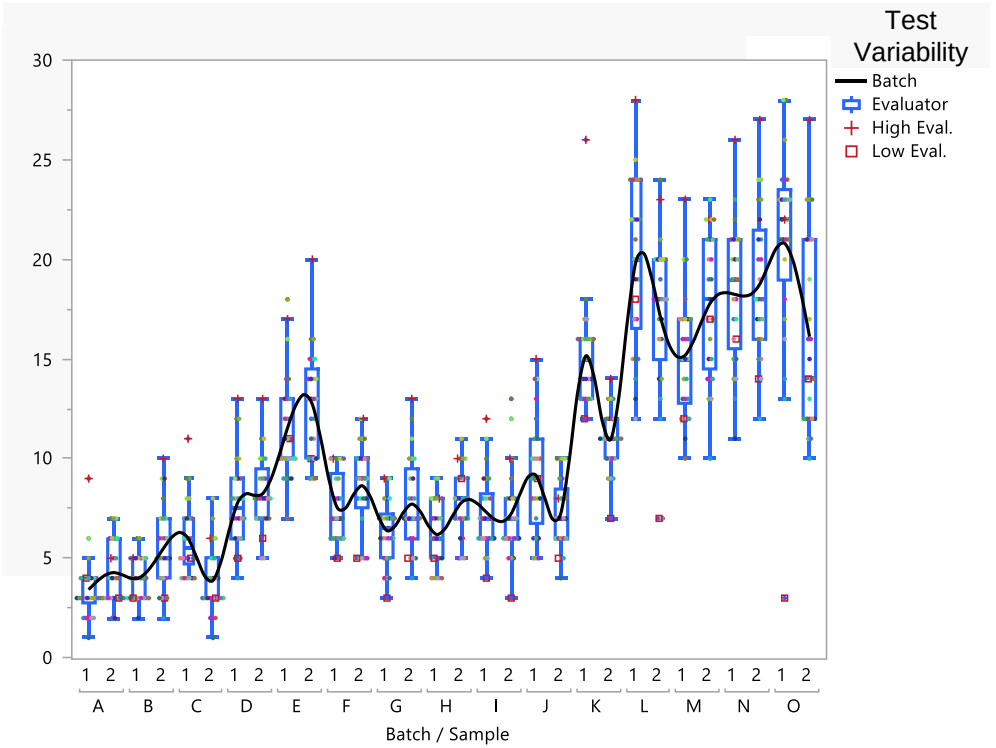
# The need for modernizing seed testing

*A need and an opportunity*

Issues with repeatability, standardization across labs, human subjectivity, training, time, operations, digitization, etc.

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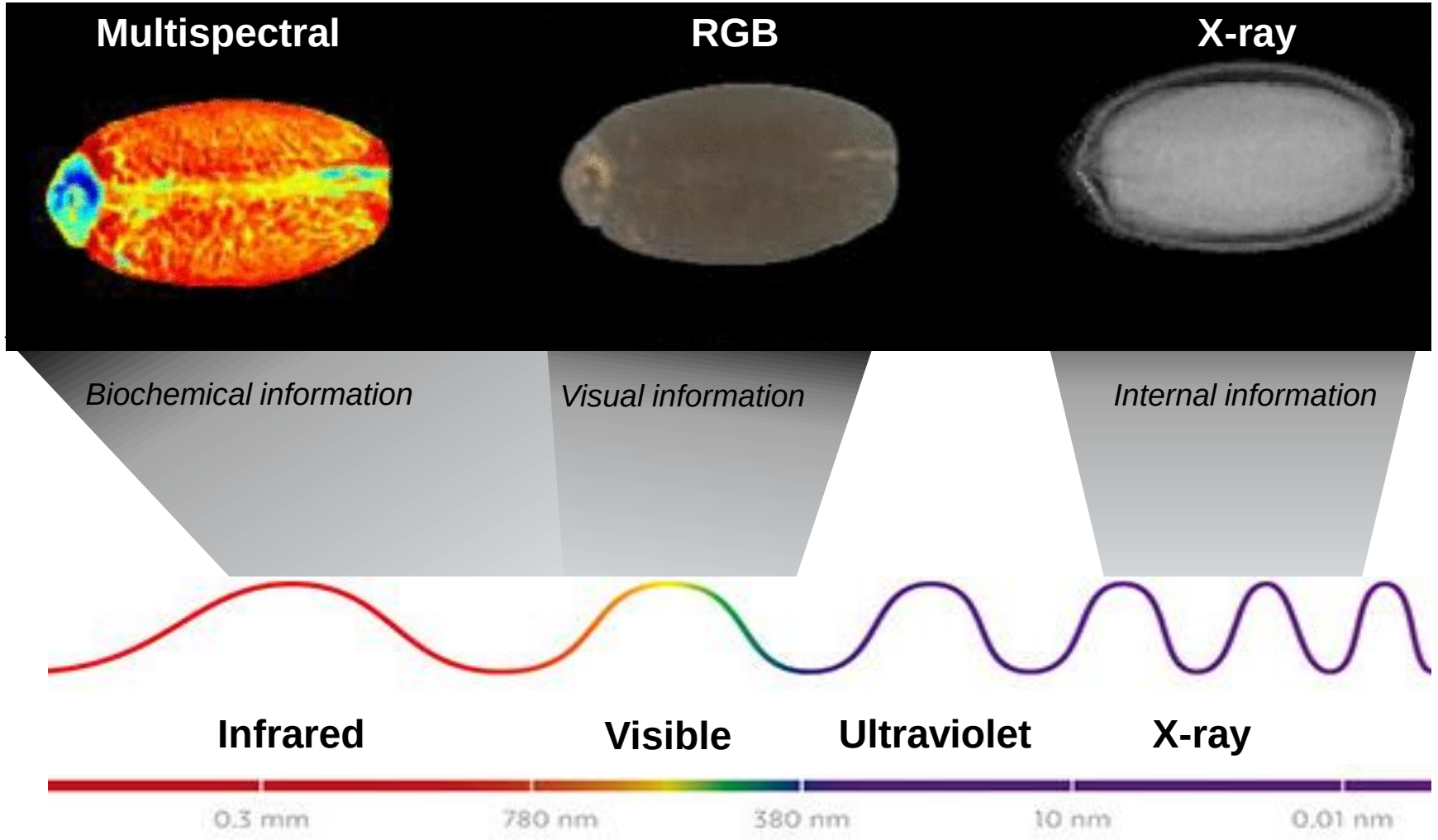
# Imaging as a tool for seed testing

*Seeing beyond the visible*

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# Automated image analysis

*Improving the testing process*

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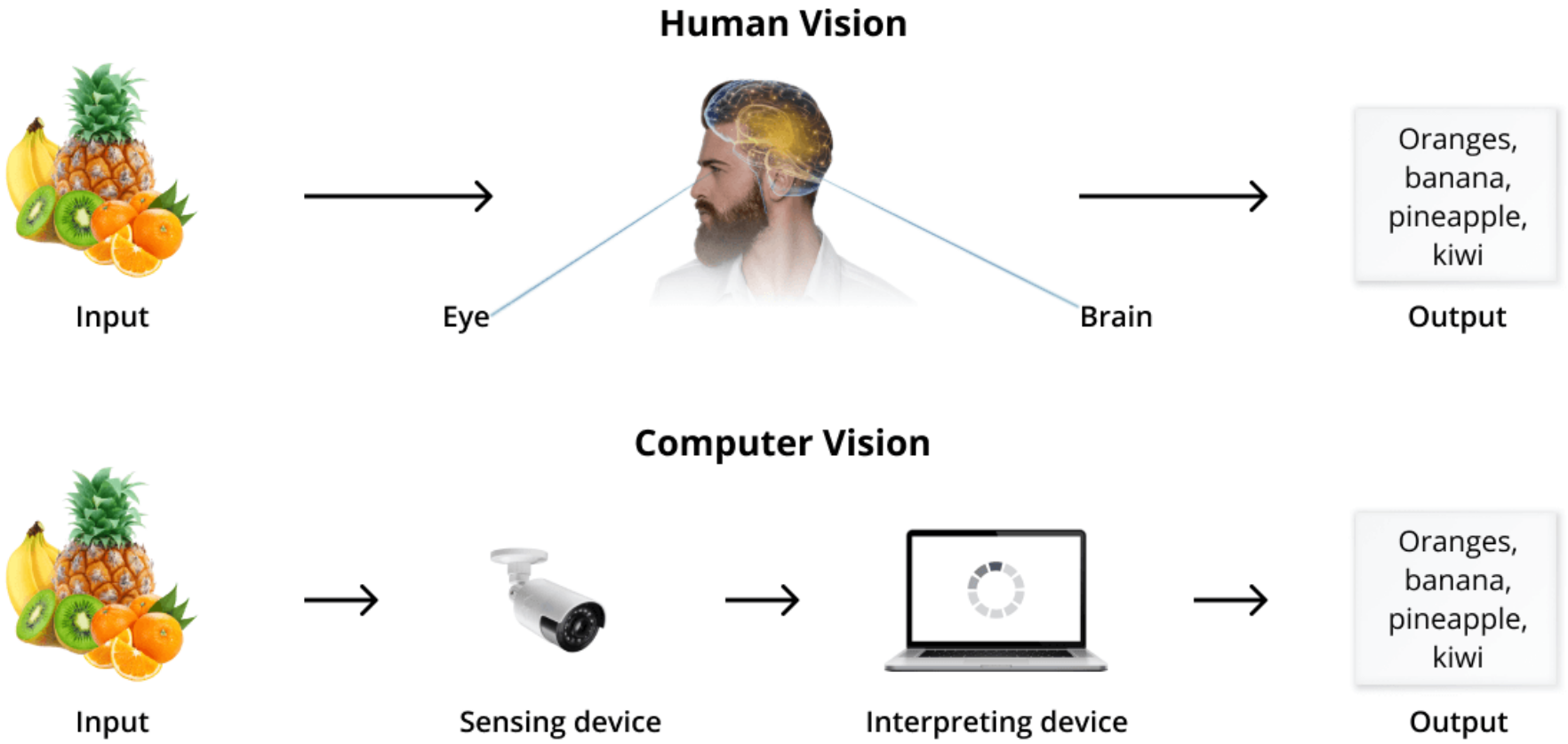
# Computer Vision

*The science of extracting meaningful information from images*

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# Computer Vision Techniques

**Semantic Segmentation**

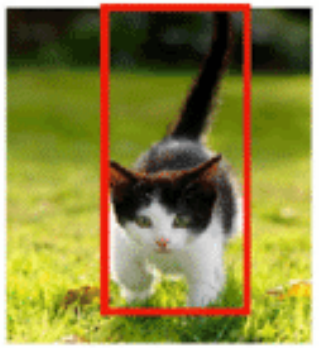
CAT GRASS TREE

**Pixels**

**Classification**

CAT

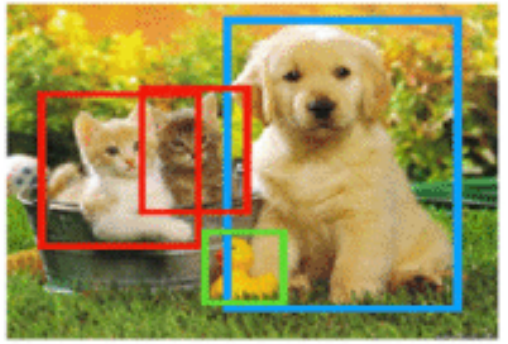
**Classification + Localization**



CAT

**Single Object**

**Object Detection**



CAT DOG DUCK

**Instance Segmentation**

CAT CAT DOG DUCK

**Multiple Objects**

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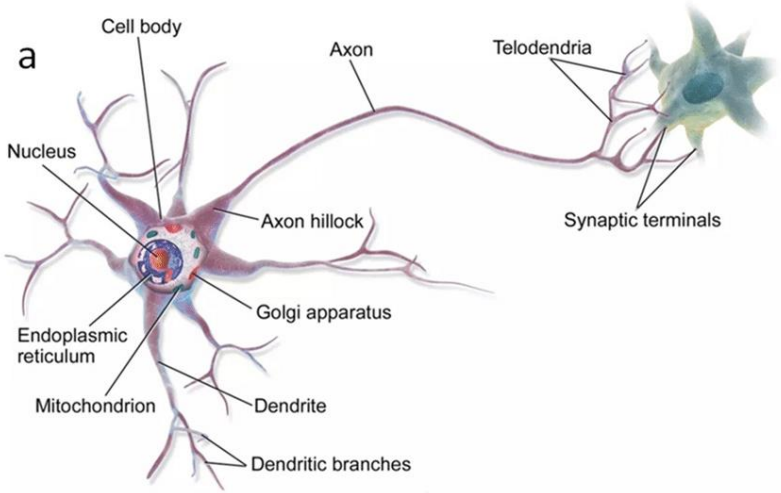
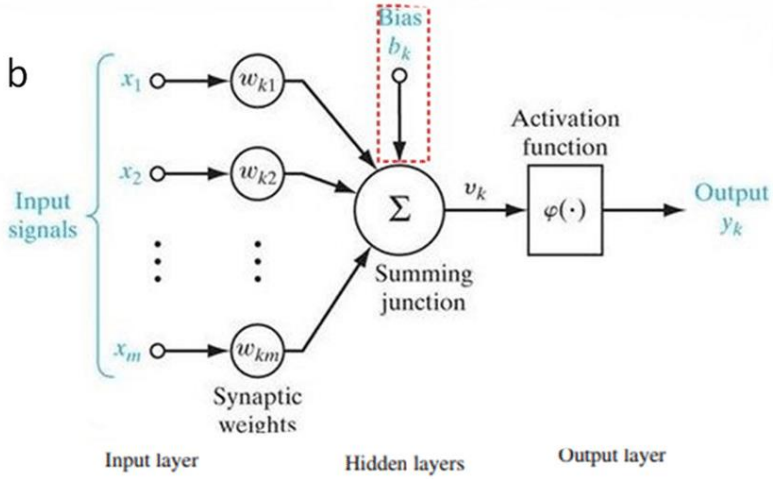
# Inspiration from biology

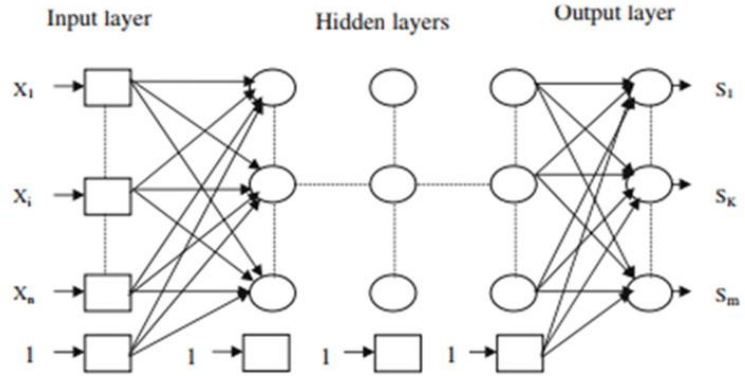
## Human neuron




## Artificial neuron




## Artificial neural network

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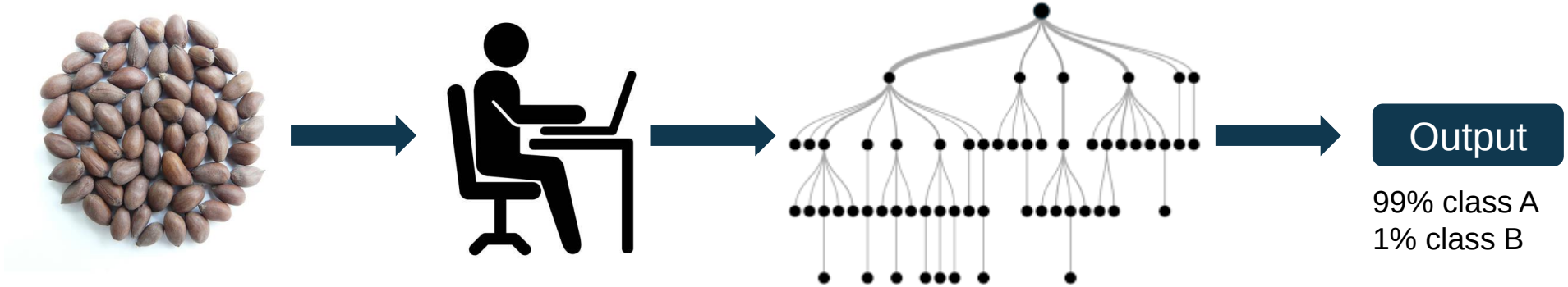
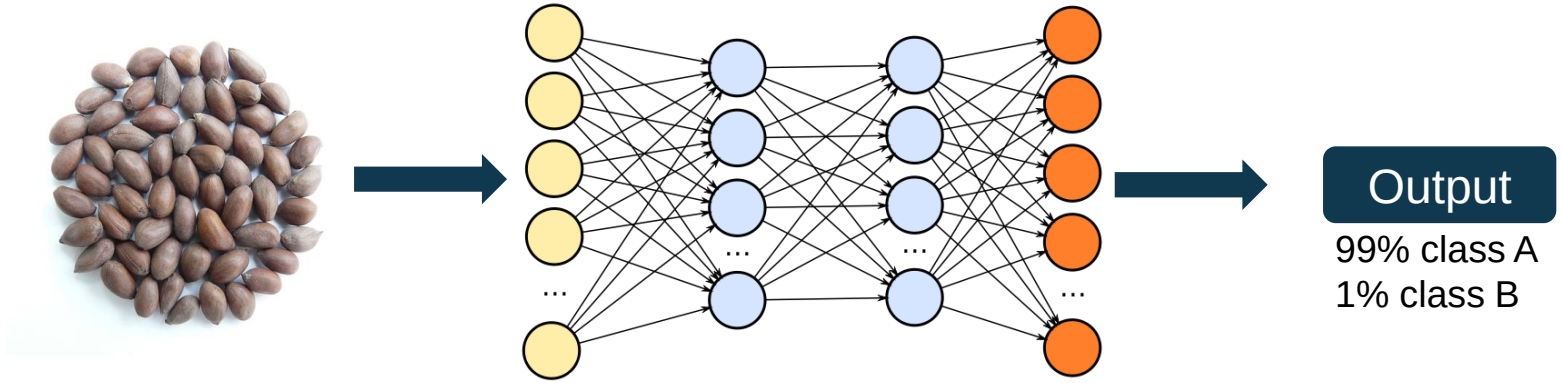
# The science of image analysis

*Traditional machine learning vs. deep learning*




*Traditional machine learning uses hand-crafted features, which is tedious and costly to develop.*




*Deep learning "learns" hierarchical representations from the data itself, and scale with more data.*

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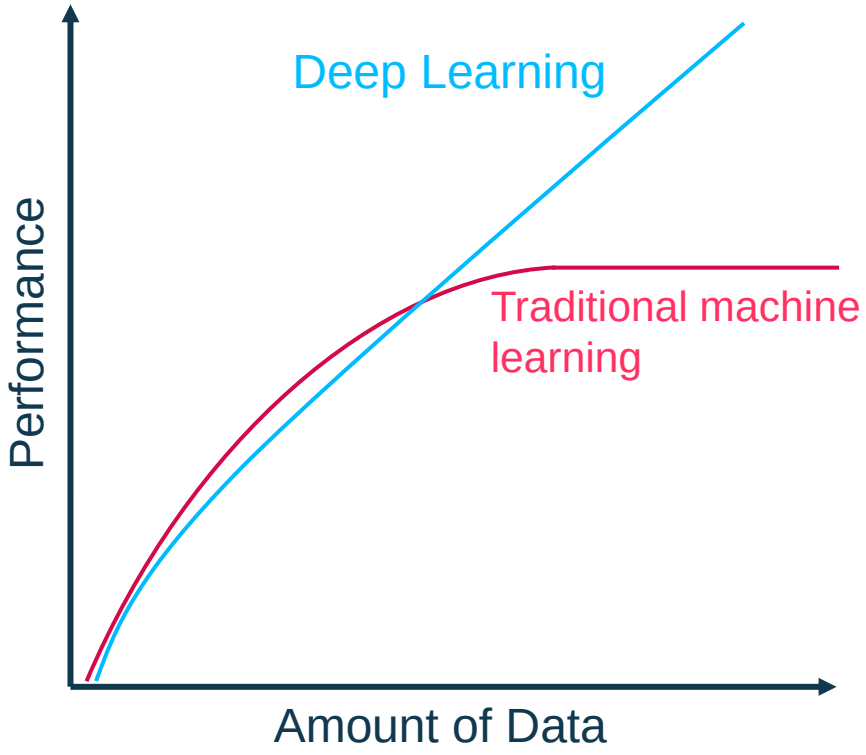
# Benefits of deep learning




- No need for feature engineering
- Transferability across multiple sites and locations
- Consistency and repeatability
- Linear and non-linear relationships
- Improved accuracy*

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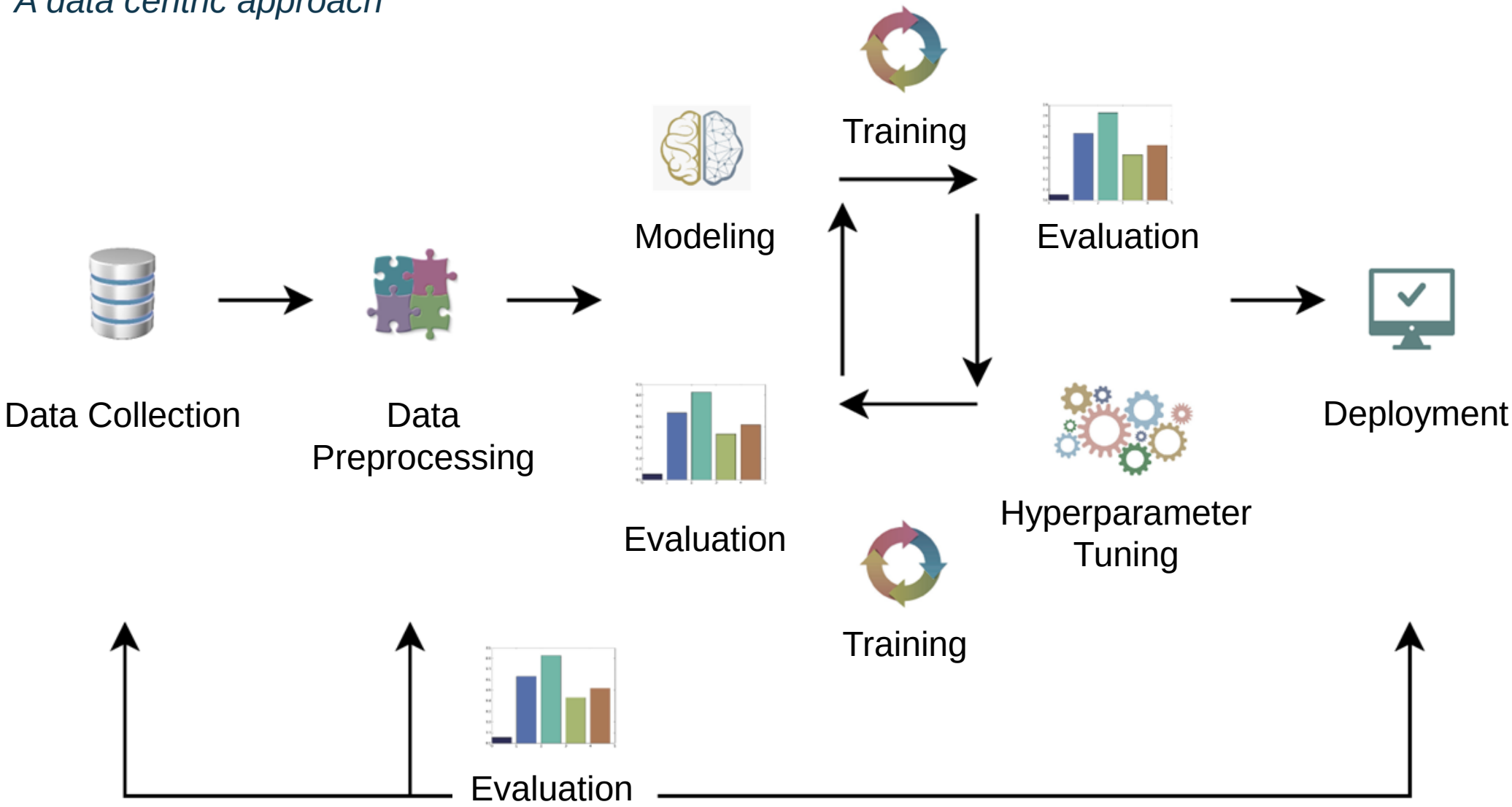
# Model development & training

*A data centric approach*

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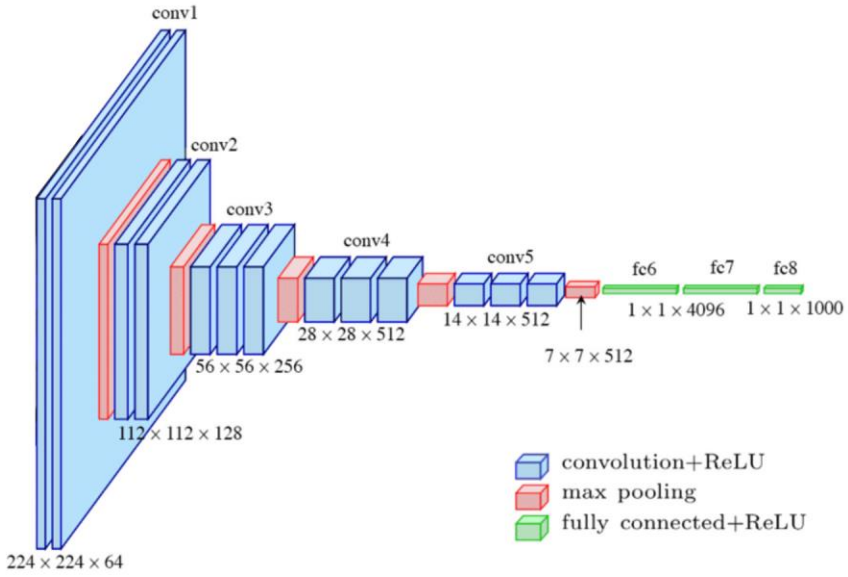
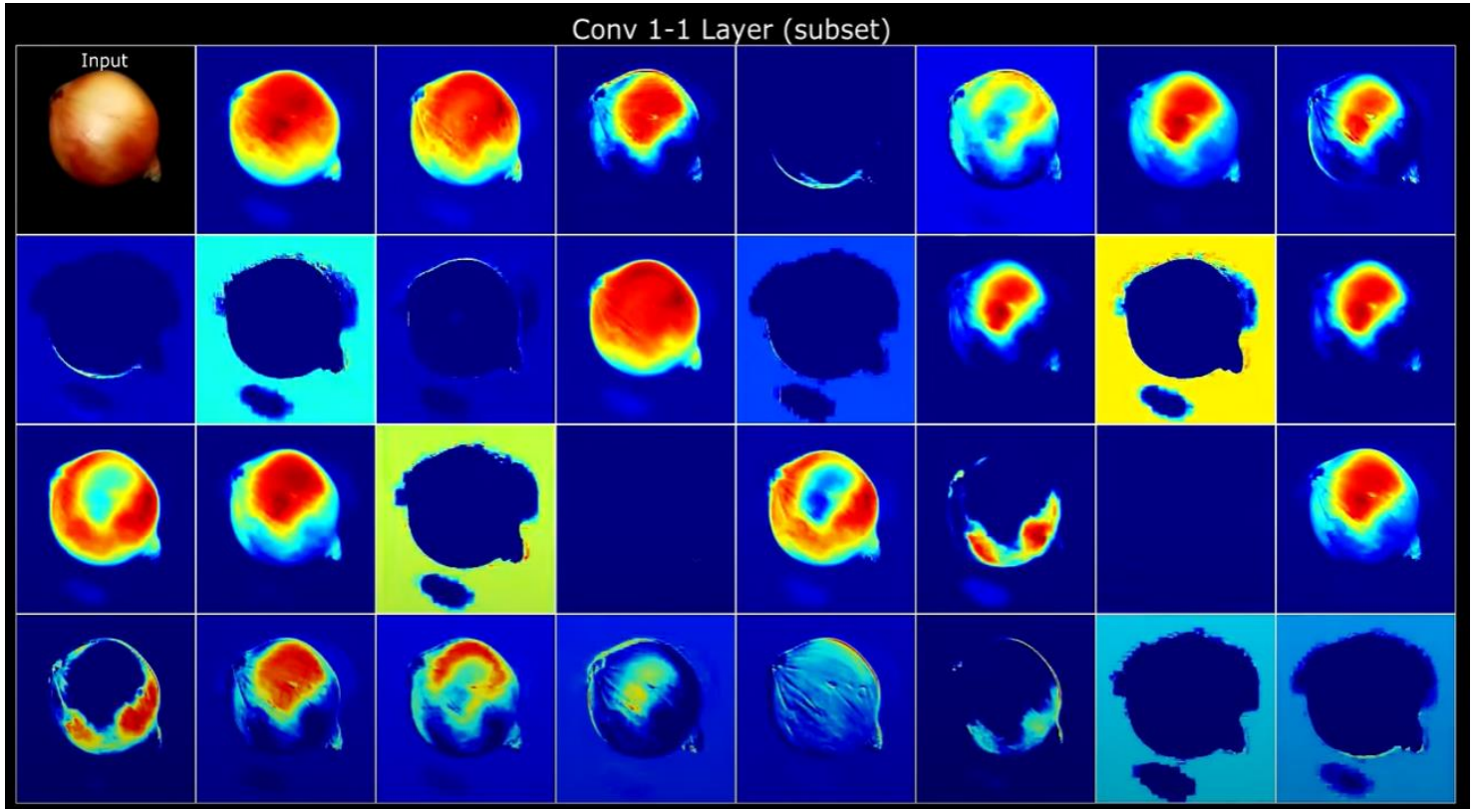
# Understanding models and their predictions




Class Activation Mapping

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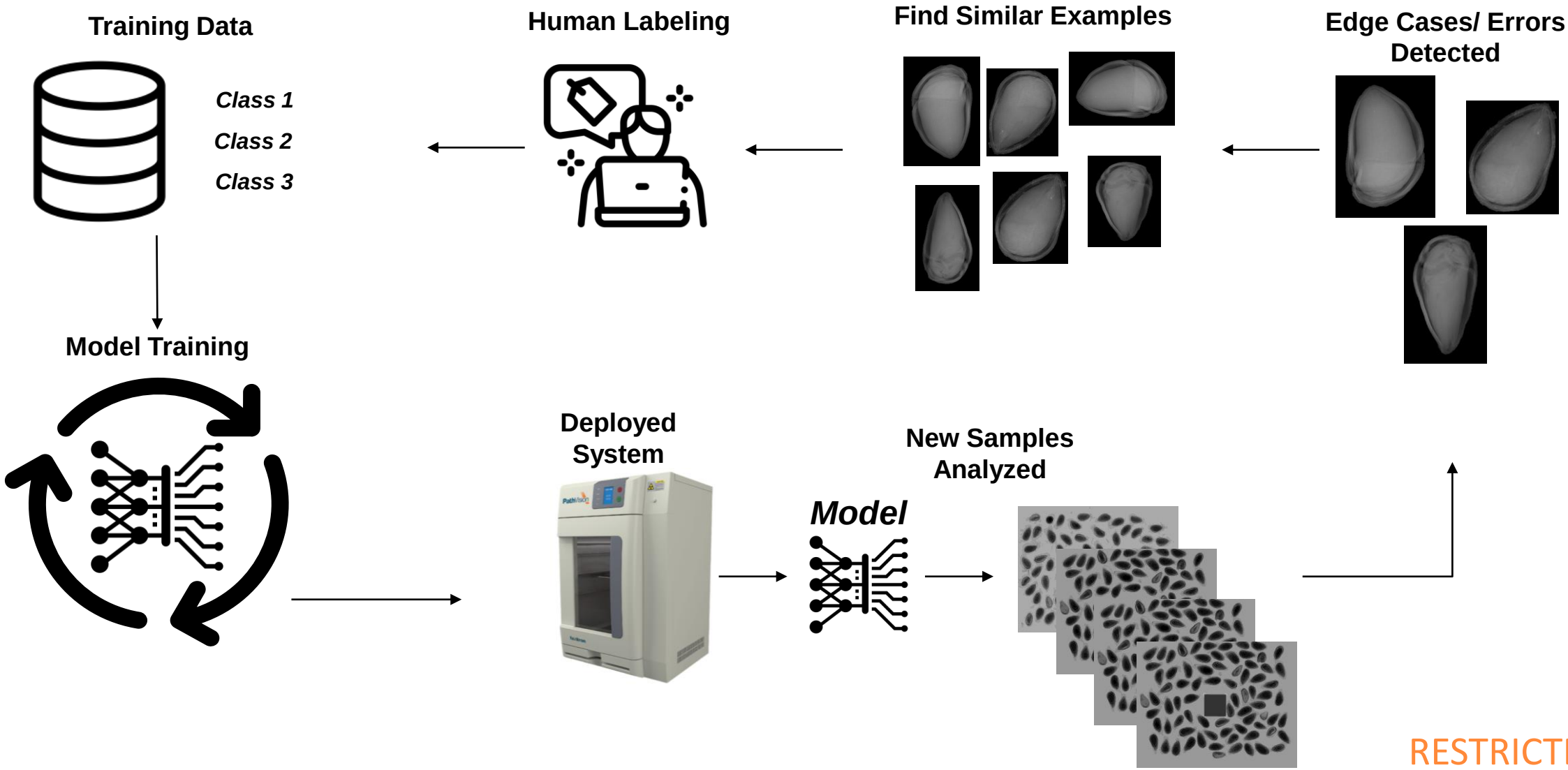
# How can we maintain a model in real world use?

*Creating a continuous learning cycle*

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# Bayer's journey to modernize seed testing

*Paving the way for the next generation of seed testing*

### *A.I. + Imaging = Opportunity*

**Technology in both imaging and algorithms to process images are currently sufficient to meet many of the seed industries needs for modernization**

### *Connecting technology & seed testing*

**Bridging the gap between technical experts and end-users.**

### *Education*

**Embracing new technologies and educating seed testing experts.**

### *Accelerating change*

**Working together with seed testing experts to develop and deliver impactful models and technology to improve operations.**

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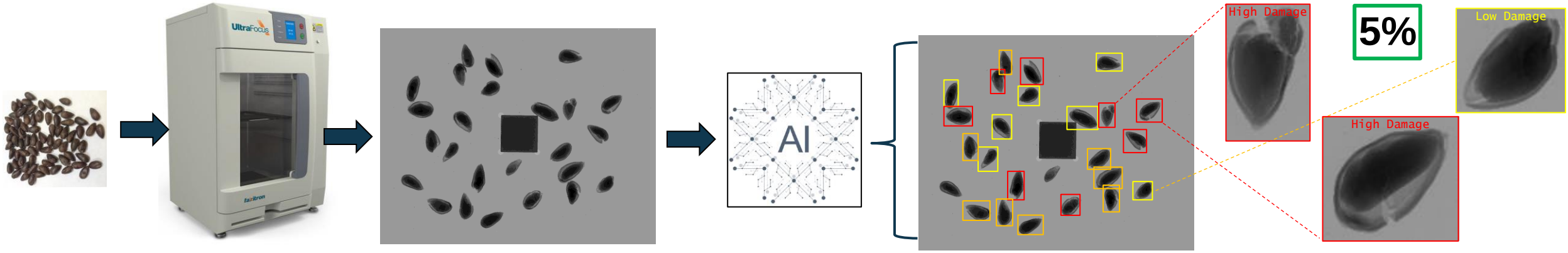
# Damage Detection Using X-ray

## *Visual Mechanical Damage Detection*

## *X-ray Damage Detection*

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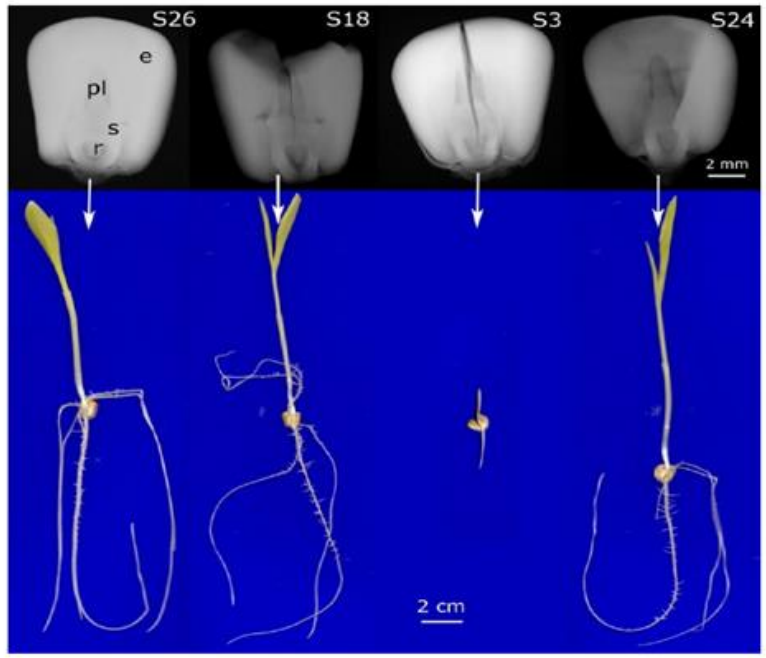
# Seed Crack Detection Using X-ray

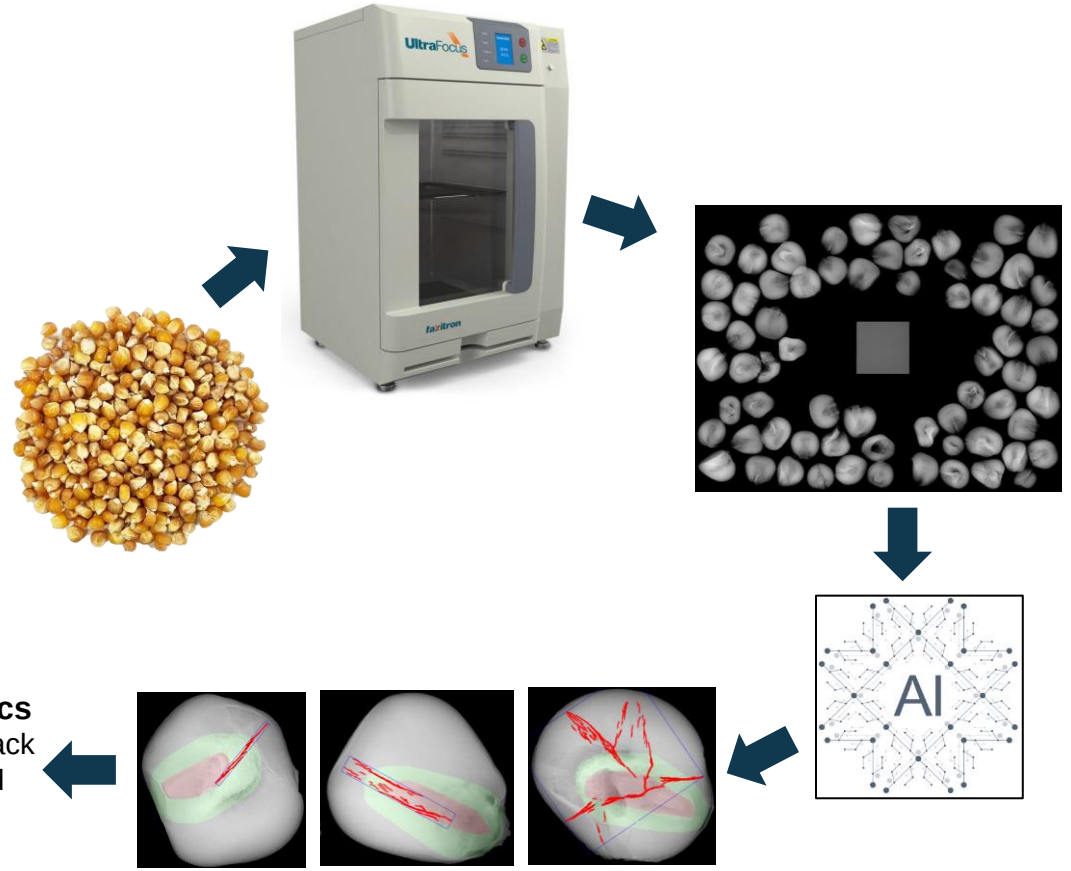
## Severe cracking greatly impacts seed quality




Risk of poor germination, health and vigor

(Gomes-Junior et.al., 2019)

## X-ray Crack Detection & Scoring




**Summary Statistics**
- XX% severe crack
- XX% uncracked

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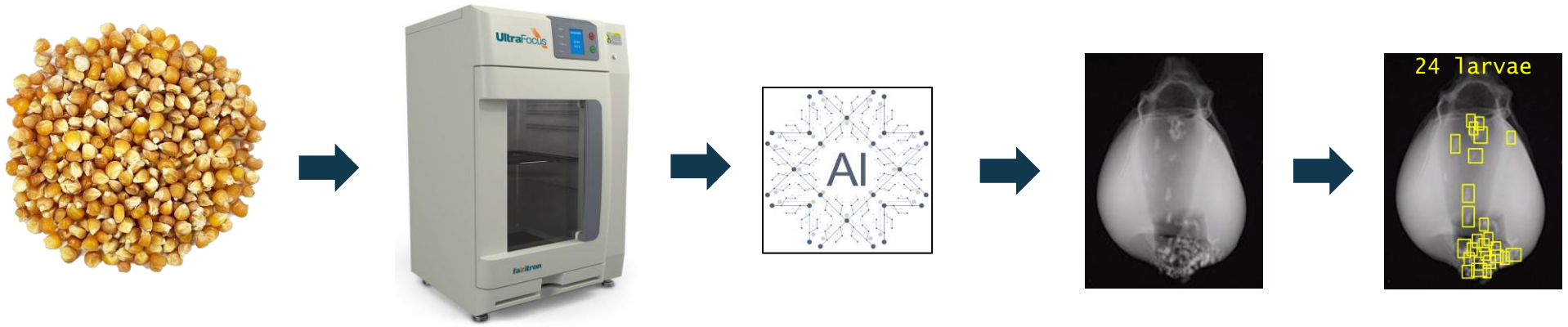
# Insect Detection Using X-ray

***Manual Test Protocol***

***Imaging + AI Test Protocol***

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# A.I. + Imaging: enabling next generation seed testing

**Enhanced decision making via automated AI models**

*Improving consistency and speed of testing*

**Improved testing methodology**

*Imaging systems that can see beyond the human eye paired with AI that is >= human interpretation*

**Creating testing consistency**

*Eliminating human subjectivity*

**Enabling time reduction in testing**

**Creating consistency in testing**

**Improving detection accuracy**

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# Current Challenges to Implementation

- Existing pre-trained models often used for transfer learning not well suited for seed imaging tasks
- Almost zero publicly available datasets to supplement internal data
- Specificity and sensitivity of many seed tests are high
  - 99% accuracy or greater
  - Zero tolerance categories
- Trying to replicate human inspection flawed

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# The Future of Seed Testing

***Imaging + A.I. to enable industry wide improvements in testing***

*Overcoming common pitfalls with imaging-based assays*

Set new standards in testing

Deliver world-class **innovation**

Pioneer **digital** transformation

# Thank you!

*For more information, please reach out via email.*

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