

# ARTIFICIAL INTELLIGENCE APPLICATIONS IN BIOMEDICAL ENGINEERING

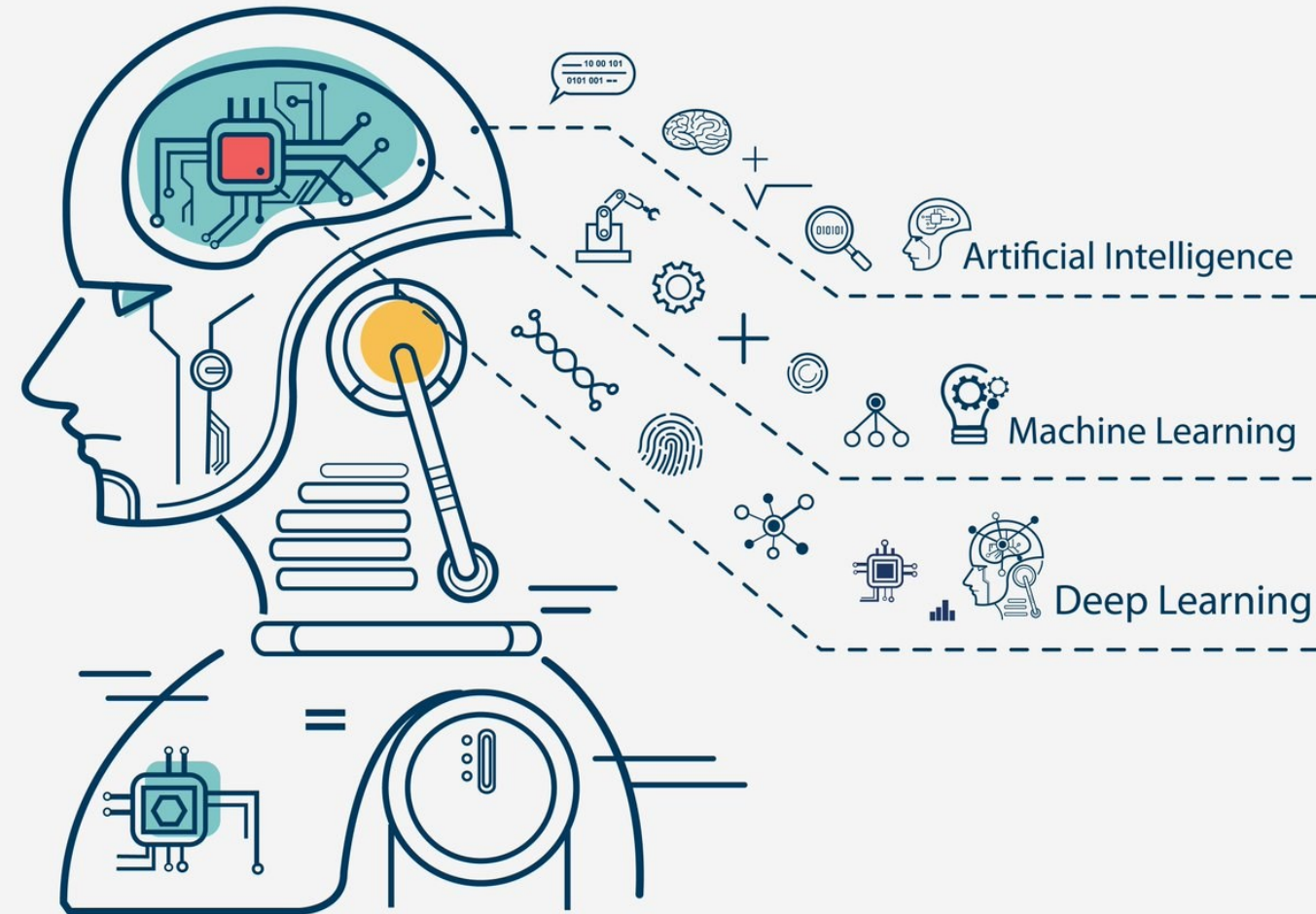
Prof. Yasser Mostafa Kadah

King Abdulaziz University, Jeddah

# Seminar Topics

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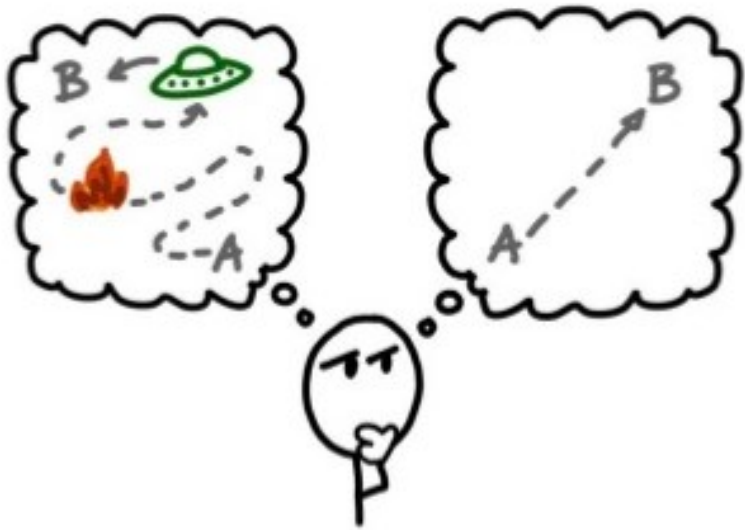
- Preamble
- Basic Definition of AI
- Technologies and Tools
- Applications in Healthcare
- Unique Challenges
- Strengths
- Concluding Remarks
  
- Demo of Using AI in CAD



# Occam's Razor

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- The simplest explanation is usually the right one (William of Occam, 14<sup>th</sup> Century)



*"When faced with two equally good hypotheses, always choose the simpler."*

## CORE PRINCIPLES IN RESEARCH



### OCCAM'S RAZOR

"WHEN FACED WITH TWO POSSIBLE EXPLANATIONS, THE SIMPLER OF THE TWO IS THE ONE MOST LIKELY TO BE TRUE."



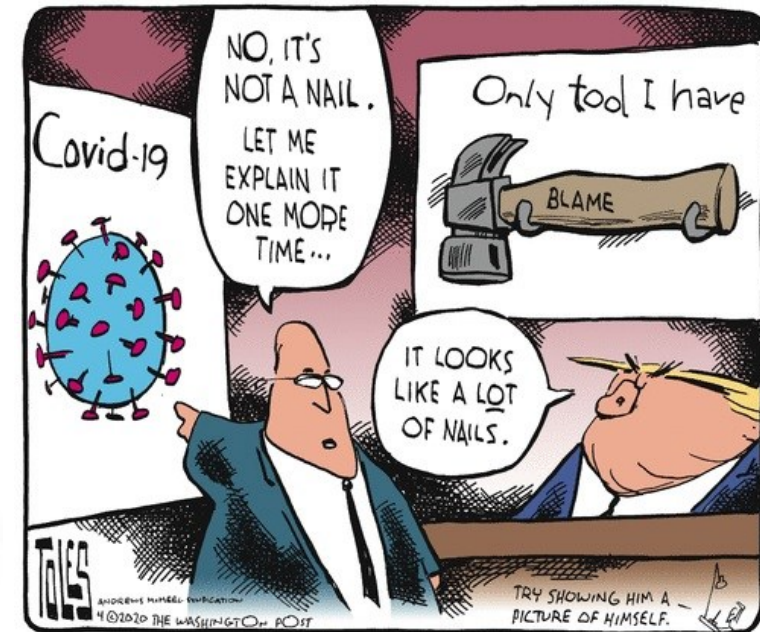
### OCCAM'S PROFESSOR

"WHEN FACED WITH TWO POSSIBLE WAYS OF DOING SOMETHING, THE MORE COMPLICATED ONE IS THE ONE YOUR PROFESSOR WILL MOST LIKELY ASK YOU TO DO."

# Law of the Instrument

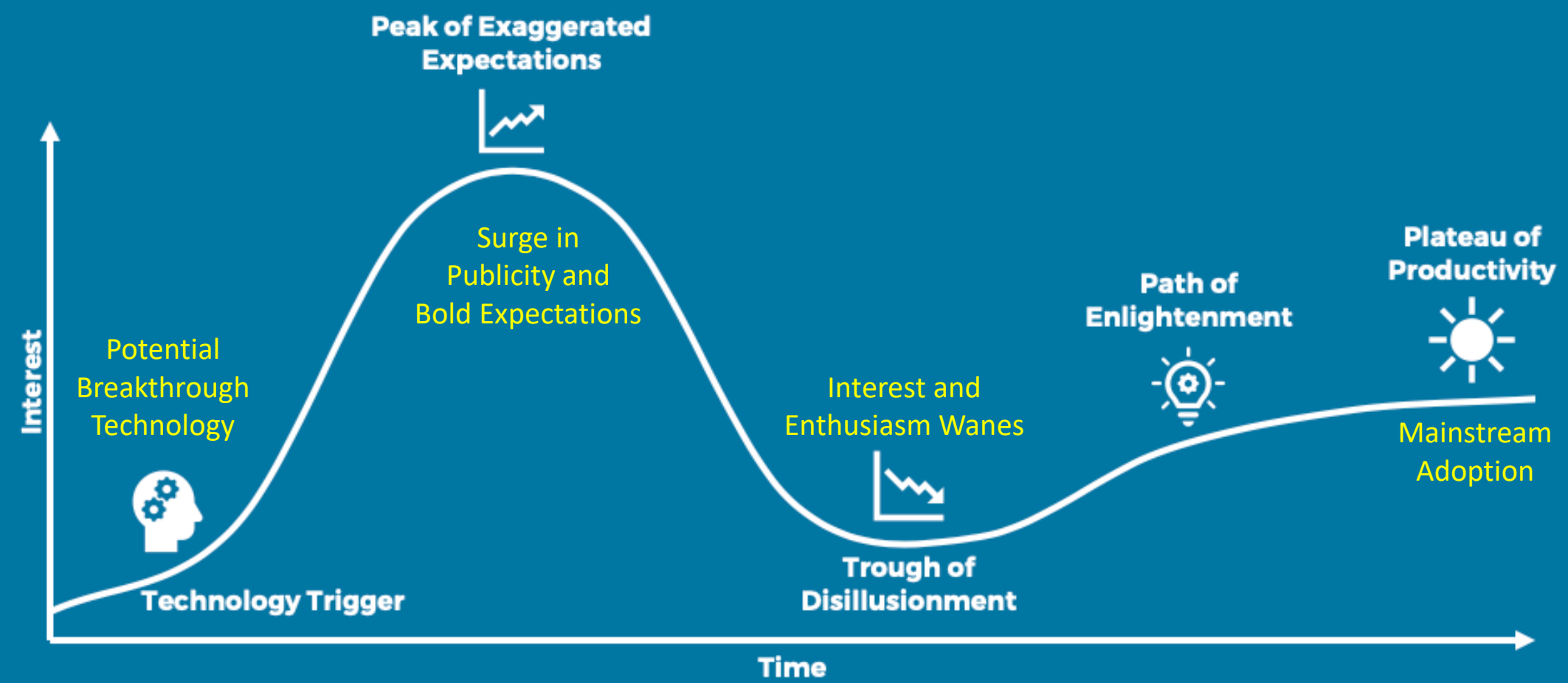
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- If all you have is a hammer, everything looks like a nail (Maslow, 1966)





# Technology Hype Cycle



# Basic Definition of AI

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- Artificial Intelligence (AI) covers broad range of technologies involving complex tasks that normally require human intervention
  - ▣ Many applications in diagnosis, prognosis, therapy and big data analysis

**AI = ML**      **Machine Learning**  
**+TD**              **Learning Data**  
**+MITL**          **Man in the Loop**

# Importance of Training Data

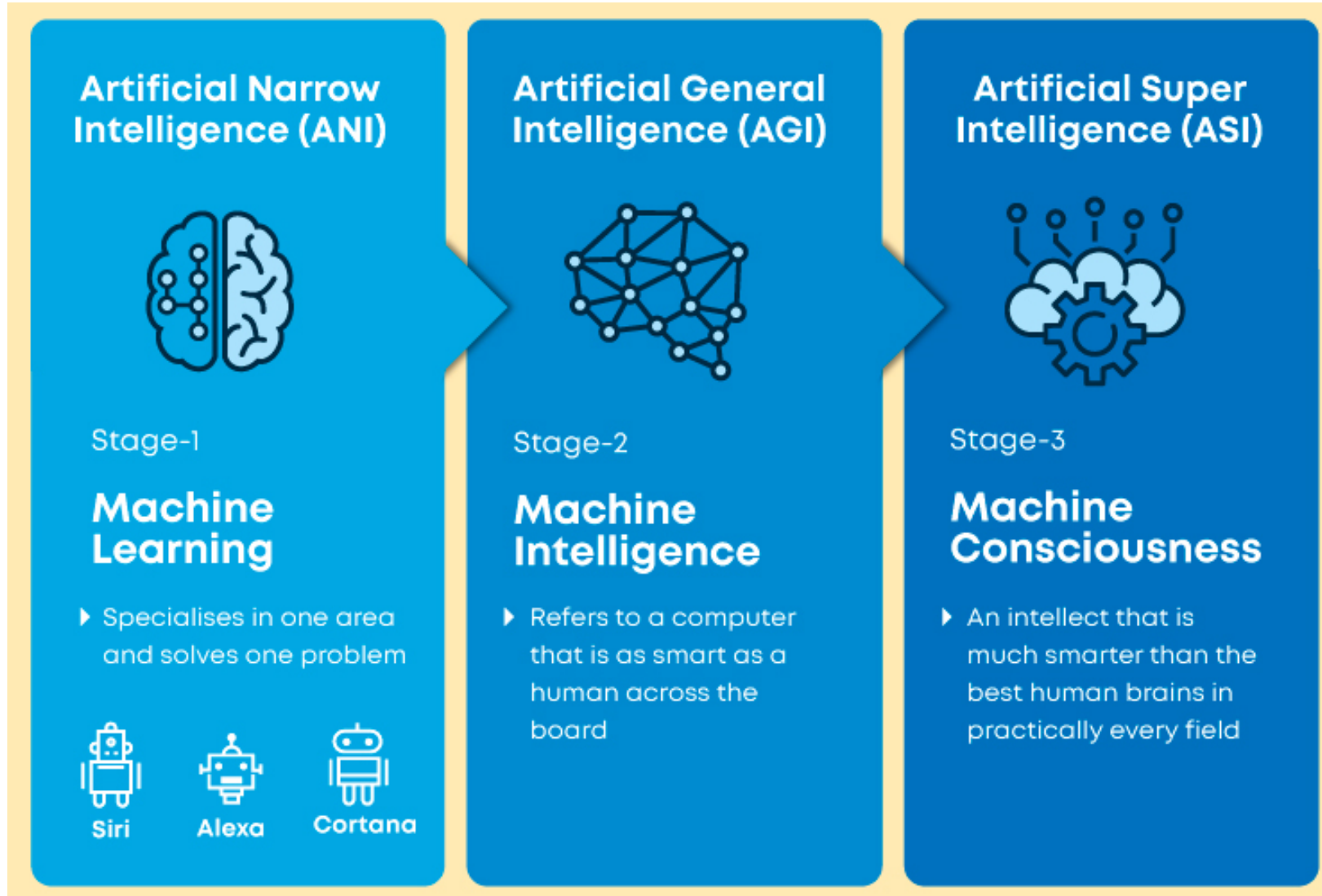
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$$f(\text{trash can}) = \text{trash can}$$

# Stages of Artificial Intelligence

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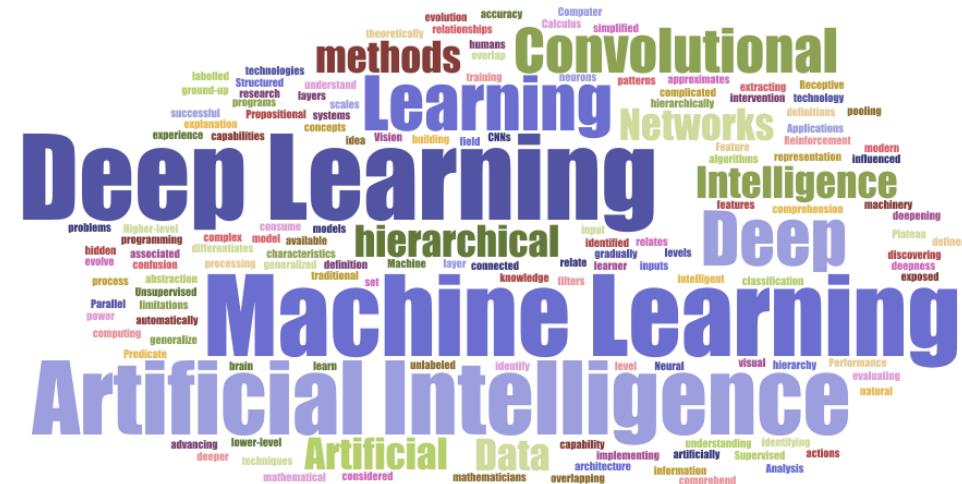




# Terminology and Categorization

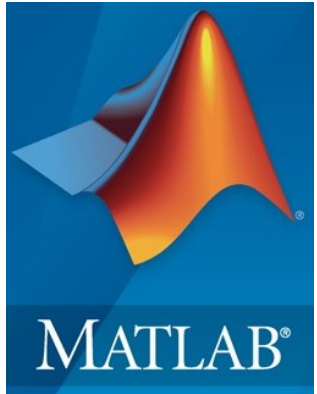
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- AI covers a broad set of technologies
  - ▣ Difficulties in understanding how AI works or its suitability for application
- Currently there is no universal terminology covering AI solutions for healthcare applications
- Simple, high-level approach to categorization could be based on different criteria
  - ▣ Complexity
  - ▣ Impacts and Benefits
  - ▣ Clinical situation

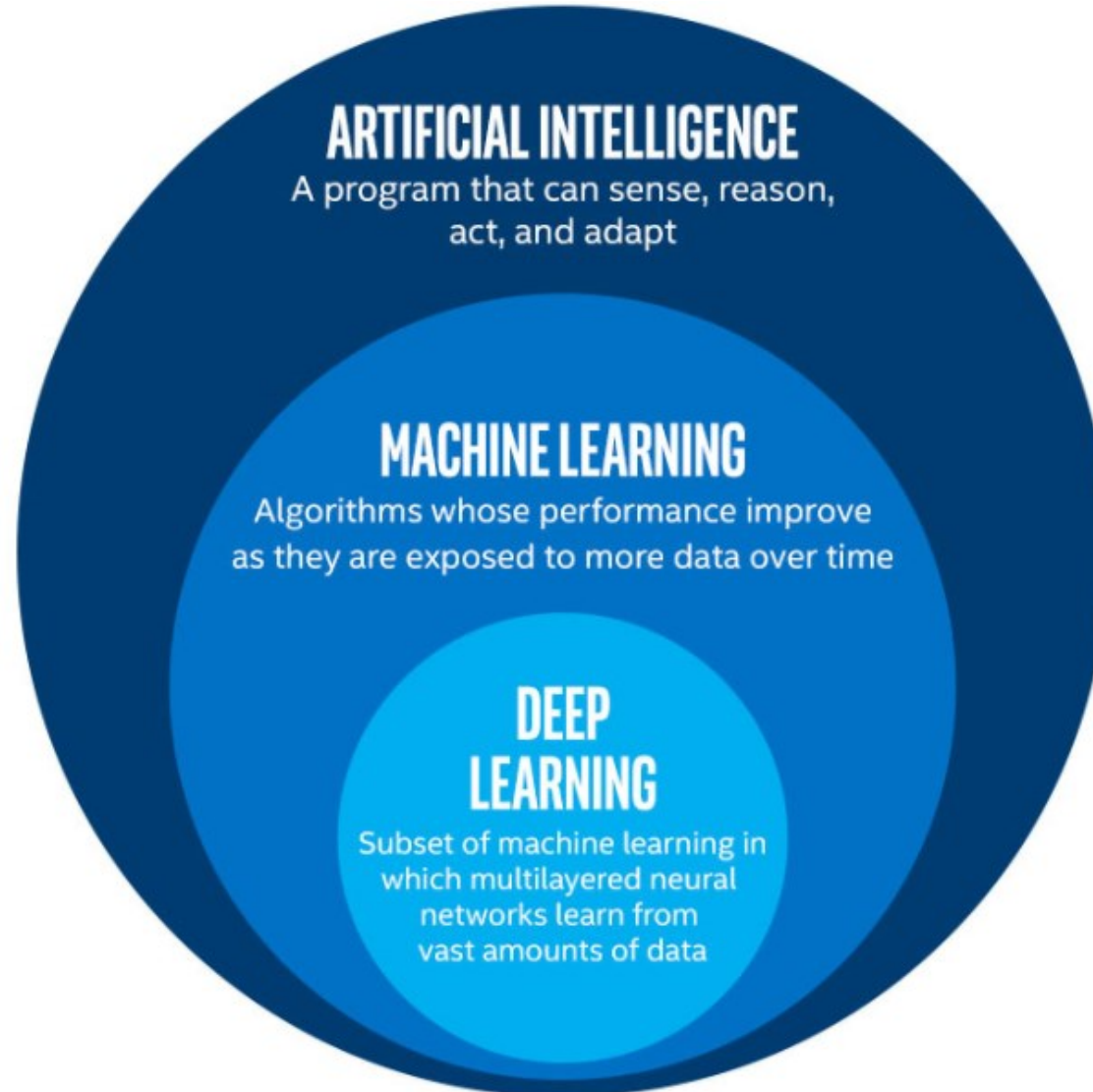


# Technologies and Tools of AI

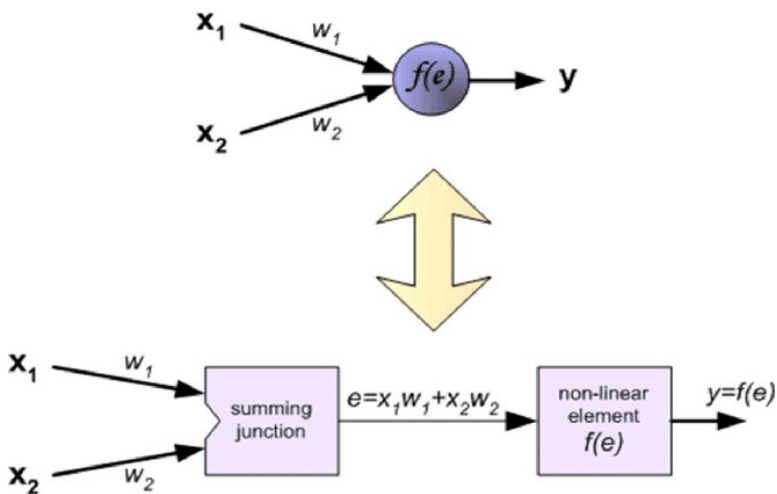
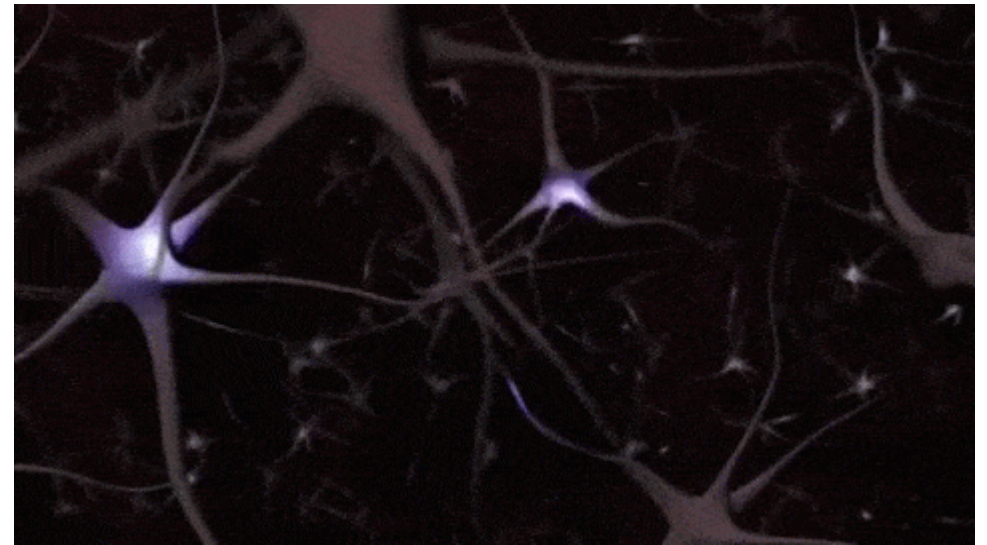
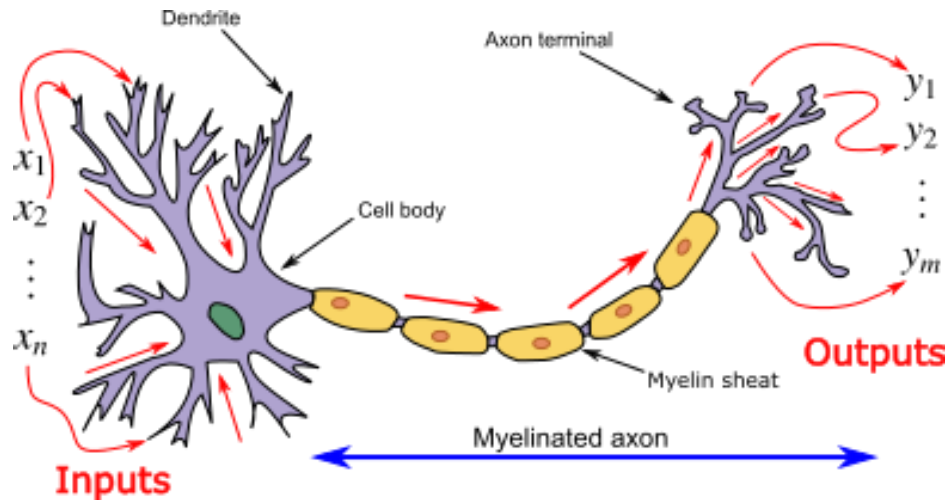
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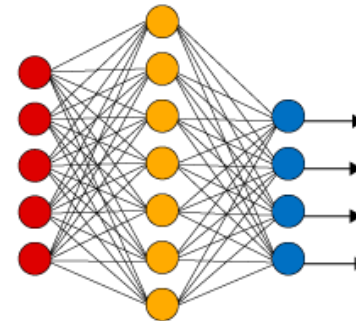
Deep Learning Toolbox™



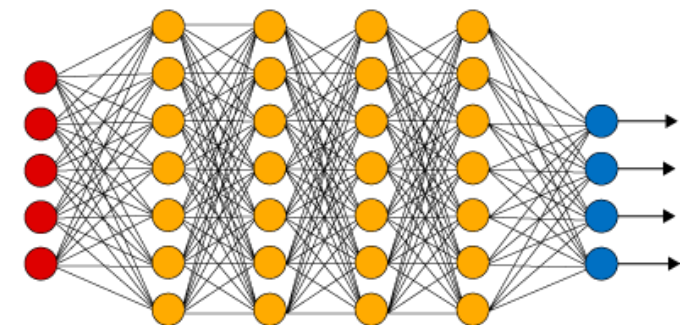
# Deep Learning Neural Networks



Simple Neural Network



Deep Learning Neural Network



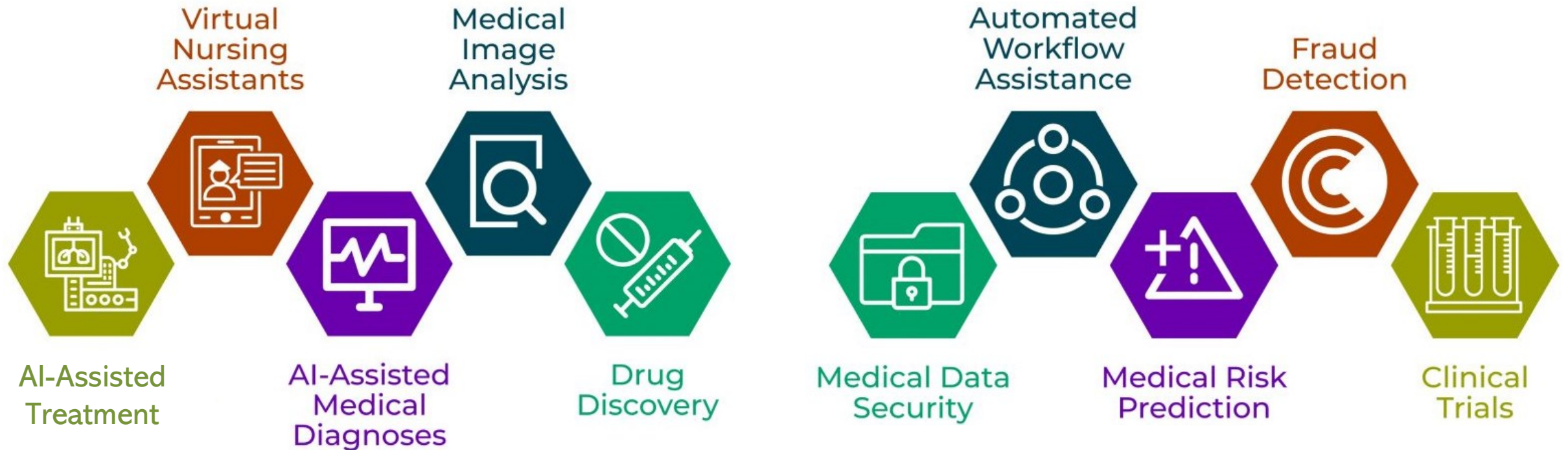
● Input Layer

● Hidden Layer

● Output Layer

# Biomedical Applications of AI

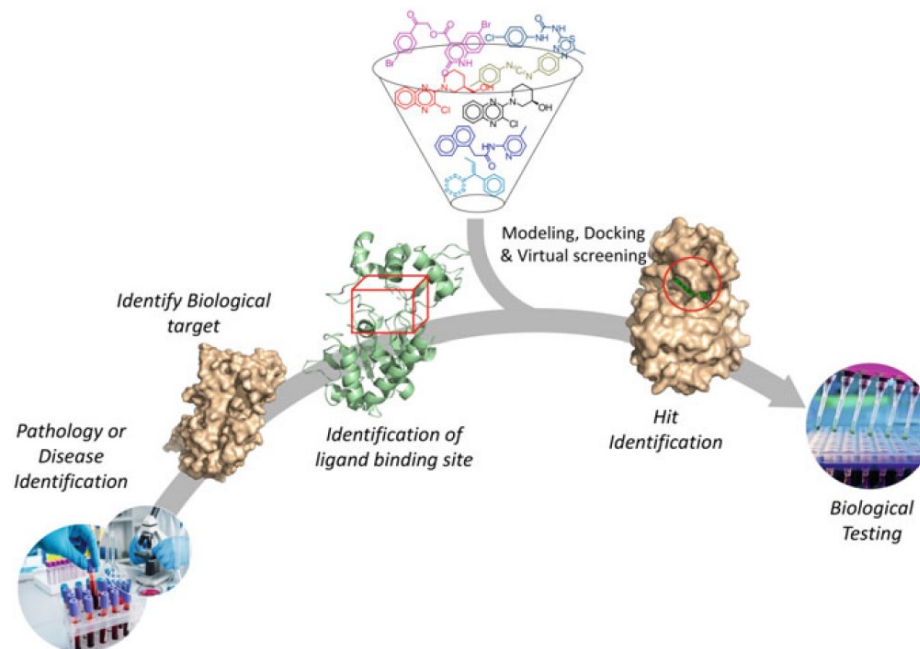
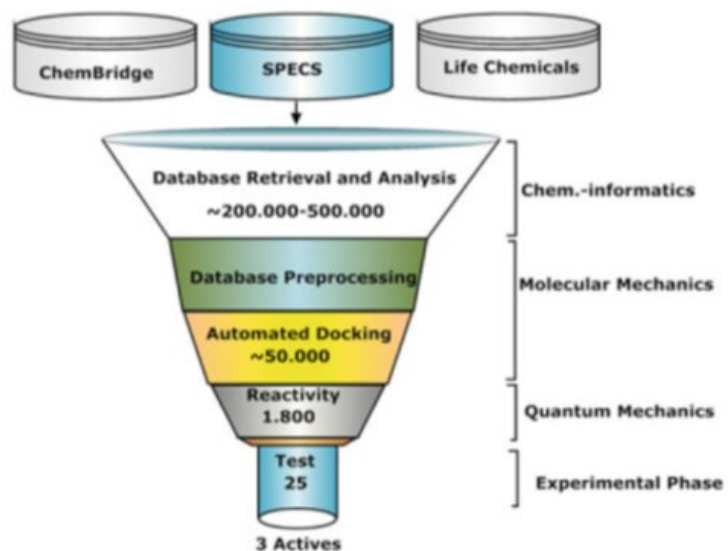
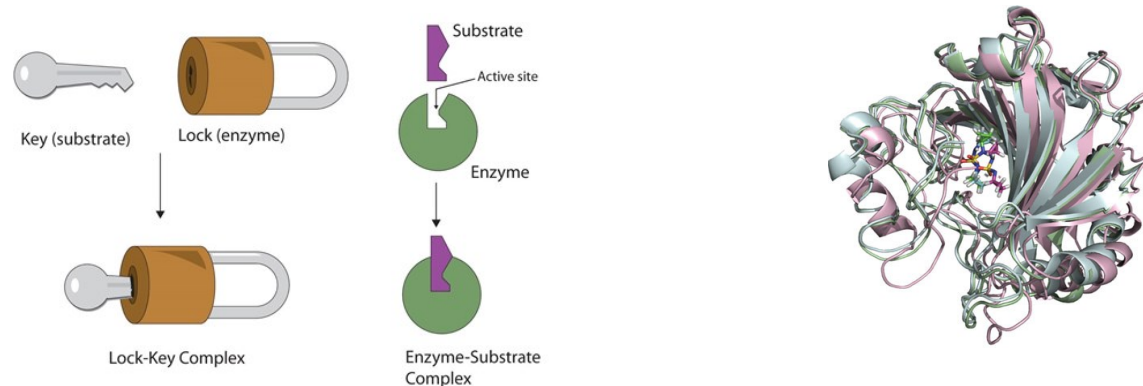
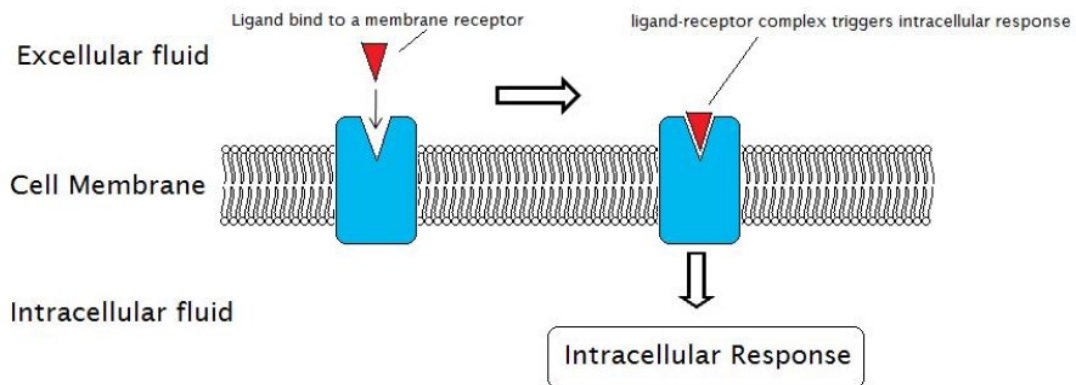
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# AI in Drug and Vaccine Design

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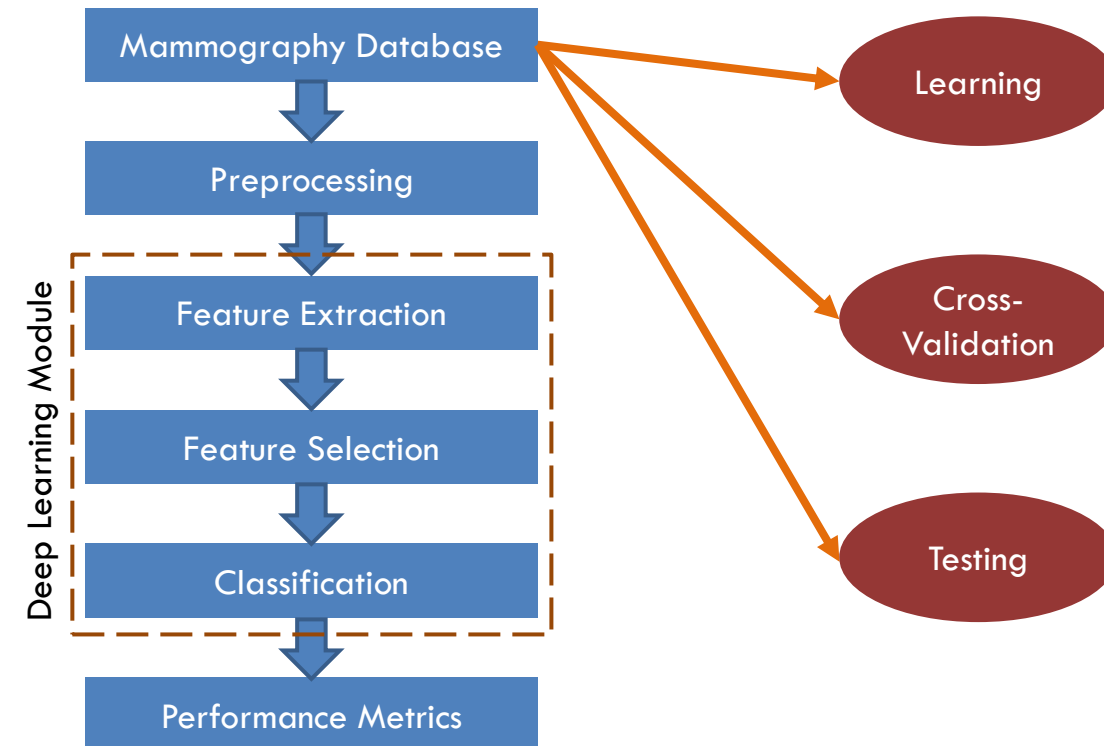
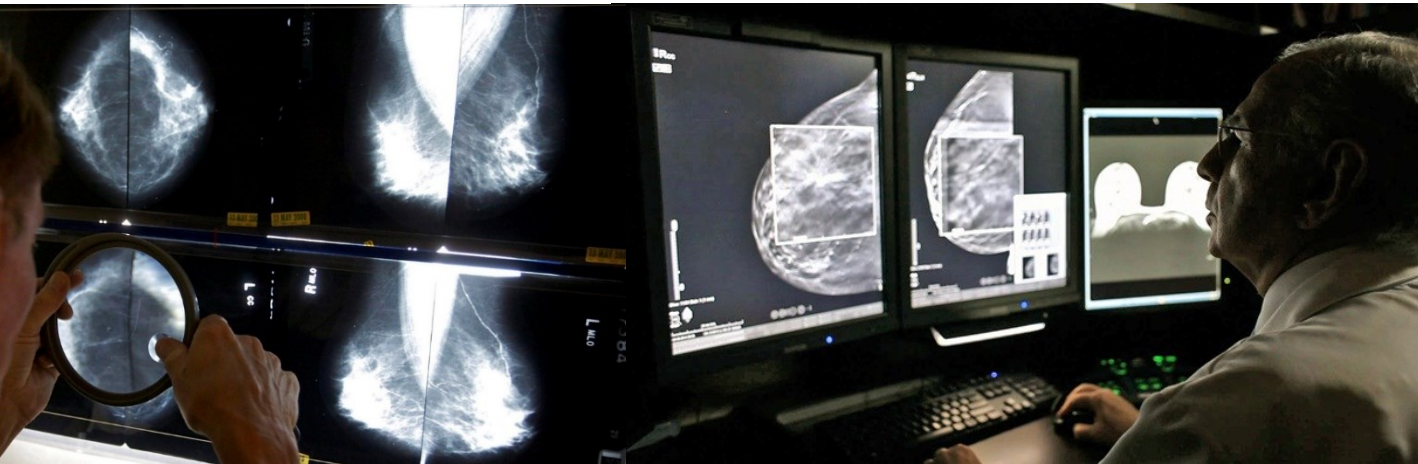




# AI in Computer-Aided Diagnosis: Mammography

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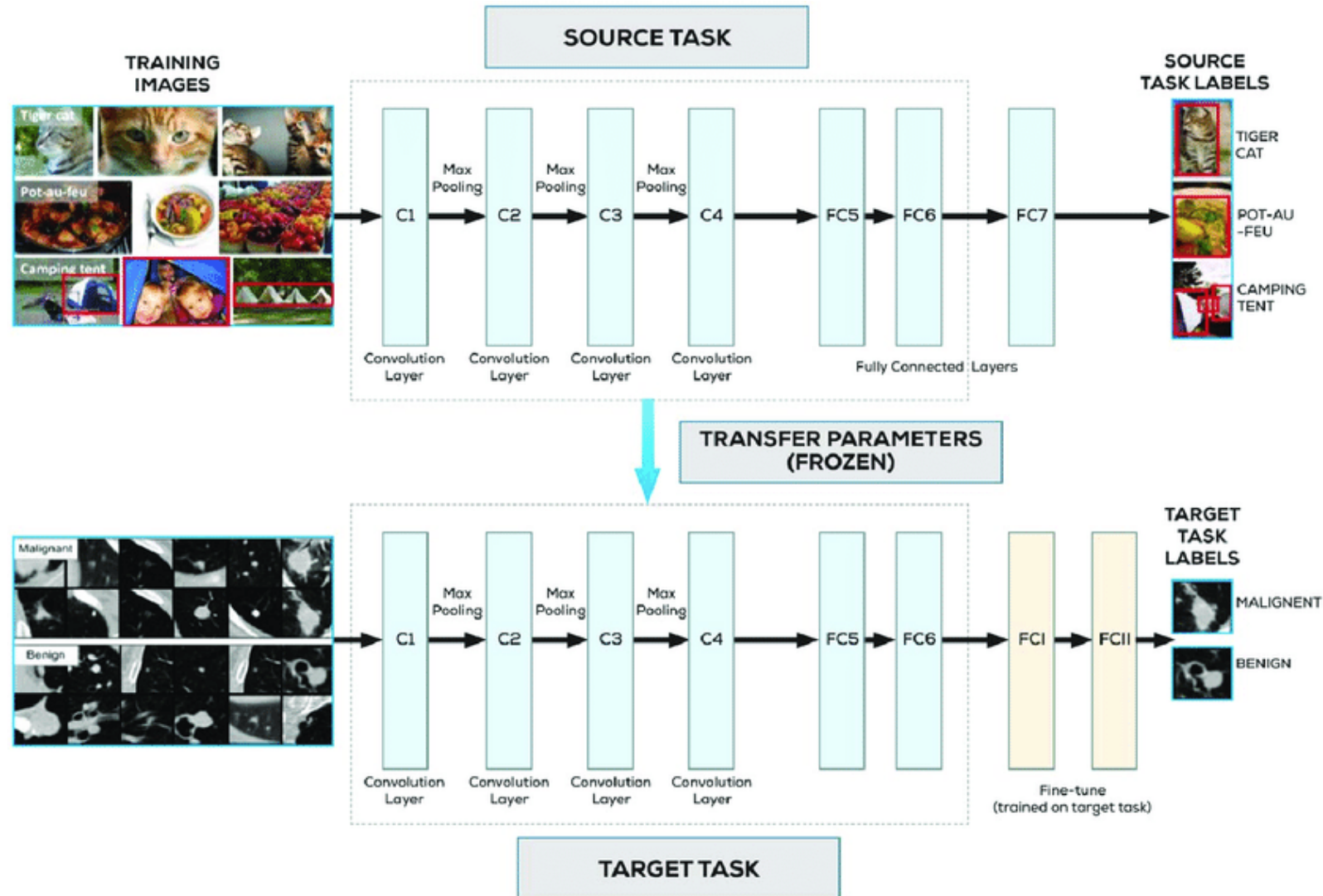
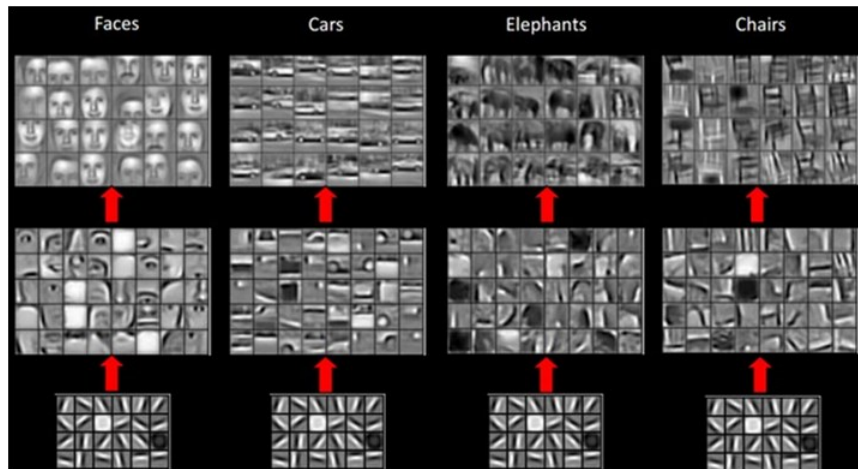
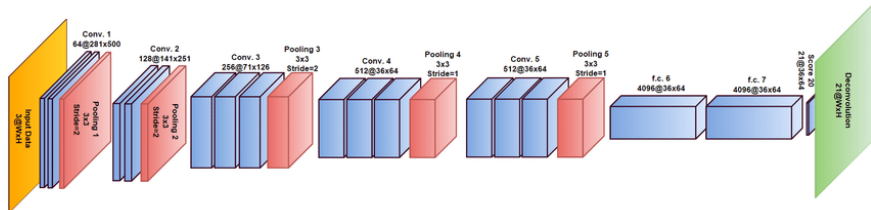
- X-ray images are captured from 2 angles and inspected for malignant lesions
  - ▣ Reading process is tiring, lengthy, costly and prone to errors
  - ▣ Shortage of radiologists compounded by increase in volume of data
- Malignant lesion detection rates: 77–87% for physicians
  - ▣ Substantial variance (29–97%)
  - ▣ Double reading to improve the performance



# Deep Learning Trick: Transfer Learning

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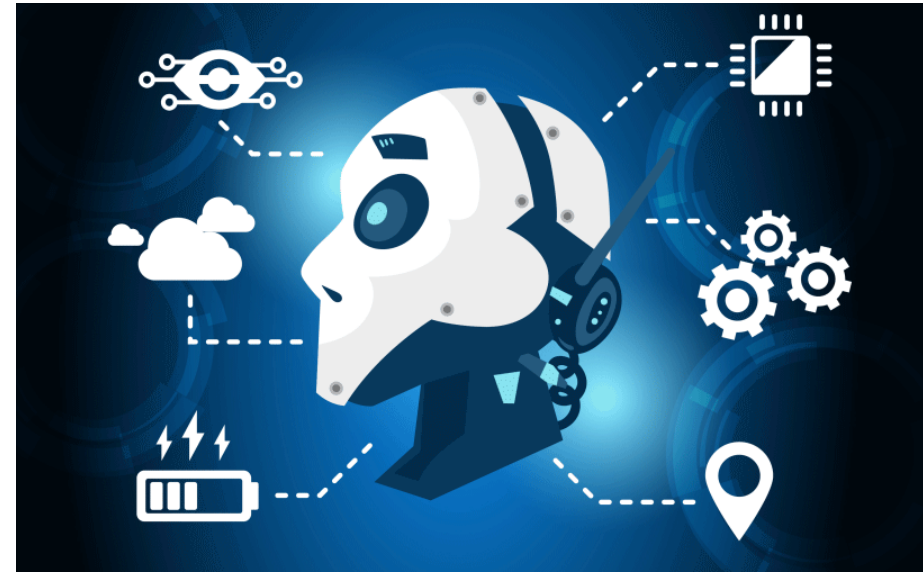
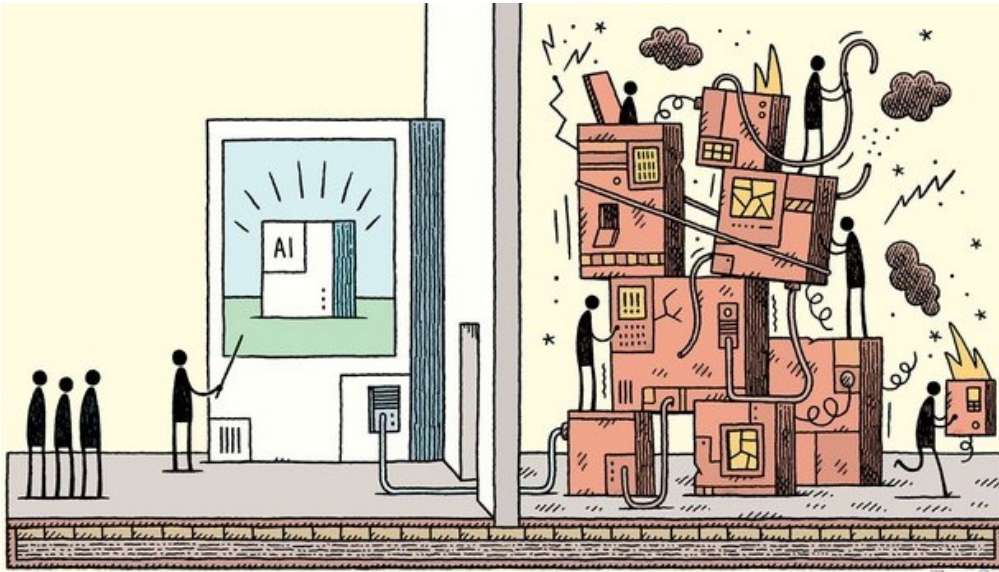
Number of parameters to be estimated  $> 1M$



# Unique Technical Challenges for AI in Healthcare

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- Data size and overfitting **Much smaller data sets than other applications**
- Data imbalance **Many more normal cases than abnormal**
- Wide physiological variability of normal cases **Ambiguity in classification**
- Dependence on data acquisition parameters **Different clinical settings**
- Knowledge gaps and Overfitting **Imperfect sampling of population**





# Natural vs Artificial Intelligence in Simple Tasks

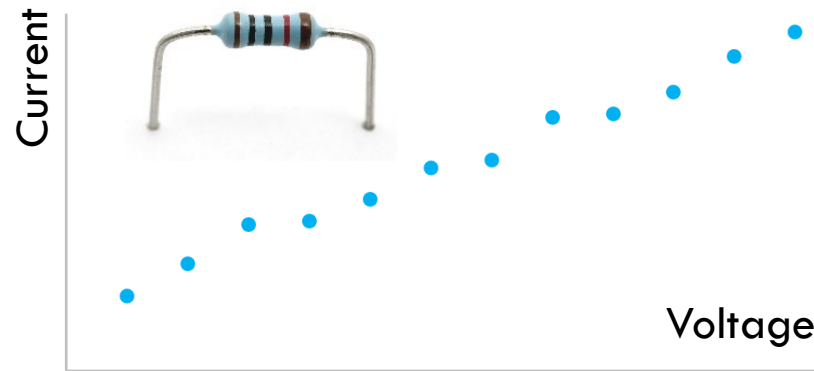
17

- Simple task: Characterization of Current vs Voltage characteristics of resistor

NI BME Student

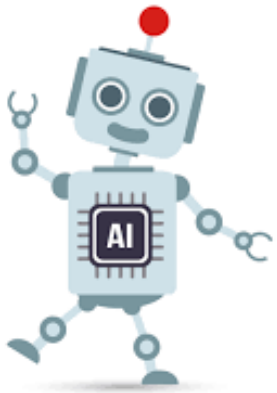


NI Model  
MSE: 2%

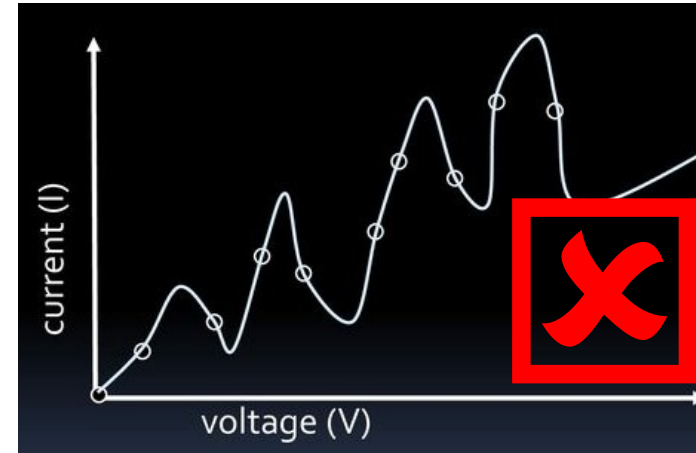
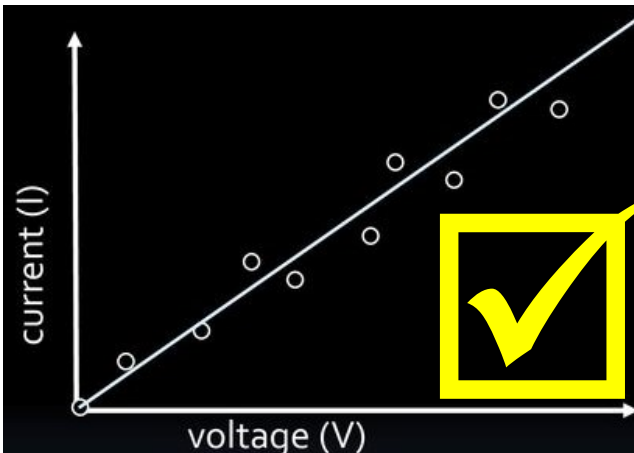


AI Model  
MSE= 0%

AI Deep Learning



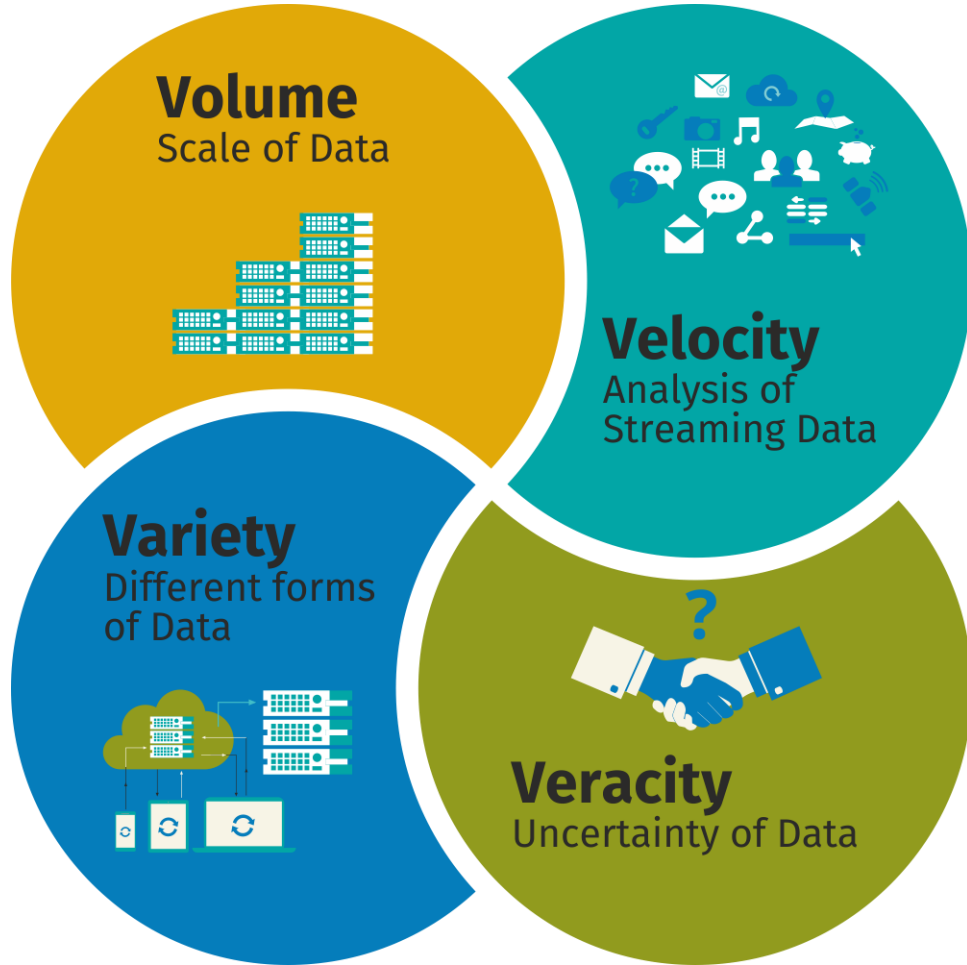
OCCAM'S RAZOR



OVERFITTING

# Strength of AI: Big Data

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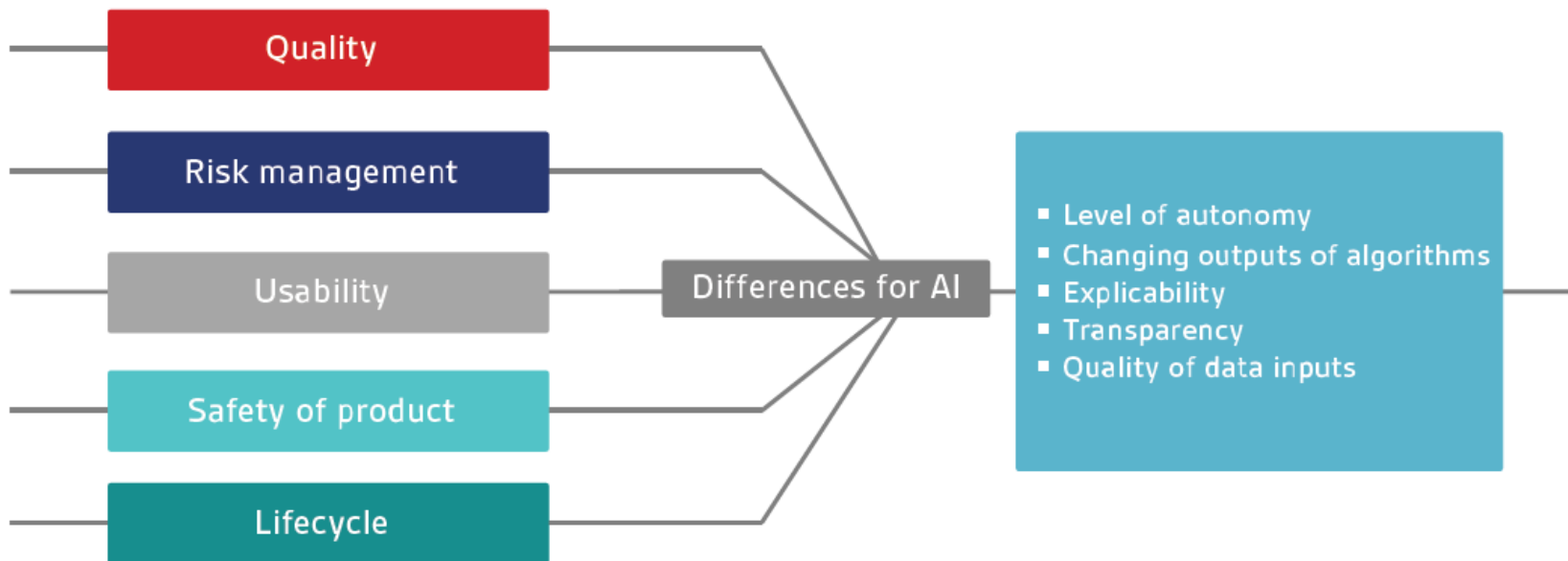




# Unique Challenges: Regulatory Issues

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- Current medical device regulations include software
  - ▣ Standards approach: traditional Software As a Medical Device (SAMD)
- AI poses new challenges in autonomy and continuous learning
- Currently there are no standards that cover definition, development, deployment and maintenance of AI in healthcare



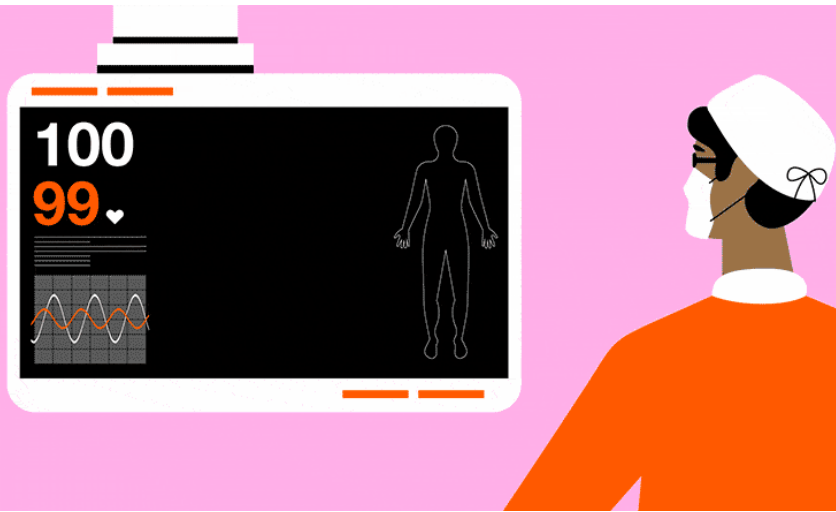
The emergence of artificial intelligence and machine learning algorithms in healthcare: Recommendations to support governance and regulation

Position paper  
Prepared by BSI and AAMI

# Unique Legal and Ethical Issues in AI Use

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- AI introduces potential for automation bias
  - ▣ Professional judgement influenced by recommendation of AI solution
- Managing accountability for the AI solution is critical
  - ▣ Agreement for liability and framework for incident reporting
- AI Regulations are separate from those for professional and ethical practices
  - ▣ Hospitals and clinicians remain accountable for decisions they make



# AI Trough of Disillusionment?

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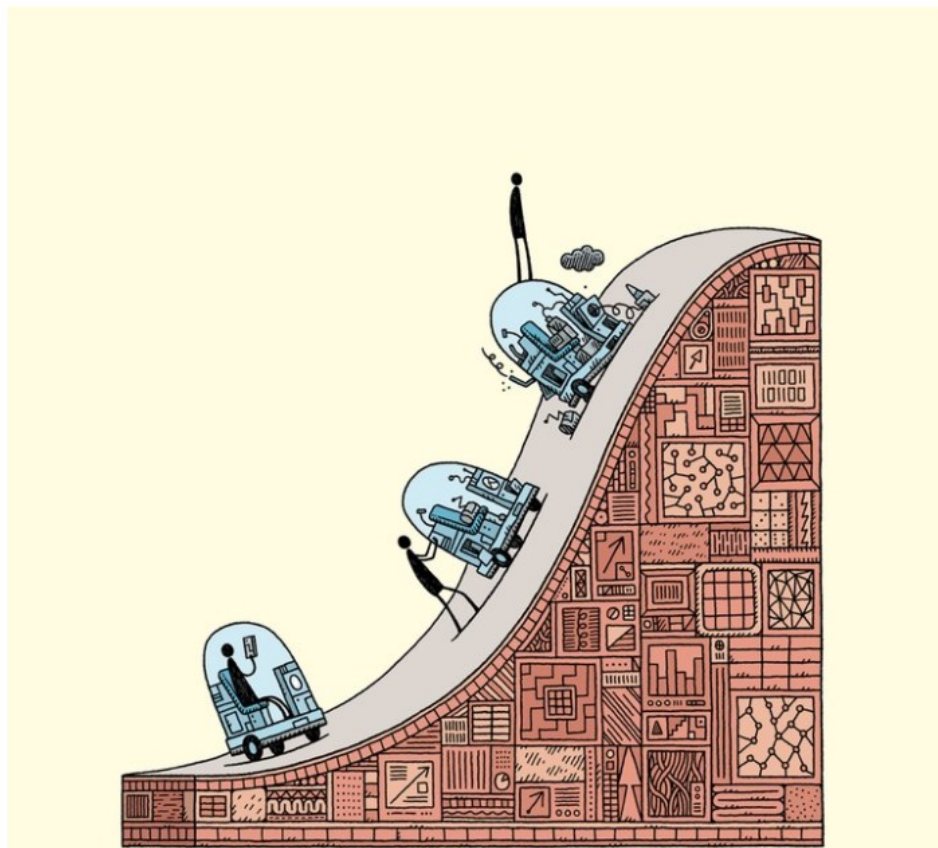
The Economist

Menu

Weekly edition

Search

← Technology Quarterly



*Steeper than expected*

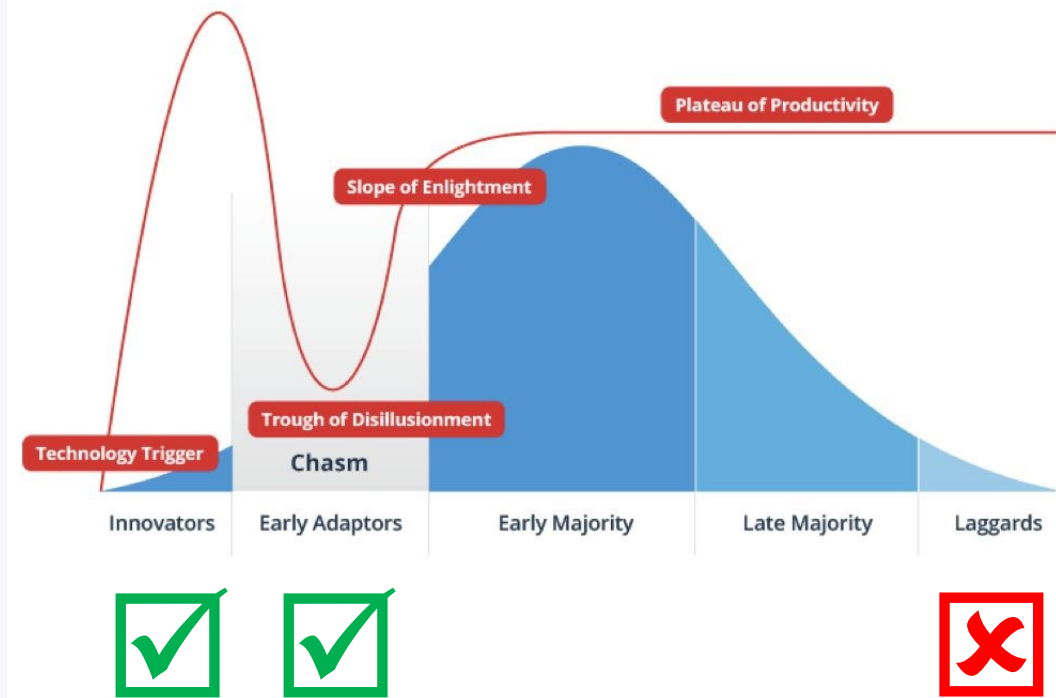
## Artificial intelligence and its limits

TECHNOLOGY QUARTERLY - JUN 13TH 2020

After years of hype, many people feel AI has failed to deliver, says Tim Cross

- Artificial intelligence and its limits: An understanding of AI's limitations is starting to sink in
- Data: For AI, data are harder to come by than you think
- The business world: Businesses are finding AI hard to adopt
- Brain scan: The potential and the pitfalls of medical AI
- Computing hardware: The cost of training machines is becoming a problem
- Automobiles: Driverless cars show the limits of today's AI
- The future: Humans will add to AI's limitations

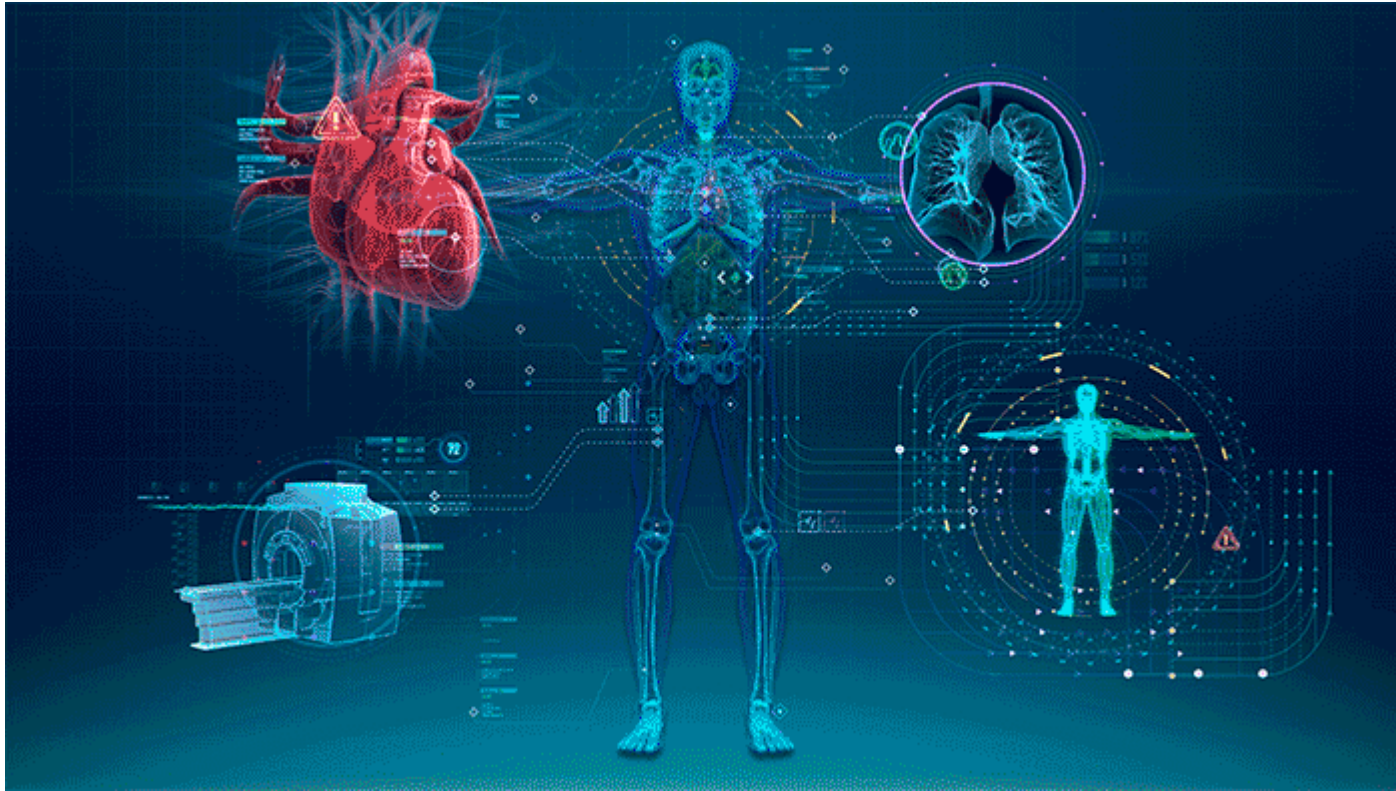
# Technology Hype Cycle: AI 2020



# Concluding Remarks

- AI is **NOT** a **HAMMER** for everything – many tools may be better
- AI has great potential in biomedical engineering especially with **BIG DATA**
- Role of AI should be to **ASSIST** not to **REPLACE** humans
- Use of AI should **NOT** be in **SIMPLE** tasks where simpler tools work well
- **LIMITATIONS** of AI should be clearly understood
- Lack of standardized **TERMINOLOGY** in AI can be misleading and confusing
- **REGULATION** and **GOVERNANCE** of AI technologies in healthcare remain a challenge that need to be addressed
- Avoid **TECHNOLOGY HYPE** and plan early realistic mainstream adoption
- **OPPORTUNITY** in AI now to join Innovators and Early Adaptors





QUESTIONS?