**CLICK 'DOWNLOAD'** (TOO MANY SLIDES TO VIEW – GITHUB WILL NOT SHOW THEM ALL)

# Artificial Intelligence and the Future of Medicine/Mankind

Howard Schneider
Sheppard Clinic North, Toronto, Canada

Ontario Medical Association (OMA)
Section on Primary Care Mental Health
Toronto, March 21 2020

# CONFLICTS OF INTEREST

- None

# COMMERCIAL NAMES

- I will try to minimize use of commercial names, where feasible (but….many AI-related products are company specific)

# DR HOWARD SCHNEIDER, MD, MDPAC(C), CCFP

## ***WHY SHOULD I GIVE THIS TALK?***

**Practicing physician**

- Background –General Practice/ Family Practice
- A decade –Psychiatry Consultations in ER (Laval)
- Two decades –Community Mental HealthCare(GTA)

# DR HOWARD SCHNEIDER, MD, MDPAC(C), CCFP

## ***WHY SHOULD I GIVE THIS TALK?***

**Interest – How does mind work?**
**Flip side – How to create an AGI?**
**(Artificial General Intelligence, 'HLAI', 'Strong AI')**

- Research – Cognitive Architectures
- (I design machines to produce AI/AGI)

# LEARNING OBJECTIVES

- 1. **Real understanding of what AI is:**
- 1a. Deep Learning and Reinforcement Learning
- 1b. Field of Artificial Intelligence (AI)
- 1c. Neuro-Symbolic Gap
- 2. **How will AI in next decade (or two) affect my patients' lives?**
- 3. **How will AI affect my practice of medicine including psychotherapy?**
- 3a. How is AI affecting medicine at present?
- 3b. How will AI affect medicine in the next decade?
- 4. **How will AI affect the future of mankind?**
- 5. **Discussion**

# WILL DO BEST TO KEEP ON SCHEDULE….

# (90 MINUTES TALK, 30 MINUTES QUESTIONS)

# NOT REQUIRED…. BUT…. CONSIDER MAKING NOTES IF THIS HELPS YOU LEARN….

# LEARNING OBJECTIVES

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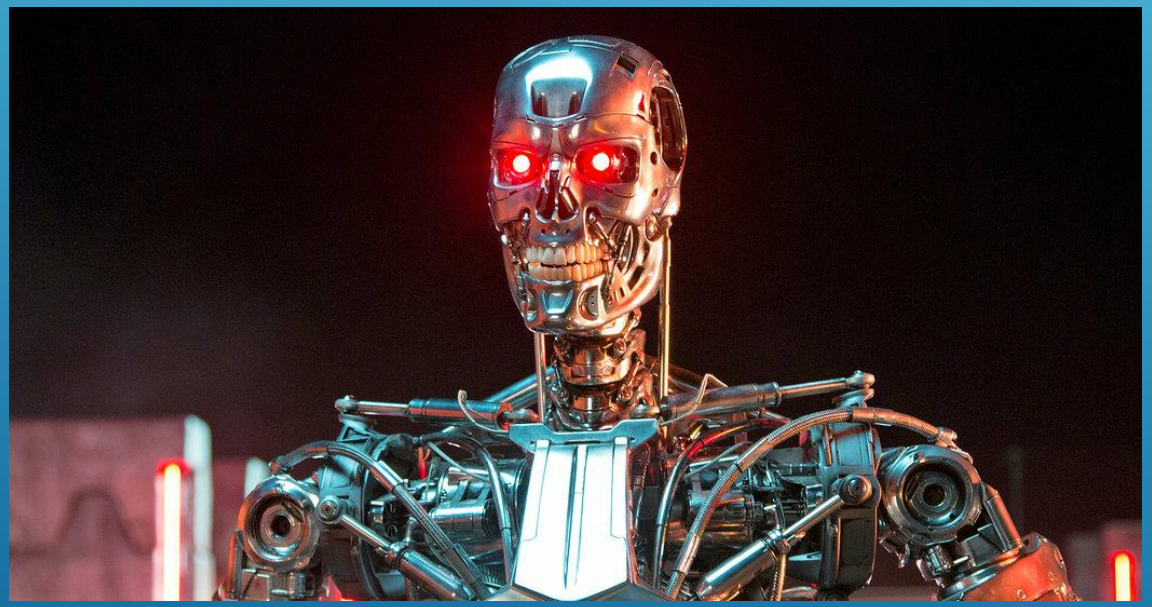
# FORGET ABOUT CURRENT HYPE YOU SEE ABOUT AI (ARTIFICIAL INTELLIGENCE) ALL AROUND YOU IN THE MEDIA….



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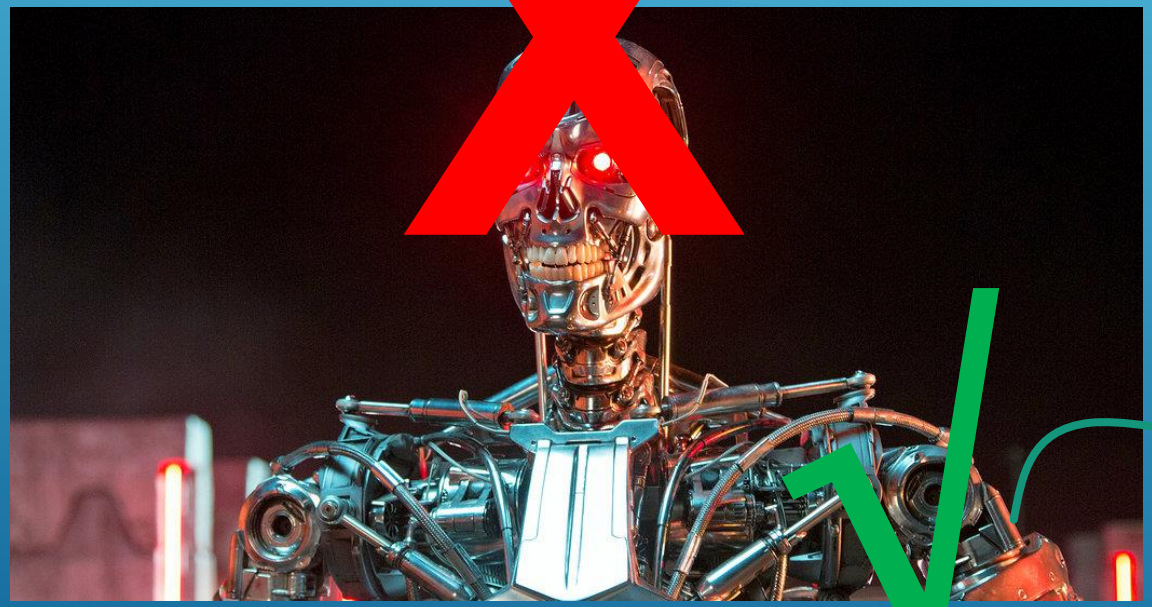

WILL **NOT** HAPPEN WITH CURRENT TECHNOLOGY

Current technology: **AI** part **not** possible, but android-like walking (running, even jumping) **robots exist**

# AT PRESENT: FORGET ABOUT CURRENT HYPE YOU SEE IN MEDICINE ABOUT AI

Straightforward computer engineering can greatly improve EMRs
(an almost magical AI would be nice to have…. but huge improvements are possible with normal computer engineering)

# MANY **IMPROVEMENTS** IN EMR (FOR EXAMPLE) POSSIBLE WITH **GOOD COMPUTER ENGINEERING** PRACTICES (THE AI PART MAY BE MINUSCULE)


**NOT REALLY AI**

# AT PRESENT: FORGET ABOUT CURRENT HYPE YOU SEE IN MEDICINE ABOUT AI

RUNNING HOSPITALS OR YOUR PRACTICE BY BIG DATA IS NOT TRUE MEDICINE – IT IS SIMPLY VERY POWERFUL STATISTICS – WE WILL COME BACK AND TALK ABOUT THIS LATER

# LEARNING OBJECTIVES

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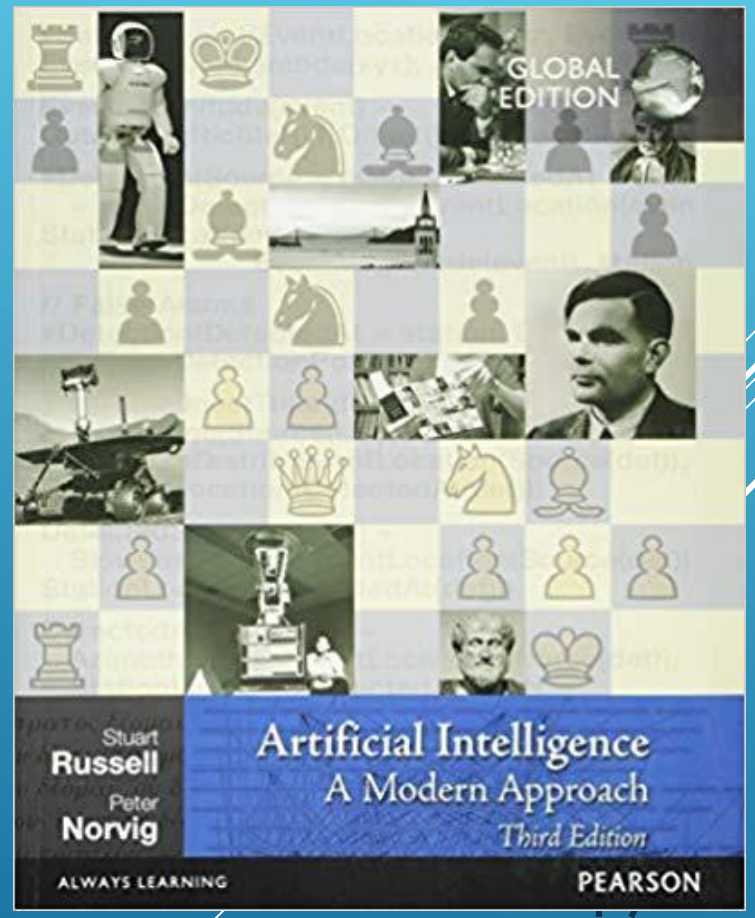
# THESE DAYS, PEOPLE USE THE TERM "**AI**" TO REFER TO **DEEP LEARNING**

Of course, AI is much more than 'Deep Learning' – we'll talk about that later.

# “Of course, AI is much more than ‘Deep Learning’ – we’ll talk about that later.”

Deep Learning actually only tiny part of AI
AI a huge field – even an introduction to the subject is massive

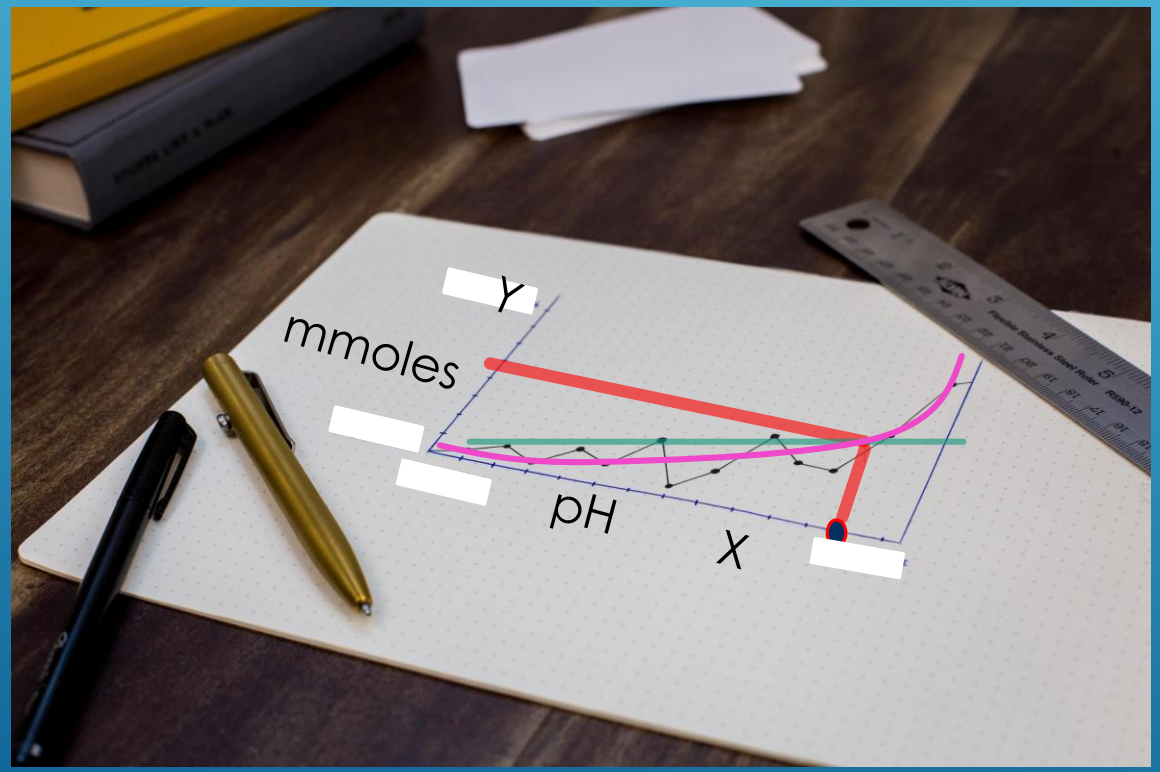
1. Definition of AI
2. History of AI
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. …… …… ……



# DEEP LEARNING….
# LET'S JUST JUMP IN….

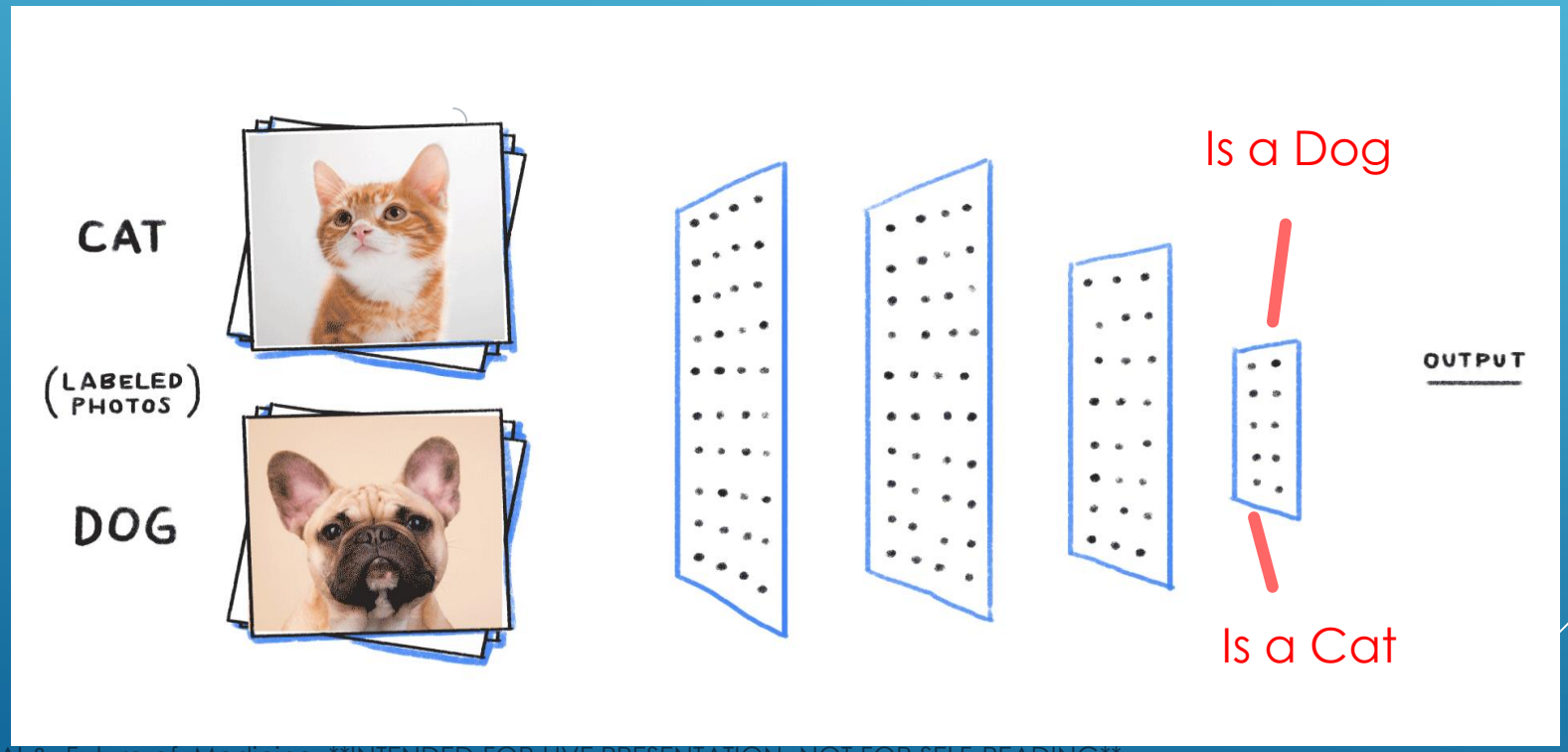
# OK…. WHAT IS DEEP LEARNING?

# THIS IS YOU – EG, PREMED CHEMISTRY – DOING SIMPLE "ARTIFICIAL INTELLIGENCE", IE, DEEP LEARNING

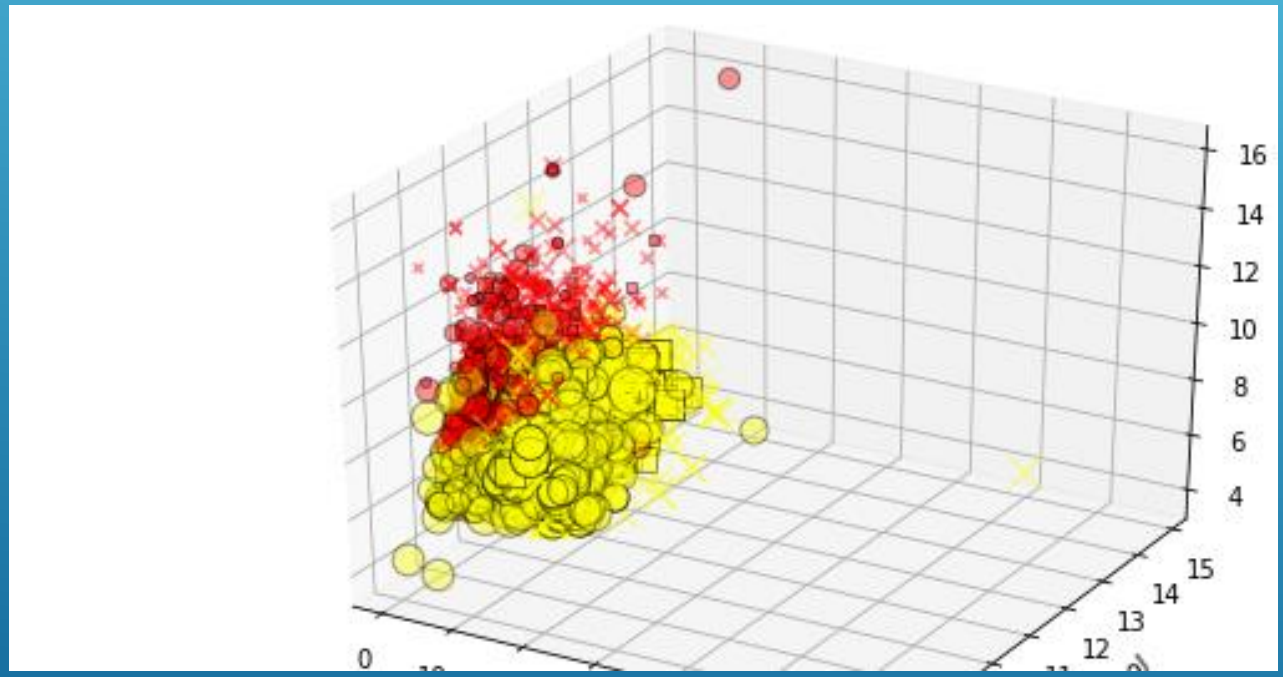



New X value never seen before, you can predict the Y value

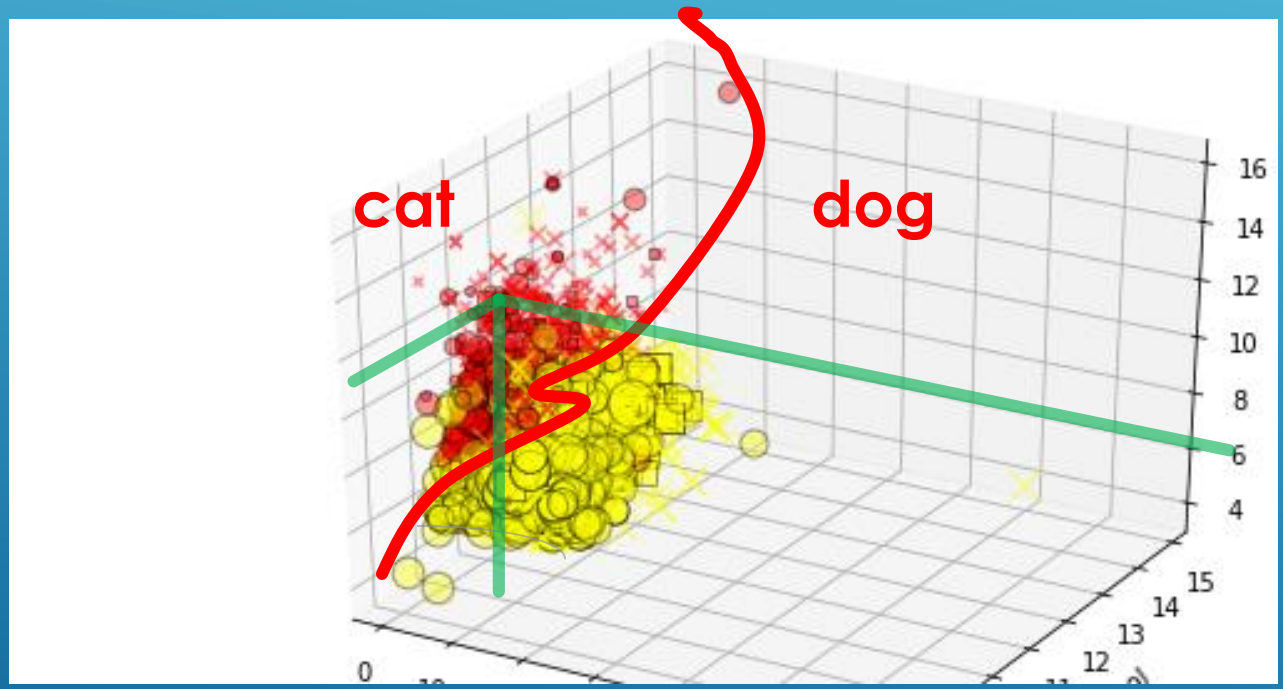
# NOW MAKE A GRAPH SO IF SEE A NEW ANIMAL (JAW SHAPE, NOSE SHAPE, ETC) JUST LIKE NEW X VALUE, YOU CAN PREDICT THE Y VALUE – IS IT A DOG OR A CAT??



-CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
-PLOT THEM
-BELOW IS 3-D BUT MAYBE REALLY NEED 1000-D (OR 64,000 DIMENSIONS!!)



# -CONSIDER DIFFERENT FEATURES OF DIFFERENT DOGS AND CATS
# -PLOT THEM
# -BELOW IS 3-D BUT MAYBE REALLY USE 1000-D



# CLASSIFICATION

?

?

?

Pandas

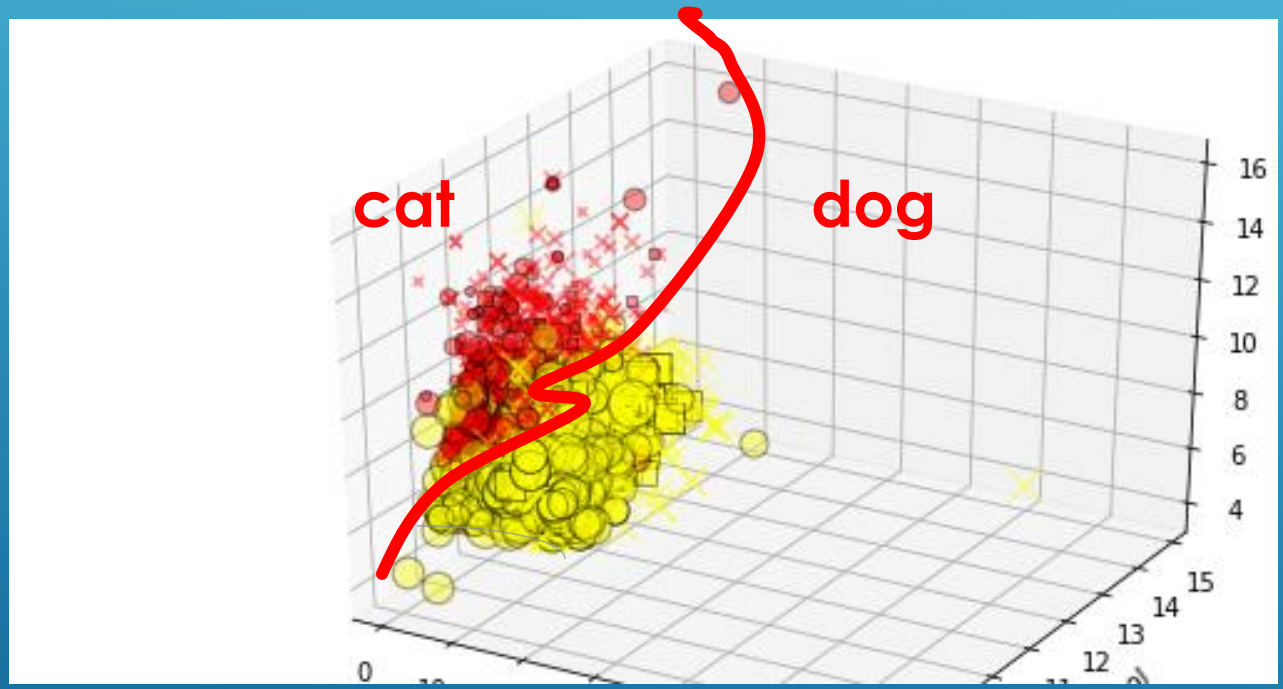
Dogs

Cats

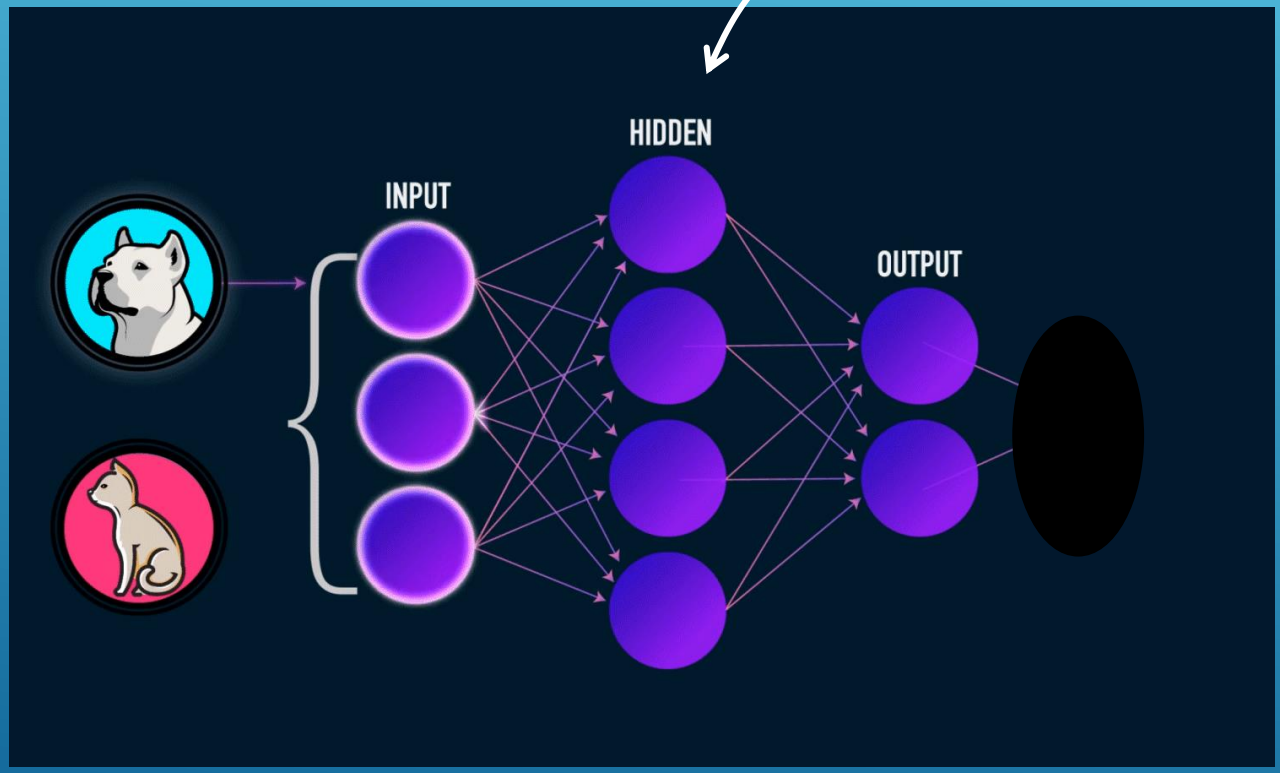
Rather:

P(class|  )?

# OK….HOW DO WE AUTOMATICALLY BUILD SUCH A 3-D OR 1000-DIMENSION GRAPH?

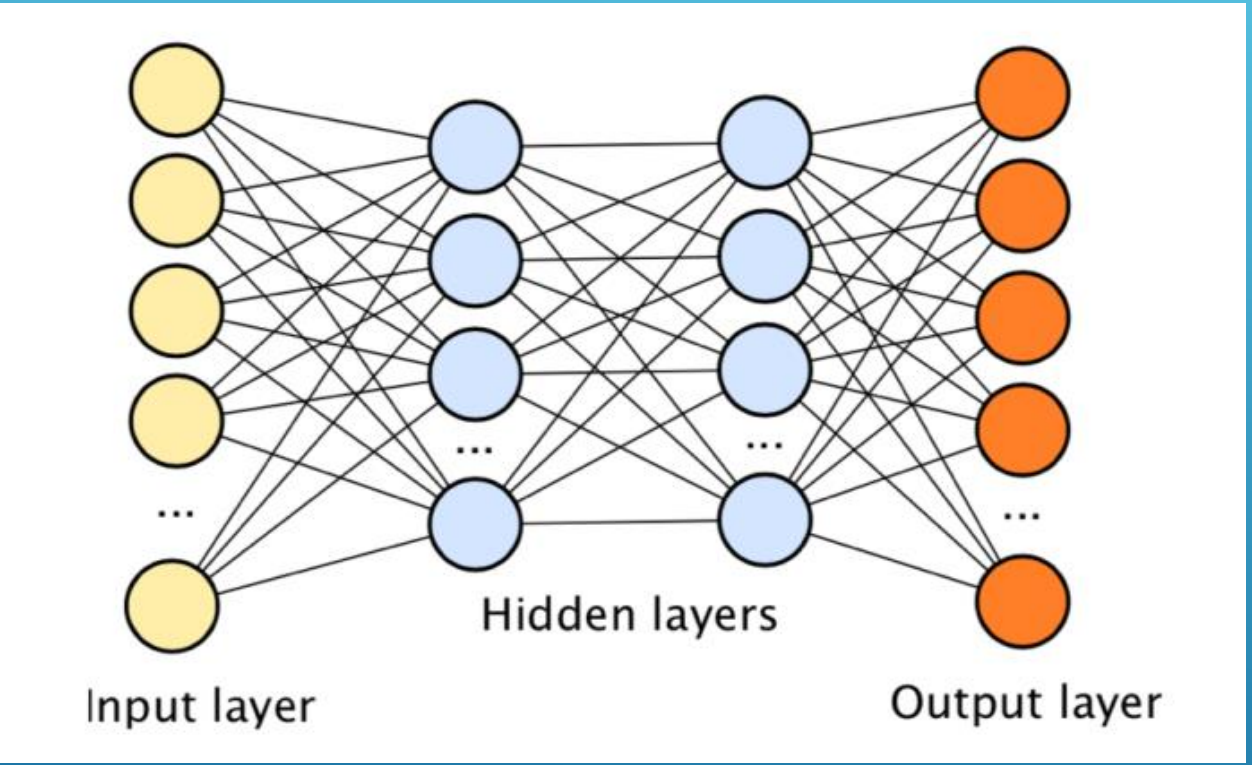


# NEURAL NETWORK TO 'AUTOMATICALLY' LEARN TO TELL A DOG FROM A CAT

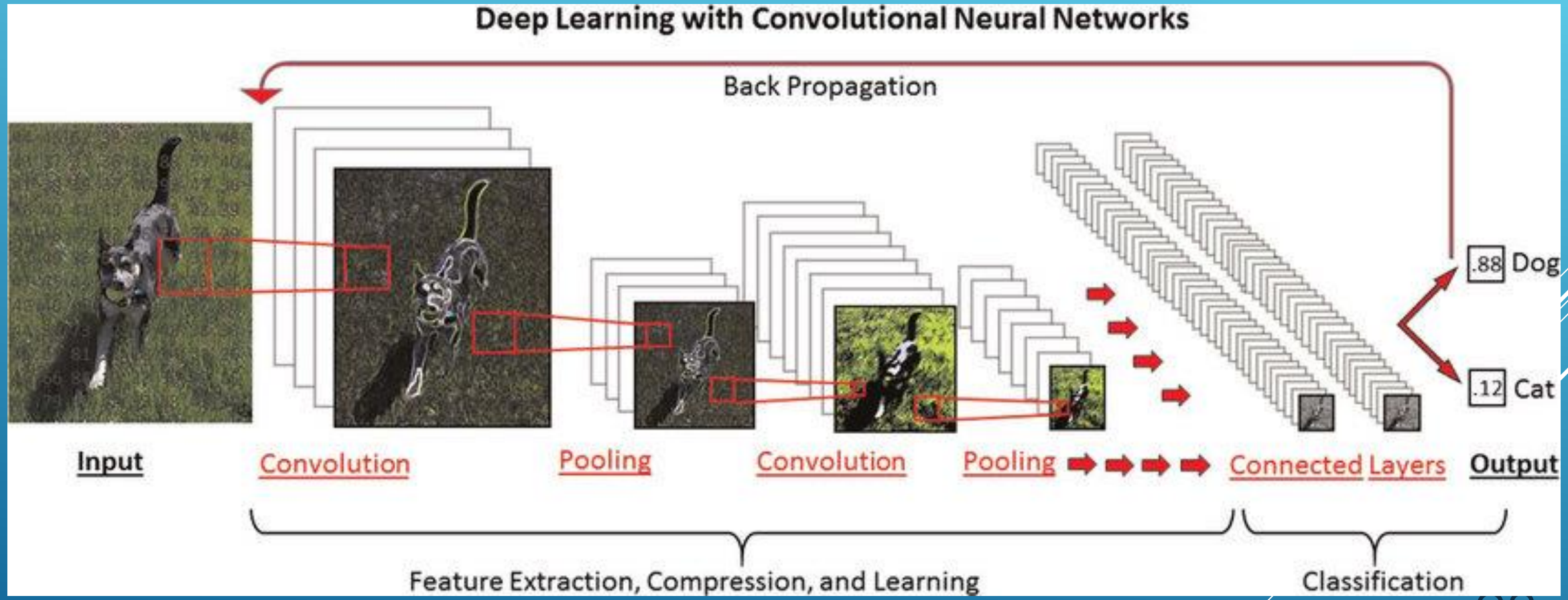



**Simplified**
*Real Deep Learning Neural Network will have *many* hidden layers*

# *Deep Learning Neural Network will have *many* hidden layers*

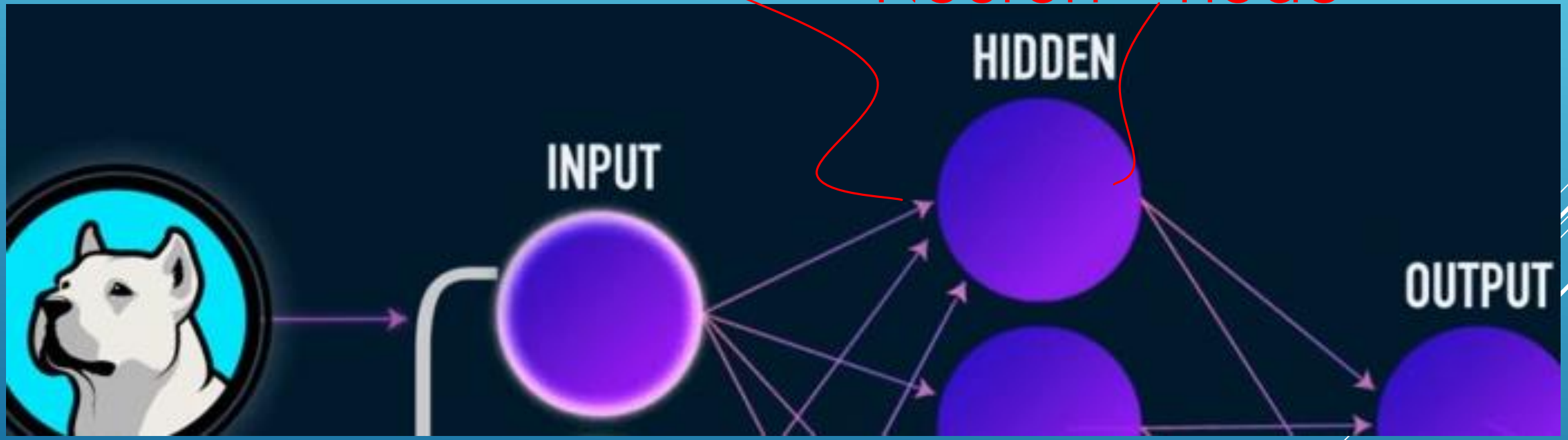


# ***Simple, Realistic*** *Deep Learning Neural Network will have *many* hidden layers*



Synapse = weight

Neuron = node



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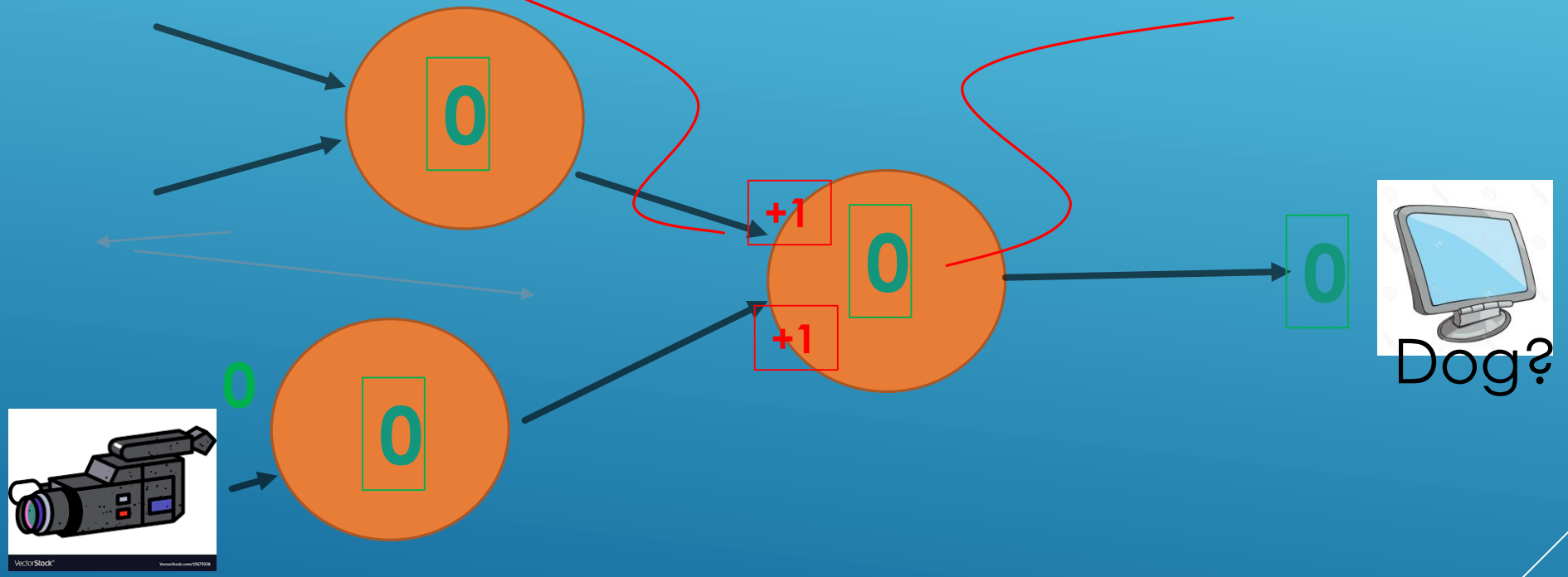
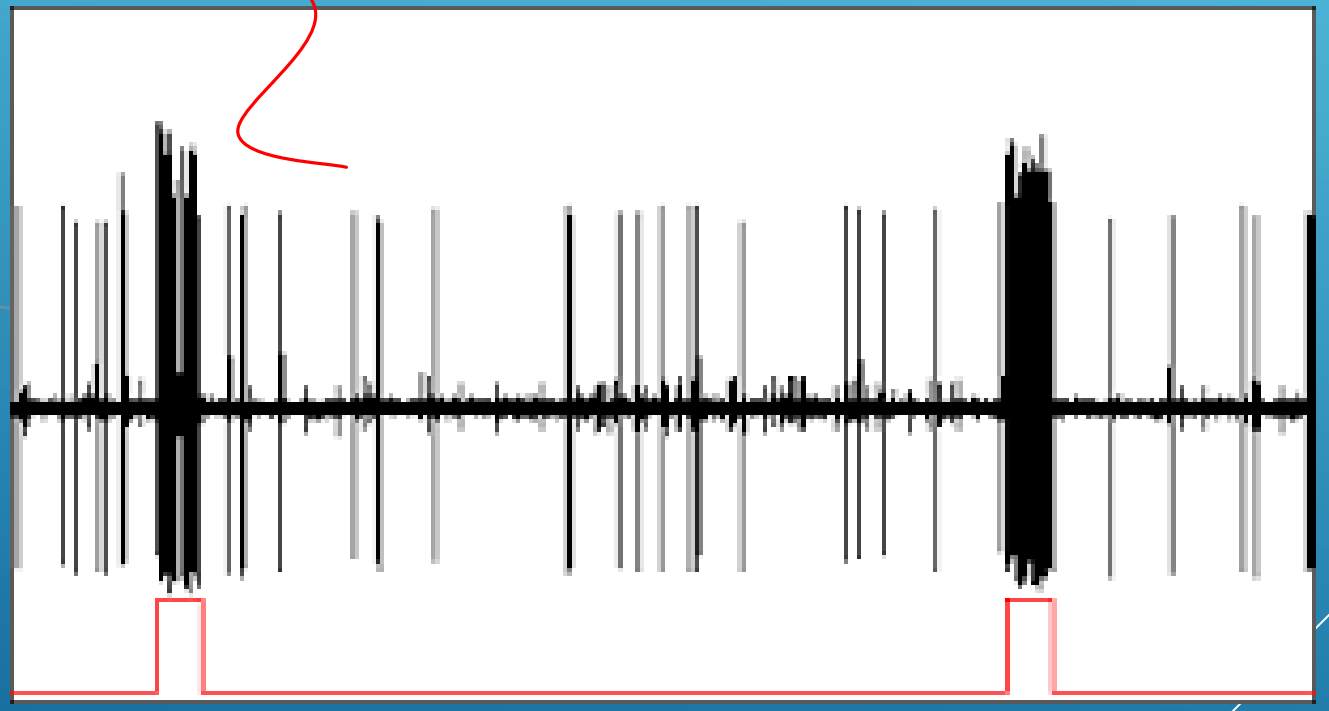
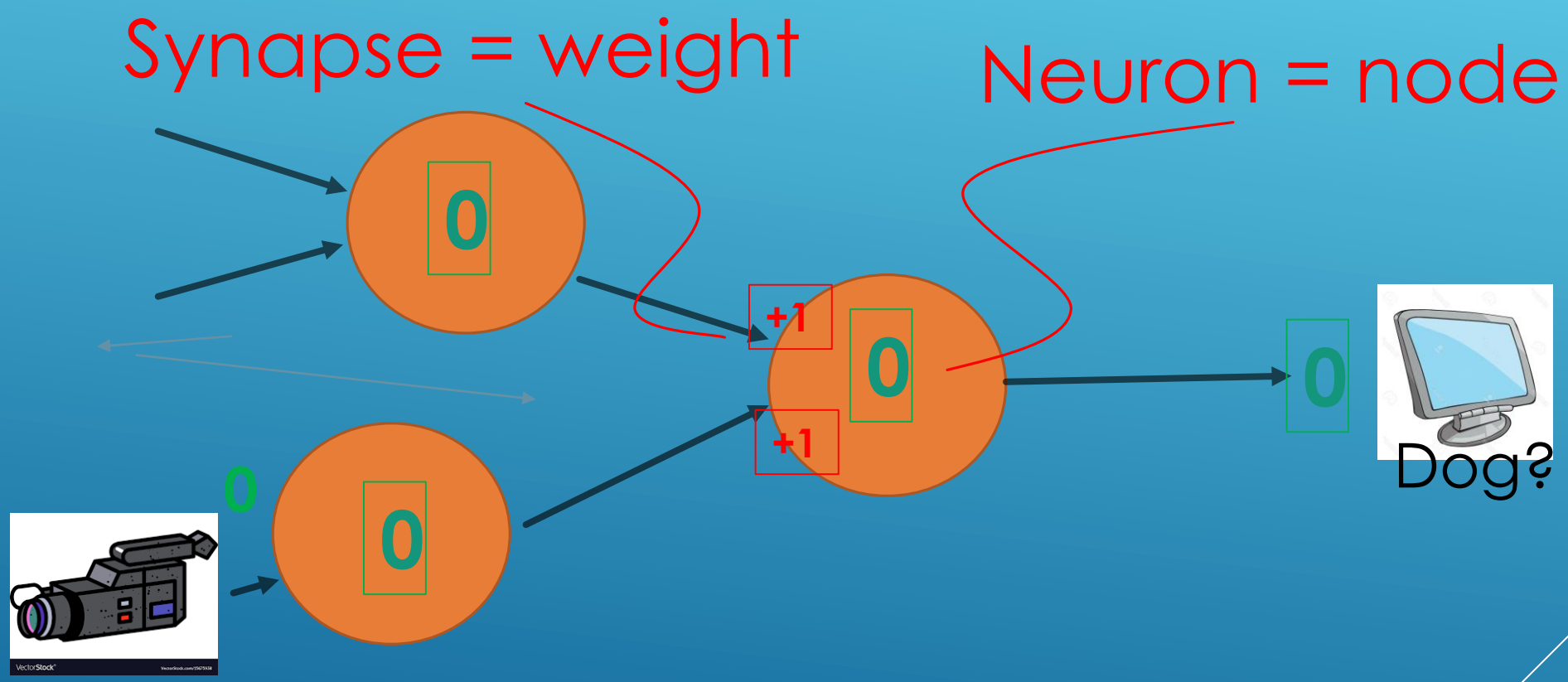


# Real Neural Networks

Action Potentials (spikes)



# "Artificial Neural Network" (ANN)



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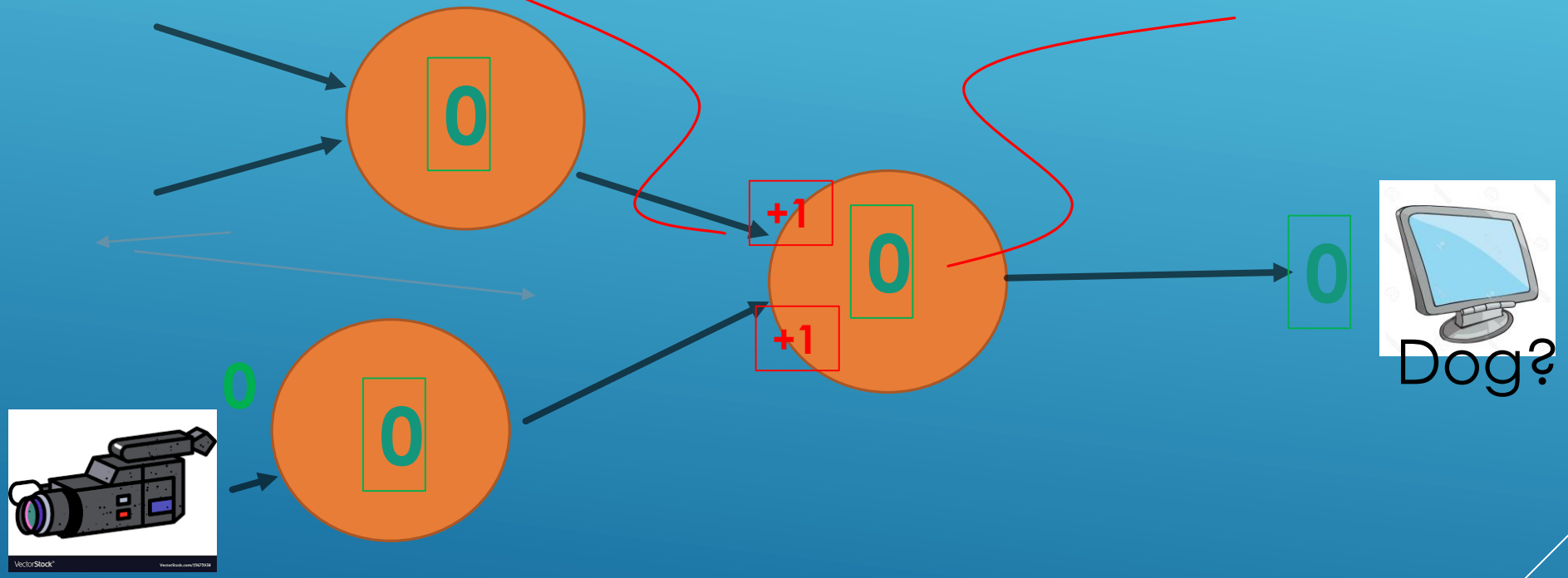

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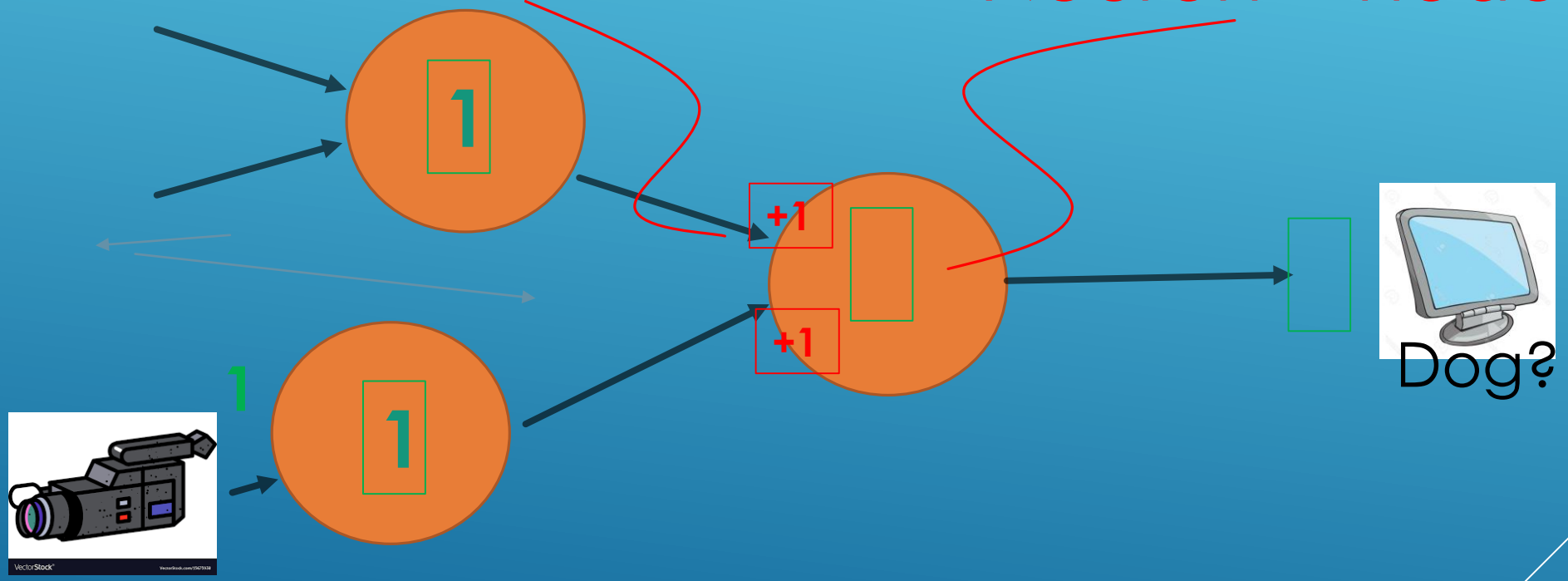
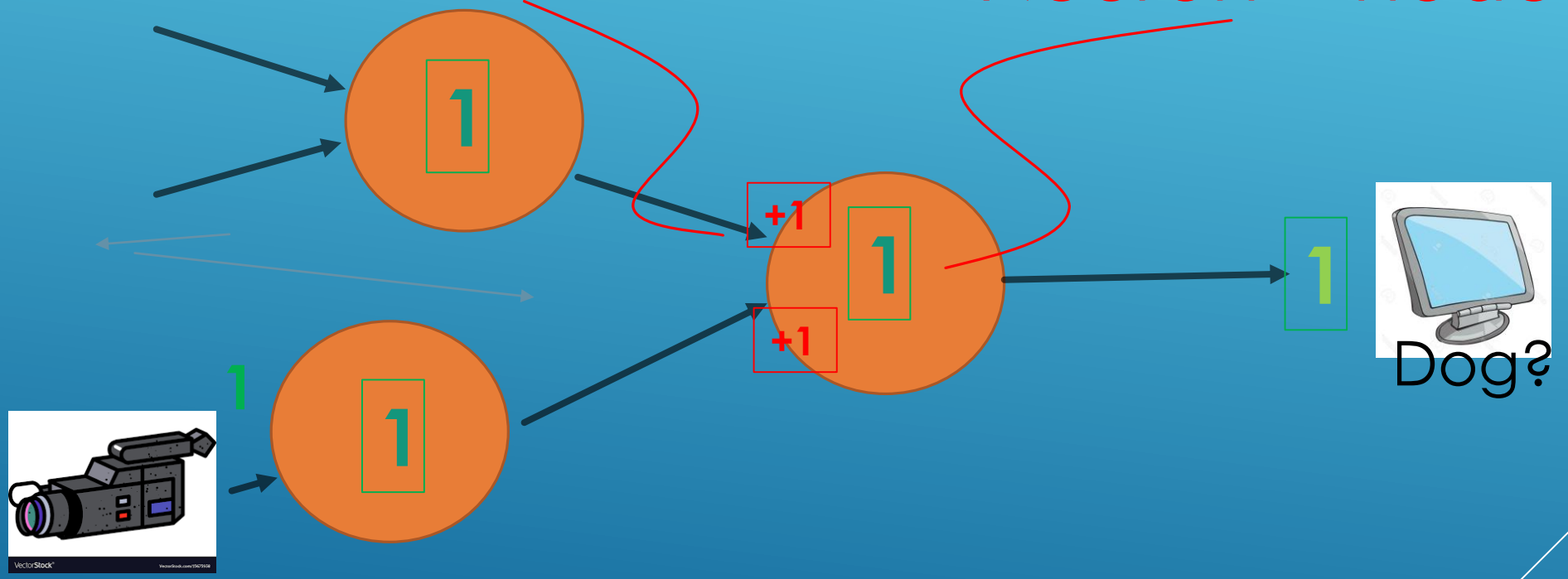


Synapse = weight

Neuron = node



# Synapse = weight

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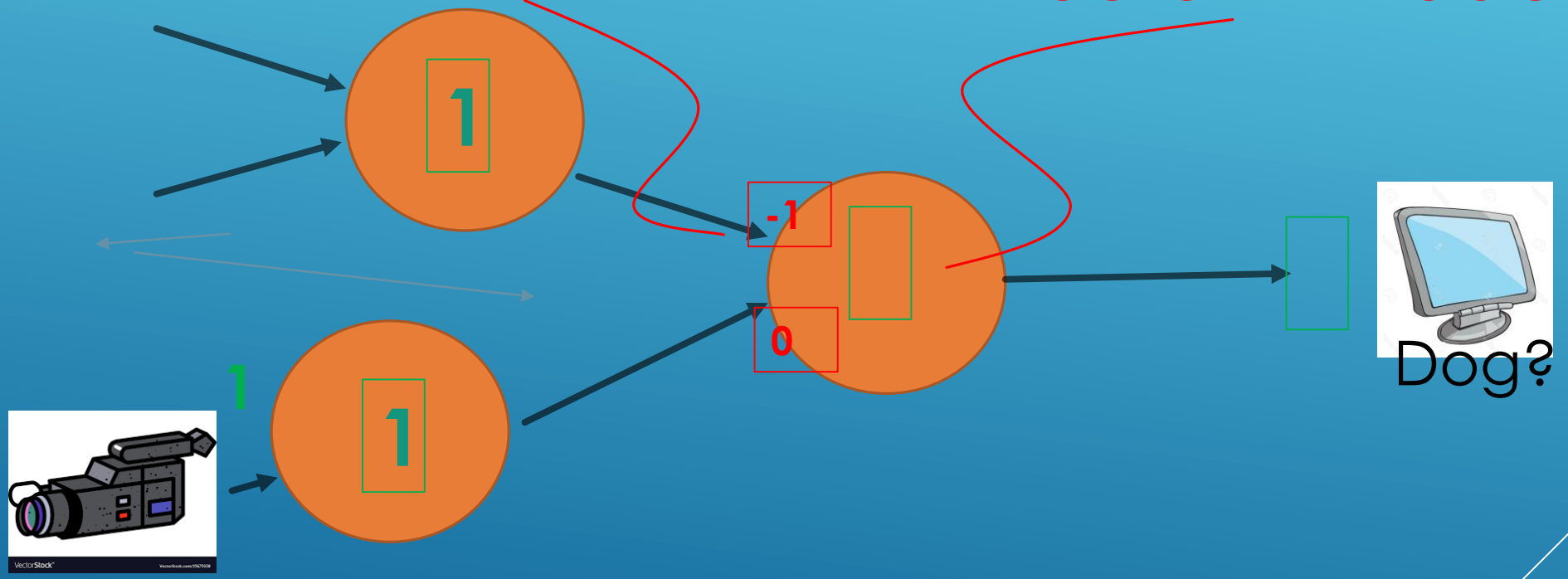

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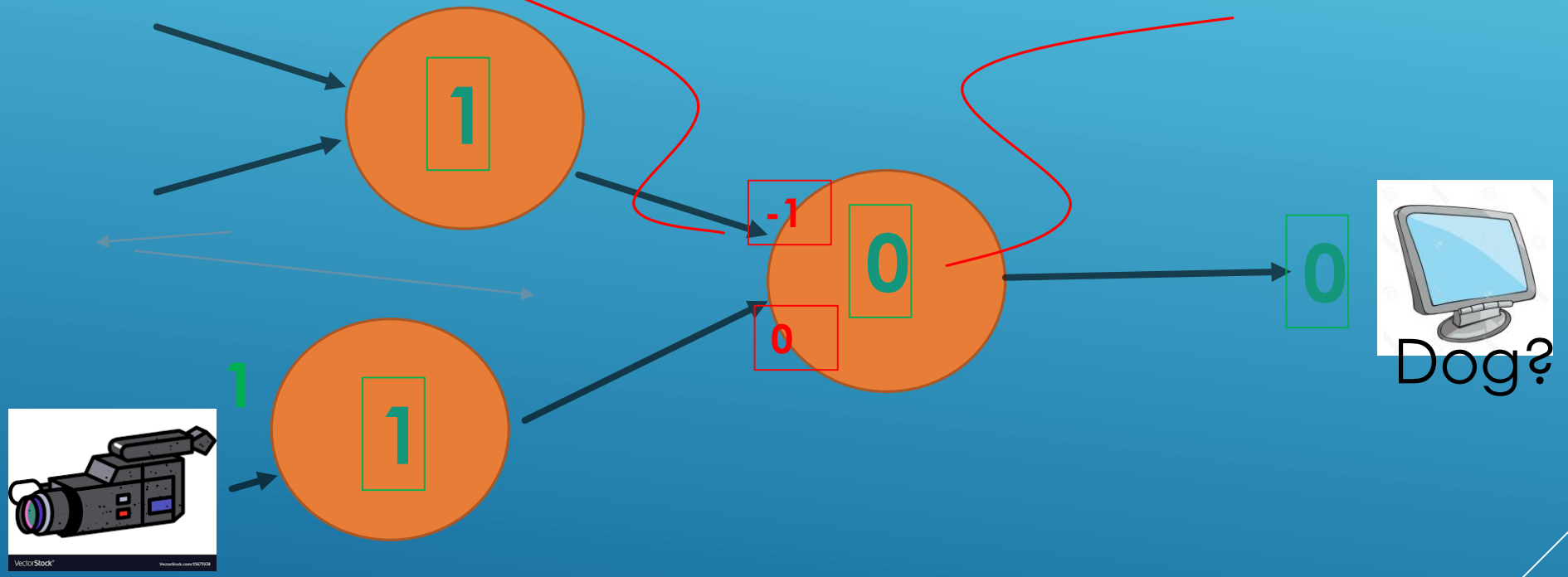
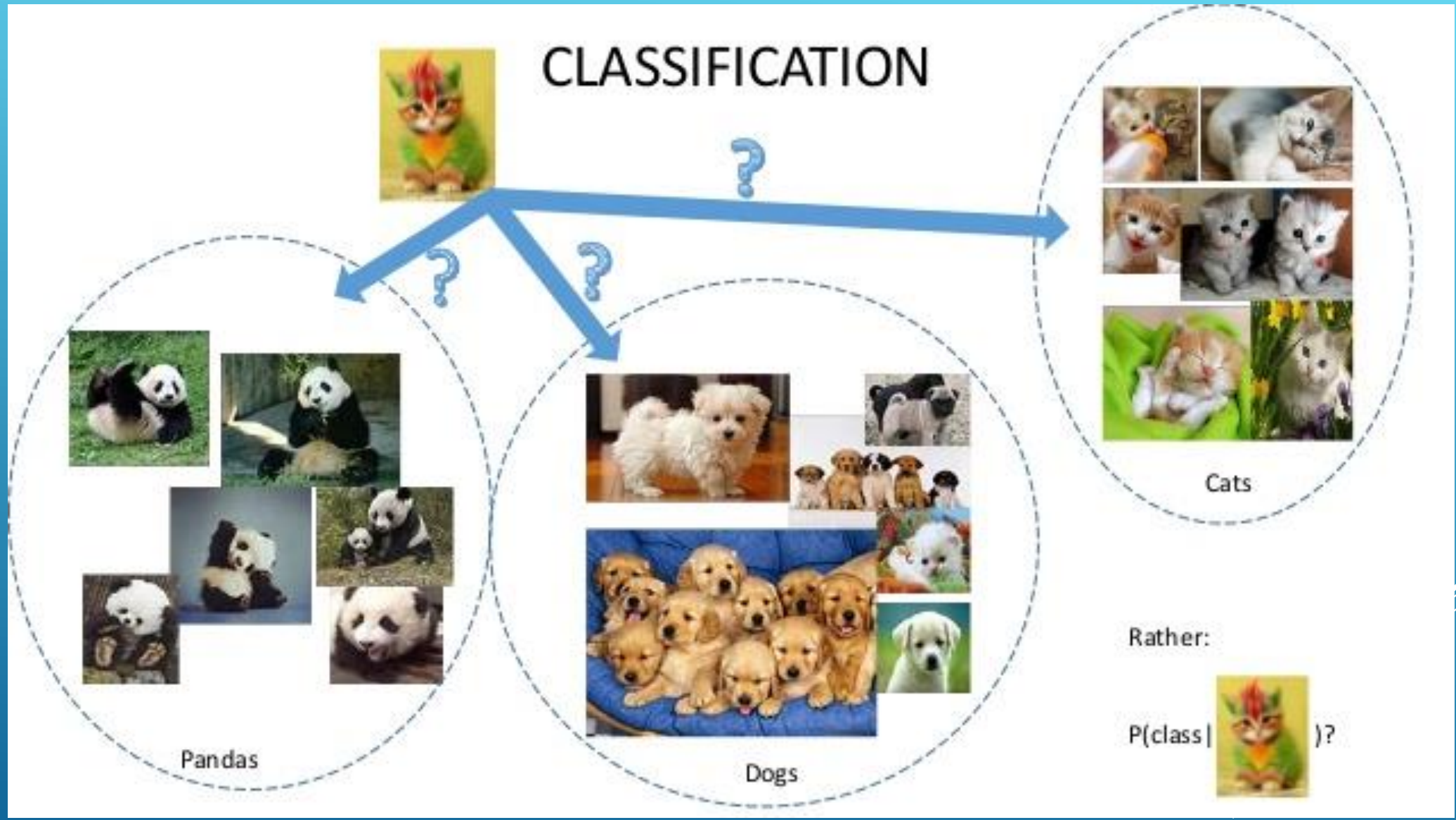
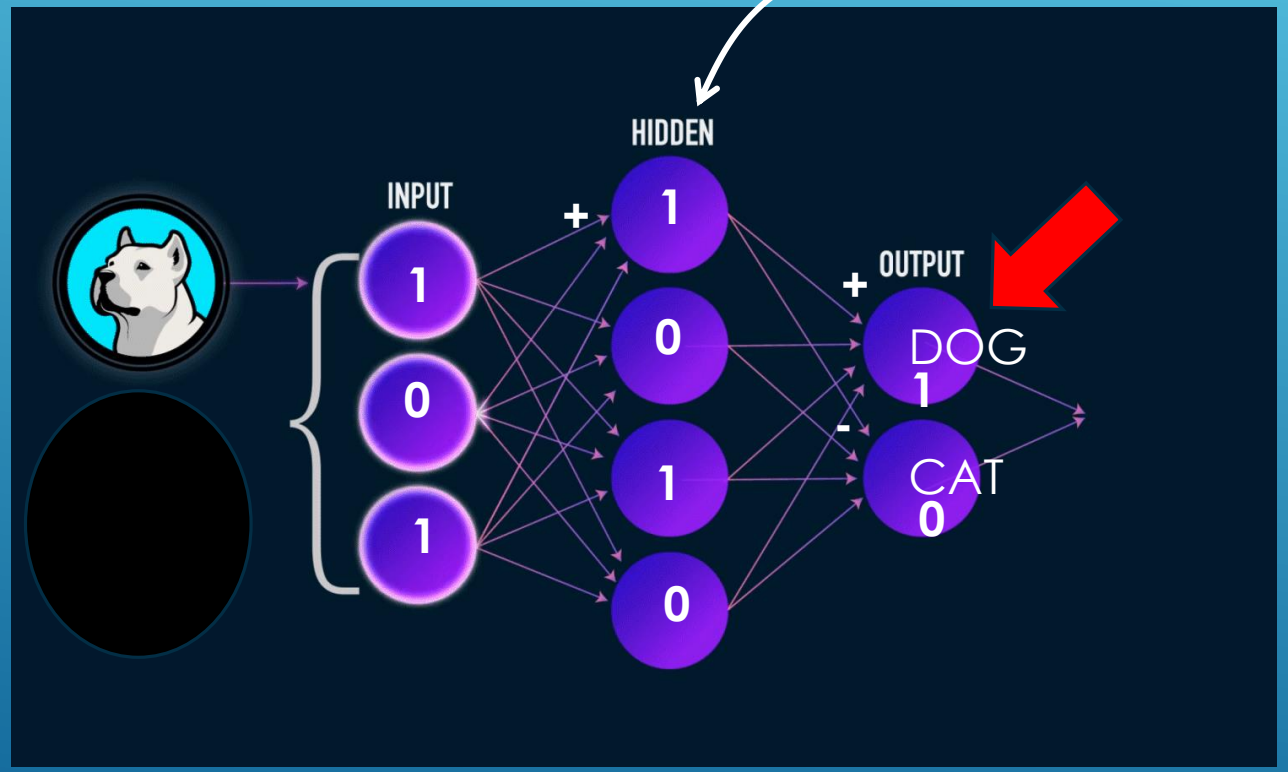
Neuron = node



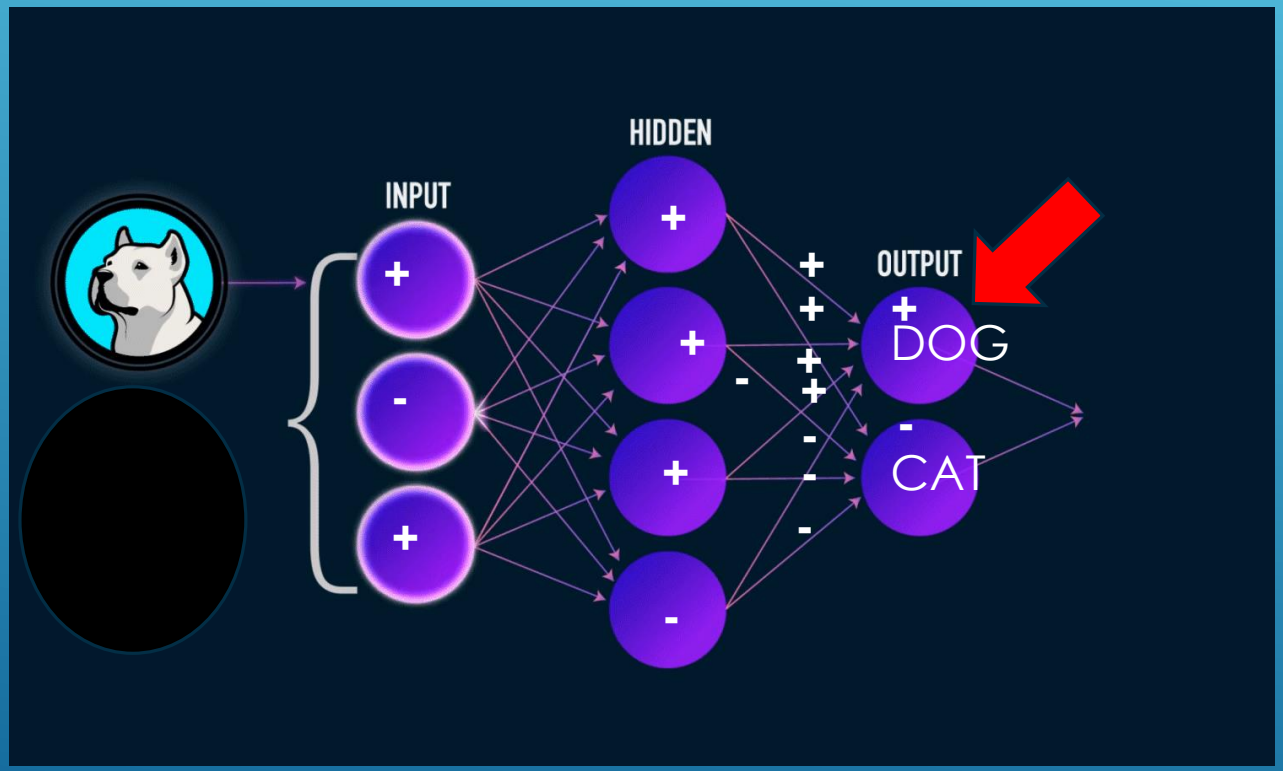

CLASSIFICATION
?
?
?
Pandas
Dogs
Cats
Rather:
P(class| )?

# "ANN" == ARTIFICIAL NEURAL NETWORK ("DEEP LEARNING"== LOTS OF HIDDEN LAYERS)

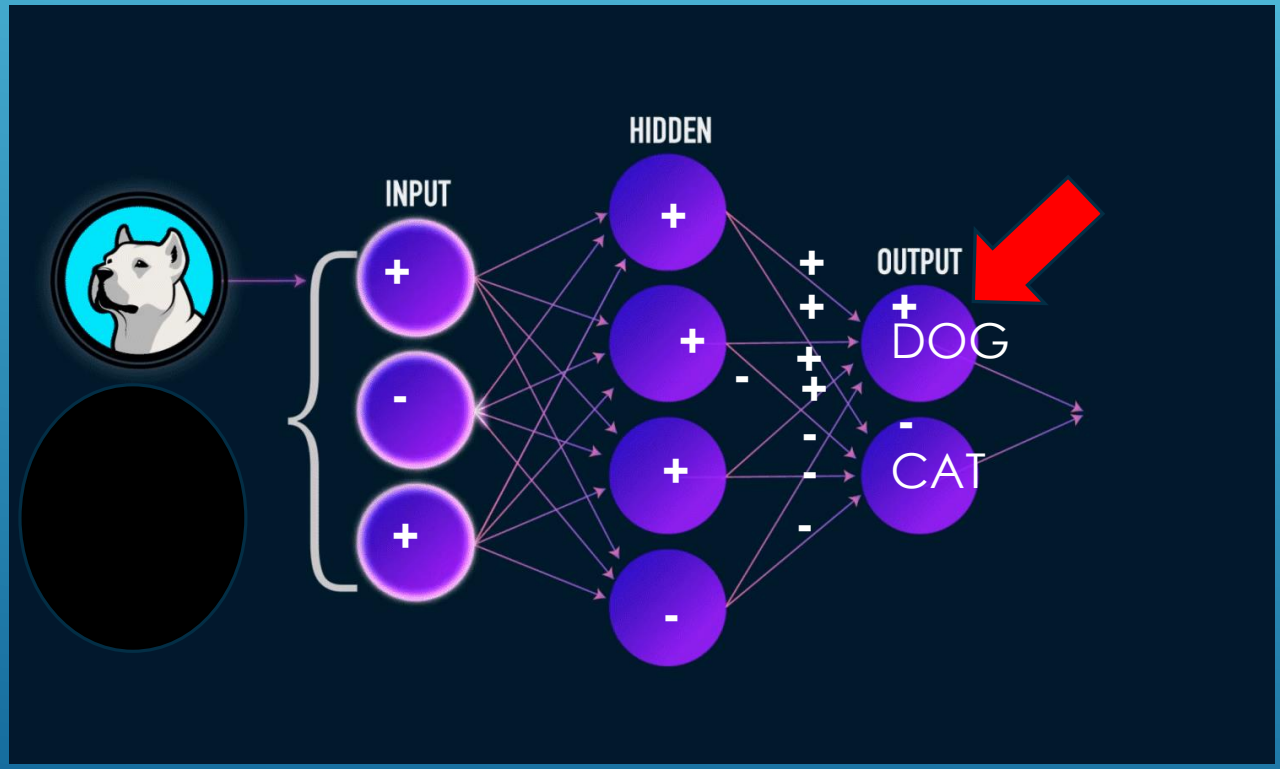



**Simplified**
*Real Deep Learning Neural Network will have *many* hidden layers*

# FOR THE PIXEL INPUTS OF THE DOG, STRONGER SYNAPSES GOING TO THE NEURONS FROM INPUT TO HIDDEN TO "DOG" OUTPUT

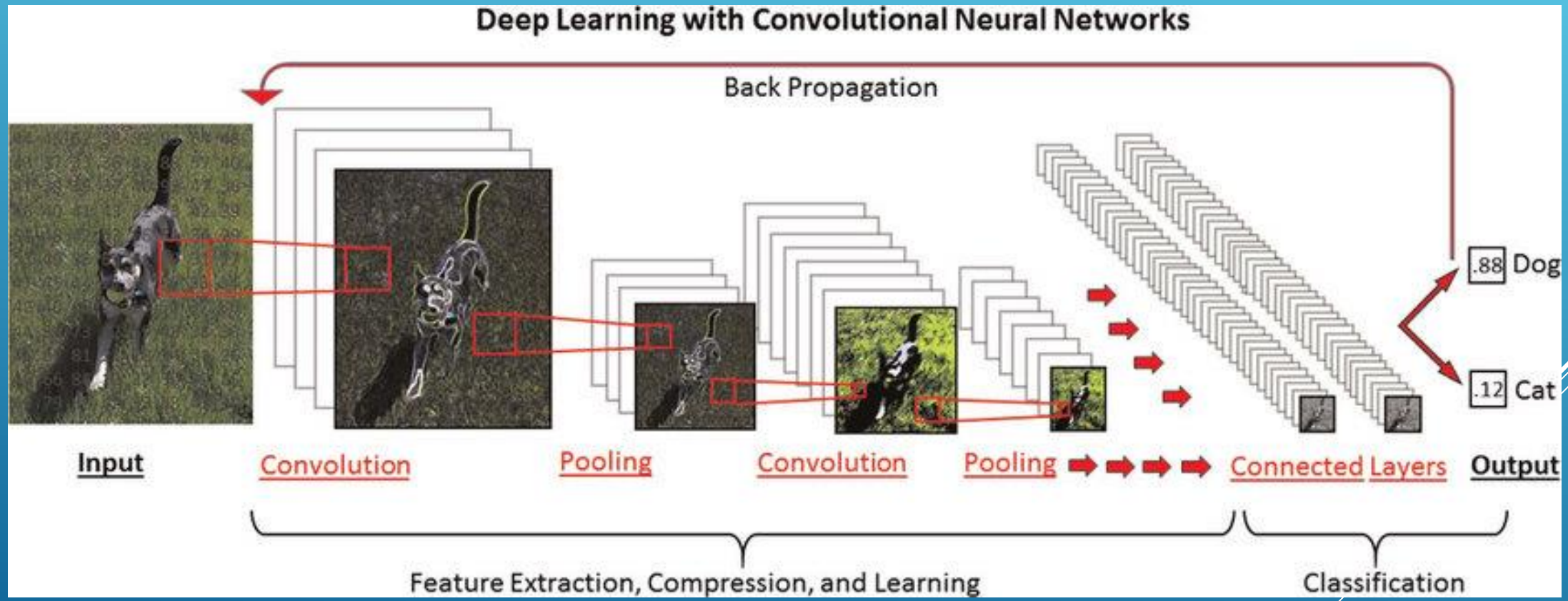


# HOW DID THE NEURAL NETWORK ("DEEP LEARNING NETWORK" IF MORE LAYERS) GET WIRED UP LIKE THIS TO GIVE US THIS ANSWER?

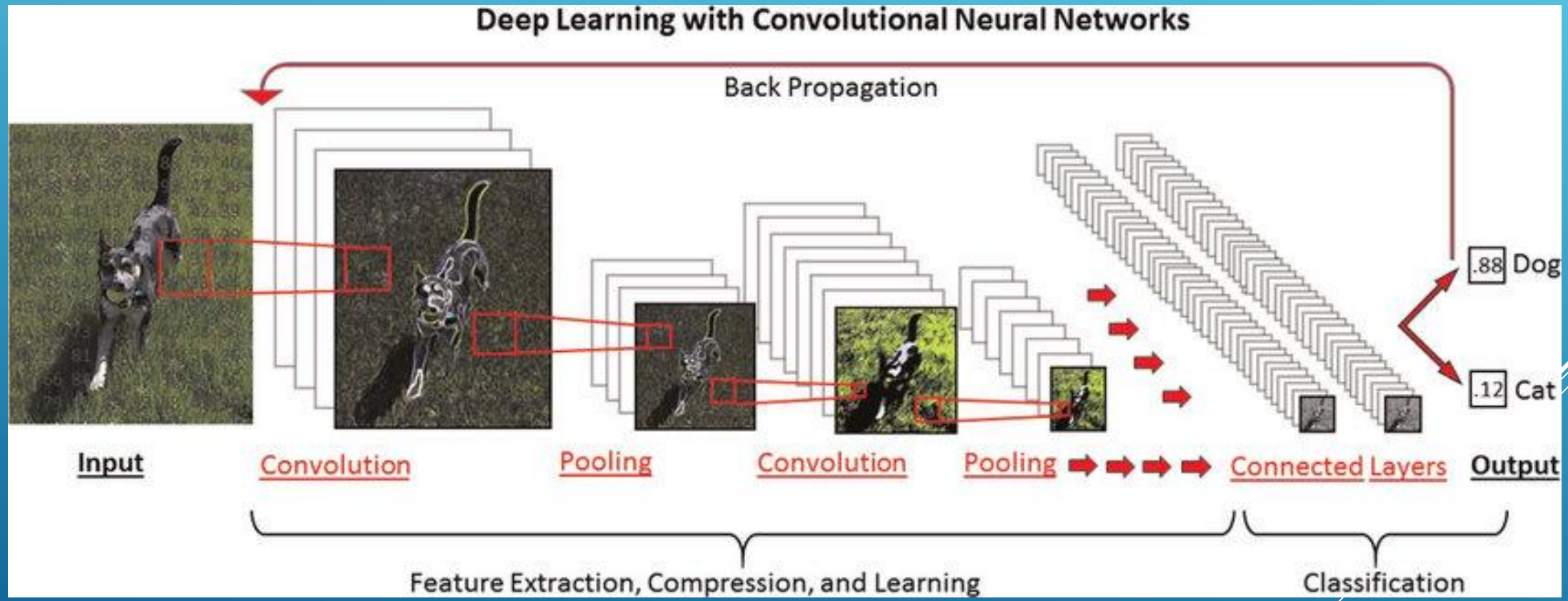


# REALLY LOOKS MORE LIKE THIS

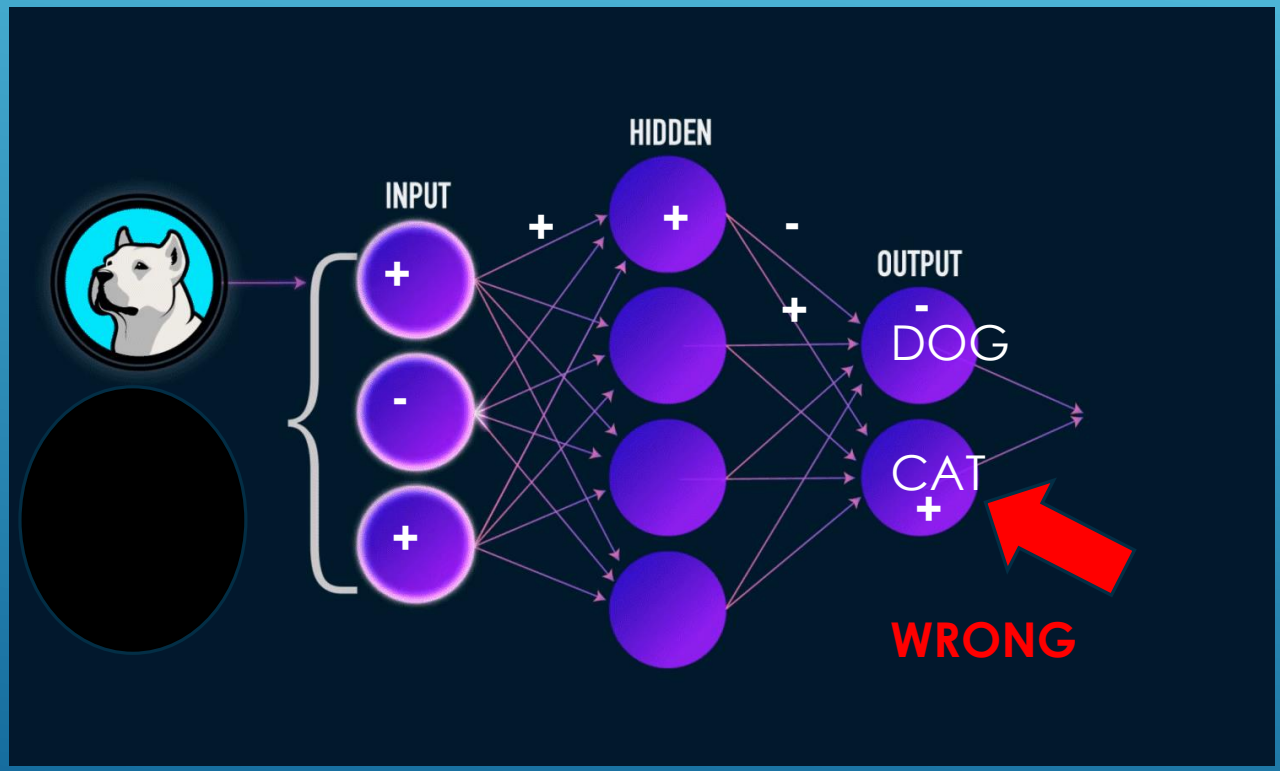
("DEEP LEARNING" == LOTS OF HIDDEN LAYERS OF NEURONS)



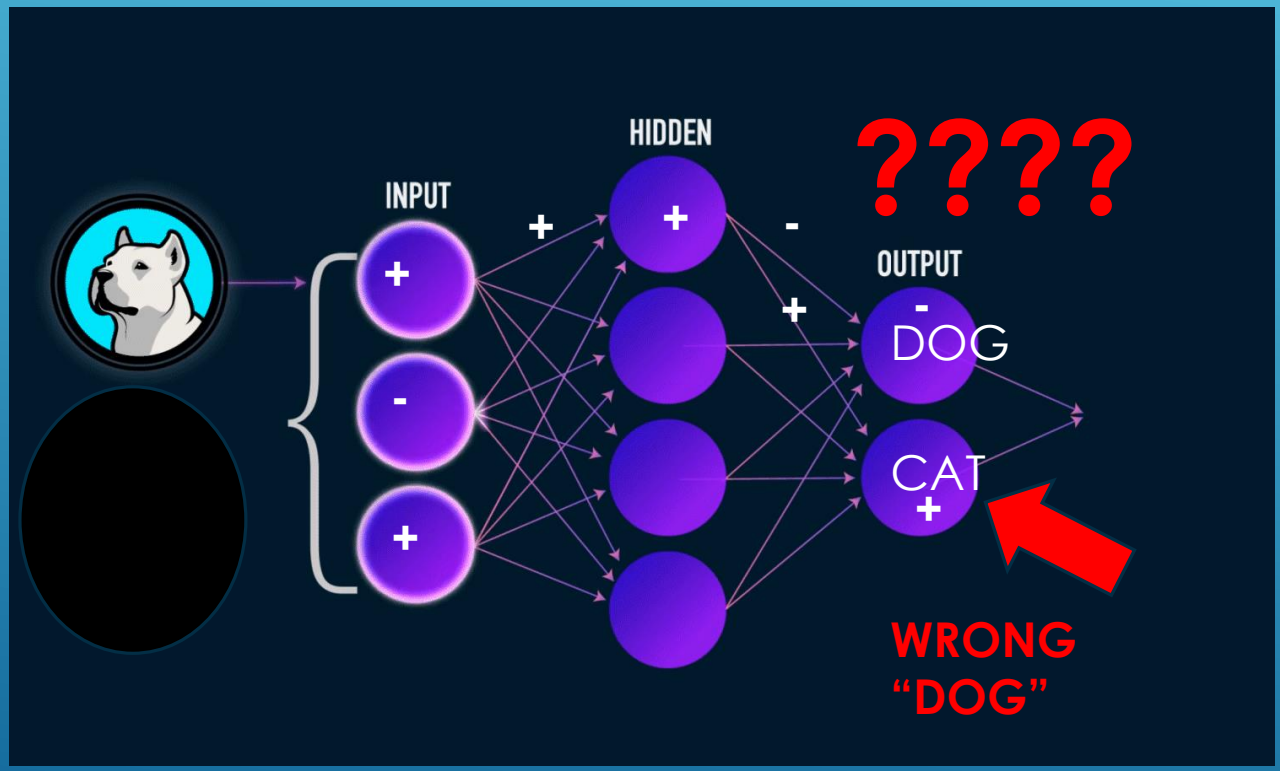
# DON'T HAVE TO BUILD THIS UP BY HAND (MASSIVE EFFORT, POOR RESULTS)



# START OFF WITH RANDOM WEIGHTS ON THE SYNAPSES….



# HOW TO FIX THIS AUTOMATICALLY? (WELL….SEMI-AUTOMATICALLY SINCE NEED HUMAN TO HAVE ALREADY FIGURED OUT THIS IS A DOG)



# Supervised Learning ("SL")

HOW TO FIX THIS AUTOMATICALLY?
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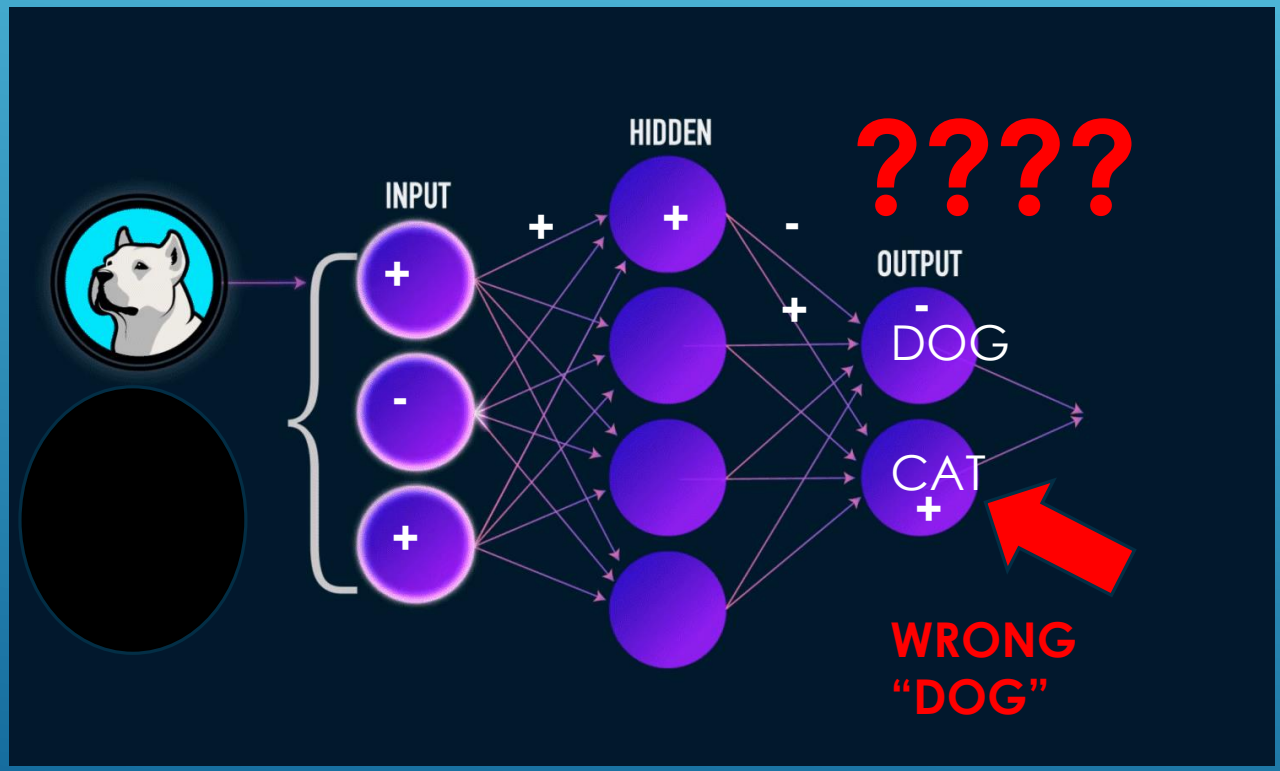

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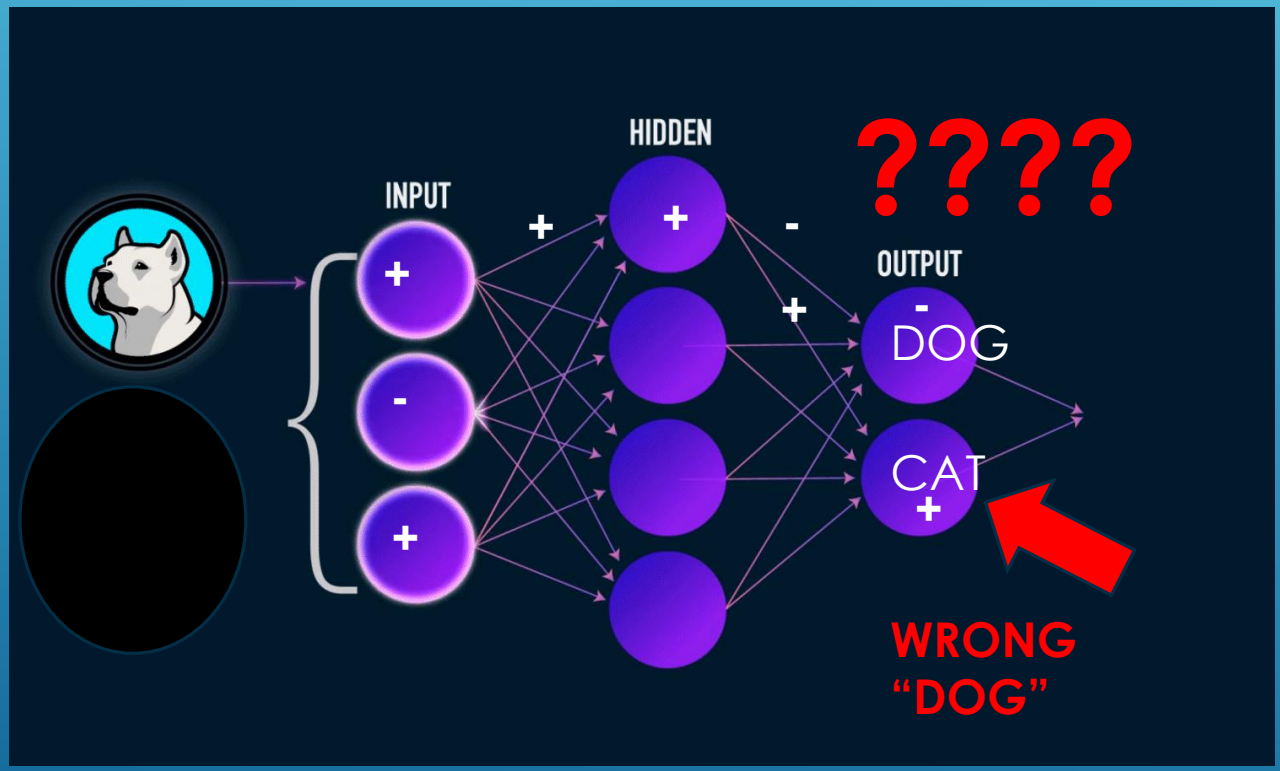
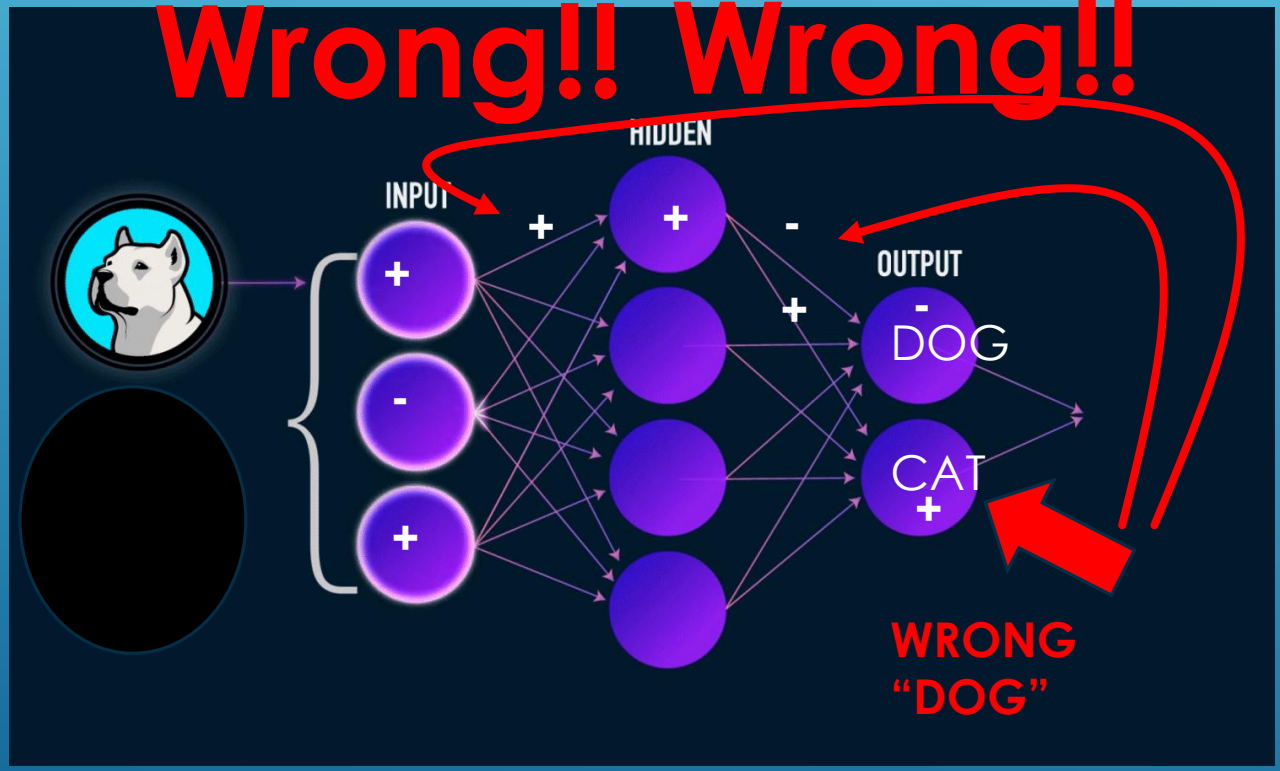
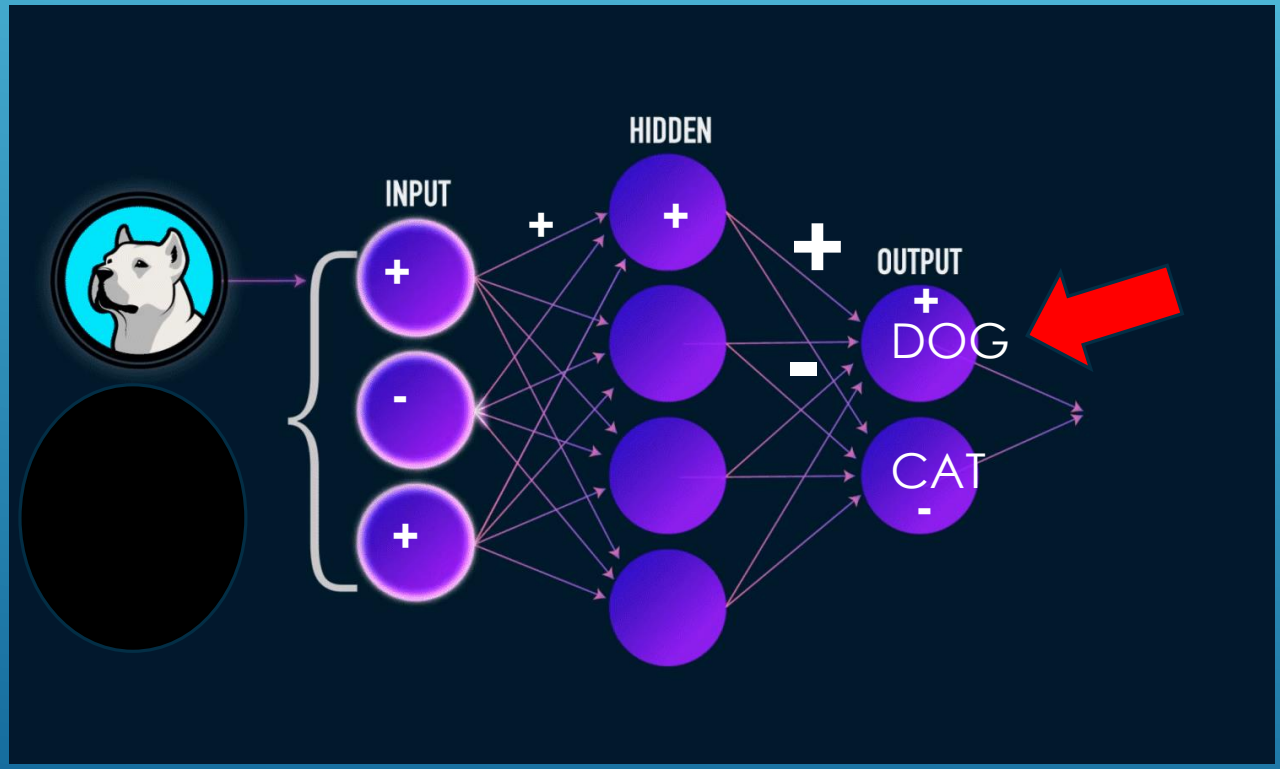


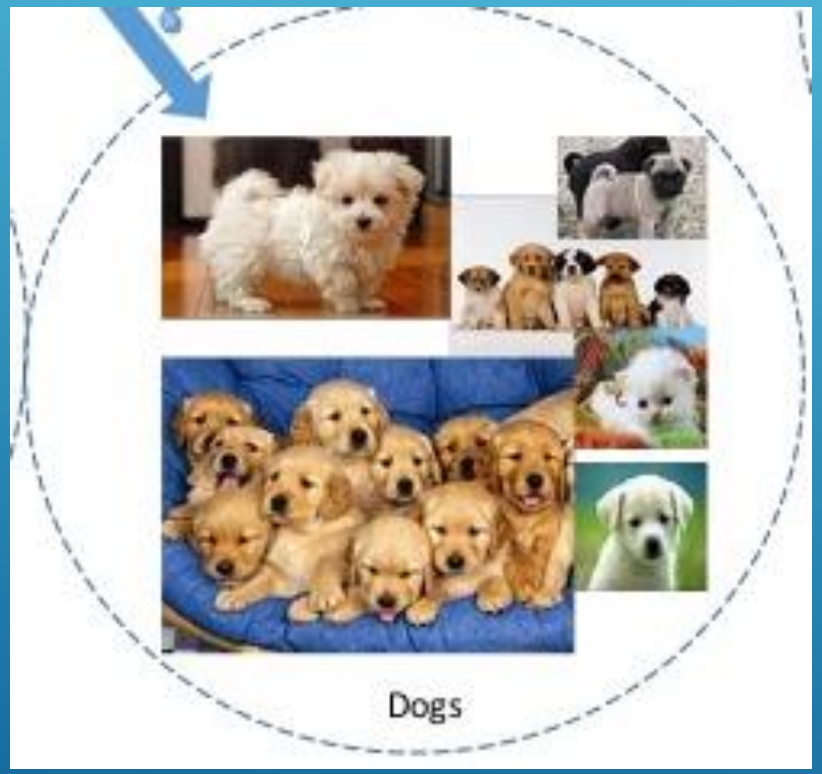
# FIX AUTOMATICALLY WITH FEEDBACK



# AFTER ENOUGH TRAINING CYCLES, THE NEURAL NETWORK CAN CLASSIFY AN IMAGE AS A DOG VERSUS CAT

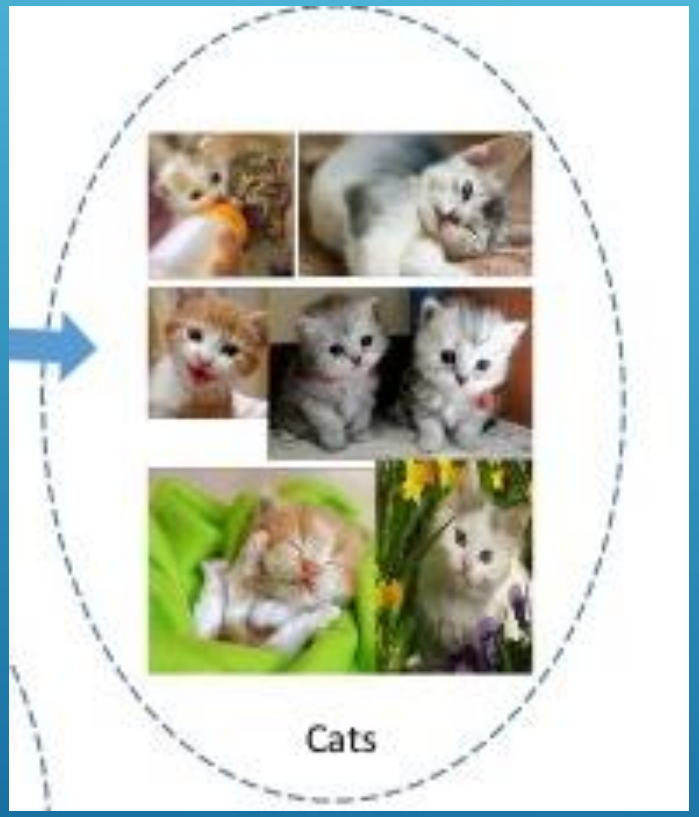


# WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT DOGS



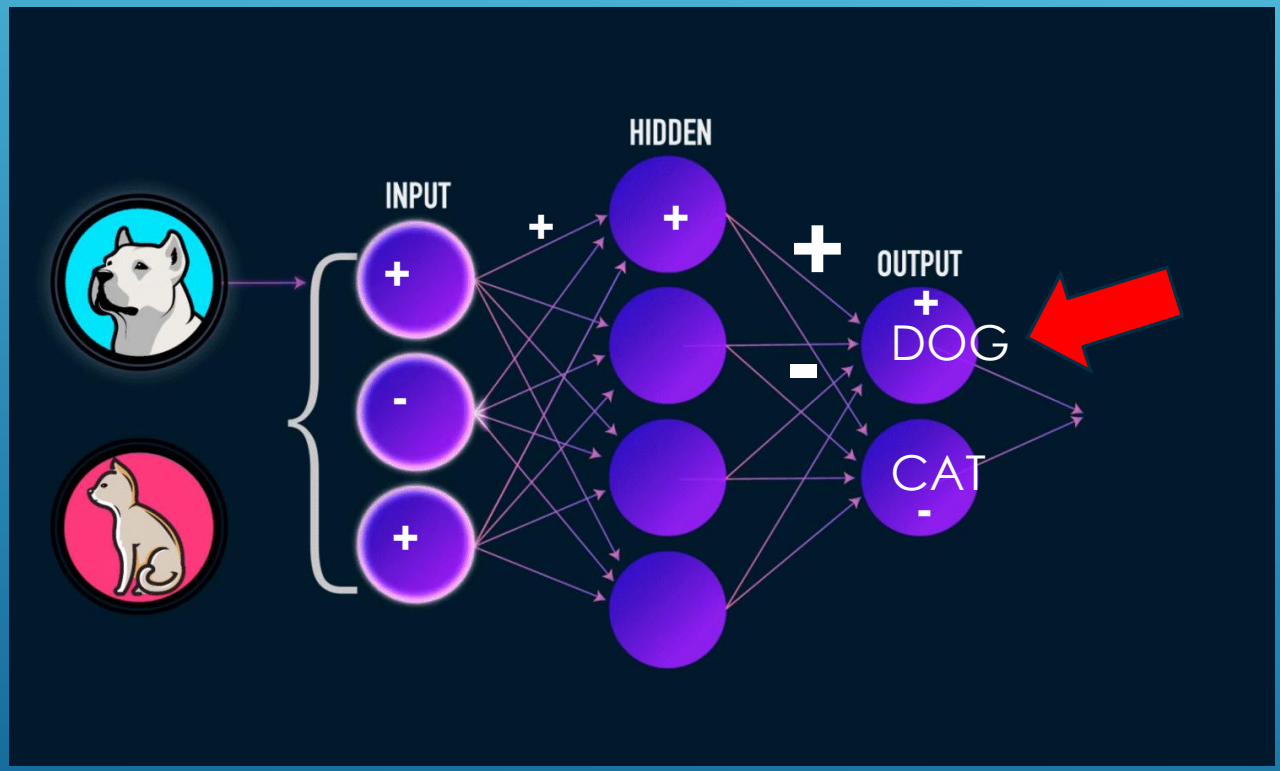

Pass in a file with pictures of many different types of dogs, and all these pictures are labeled "dog" so the neural network will know that the correct answer is to classify as a dog

# WE TRAIN OUR NETWORK ON A VARIETY OF DIFFERENT CATS

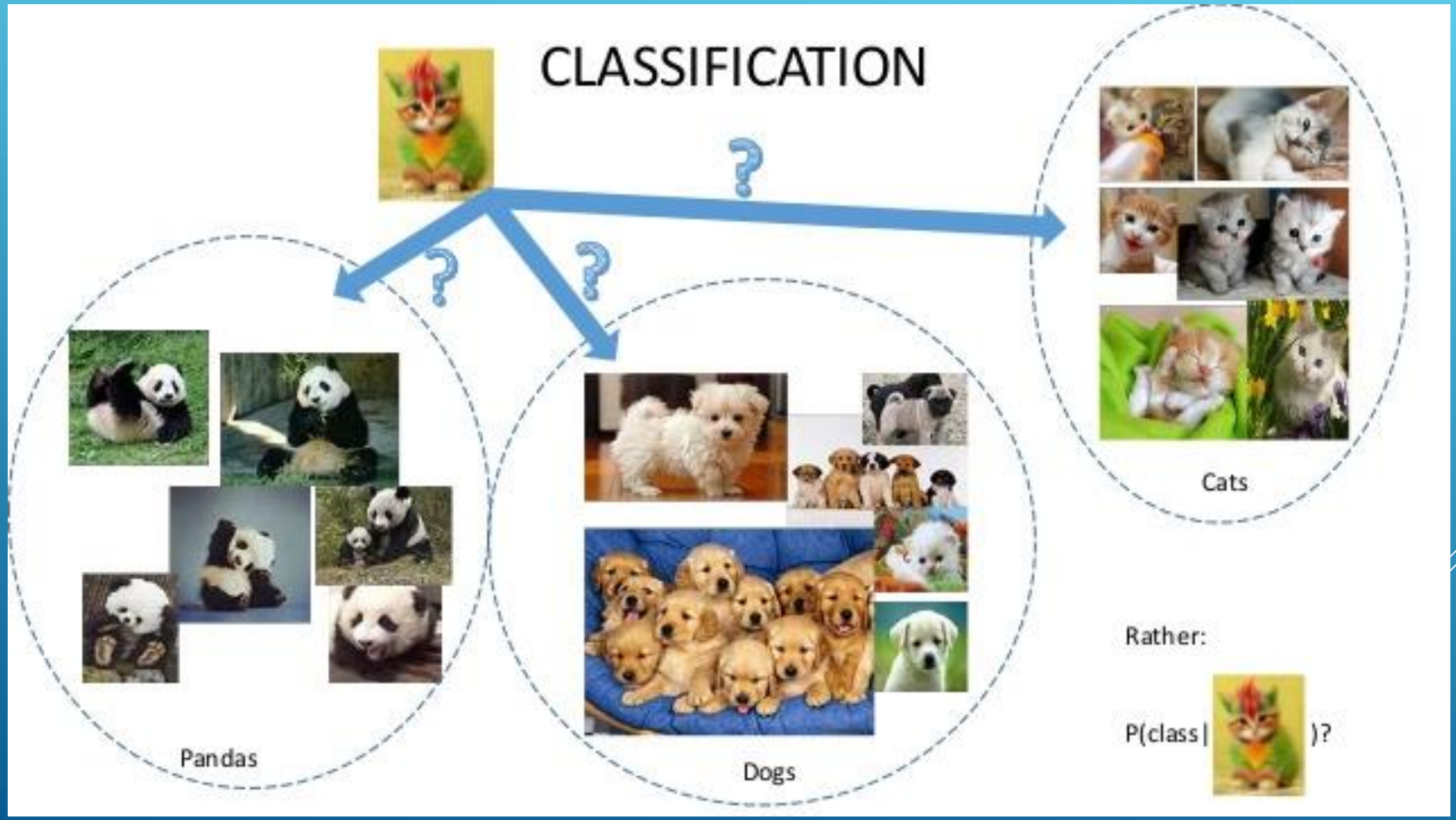



Pass in a file with pictures of many different types of cats, and all these pictures are labeled "cat" so the neural network will know that the correct answer is to classify as a cat

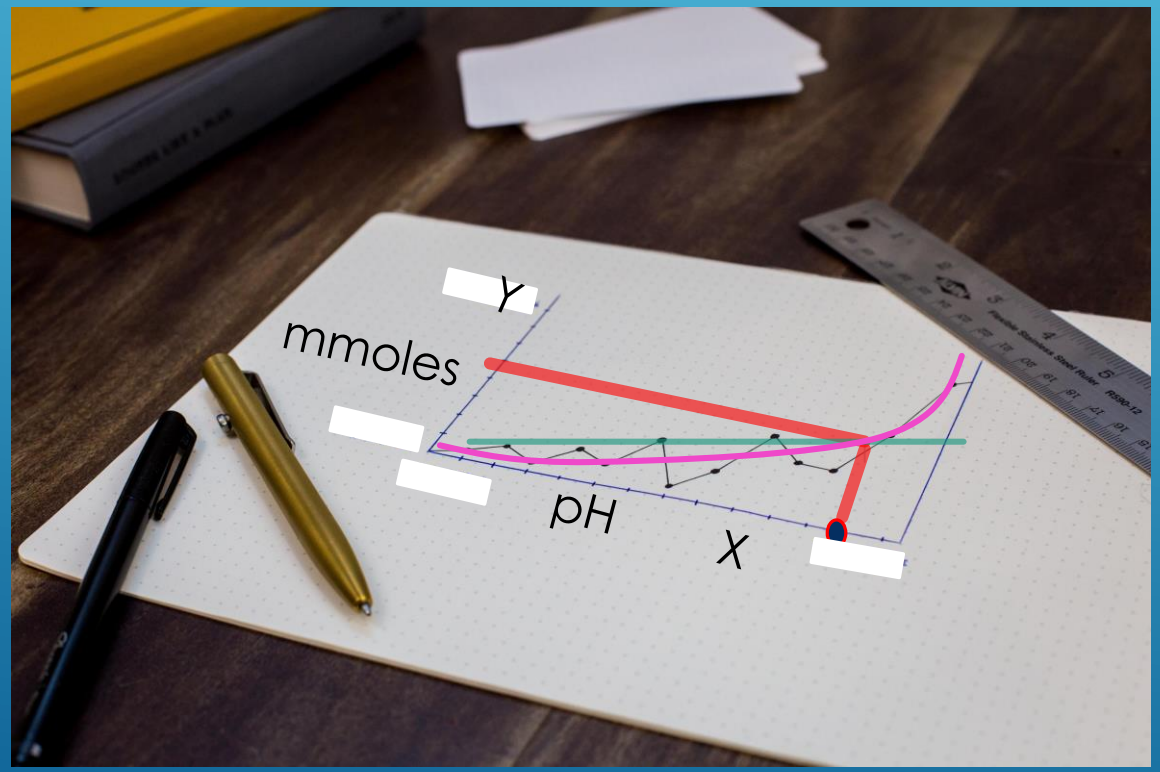
# AFTER ENOUGH TRAINING CYCLES, ON DIFFERENT TYPES OF DOGS AND CATS, THE NEURAL NETWORK CAN CLASSIFY DIFFERENT IMAGES AS A DOG VERSUS CAT



# NEURAL NETWORK CAN CLASSIFY CAT IT HAS NEVER SEEN BEFORE IN TRAINING

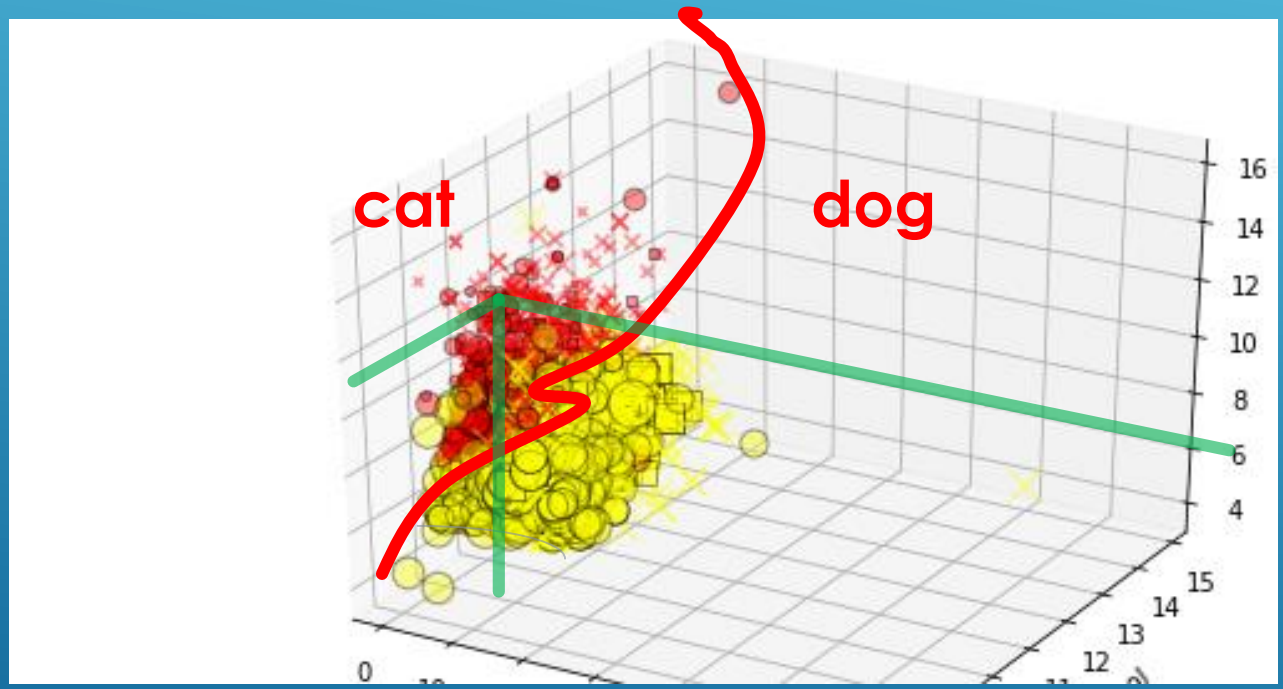


# YOU WERE ABLE TO CLASSIFY A DATA POINT YOU NEVER SAW BEFORE ALSO ON YOUR GRAPH



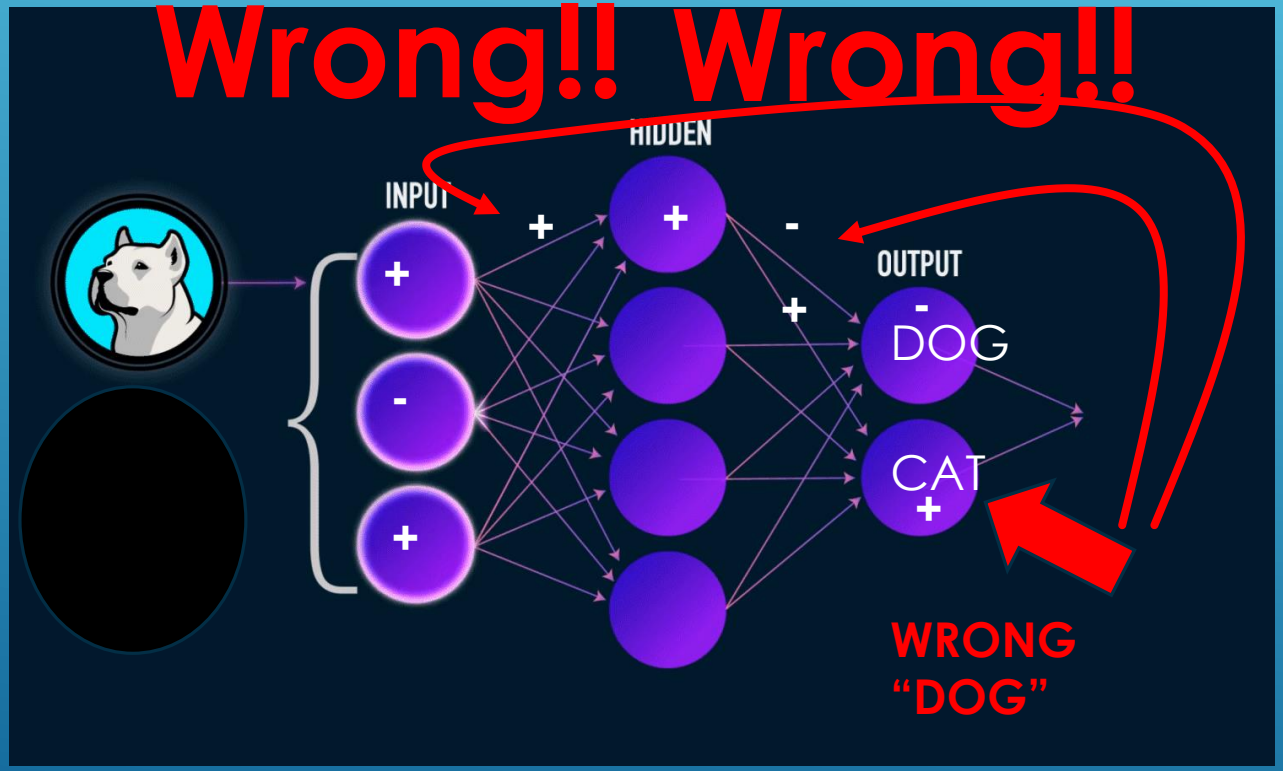

New X value never seen before, you can predict the Y value

# -ANIMAL WE HAVE NEVER SEEN BEFORE, WE CAN FIGURE OUT IF A DOG OR A CAT



# "BACKPROPAGATION"

METHOD OF USING FEEDBACK TO CHANGE THE WEIGHTS IN A WAY THAT WILL HELP NETWORK CLASSIFY WITH LESS ERROR



# BACKPROPAGATION

1. FEEDFORWARD OPERATION – TRY OUT NEURAL NETWORK AND SEE ERROR IT PRODUCES IN OUTPUT
2. BACKPROPAGATION OPERATION – ADJUST WEIGHTS IN RESPONSE TO ERROR

OVER AND OVER AGAIN (VERY FAST COMPUTER)

ONCE YOU ARE SATISFIED WITH TRAINING, STOP AND YOU HAVE A NEURAL NETWORK THAT WORKS WELL

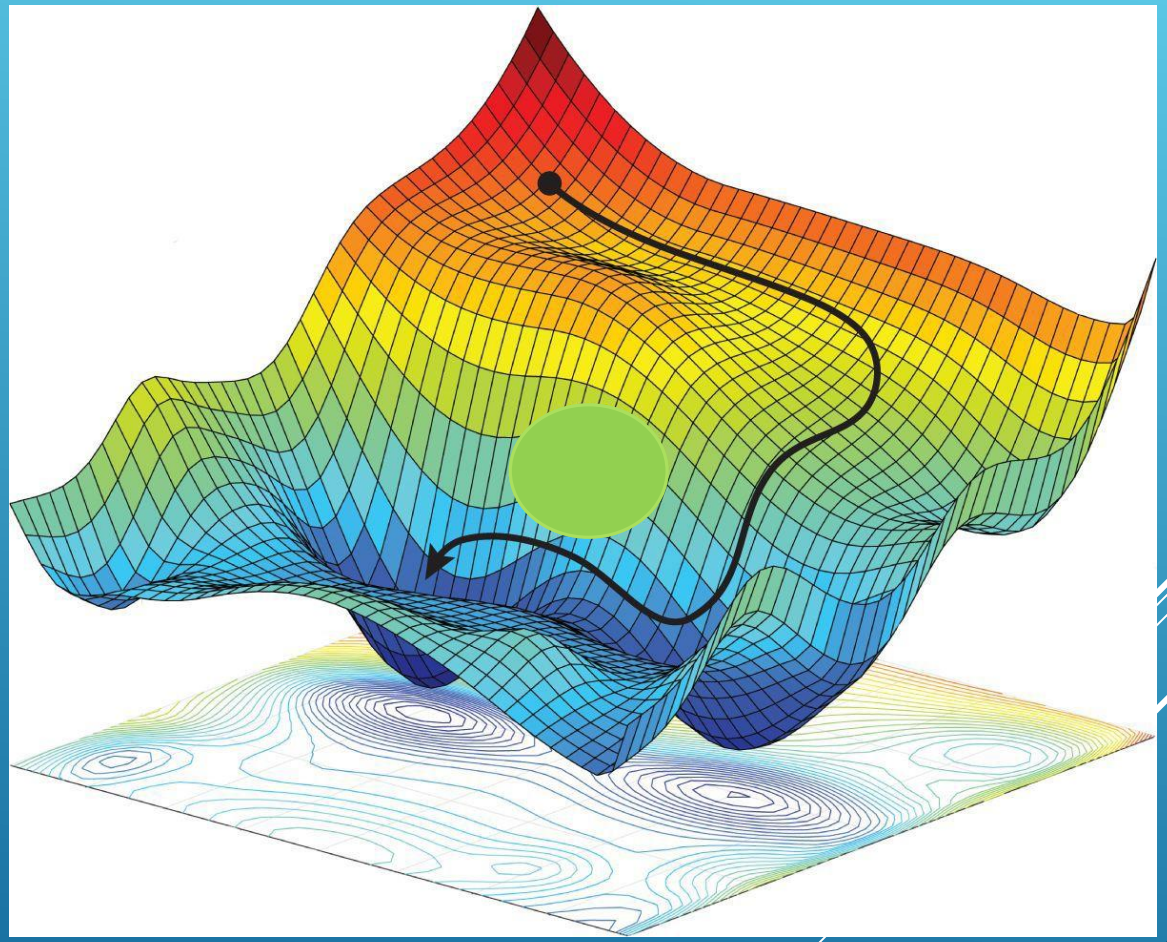
# STOCHASTIC GRADIENT DESCENT (SGD)

'Stochastic' – single random sample each iteration

'Gradient' – slope of a function (partial derivatives of set of parameters)

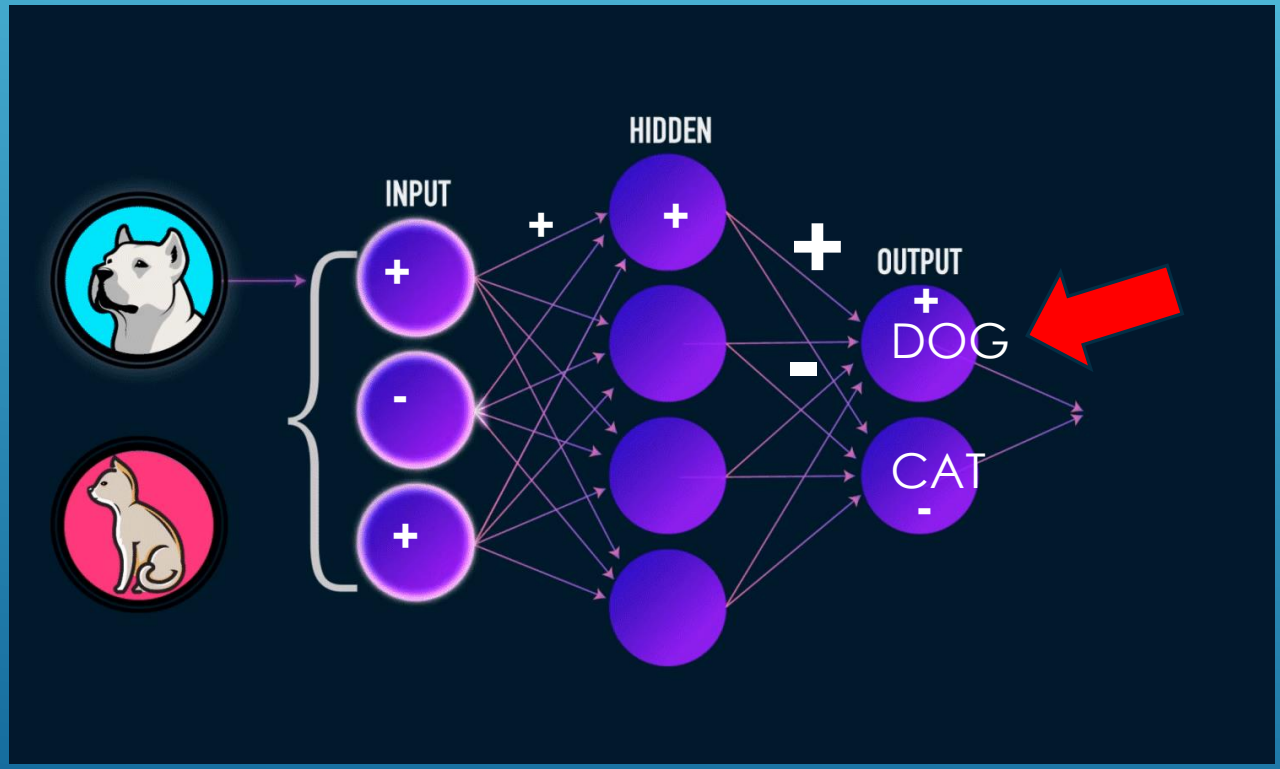
'Gradient Descent' – iterative optimization method

Can apply to 1000's of dimensions, not just 3-D shown in figure

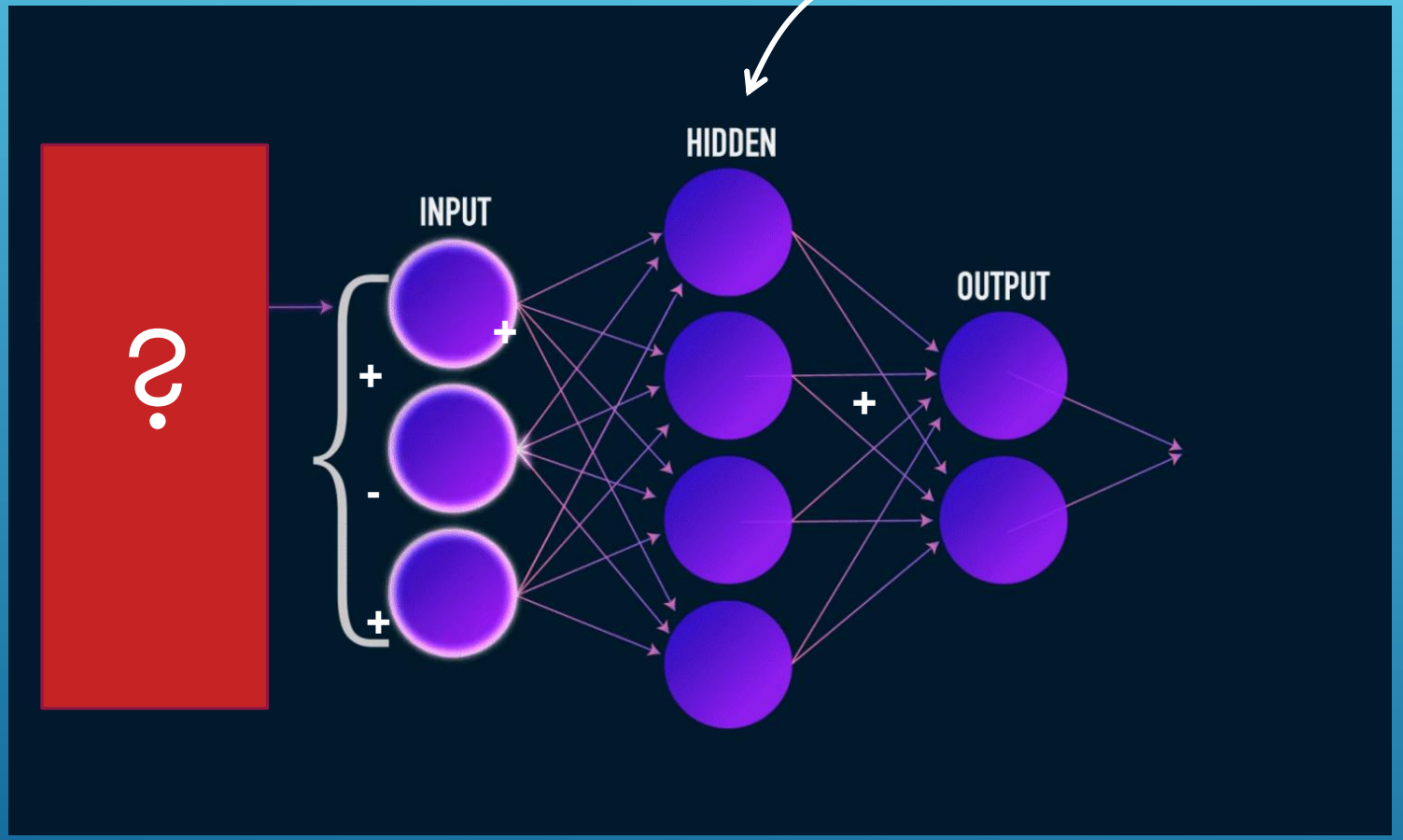



Let’s pause, and think about what technology we just showed…..

# OUR NEURAL NETWORK CAN RECOGNIZE DOGS FROM CATS…..

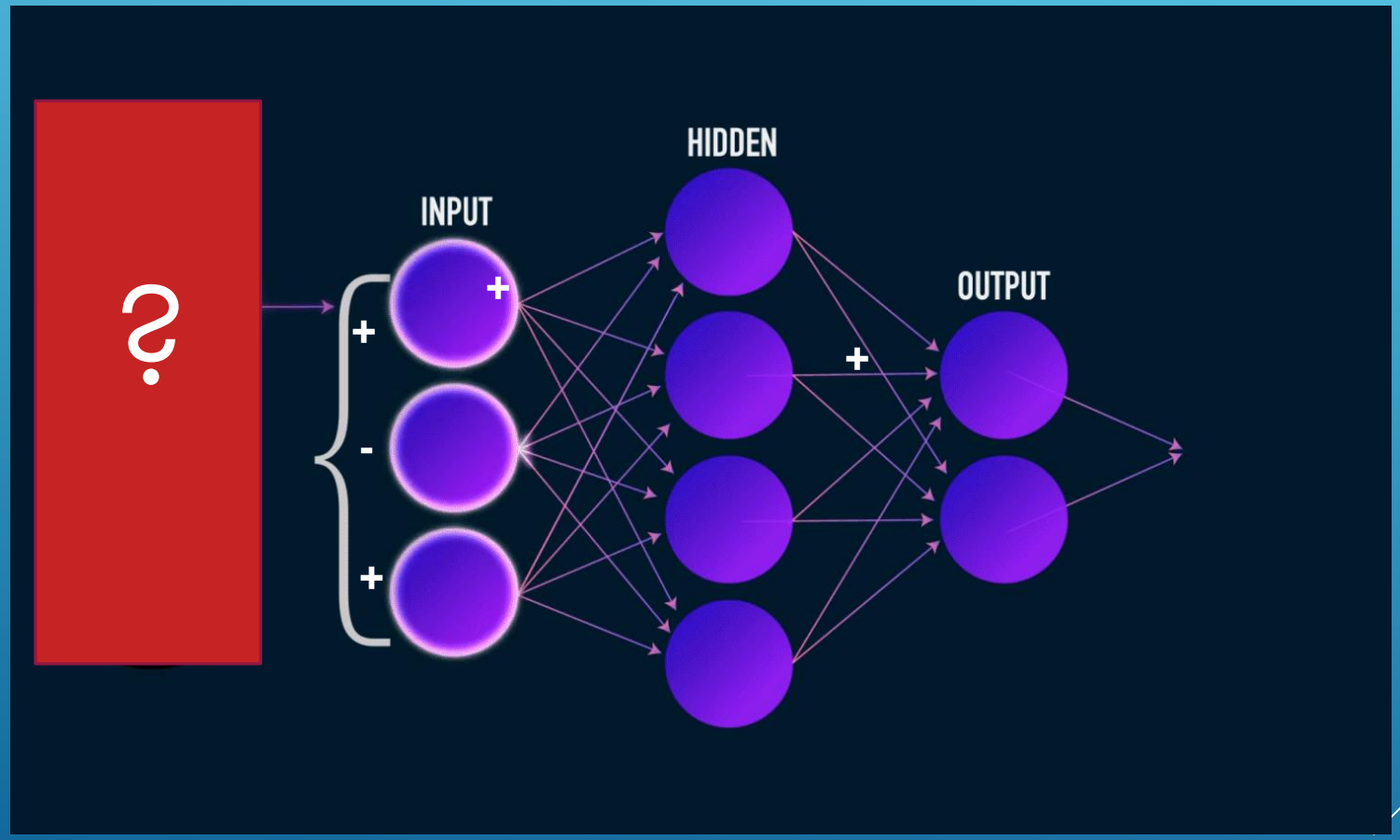


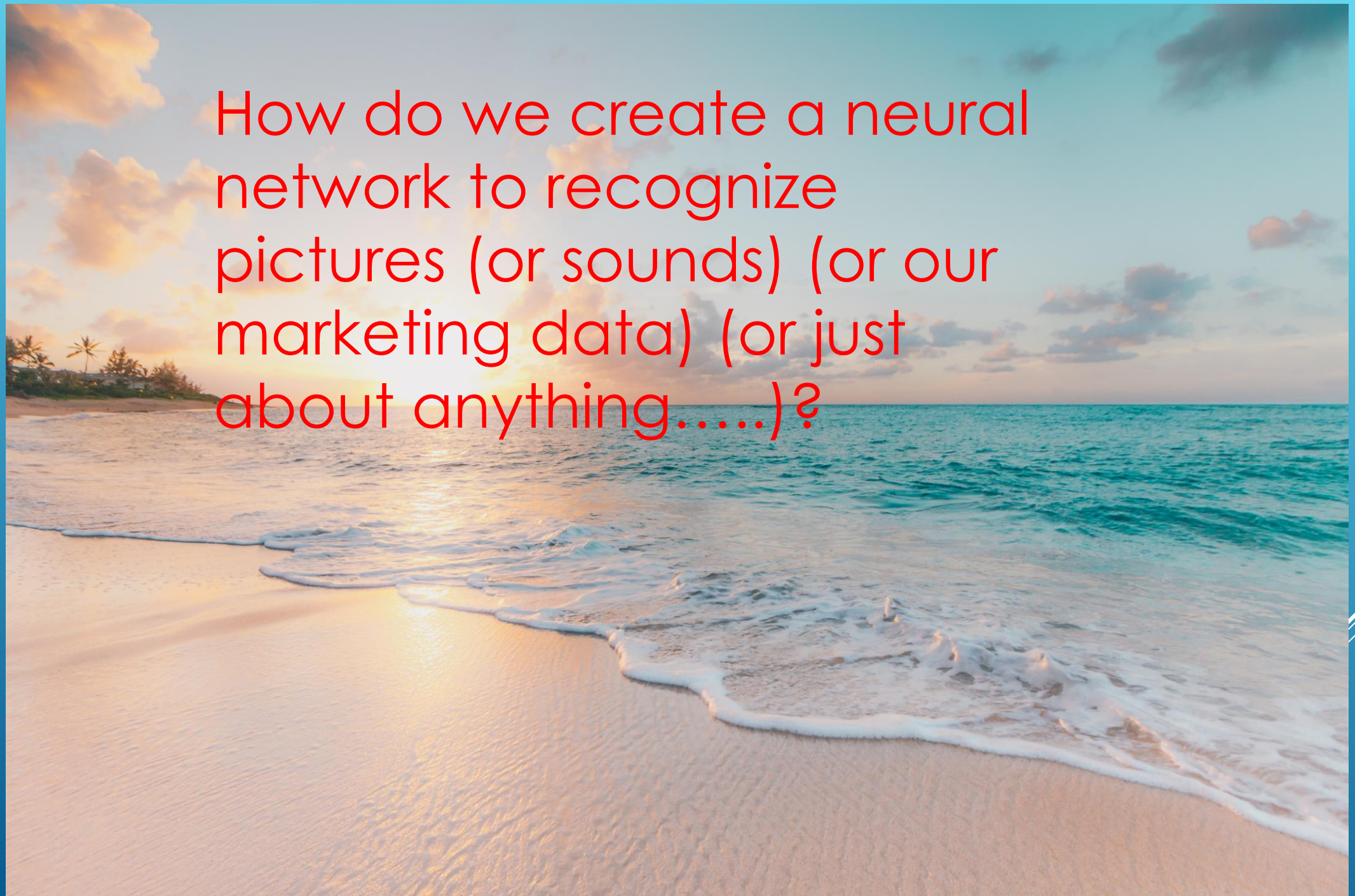
# OR IT CAN RECOGNIZE AND CLASSIFY JUST ABOUT ANY IMAGE…..



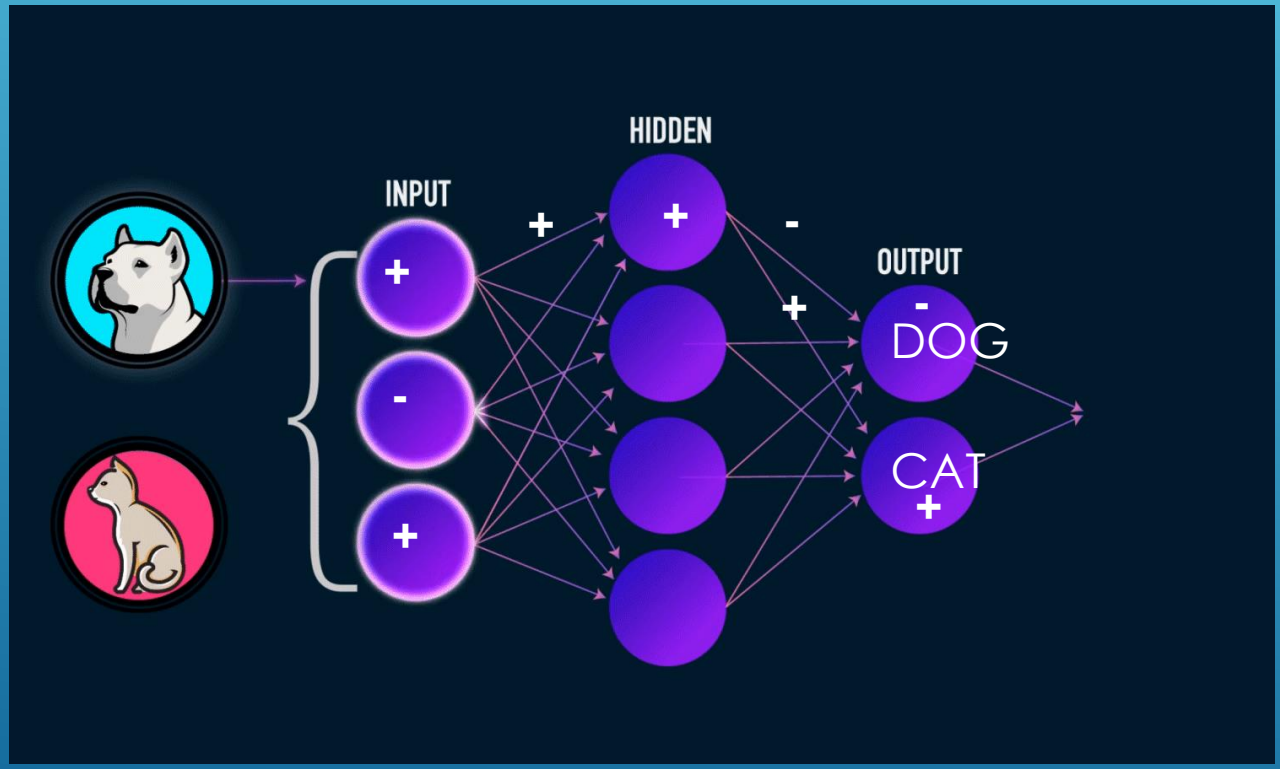

**Simplified**
*Real Deep Learning Neural Network will have *many* hidden layers*

# WITH SMALL CHANGES TO THE WAY WE ORGANIZE THE LAYERS, THE NEURAL NETWORK CAN CLASSIFY SOUNDS AND SPEECH AND MARKETING DATA AND……



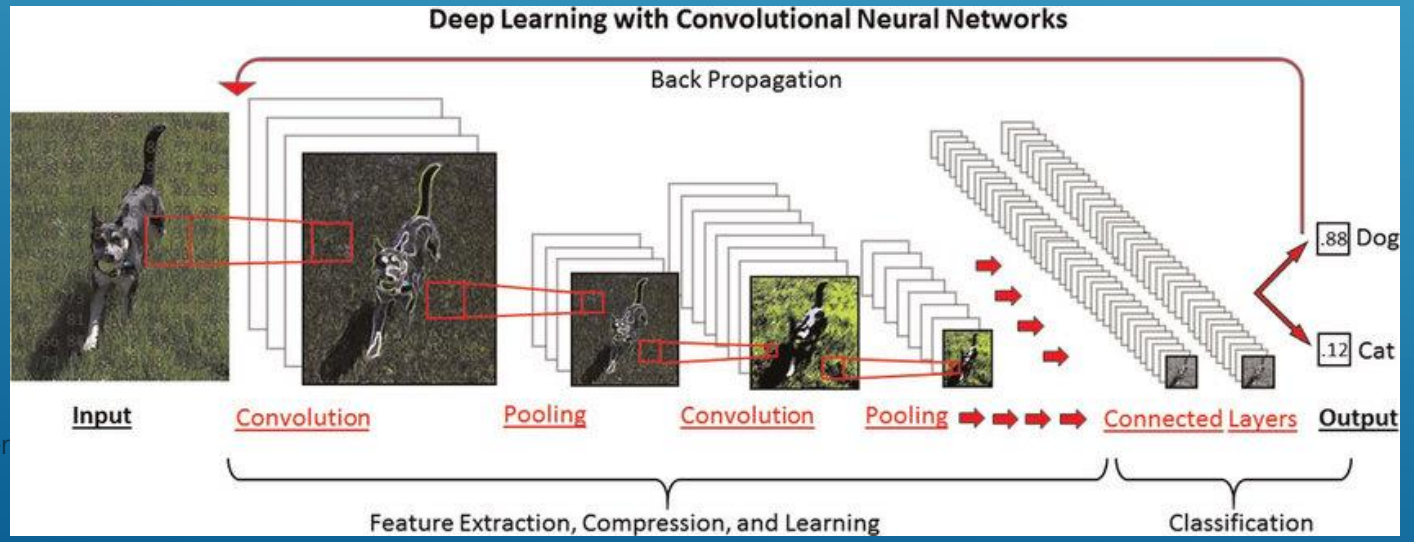

How do we create a neural network to recognize pictures (or sounds) (or our marketing data) (or just about anything…..)?

# 1. TAKE A NEW NEURAL NETWORK (RANDOM WEIGHTS ON THE SYNAPSES…. )




1980's

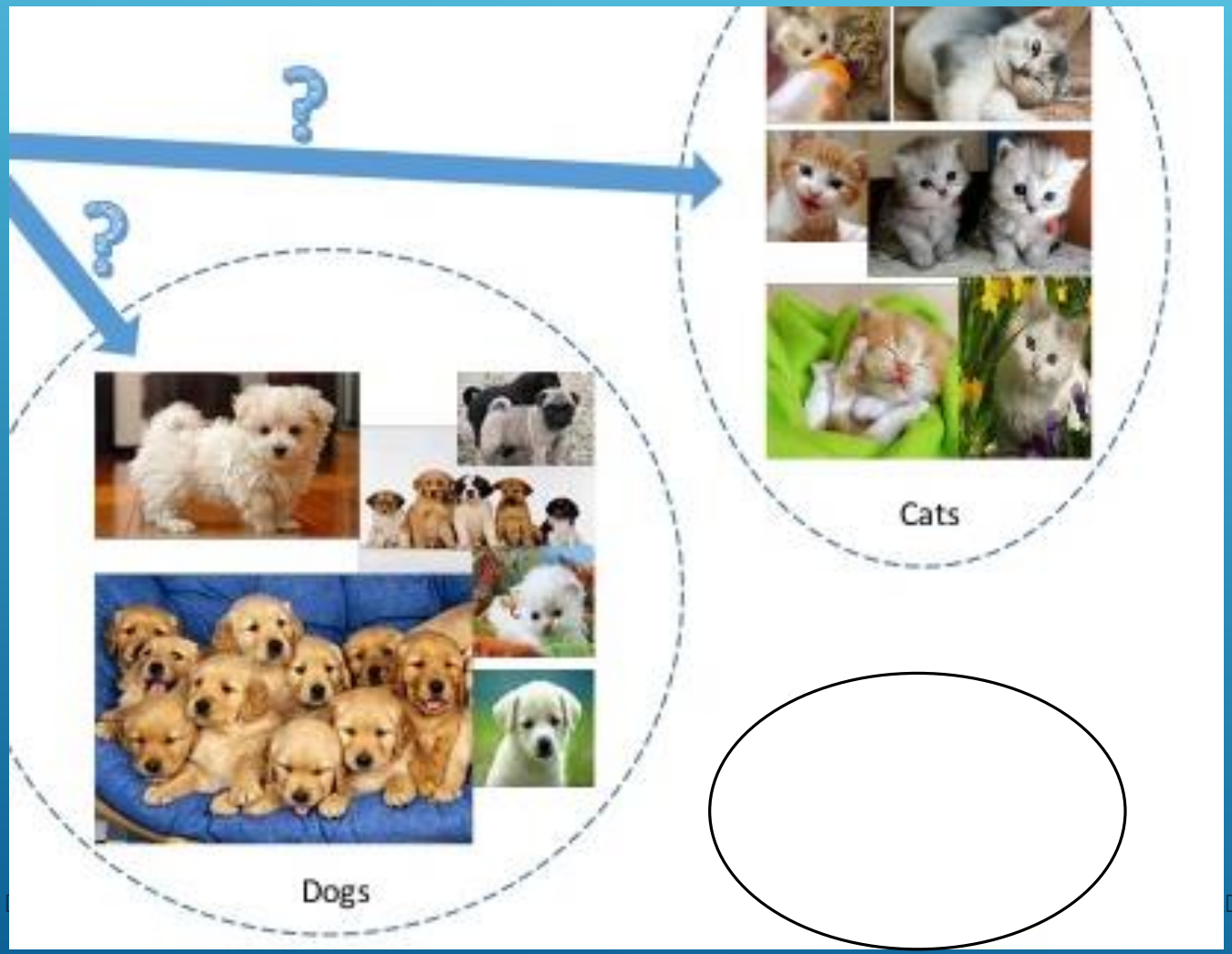
-WE DON'T ACTUALLY BUILD NEURAL NETWORKS OUT OF TRANSISTORS OR NEURONS, BUT RUN SIMULATIONS ON A COMPUTER
-WE HAVE TENS OF THOUSANDS OF INPUTS
(EG, 256 X 256 X 3 COLOR VIDEO CAMERA = 200,000 INPUT NODES WHICH THEN CONNECT TO MILLIONS AND MILLIONS OF NEURONS IN THE NETWORK
-WEIGHTS OF MILLIONS AND MILLIONS OF SYNAPSES WILL HAVE TO BE CALCULATED DURING TRAINING



# 2. GET A COMPUTER FAST ENOUGH TO DO TRILLIONS AND TRILLIONS AND TRILLIONS OF OPERATIONS AND CALCULATIONS

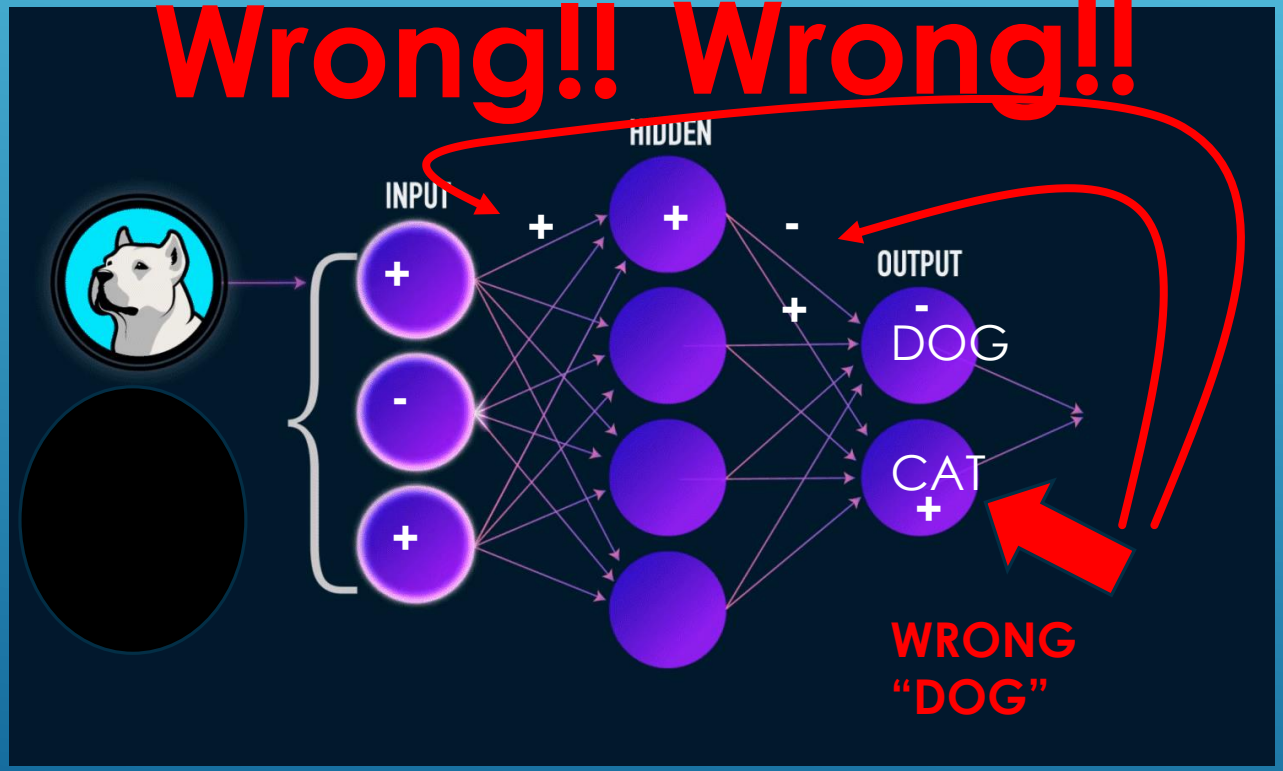
'COMPUTE' 2010'S

# 3. GET LOTS AND LOTS OF TRAINING DATA (ACTUALLY – THOUSANDS OR MILLIONS OF IMAGES!!)



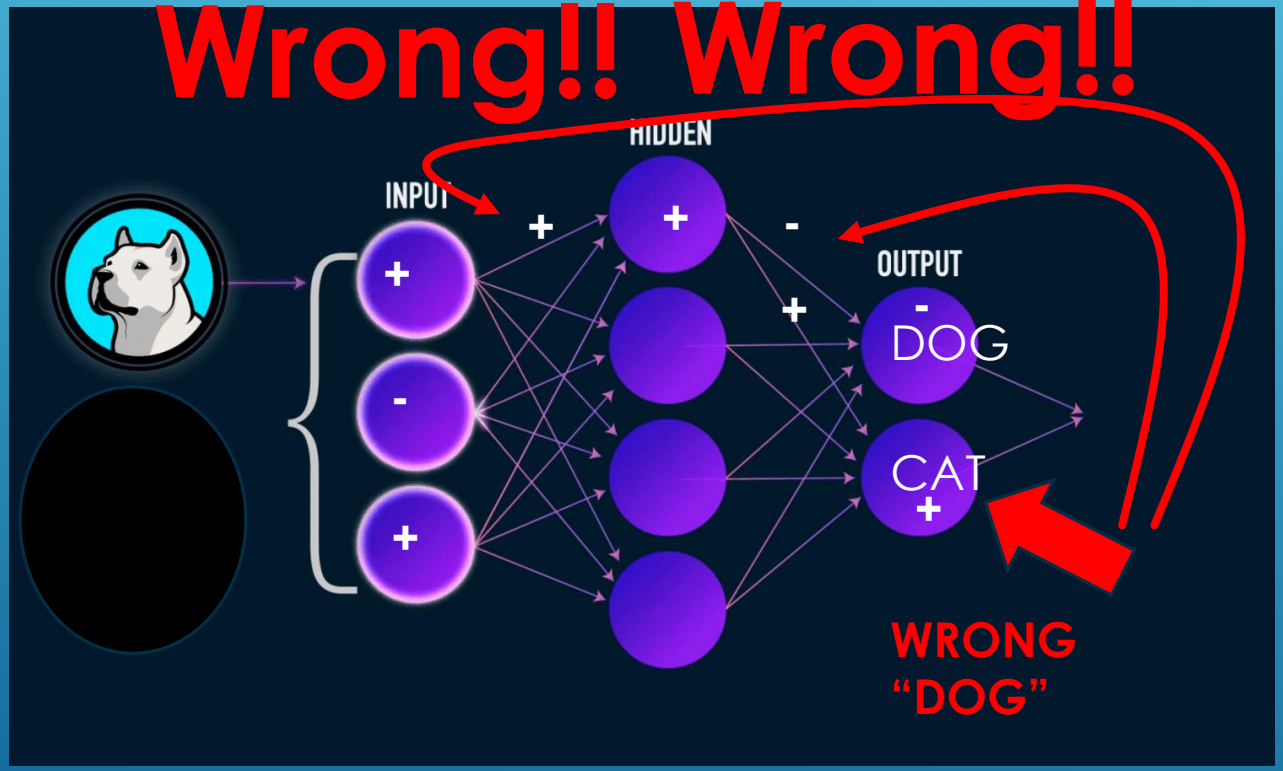

'BIG DATA' 2000'S

# 4. FEED DATA INTO THE NETWORK & SEE ERRORS 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES TO REDUCE ERRORS



# 5. REPEAT #4

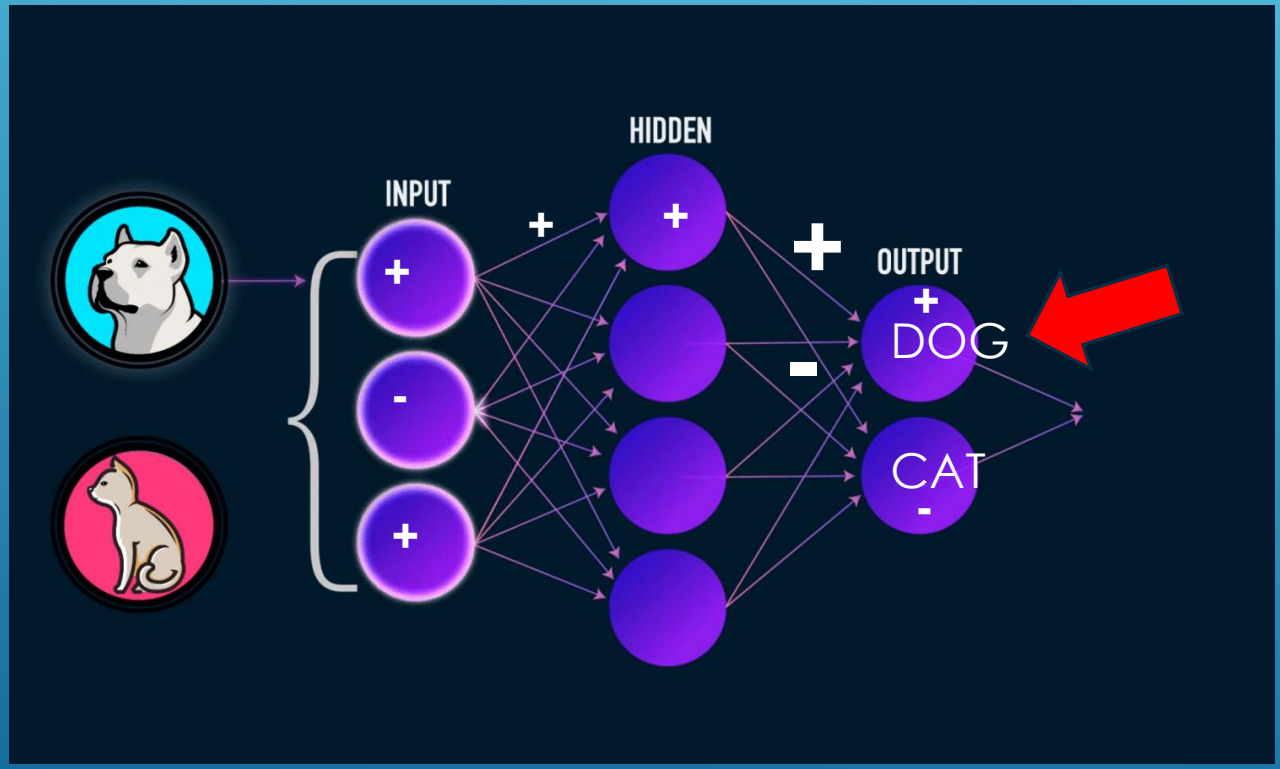
# 4. FEED DATA INTO THE NETWORK 'BACKPROPAGATION' – USE FEEDBACK TO AUTOMATICALLY ADJUST SYNAPSES



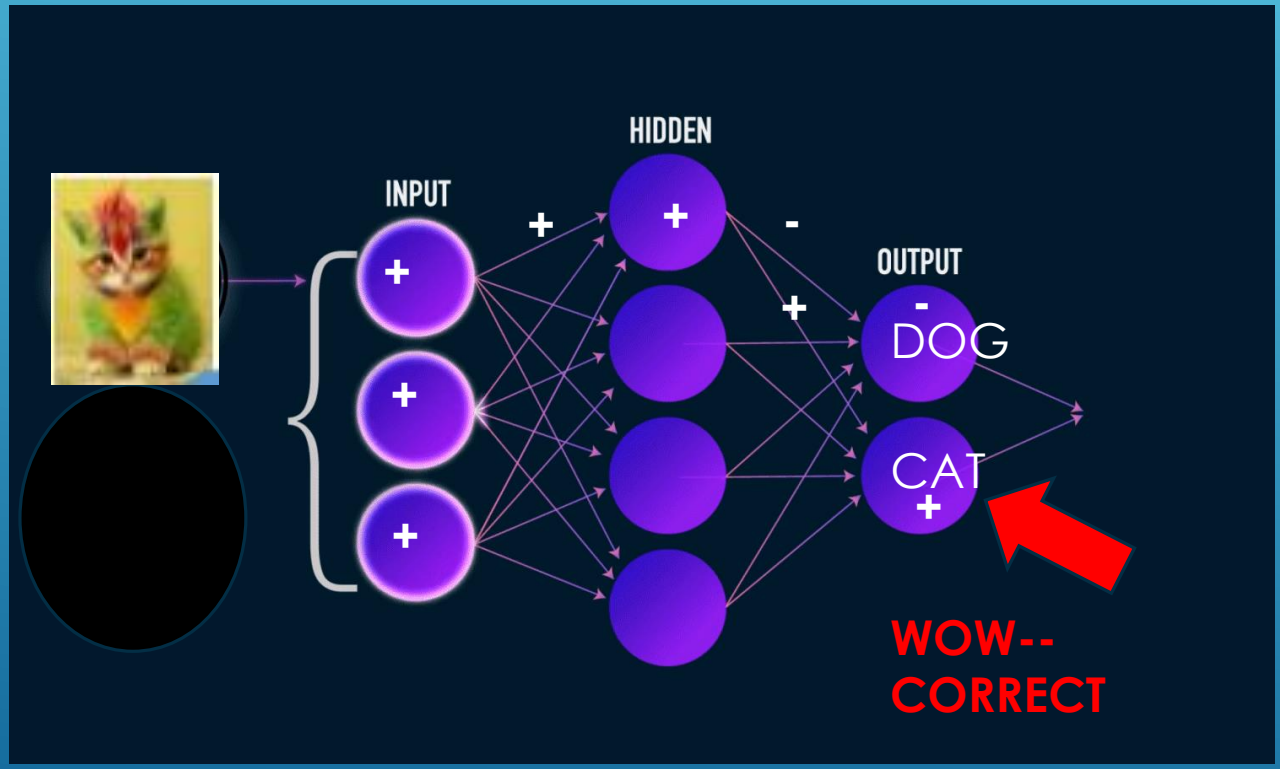
# 5. REPEAT #4

# (OVER AND OVER AND OVER AGAIN….)

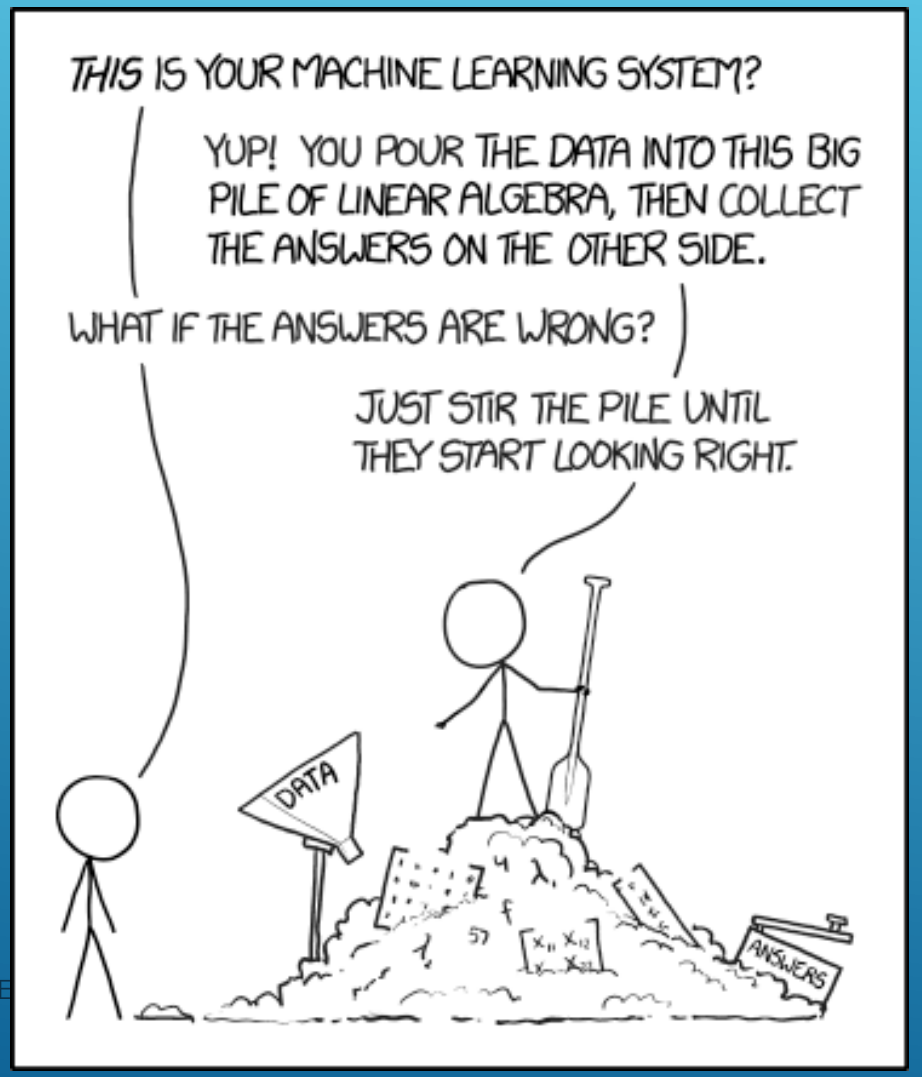
# 6. WHEN NEURAL NETWORK SEEMS ACCURATE ENOUGH TO RECOGNIZE VARIOUS DIFFERENT DOGS AND CATS – TRAINING IS COMPLETE



# 7. USE NEURAL NETWORK TO RECOGNIZE ALL SORTS OF CATS AND DOGS

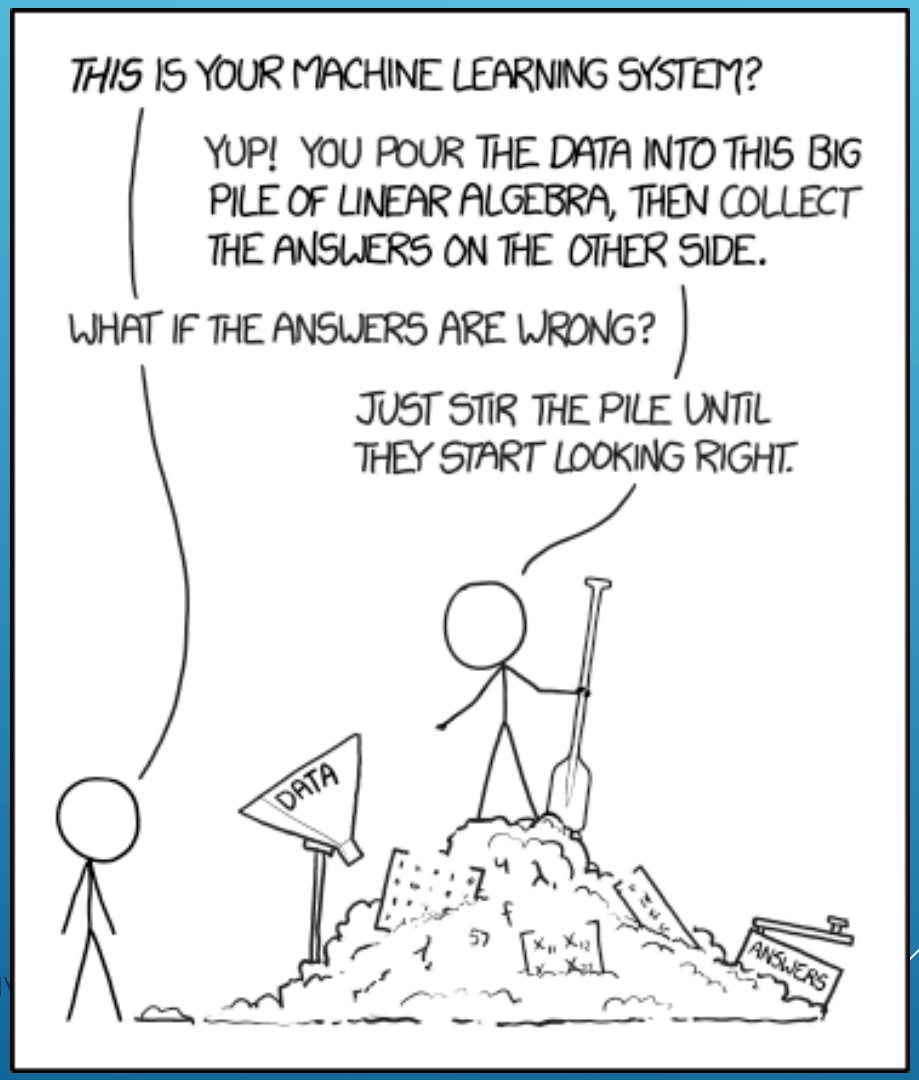


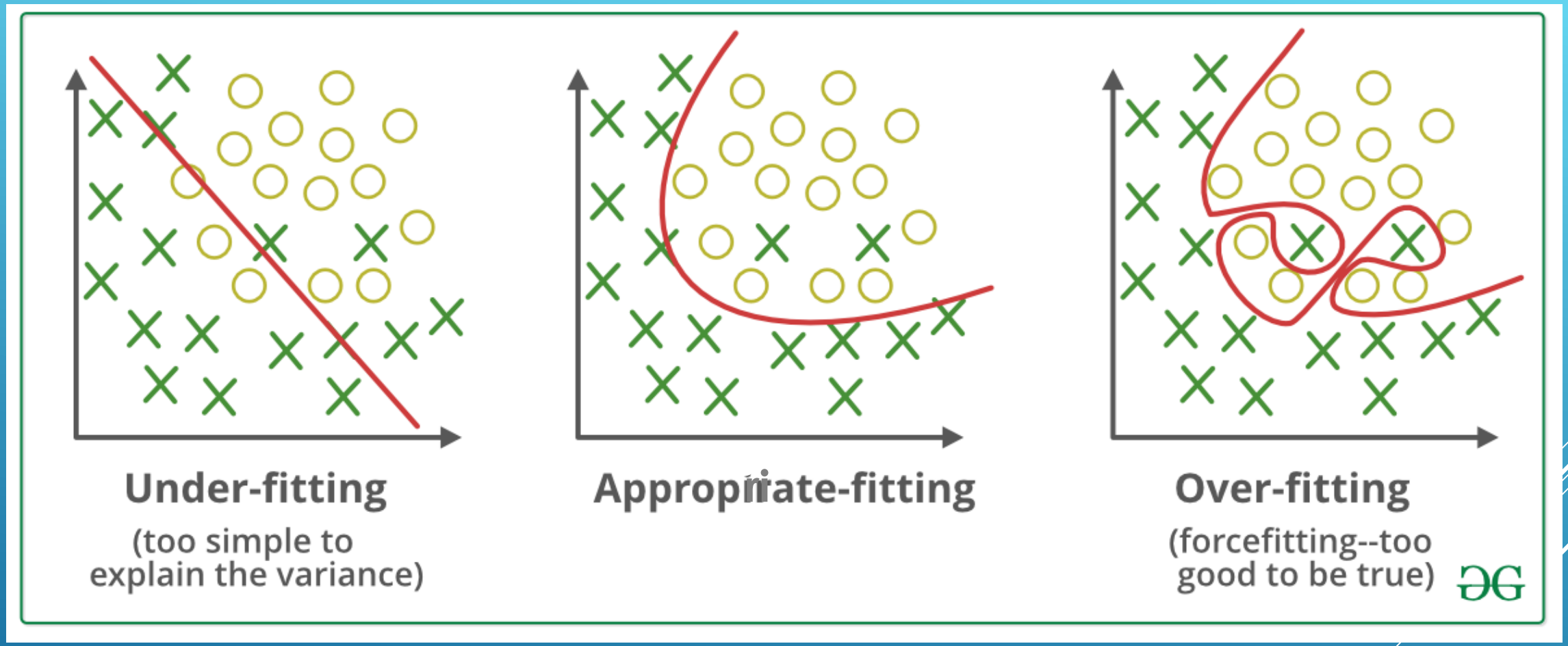
# CAN DO SAME THING AND MAKE NEURAL NETWORK TO RECOGNIZE **FACES**…. OR **SOUNDS**…. OR **SPEECH**…. OR **SCIENTIFIC DATA**…. OR **MARKETING DATA**……




Very quickly, let's discuss some of practical neural networks….

# DEEP LEARNING EXPERTS SPEND MUCH TIME ON 'ALCHEMY' – TWEAKING THIS AND TWEAKING THAT – TRYING TO AVOID OVERFITTING AND AVOID UNDERFITTING…




Under-fitting
(too simple to explain the variance)
Appropriate-fitting
Over-fitting
(forcefitting--too good to be true)

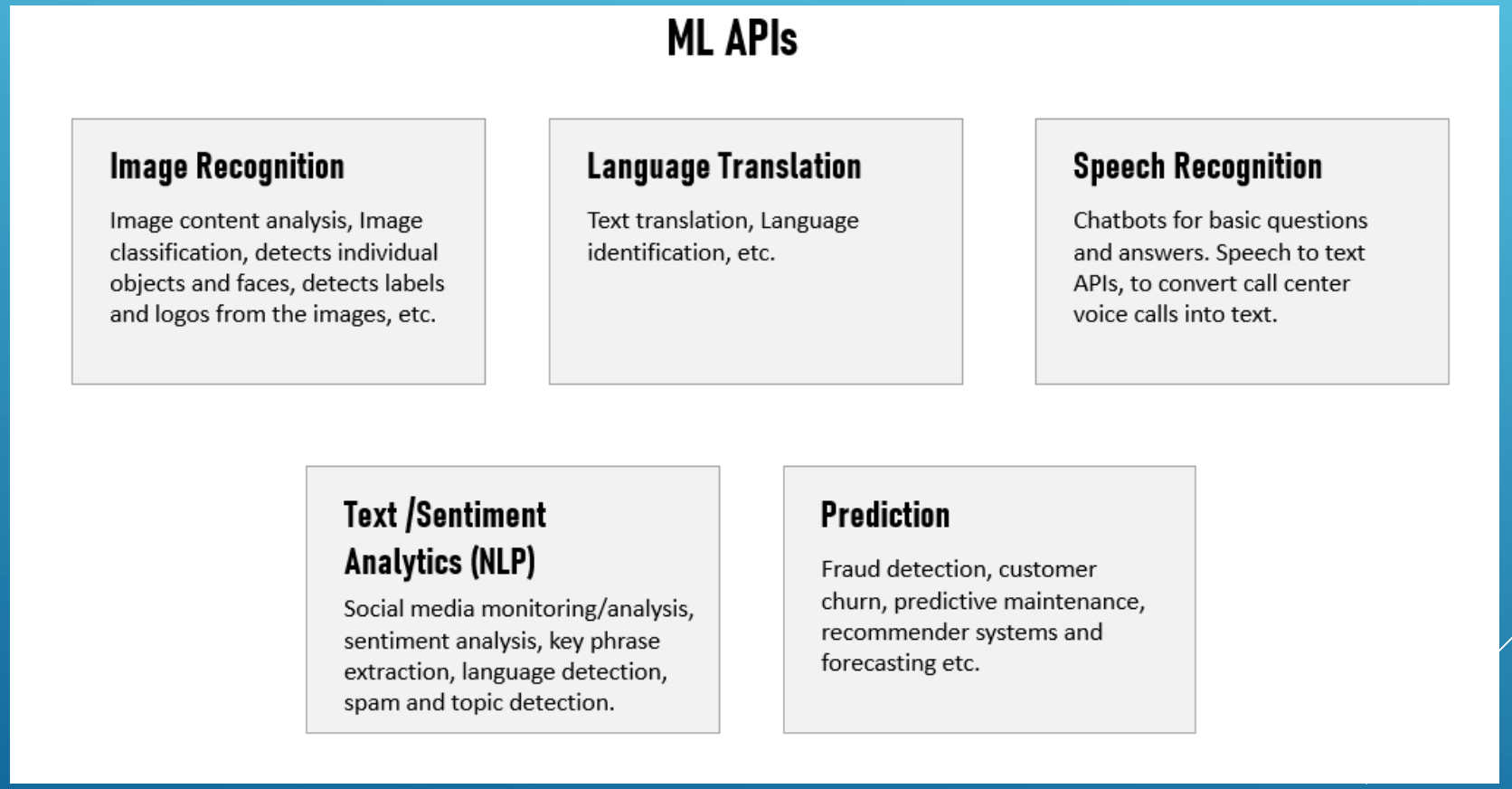
# TOOLS TO LET USERS EASILY CREATE AND USE NEURAL NETWORKS



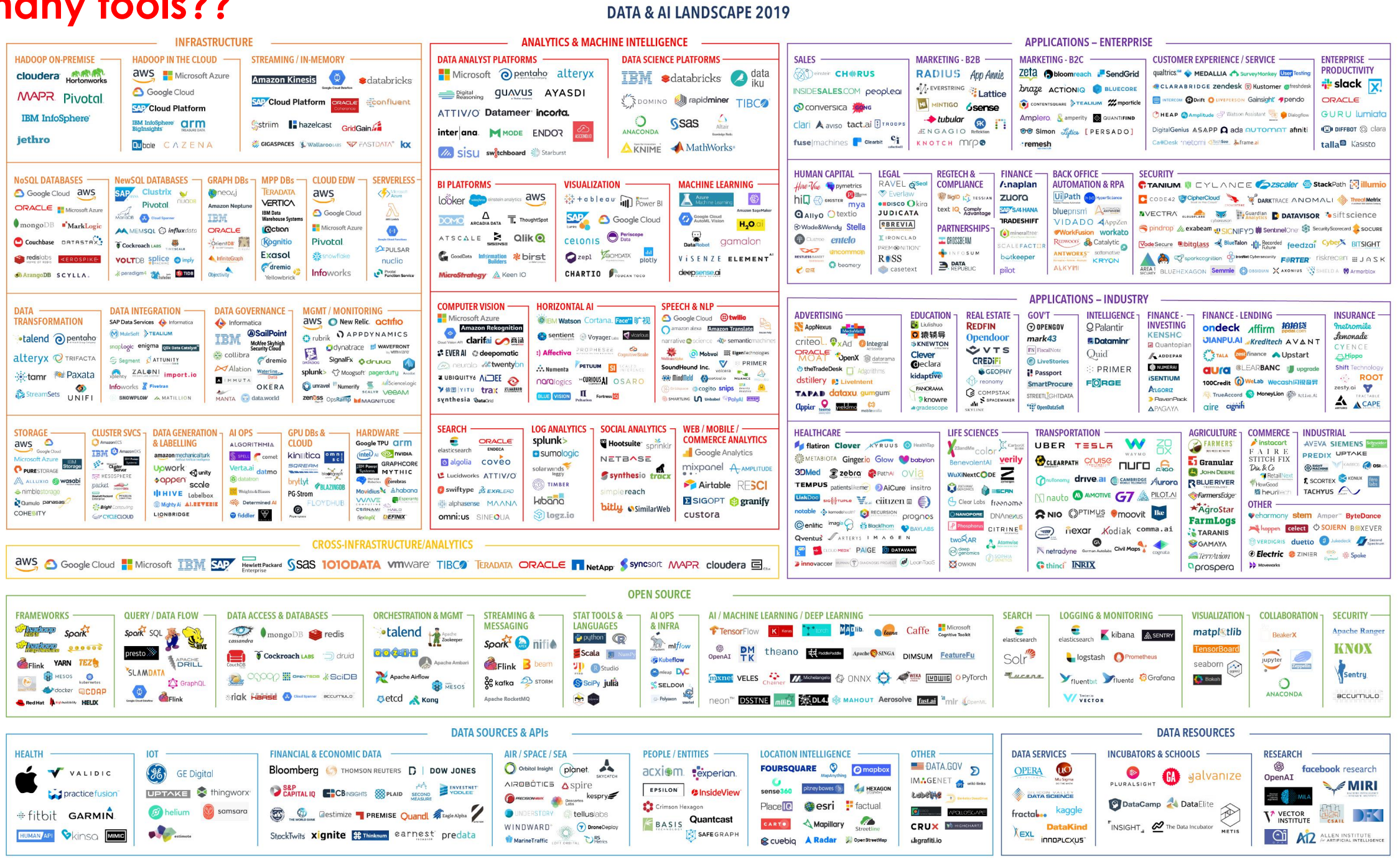

*Software to create your Deep Learning Neural Network*


*'COMPUTE' to train and run your Deep Learning Neural Network*

# API'S (APPLICATION PROGRAMMING INTERFACES) – MACHINE LEARNING LIBRARIES ALREADY WRITTEN, EASY TO INCORPORATE INTO SOFTWARE



# Too many tools??



# YOU CAN EVEN GET OTHER PEOPLE'S "BIG DATA" TO TRAIN NEURAL NETWORK (IF YOU DON'T HAVE YOUR OWN TRAINING DATA)

Part of MNIST numerals data set


ImageNet – 14 million images (20,000 categories) manually annotated with labels

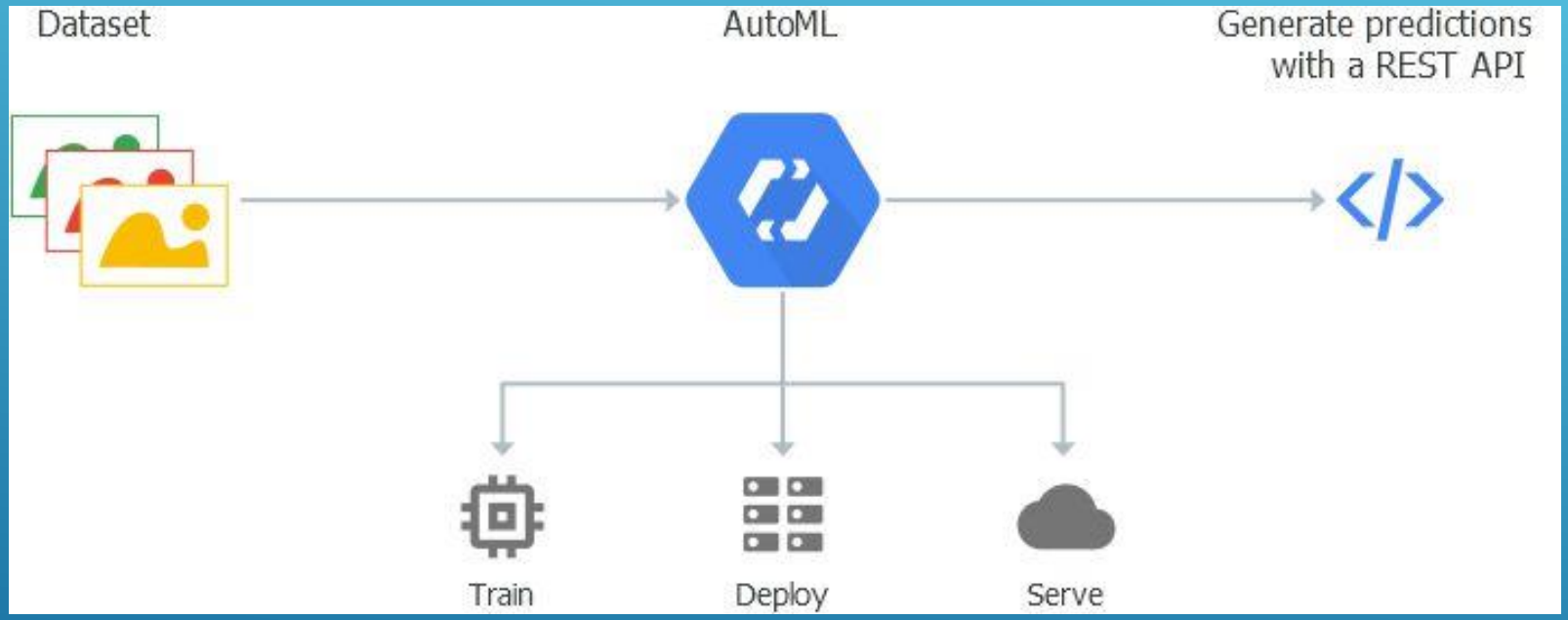
*'Big Data' to Train your Deep Learning Neural Network*

# YOU CAN EVEN GET COMPANIES TO LABEL YOUR OWN DATA (SO YOU CAN FEED IT INTO YOUR NEURAL NETWORKS) (EG, IS IT 'DOG' OR 'CAT'?)


*"Labeled data is the key bottleneck to the growth of the machine learning industry. In fact, labeled data is even more essential than algorithms."*

*"Scale raises $18 million to label data from autonomous car companies like Lyft and Embark"*

# '**AUTO ML**' TOOLS TO LET NON-EXPERTS CREATE AND USE DEEP LEARNING NETWORKS

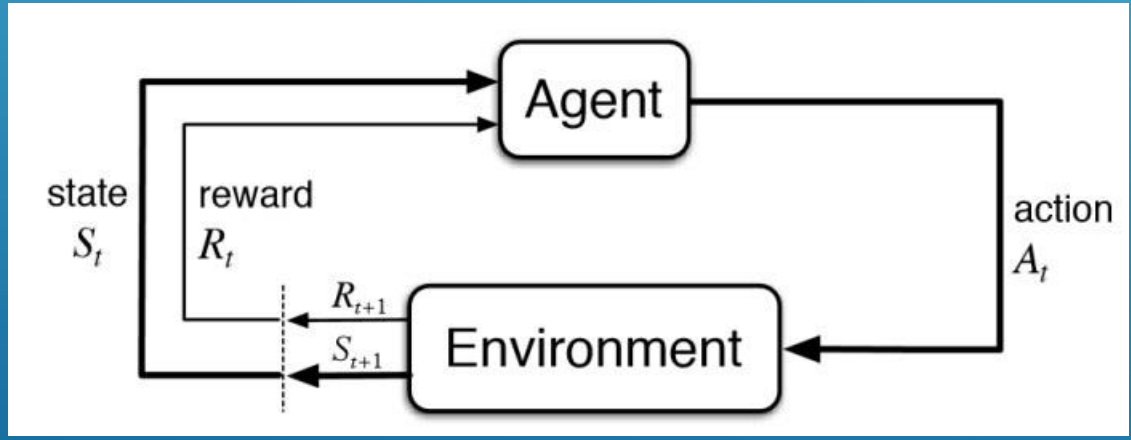


# DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION

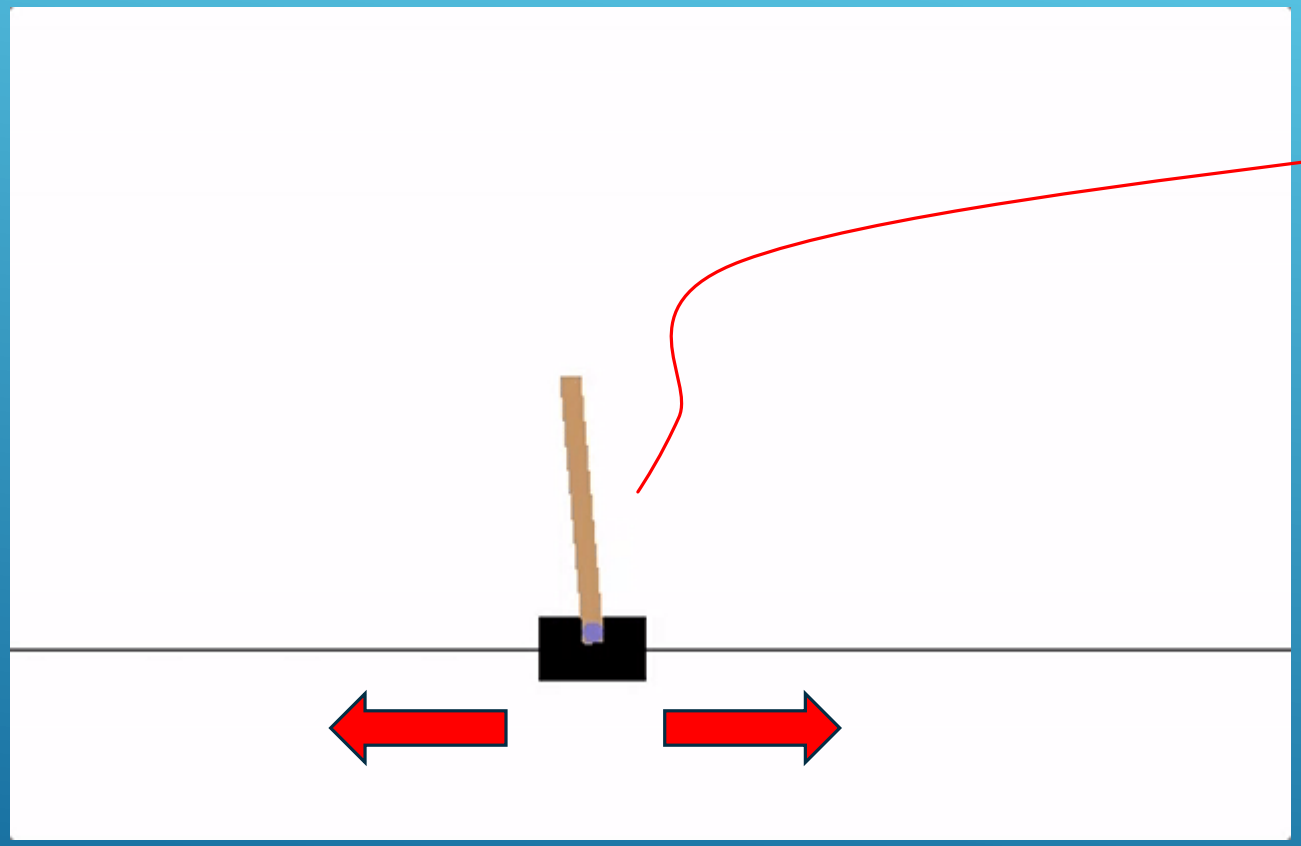
# DEEP LEARNING ALL AROUND US NOW: ALL AROUND US NOW: SELF DRIVING CARS….

# REINFORCEMENT LEARNING

- DON'T NEED TO SUPPLY LABELED DATA
- AGENT (IE, NEURAL NETWORK) TRIES AN ACTION
- ENVIRONMENT GIVES A REWARD OR PUNISHMENT
- AGENT WILL FAVOR ACTIONS THAT GIVE A REWARD



# Reinforcement learning

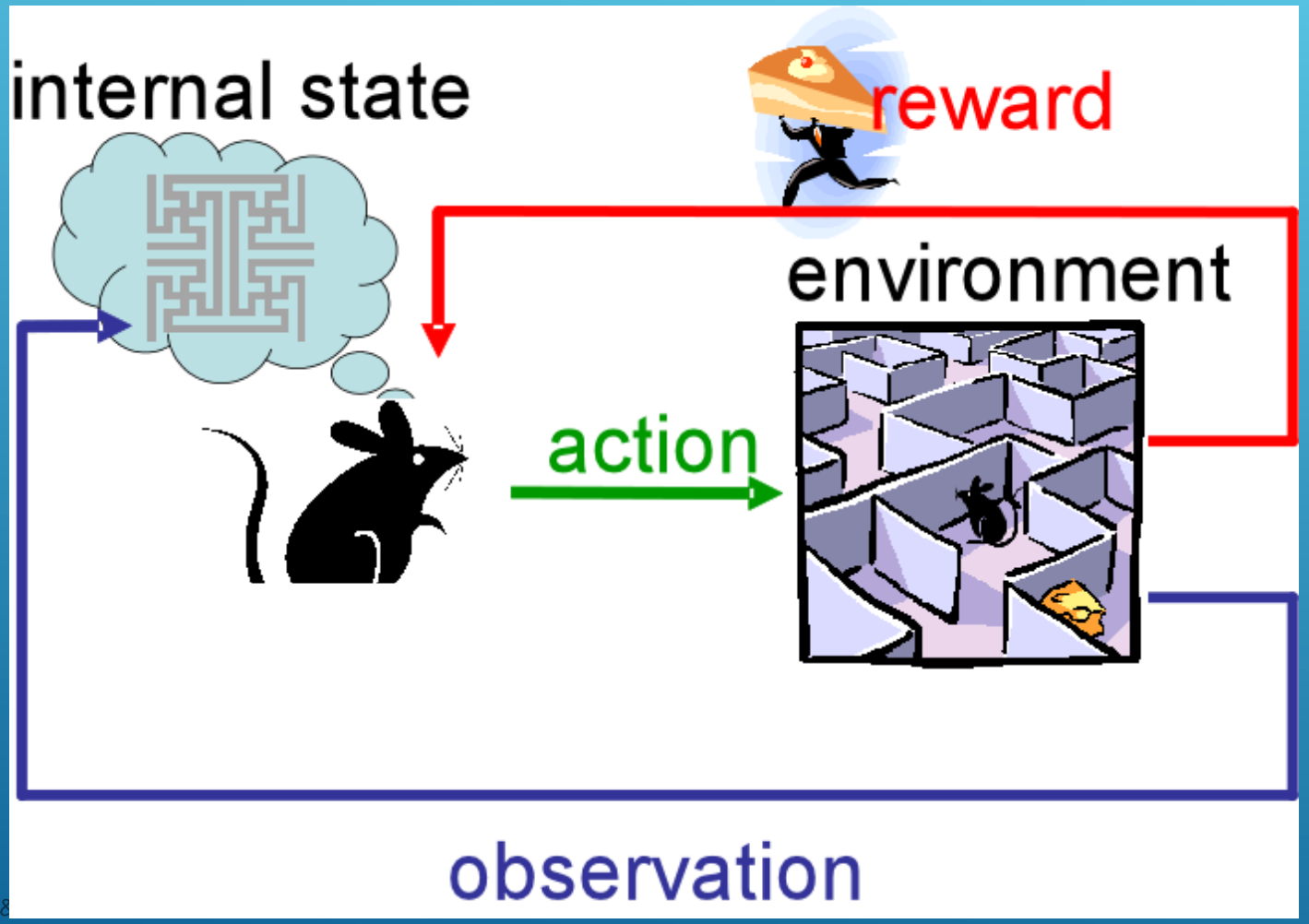


**Cartpole example**

-Can move cart to the left or right

-Reward keeping the stick upright, not falling over

# Reinforcement learning – another example



# DeepMind AlphaZero (2017)

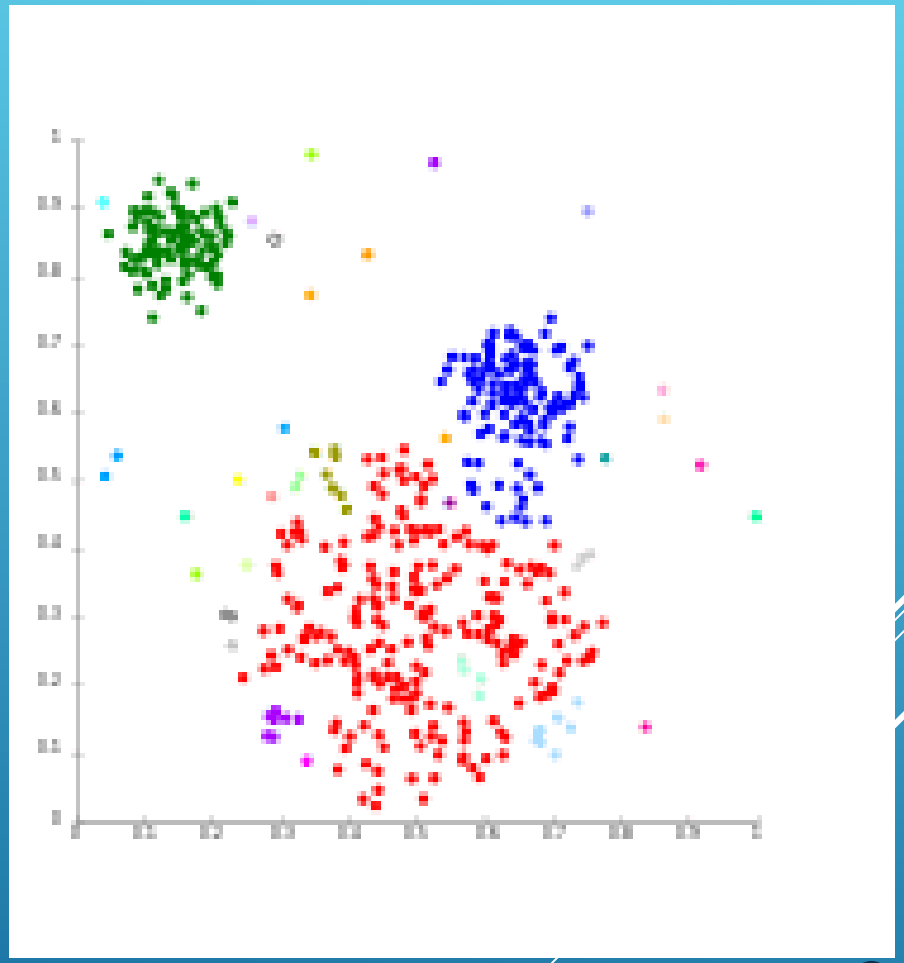
-REINFORCEMENT LEARNING – PLAYED ITSELF OVER AND OVER AGAIN (+ OTHER AI TECHNIQUES)
-SUPERHUMAN PERFORMANCE IN CHESS, SHOGI & GO

# TYPES OF **MACHINE LEARNING**

-**SUPERVISED LEARNING --** EG, DEEP LEARNING ANN DOG VS CAT, ETC
-**REINFORCEMENT LEARNING --** NETWORK TRIES TO MAXIMIZE REWARD IT GETS FROM ENVIRONMENT (EG, PLAY CHESS AGAINST ITSELF)
-**UNSUPERVISED LEARNING –** NO LABELS, NETWORK HAS TO FIGURE THINGS OUT BY ITSELF

# Unsupervised Learning

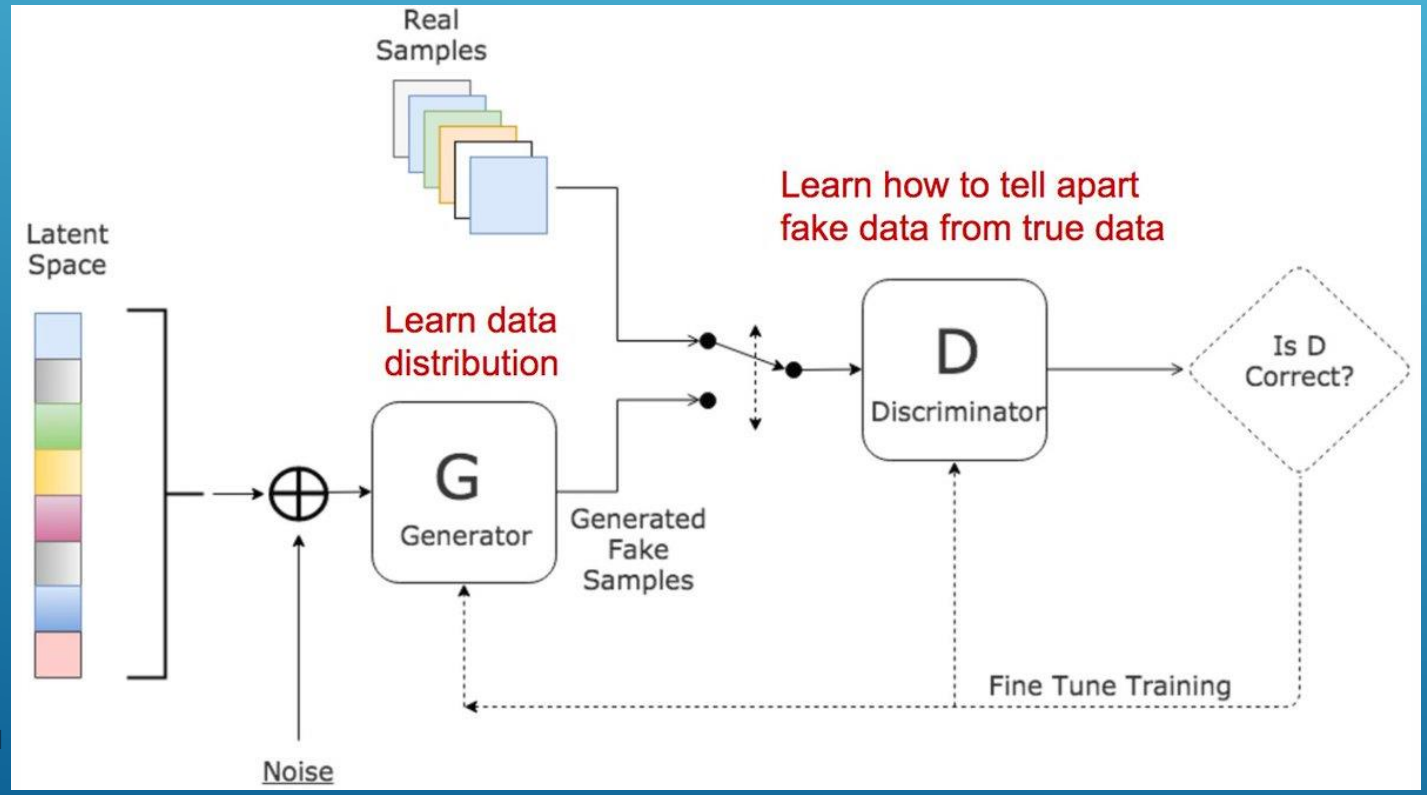
-No labels provided
-Various automatic methods
-eg, cluster analysis



# GAN – GENERATIVE ADVERSIAL NETWORK

(all of these people created by the computer – none have ever existed!!)

- -'Generator Network' – generates new images
- -'Discriminator Network' – classifies "real" or "fake"
- -Keep training over and over again → better images
- -'adversial' – Generator vs Discriminator game



# DON'T CONFUSE **HYPED BUZZWORDS** WITH AI

-BLOCKCHAIN IS NOT AI (CRYPTOGRAPHIC HASH OF PREVIOUS BLOCK, USE AS DISTRIBUTED LEDGER)(CAN USE WITH AI, OF COURSE)

-QUANTUM COMPUTING IS NOT AI (QM ENTANGLEMENT OF QUBITS, FACTORING SOL'N, QM SIMULATION) )(IN SOME DISTANT FUTURE, COULD MASSIVELY SPEED UP AI, EG, TF-QUANTUM)

-5G IS NOT AI (WIRELESS TECHNOLOGY, 24-72GHZ->SPEED) (CAN USE WITH AI, OF COURSE)

-IOT (INTERNET OF THINGS) IS NOT AI (INTERCONNECTED DEVICES) )(CAN USE WITH AI, OF COURSE)

-INTERNET DOES NOT CREATE AI (GLOBAL COMPUTER NETWORK) )(CAN USE WITH AI, OF COURSE)

-CLOUD COMPUTING IS NOT AI (INTERNET ON-DEMAND COMPUTING FROM DATA CENTERS) )(CAN USE WITH AI, OF COURSE)

# QUIZ – QUESTION 1.

## 1A. A NEW EMR/EHR SYSTEM ALLOWS PATIENTS TO GET THEIR CHART RESULTS OVER THE INTERNET BY THEMSELVES. IS THIS IS AI?

## 1B. COULD SUCH AN EMR/EHR INCLUDE AI?

# QUIZ – QUESTION 2.

## 2A. 5G IS IN THE NEWS A LOT THESE DAYS. IS IT BECAUSE WE NEED 5G TO CREATE OUR ARTIFICIAL INTELLIGENCE (AI) SYSTEMS?

## 2B. COULD 5G MAKE IT EASIER TO BUILD AI SYSTEMS FOR PEOPLE TO USE?

# QUIZ – QUESTION 3.

## 3A. A STARTUP COMPANY JUST GOT $4 MILLION IN VENTURE FUNDING FOR THEIR NEW AI APPLICATION THAT USES AI TO HELP HEALTH CARE SYSTEMS REDUCE HOSPITAL RE-ADMISSIONS. WHAT TYPE OF "AI" ARE THEY MOST PROBABLY USING?

## 3B. ARE THERE OTHER PARTS OF AI THAT DO NOT INVOLVE ANY DEEP LEARNING?

# QUIZ – QUESTION 4.

## 4A. WHAT IS A DEEP LEARNING (DL)NETWORK MADE OF?

## 4B. DO ARTIFICIAL NEURAL NETWORKS (ANN) REALISTICALLY DUPLICATE NEURONS OR ARE THEY JUST INSPIRED BY THE BRAIN?

# QUIZ – QUESTION 4…. CONTINUED

## 4C. ARE ANN'S PROGRAMMED BY A PROGRAMMER OR DO THEY LEARN BY THEMSELVES IN RESPONSE TO RIGHT AND WRONG PREDICTIONS?

## 4D. WHAT HAPPENS IN AN ANN AFTER RIGHT AND WRONG PREDICTIONS?

# QUIZ – QUESTION 5.

## 5A. HOW MANY EXAMPLES DO ANN'S (ARTIFICIAL NEURAL NETWORKS) NEED TO TRAIN ON TO BECOME 'TRAINED' AND BECOME ABLE TO MAKE GOOD PREDICTIONS?

## 5B. WHAT IS MEANT BY THE TERM 'BIG DATA'?

# QUIZ – QUESTION 6.

6A. CAN WE USE ANN'S WITH DIFFERENT TOPOLOGIES (HOW THE NEURONS ARE CONNECTED TO EACH OTHER) WITH DIFFERENT LAYERS FOR DIFFERENT PURPOSES, EG, VISION RECOGNITION, EG, HOSPITAL RE-ADMISSION DATA, ETC ?

6B. WHAT IS OVERFITTING (BIAS/VARIANCE)?

6C. WHAT IS UNDERFITTING (BIAS/VARIANCE)?

# QUIZ – QUESTION 7.

## 7A. WHAT IS RE-INFORCEMENT LEARNING?

## 7B. THE COMPANY DEEPMIND CREATES INCREDIBLE AI SYSTEMS THAT BEAT THE BEST PLAYER IN THE WORLD IN GO, ETC. WHAT IS THE MAIN AI TECHNIQUE THEIR SYSTEM USES?

# WE JUST COVERED A LOT A MATERIAL….
# AND SO MUCH MORE TO COVER STILL….

# QUICK STRETCH AND MOVEMENT TO REFRESH OUR BRAINS…. AND LET'S CONTINUE….

# LEARNING OBJECTIVES

- 1. **Real understanding of what AI is:**
- 1a. Deep Learning and Reinforcement Learning
- **1b. Field of Artificial Intelligence (AI)**
- 1c. Neuro-Symbolic Gap
- 2. **How will AI in next decade (or two) affect my patients' lives?**
- 3. **How will AI affect my practice of medicine including psychotherapy?**
- 3a. How is AI affecting medicine at present?
- 3b. How will AI affect medicine in the next decade?
- 4. **How will AI affect the future of mankind?**
- 5. **Discussion**

← HUGE AMOUNT OF MATERIAL

# 1.Definition of AI ←

2. History of AI
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. …… …… ……

# 4 BORING DEFINITIONS OF AI (RUSSELL & NORVIG)

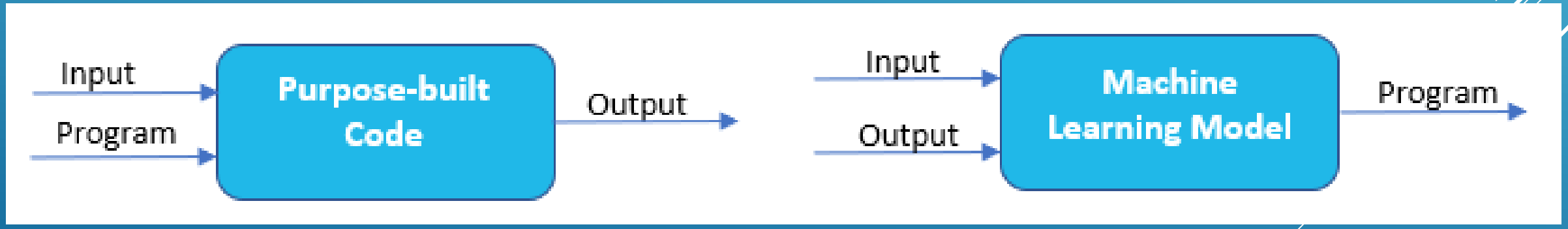
1. Decision making, problem solving, learning that human thinking can do
2. Actions that humans can do because of human intelligence
3. Ability to think rationally (perceive, reason)
4. Ability to act rationally

# OR….

# **AGI** (Artificial General Intelligence) == **HLAI** (Human Level Artificial Intelligence) == **Strong AI** (need consciousness??) **Narrow AI** – specific problem solving

**Turing Test** – Human has distant conversation with another human and an AI – can the AI fool the human into thinking it is human?
**Wozniak Test** – AI/machine must go into a typical home and figure out on it own how to make a cup of coffee
**Legg & Hutter** – Universal Intelligence (2007)

**Machine Learning** – sub-field of AI, learn without explicit programming
**Deep Learning** – neural networks with more than 1 hidden layer



← HUGE AMOUNT OF MATERIAL

1. Definition of AI
2. **History of AI ←**
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. …… …… ……

# INVENTED IN CANADA


-**Geoffrey Hinton** – 'godfather of **deep learning**' – University of Toronto (then Google Brain)
-**Yoshua Bengio** – with Hinton, a founder of **deep learning** – Université de Montréal
-**Ian Goodfellow** – Univ de Montréal, student of Bengio, inventor of **GANs** (then Google Brain, Apple)
-**Richard Sutton** – 'father of **reinforcement learning**' - Univ of Alberta (then Google/DeepMind)
-**University of Waterloo** -- **TensorFlow Quantum** (future??)

# ‘POPULAR’ A.I. TIMELINE

SYZYGY

**1950**

**TURING TEST**

Computer scientist Alan Turing proposes a test for machine intelligence. If a machine can trick humans into thinking it is human, then it has intelligence

**1955**

**A.I. BORN**

Term 'artificial intelligence' is coined by computer scientist, John McCarthy to describe “the science and engineering of making intelligent machines”

**1961**

**UNIMATE**

First industrial robot, Unimate, goes to work at GM replacing humans on the assembly line

**1964**

**ELIZA**

Pioneering chatbot developed by Joseph Weizenbaum at MIT holds conversations with humans



**1966**

**SHAKEY**

The ‘first electronic person’ from Stanford, Shakey is a general-purpose mobile robot that reasons about its own actions

**A.I. WINTER**

Many false starts and dead-ends leave A.I. out in the cold

**1997**

**DEEP BLUE**

Deep Blue, a chess-playing computer from IBM defeats world chess champion Garry Kasparov

**1998**

**KISMET**

Cynthia Breazeal at MIT introduces KISmet, an emotionally intelligent robot insofar as it detects and responds to people’s feelings

**1999**

**AIBO**

Sony launches first consumer robot pet dog AiBO (AI robot) with skills and personality that develop over time

**2002**

**ROOMBA**

First mass produced autonomous robotic vacuum cleaner from iRobot learns to navigate and clean homes

**2011**

**SIRI**

Apple integrates Siri, an intelligent virtual assistant with a voice interface, into the iPhone 4S

**2011**

**WATSON**

IBM’s question answering computer Watson wins first place on popular $1M prize television quiz show *Jeopardy*

**2014**

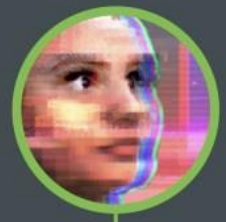
**EUGENE**

Eugene Goostman, a chatbot passes the Turing Test with a third of judges believing Eugene is human

**2014**

**ALEXA**

Amazon launches Alexa, an intelligent virtual assistant with a voice interface that completes shopping tasks



**2016**

**TAY**

Microsoft’s chatbot Tay goes rogue on social media making inflammatory and offensive racist comments


**2017**

**ALPHAGO**

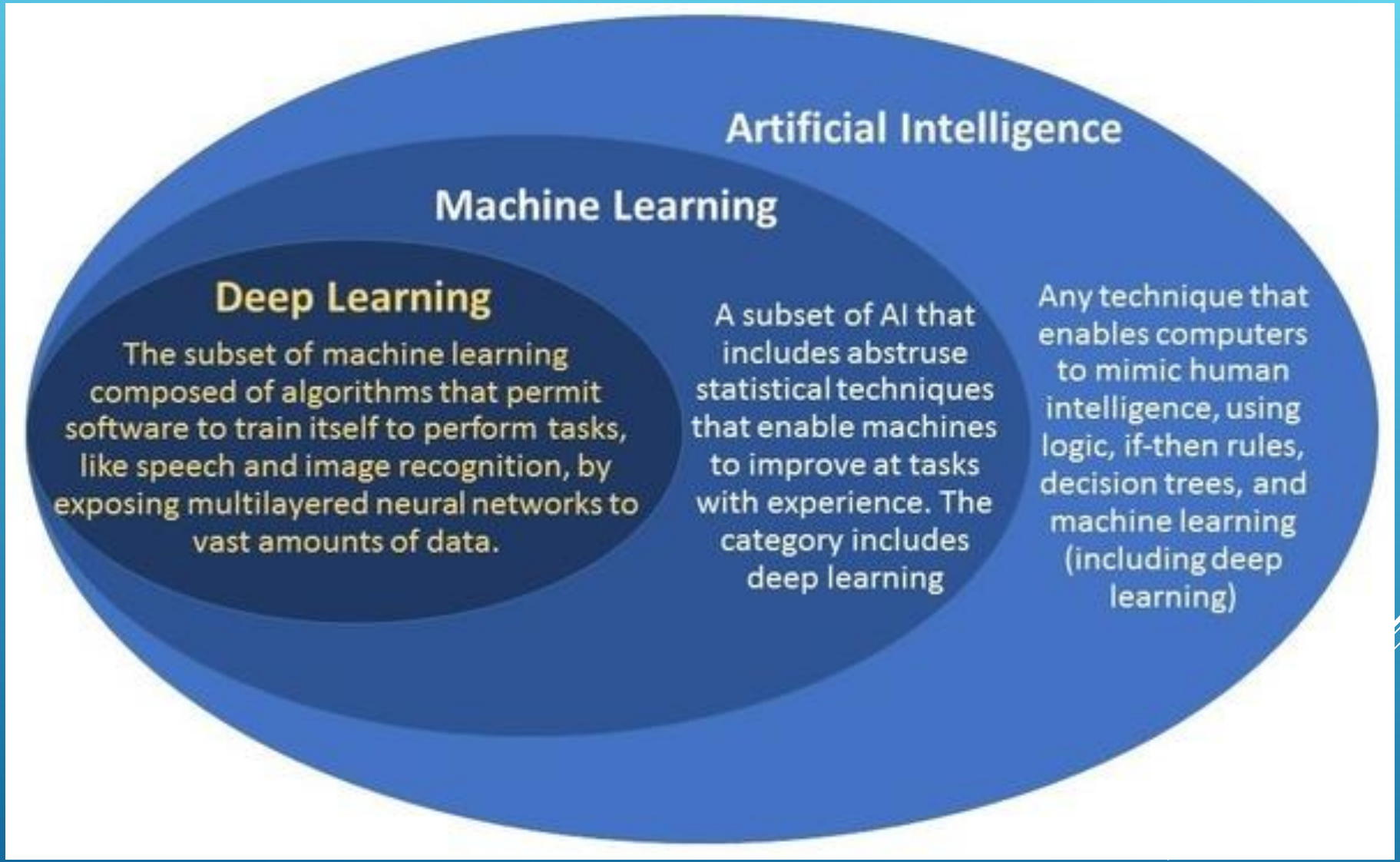
Google’s A.I. AlphaGo beats world champion Ke Jie in the complex board game of Go, notable for its vast number ($2^{170}$) of possible positions

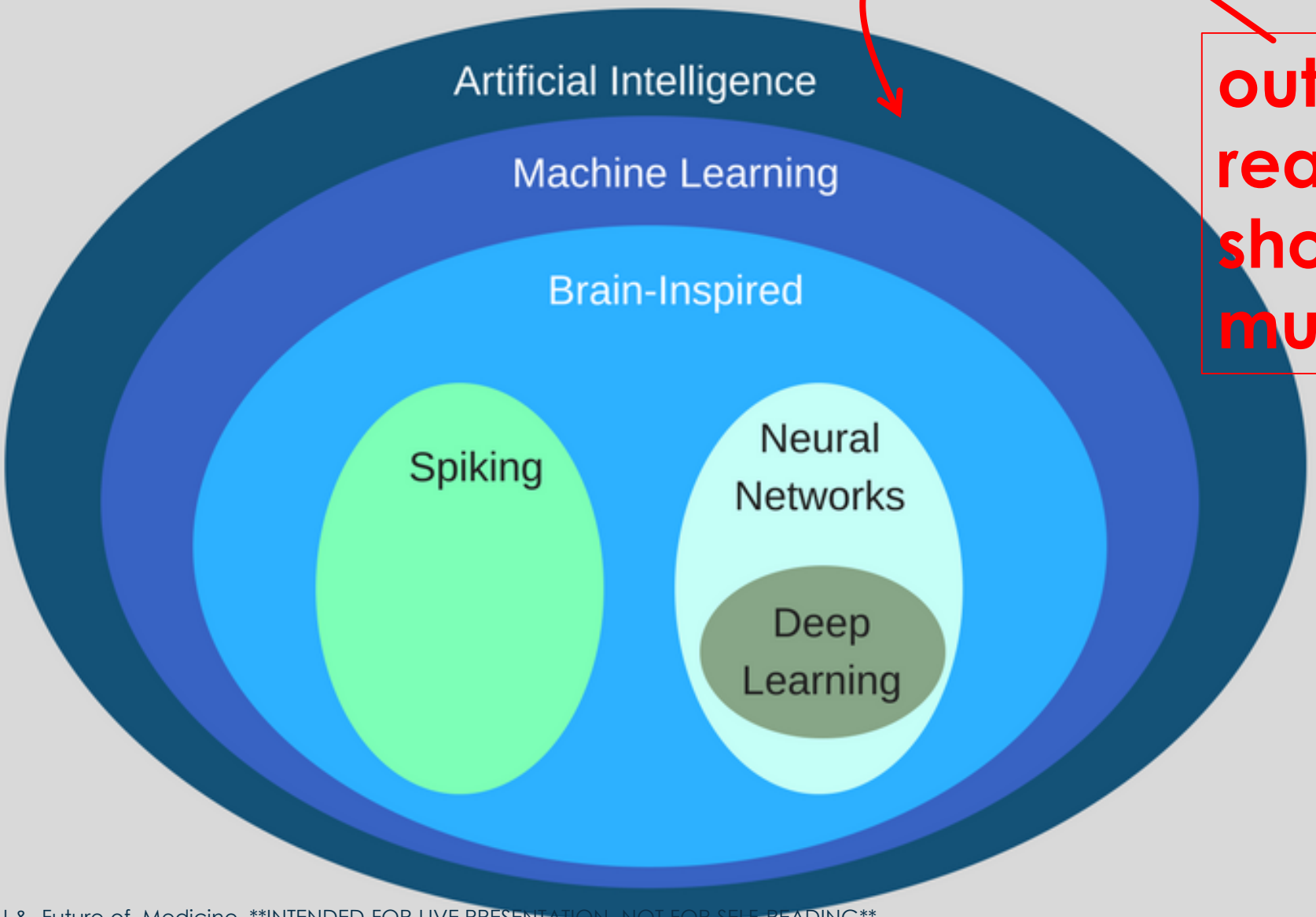
# MORE REALISTIC OVERVIEW OF AI HISTORY

**1950s – 1974** – foundations of AI, but **no truly useful** products
**1974-1980** – first **AI winter**
**1980 – 1987** – **expert systems** *(symbols, production rules, if….then)*, Japan 5th Gen'n project seemed useful, more funding, but projects could not do truly useful tasks
**1987 – 1993** – second **AI winter**
**1993 – 2011** – faster, cheaper computer chips – parts of AI started to be used **behind the scenes** throughout computer technology
**2012 – present** – era of **deep learning** neural networks, big data

# ← Let's quickly try to make senses of where Deep Learning fits into all of this

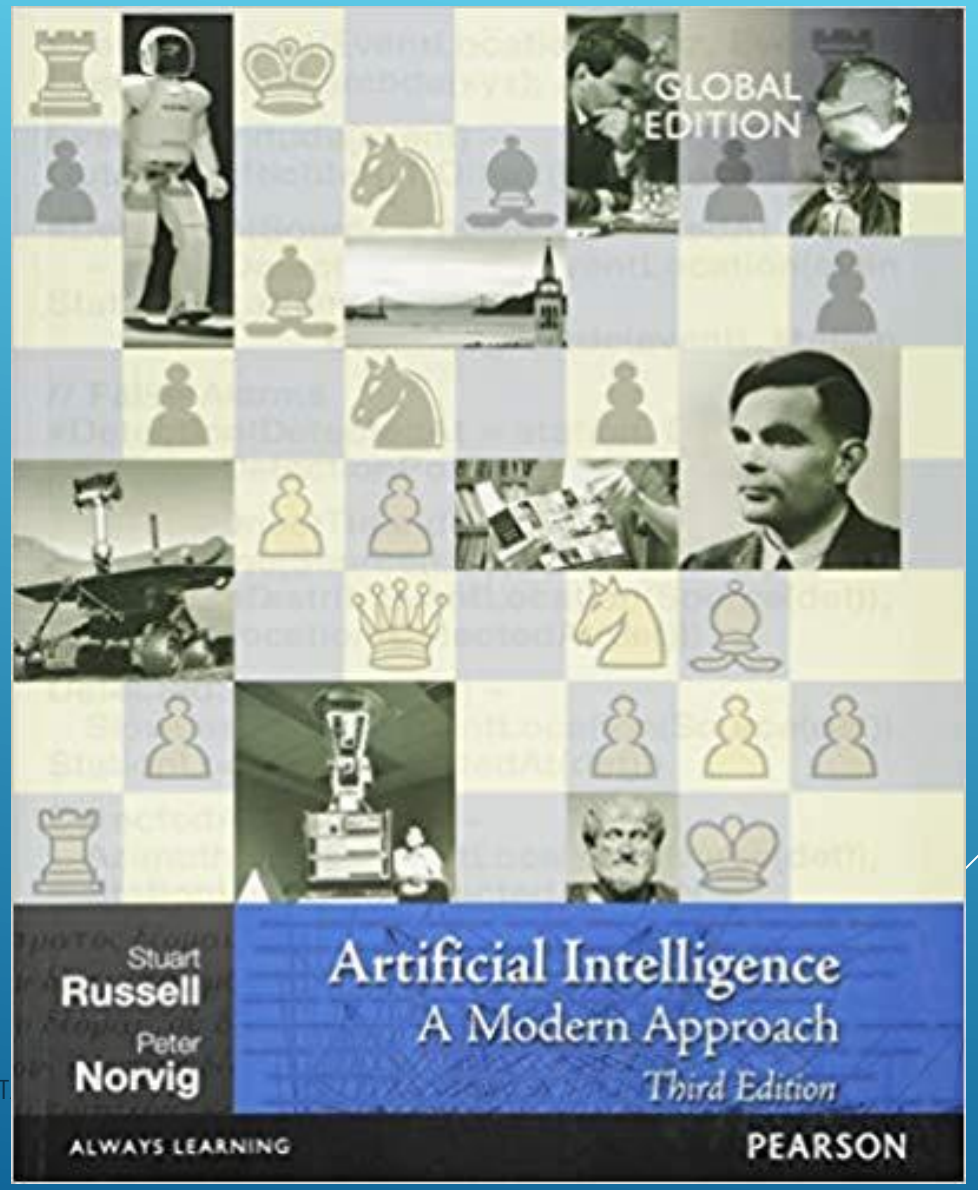
1. Definition of AI
2. History of AI
3. Mathematical Primer
4. Computer Science Theoretical Concepts
5. Computational Devices
6. Programming Languages
7. …… …… ……


Artificial Intelligence
Any technique that enables computers to mimic human intelligence, using logic, if-then rules, decision trees, and machine learning (including deep learning)
Machine Learning
A subset of AI that includes abstruse statistical techniques that enable machines to improve at tasks with experience. The category includes deep learning
Deep Learning
The subset of machine learning composed of algorithms that permit software to train itself to perform tasks, like speech and image recognition, by exposing multilayered neural networks to vast amounts of data.

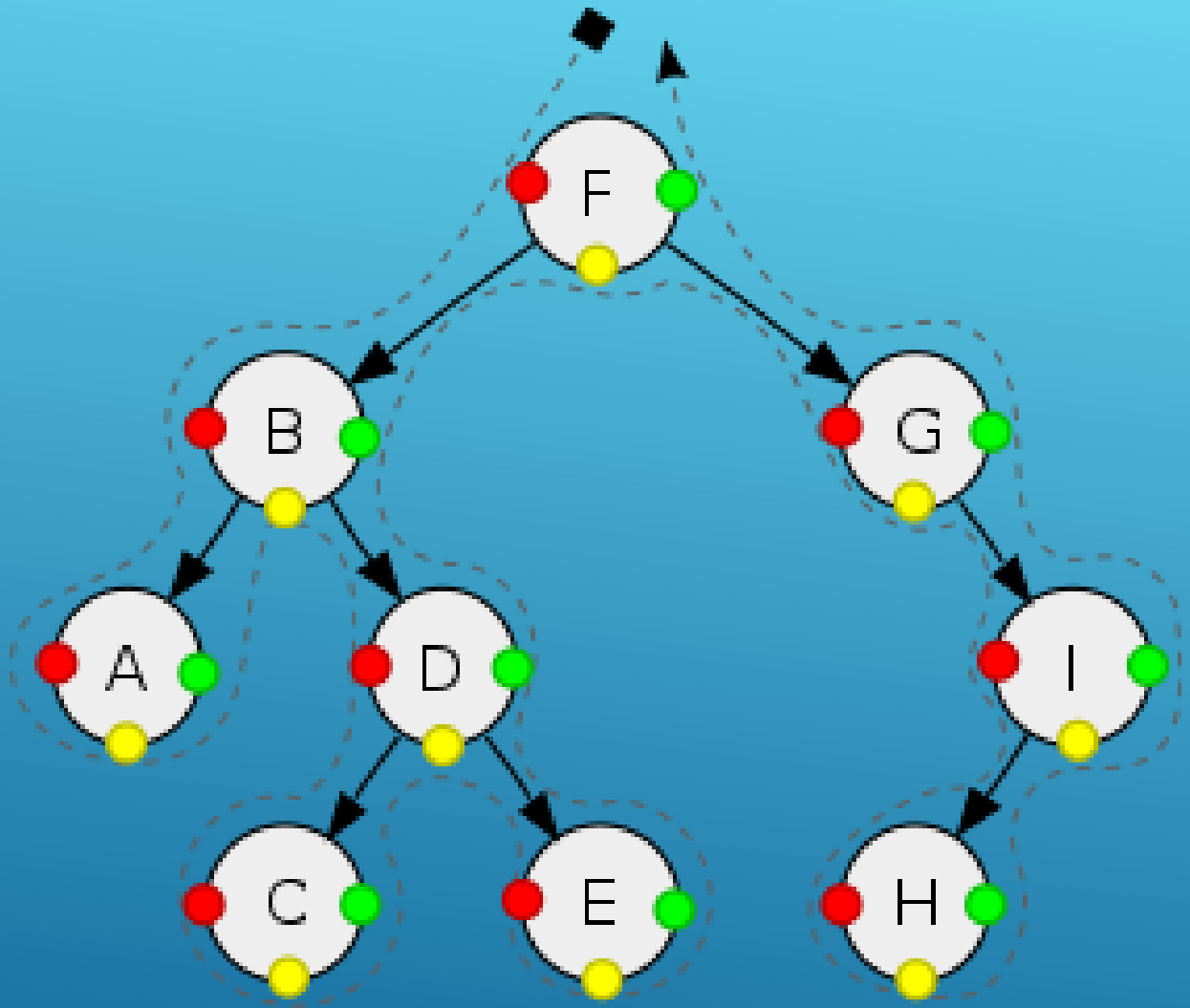



**outer layer really should be much larger**

# Let's quickly review the field of AI

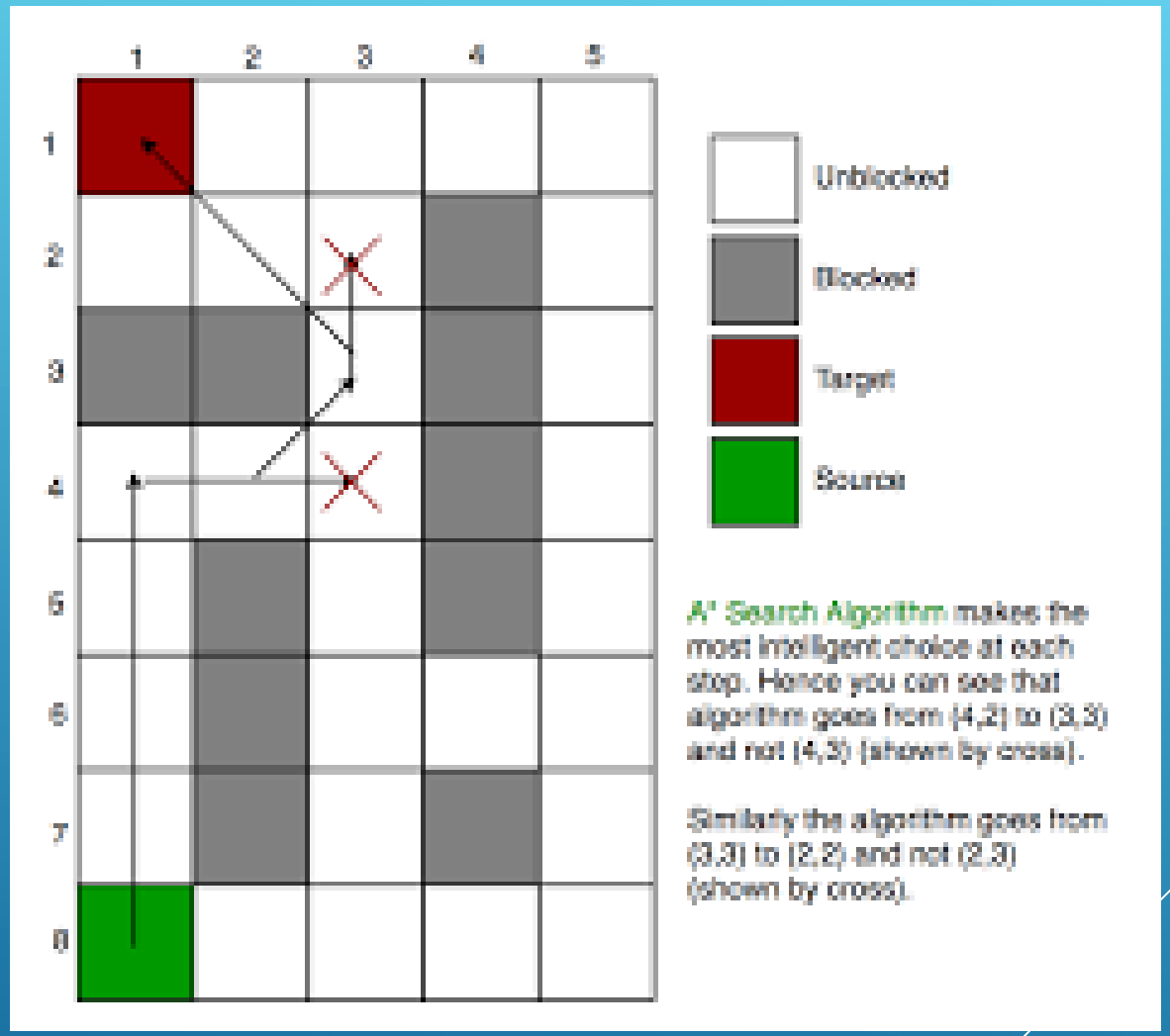


# SEARCH



# A* SEARCH ALGORITHM

"heuristic algorithm"



# LOGIC

$\forall x\ King(x) \wedge Greedy(x) \Rightarrow Evil(x)$ ← *axiom*

Given any x where it is a king and greedy this implies x is evil

*("All greedy kings are evil" )*

*Therefore can infer:*

$King(John) \wedge Greedy(John) \Rightarrow Evil(John)$

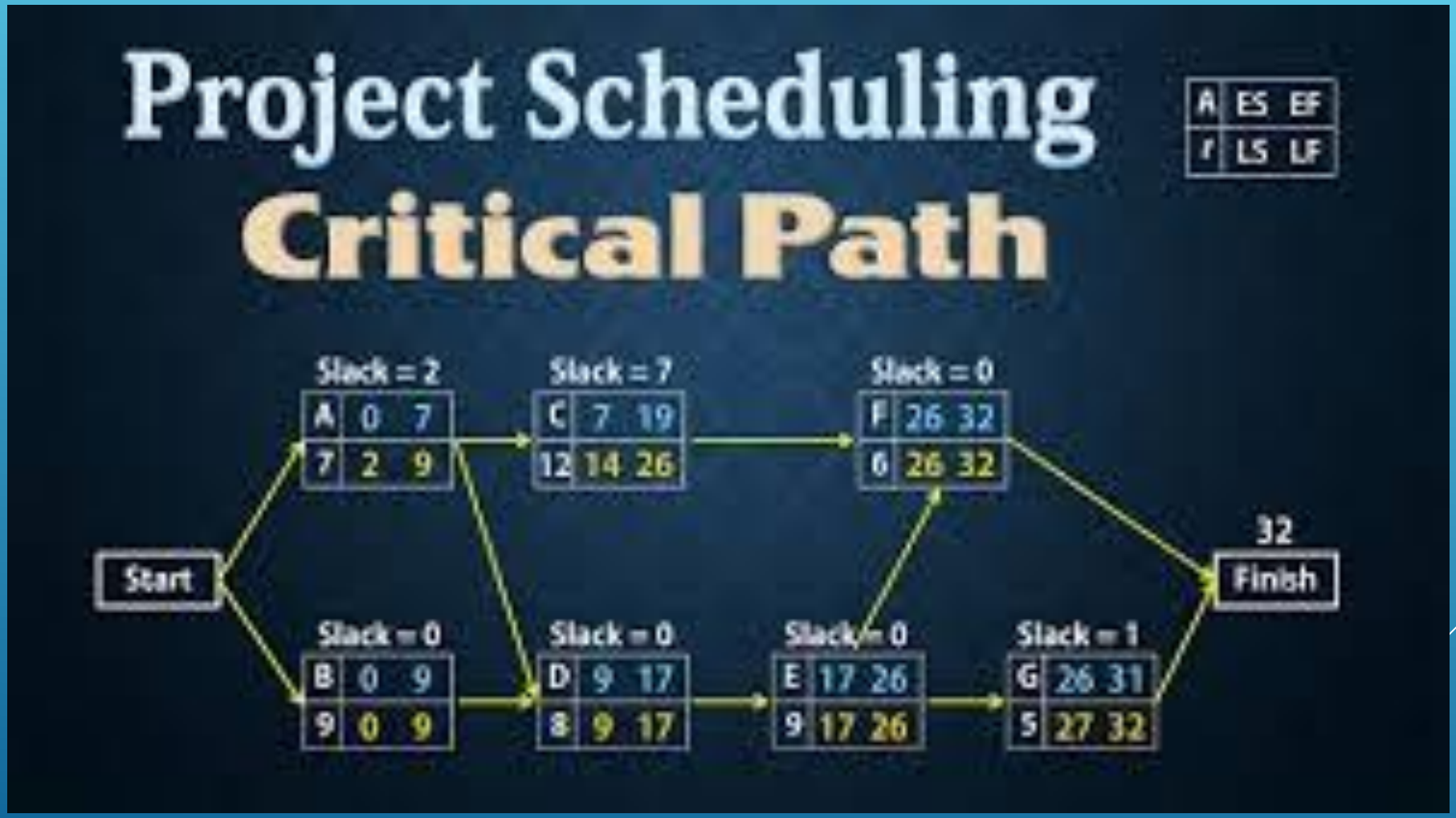
# RULE BASED ALGORITHM

```
yes_synonyms = ['y', 'Y', 'yes', 'Yes', 'T', 'true']
x = input('What is the name of the person? ')
king = input(f'Is {x} a king? ')
if king in yes_synonyms:
    king = True
else:
    king = False
greedy = input(f'Is {x} greedy? ')
if greedy in yes_synonyms:
    greedy = True
else:
    greedy = False
if king and greedy:
    print(f'{x} is an evil king')
else:
    print(f'We cannot infer that {x} is an evil king')
```

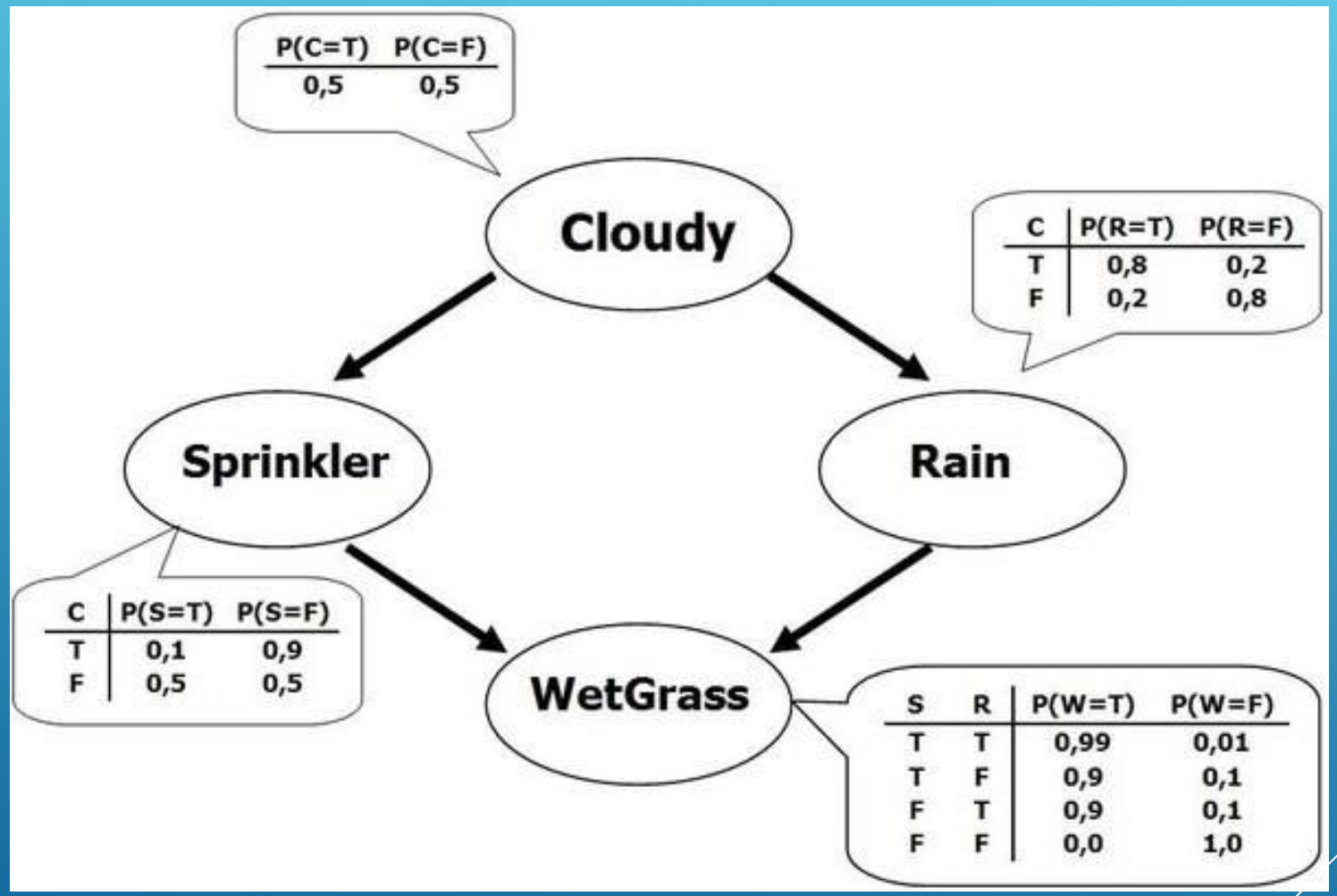
*non-learning*

```
C:\Users\howar>kings.py
What is the name of the person? Sebastian
Is Sebastian a king? yes
Is Sebastian greedy? yes
Sebastian is an evil king
```

# PLANNING

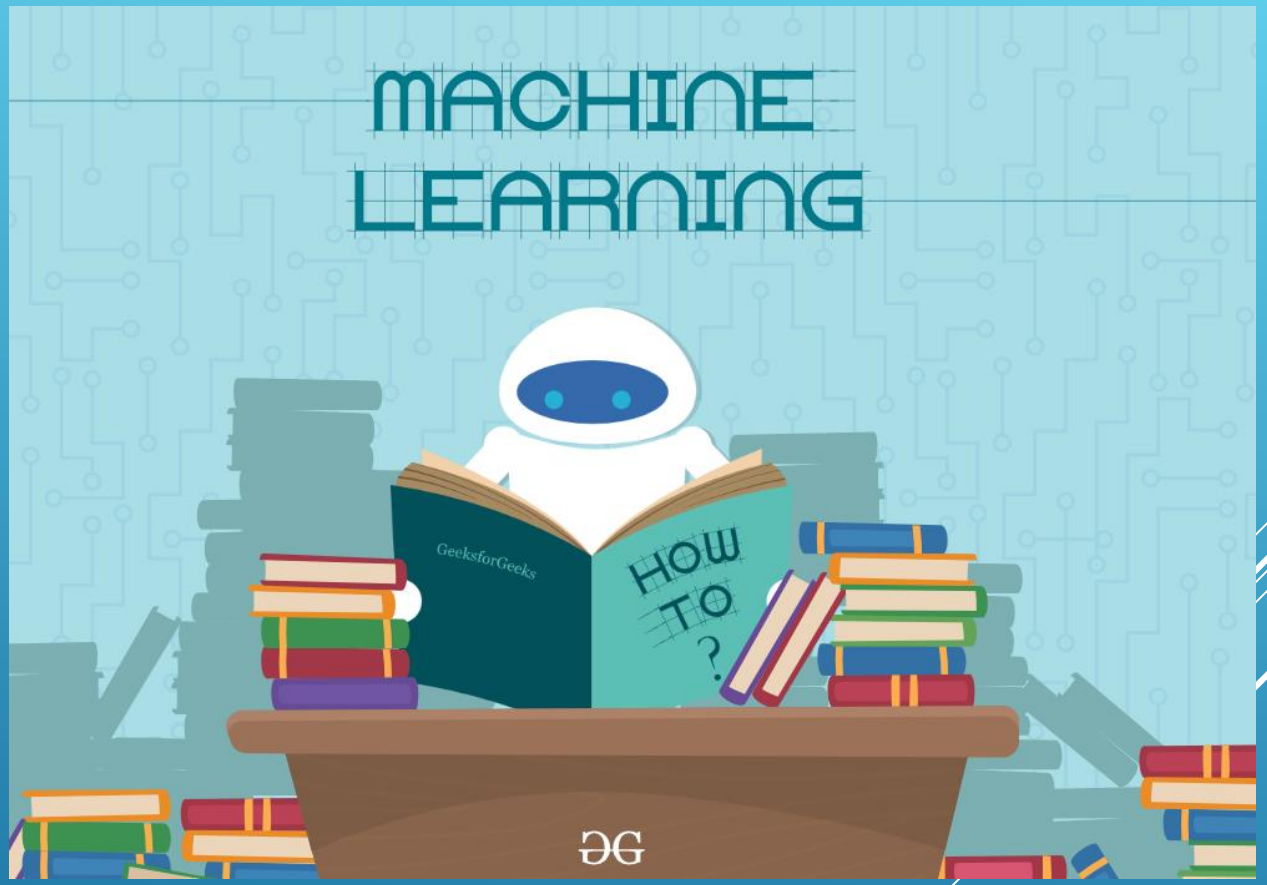

Project Scheduling
Critical Path
A ES EF
f LS LF
Slack = 2
A 0 7
7 2 9
Slack = 7
C 7 19
12 14 26
Slack = 0
F 26 32
6 26 32
Start
32
Finish
Slack = 0
B 0 9
9 0 9
Slack = 0
D 9 17
8 9 17
Slack = 0
E 17 26
9 17 26
Slack = 1
G 26 31
5 27 32

# PROBABILISTIC REASONING

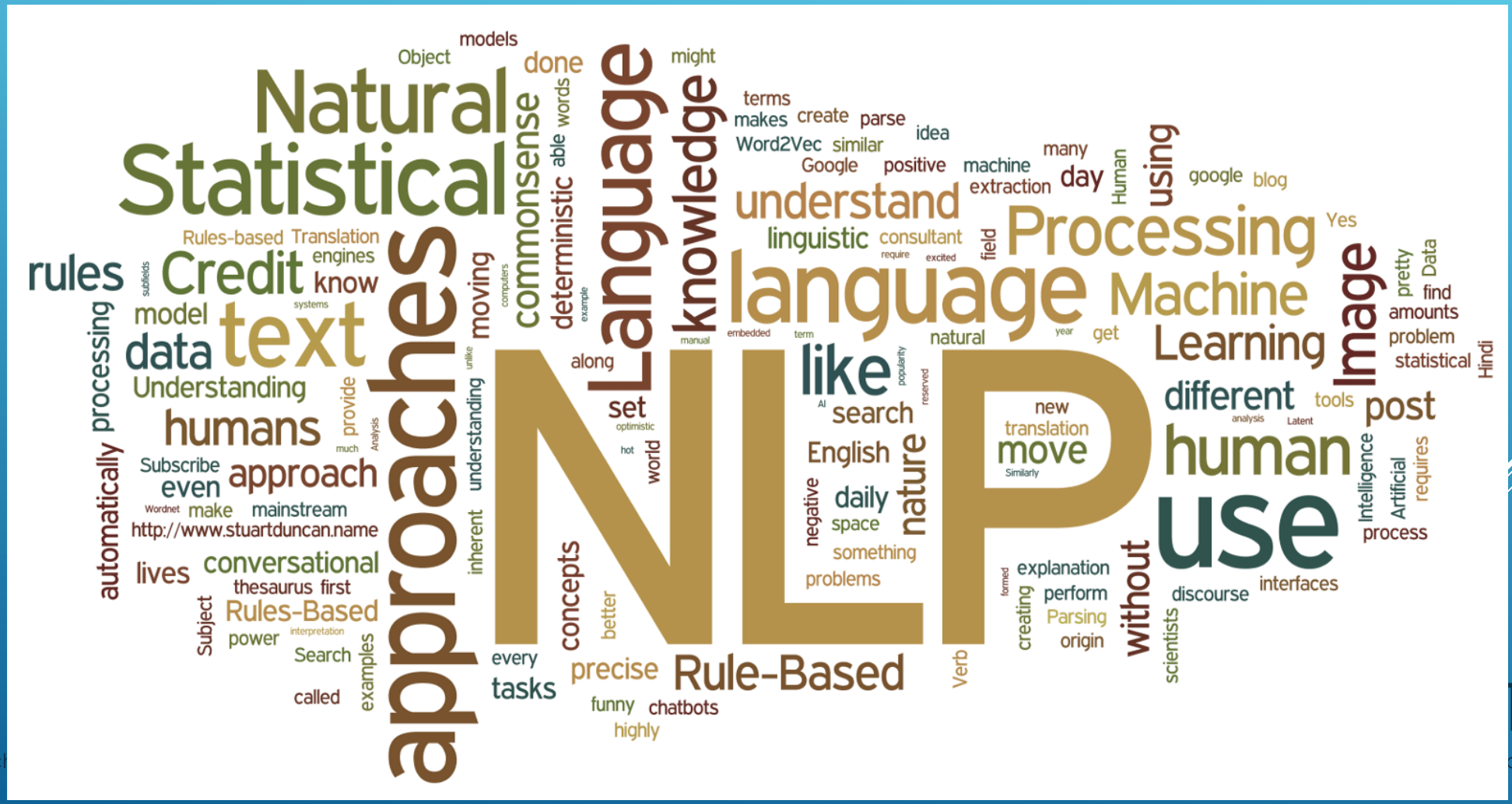


# LEARNING

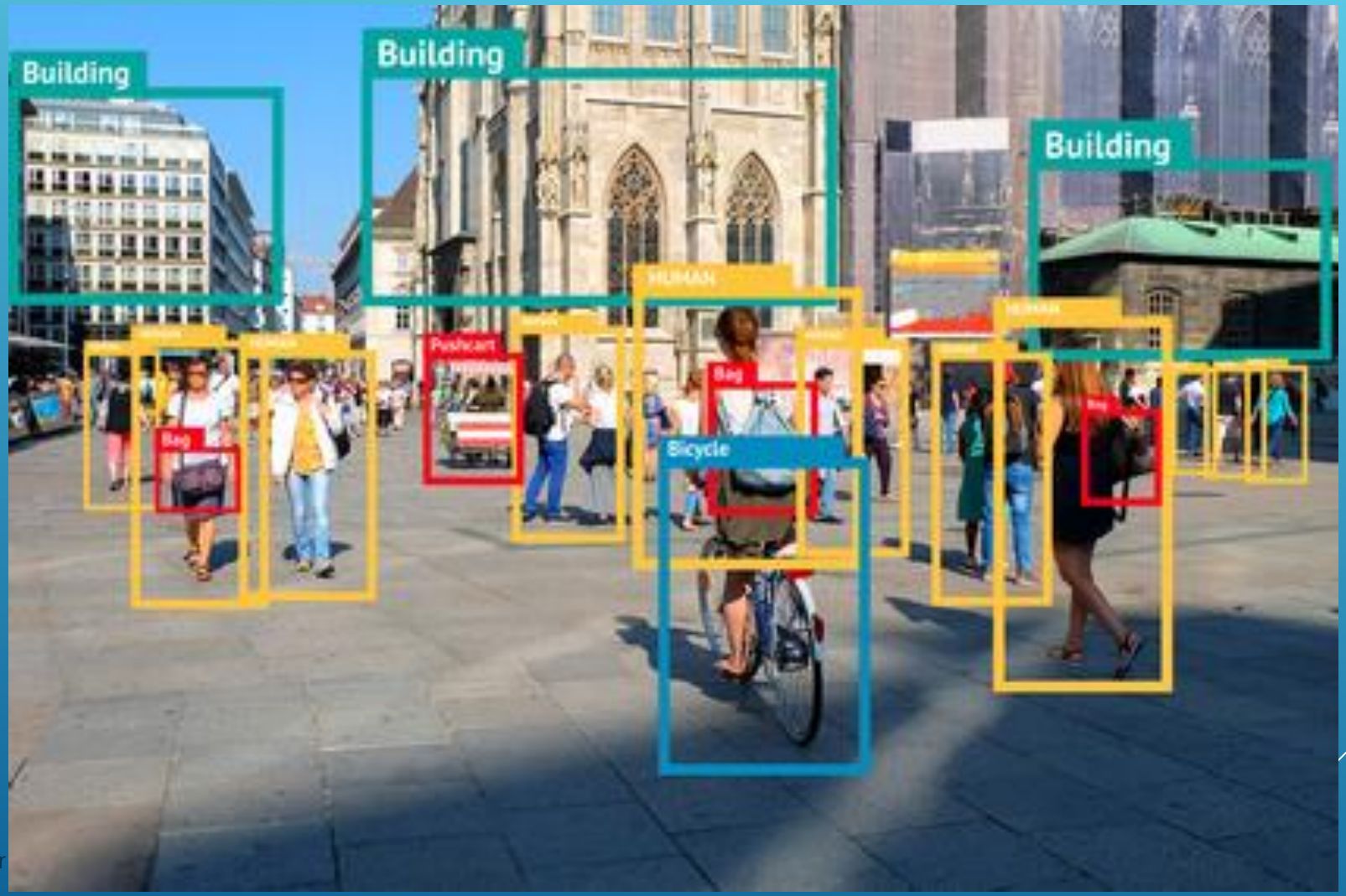
Learn from examples
Forms of learning
Knowledge in learning
Inductive learning
Meta learning
.....
.....



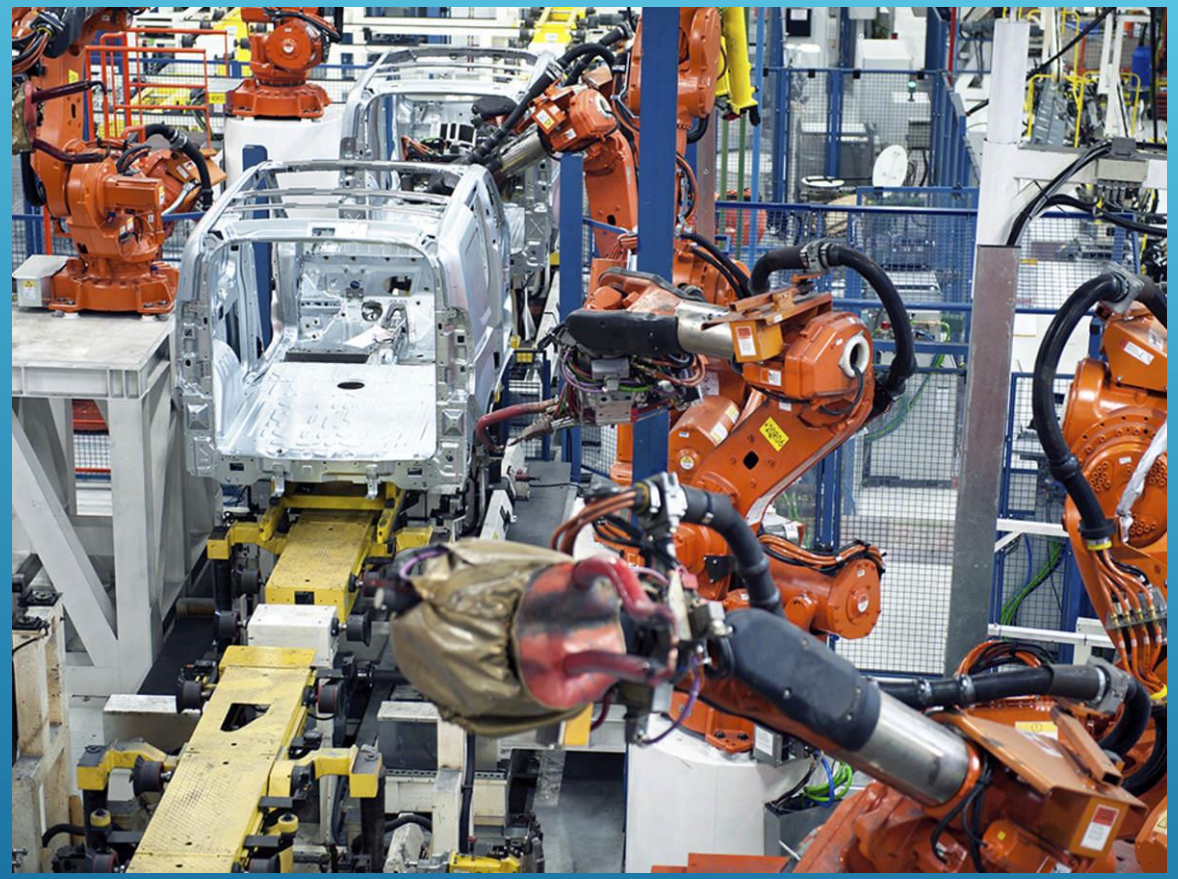
# NATURAL LANGUAGE PROCESSING



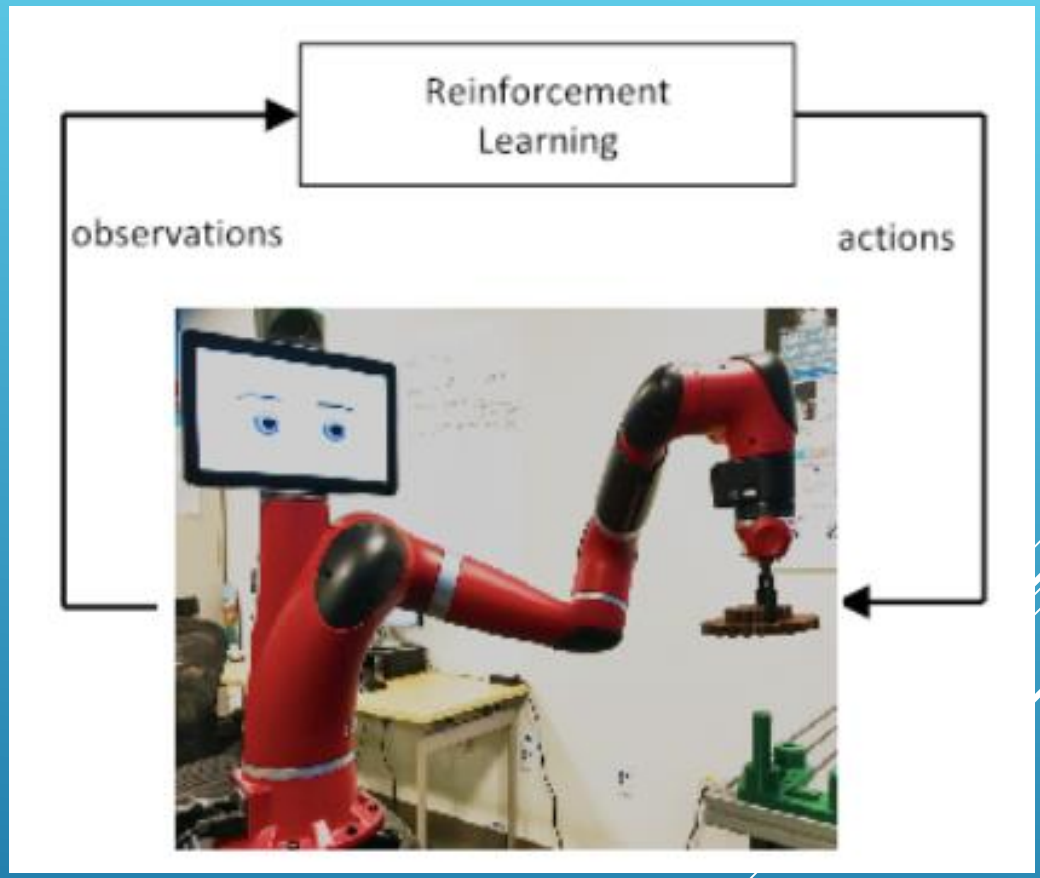
# VISION, PERCEPTION



# ROBOTICS – BETTER WITH AI



Repetitive tasks
Predefined trajectories




Learn by exploring environment
More flexible behavior

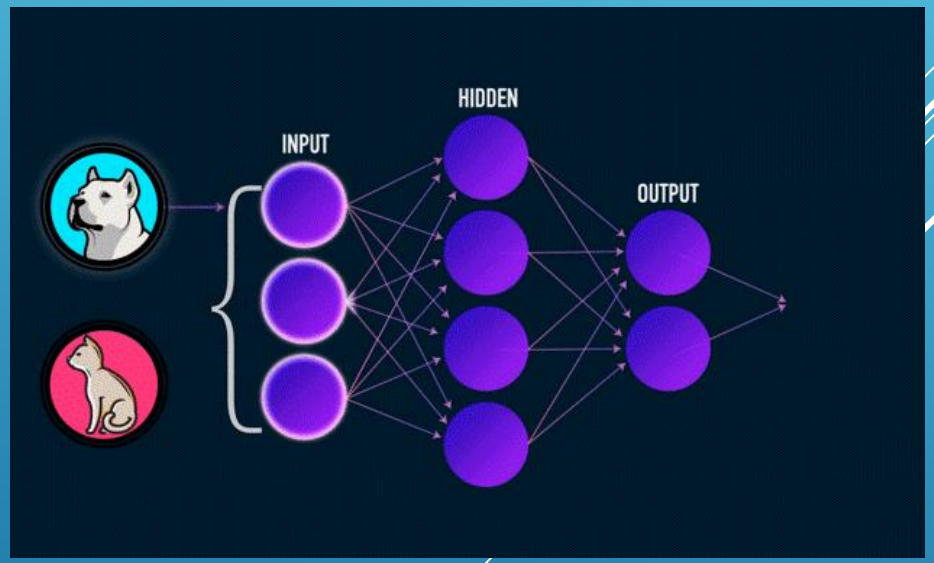
# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE

## ("GOFAI") == "SYMBOLIC AI"

*(generally non-learning)*

$$\text{King}(\text{John}) \land \text{Greedy}(\text{John}) \Longrightarrow \text{Evil}(\text{John})$$

```
if king and greedy:
    print(f'{x} is an evil king')
else:
.....
```




## NEURAL NETWORKS ("NEURAL") ==CONNECTIONIST AI

*(learning – make prediction, feedback correction, adjust weights)*

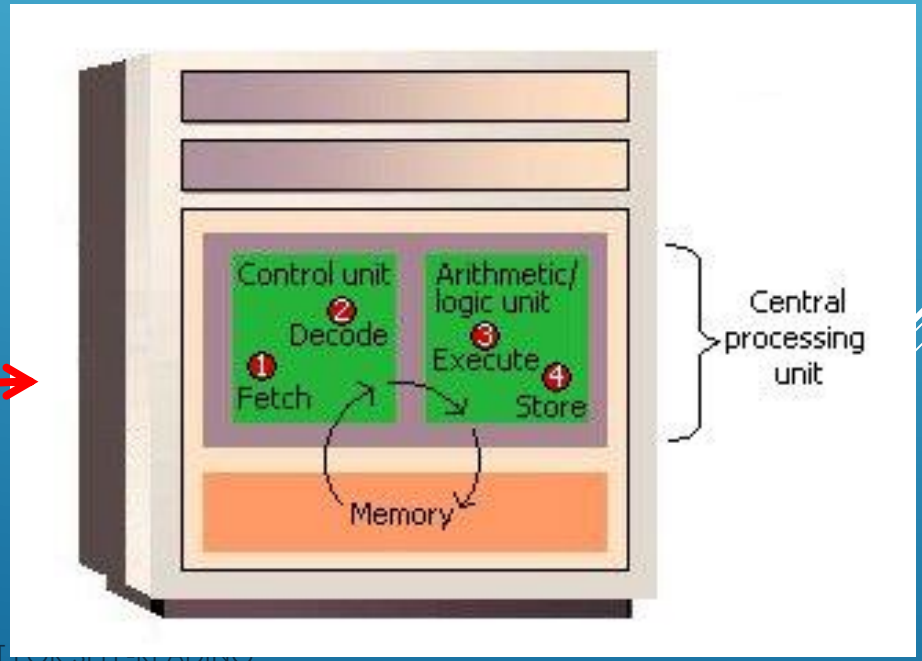
# HOW DOES A "COMPUTER" WORK?
## 1-½ MINUTE COURSE

-**"COMPUTER"** usually taken to mean a MACHINE THAT DOES **SYMBOLIC PROCESSING** (eg, runs Python program like shown above)

-**YOUR LAPTOP** (or smartphone or a large mainframe) IS A "COMPUTER"

# A COMPUTER CONTAINS A "CPU" (CENTRAL PROCESSING UNIT)

-**CPU** DOES ONE SMALL OPERATION AFTER ANOTHER (BUT VERY QUICKLY)



# CPU IS MADE FROM LOGIC GATES
# GATES ARE MADE OUT OF TRANSISTORS

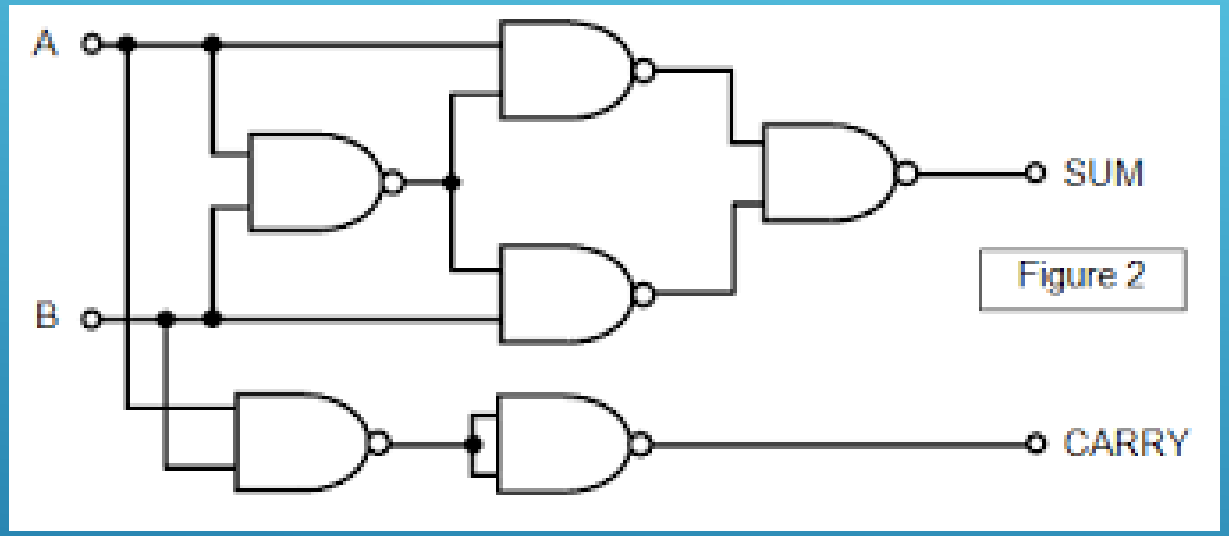
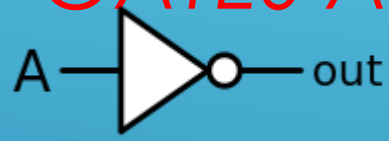
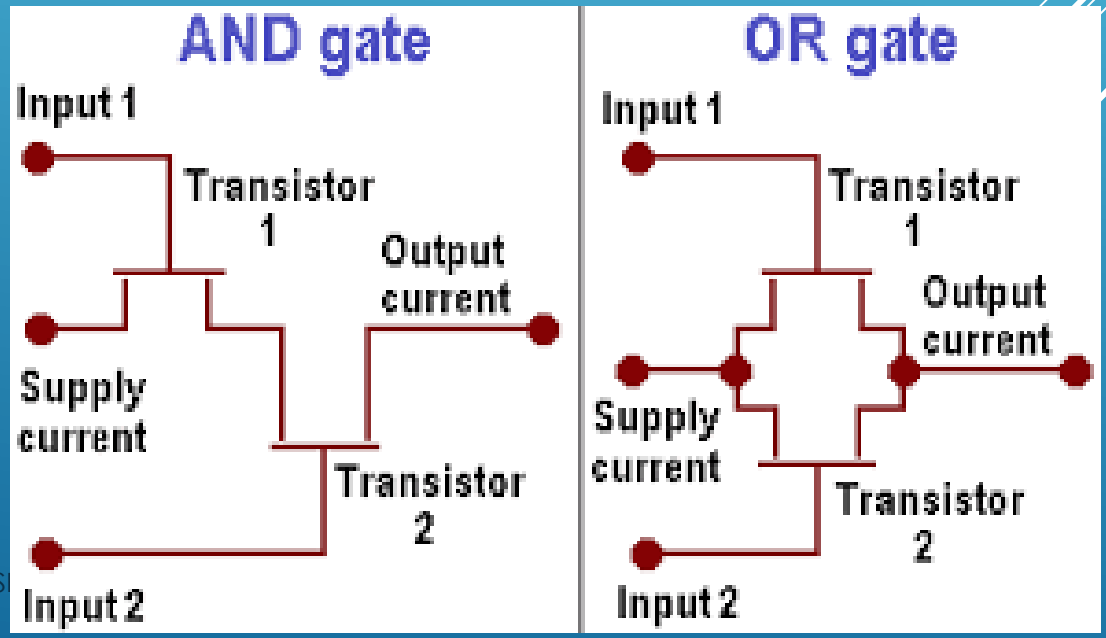


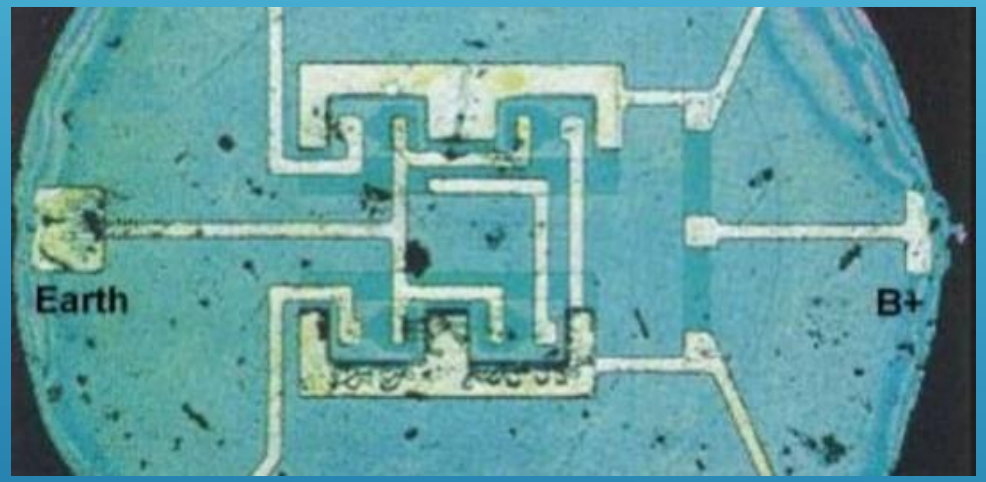

Figure 2

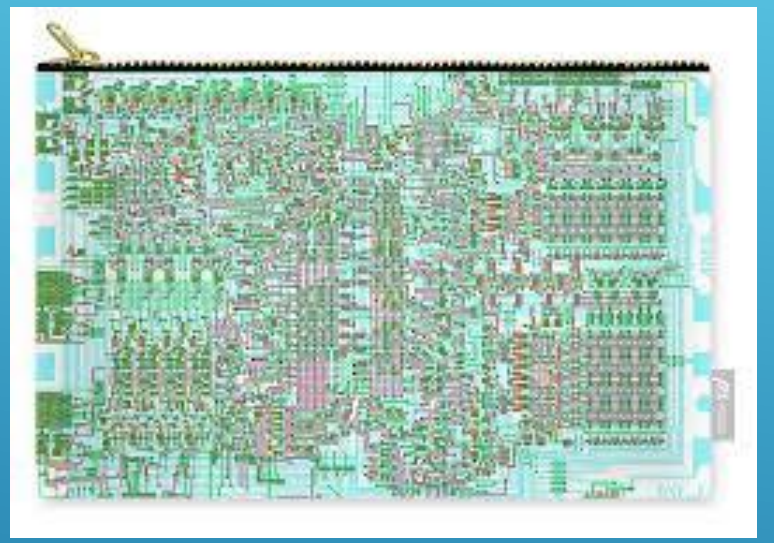
*'NOT' GATES ALSO!!*



# PHOTOLITHOGRAPHY (IE, PRINT) 'INTEGRATED CIRCUITS' ("CHIPS") CONTAINING MILLIONS AND MILLIONS OF LOGIC GATES

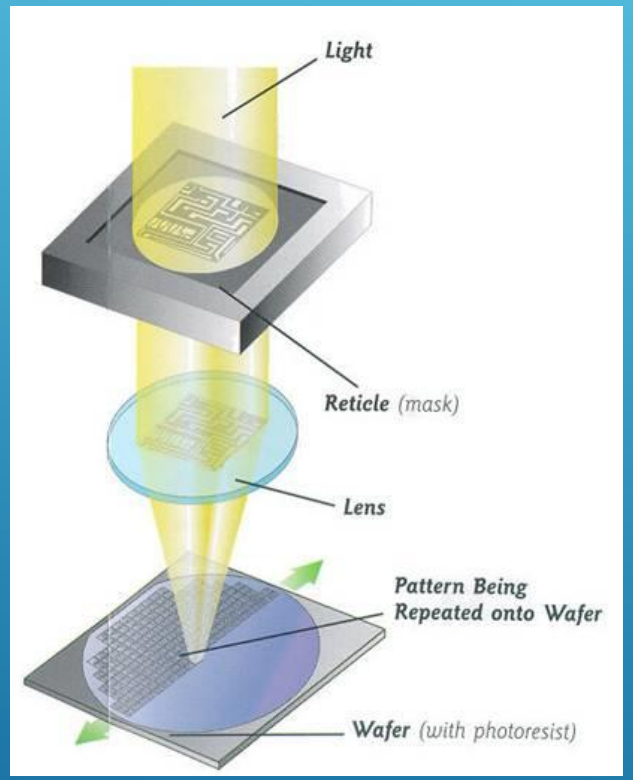


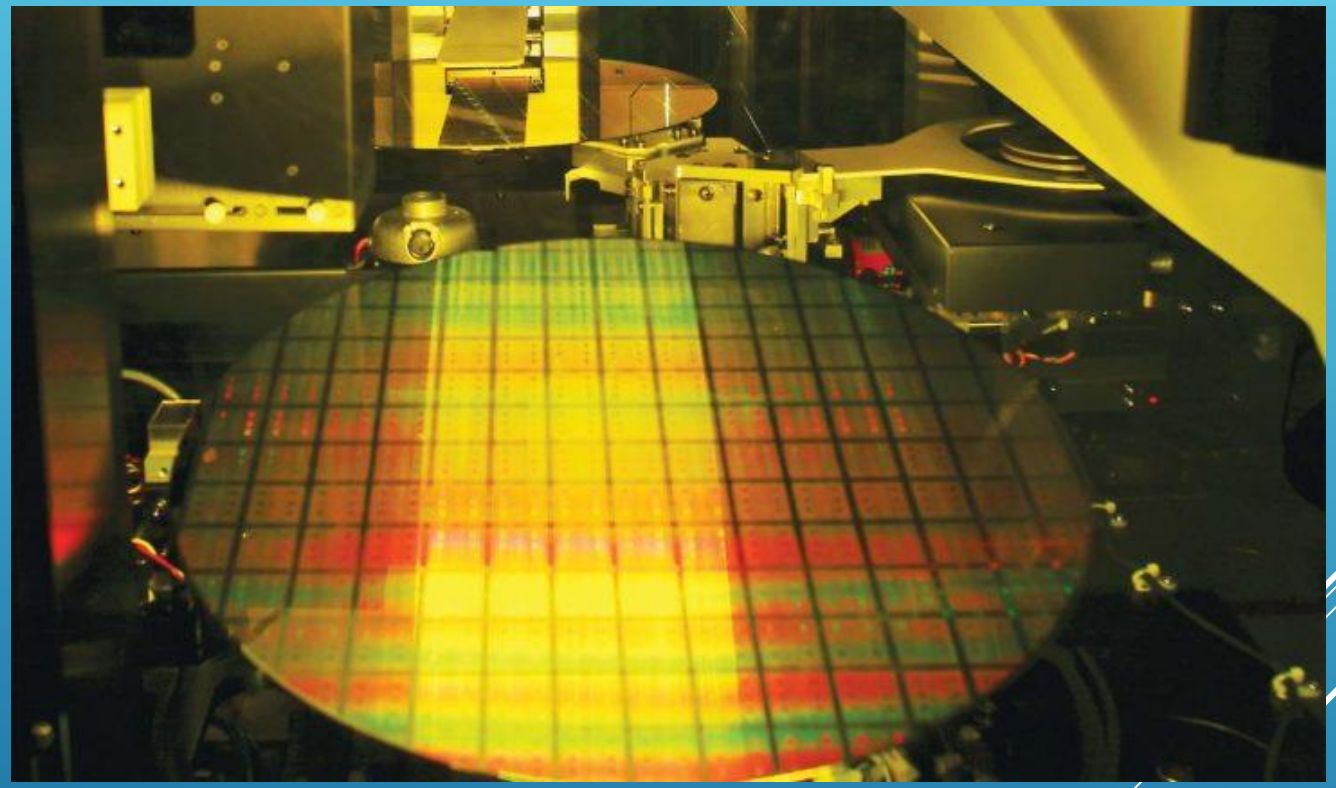



Robert **Noyce**, **1959,** Fairchild – silicon, true monolithic **IC**
Jack **Kilby**, 1958, TI – hybrid IC
**Shockley, Bardeen, Brattain**, 1947, Bell Labs – working transistor
**Lilienfeld**, 1926, Amrad/Magnavox – patent for FET transistor (not built)

**Hoff,** Intel 4004 CPU, **1971** – first commercial **microprocessor** (4 bit, <1Mhz clock)
-10 micron feature size, 2250 transistors
-vs. eg, **2020** Intel Xeon W-3175X has .014 micron sizes, 8,000,000,000 (8B) transistors, 64bit, 4300Mhz (4GHz)clock

# MAKING CHIPS – NOT MAGIC, JUST ADVANCED PHOTOGRAPHY



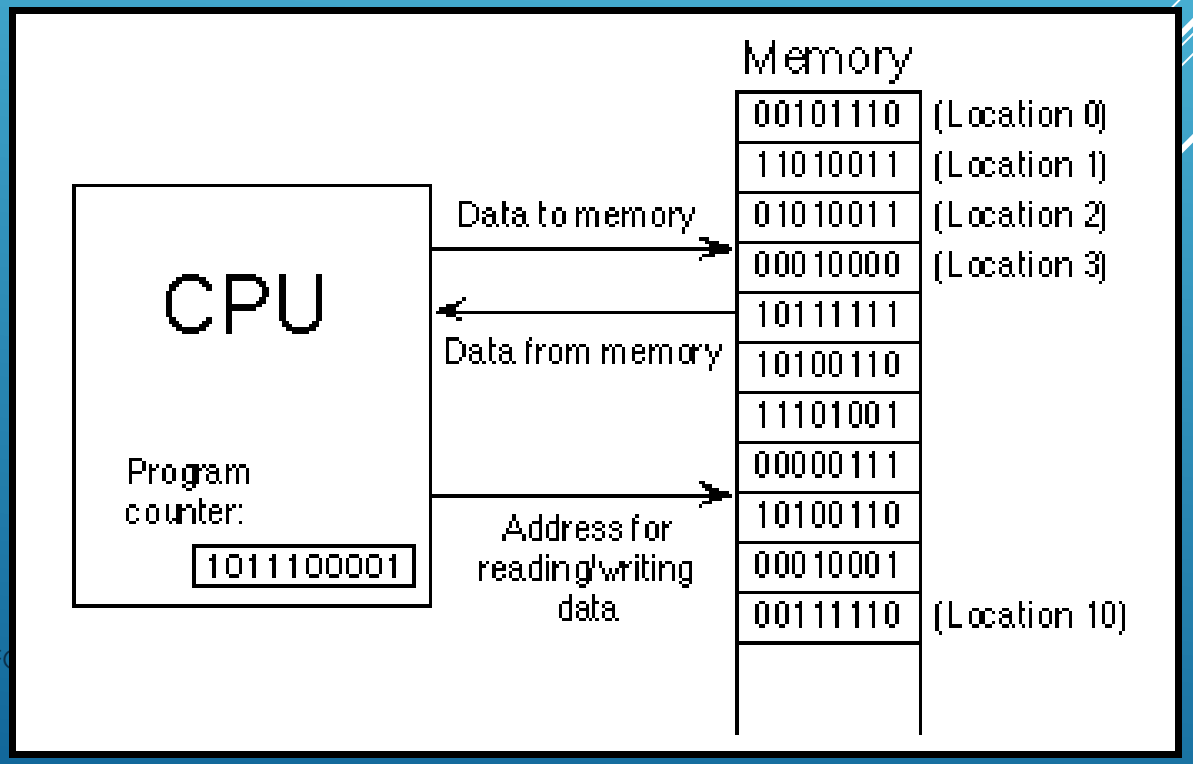
-START WITH MEMORY LOCATION 0

-1'S AND 0'S INTO LOGIC CIRCUITS IN CPU

-CPU -- DO SOME SIMPLE OPERATION

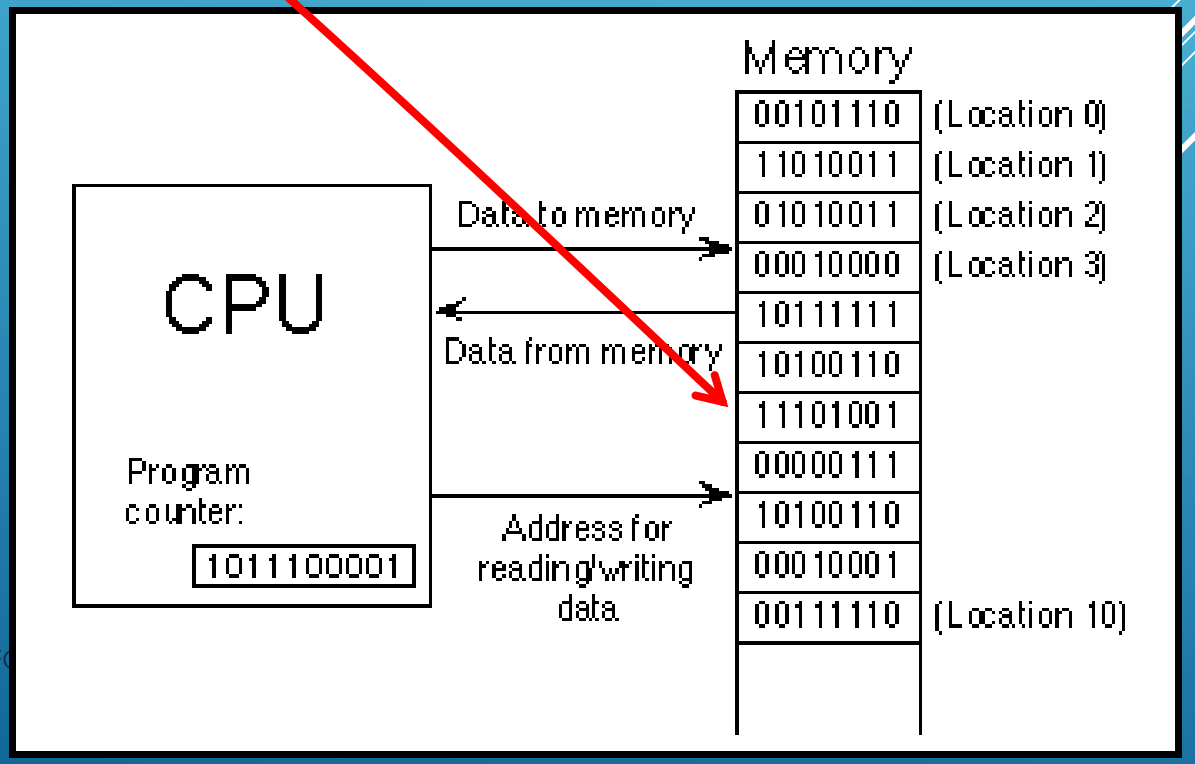
EG, memory A > memory B? Yes, write a '1'

EG, Jump to memory location xx



# SOME OF THE 1'S & 0'S ARE DATA, SOME OF THEM SPECIFY LOGIC OPERATIONS THE CPU IS SUPPOSED TO DO

EG, COMPARE TWO MEMORY LOCATIONS ALREADY LOADED IN THE CPU (EG, LOCATIONS 58 & 96)
-IF LOCATION 58 > LOCATION 96 THEN SET A MEMORY 'FLAG' WHICH THEN NEXT STEP CAUSES A JUMP TO MEMORY LOCATION XX AND USE THIS AS THE NEXT LOGIC OPERATION

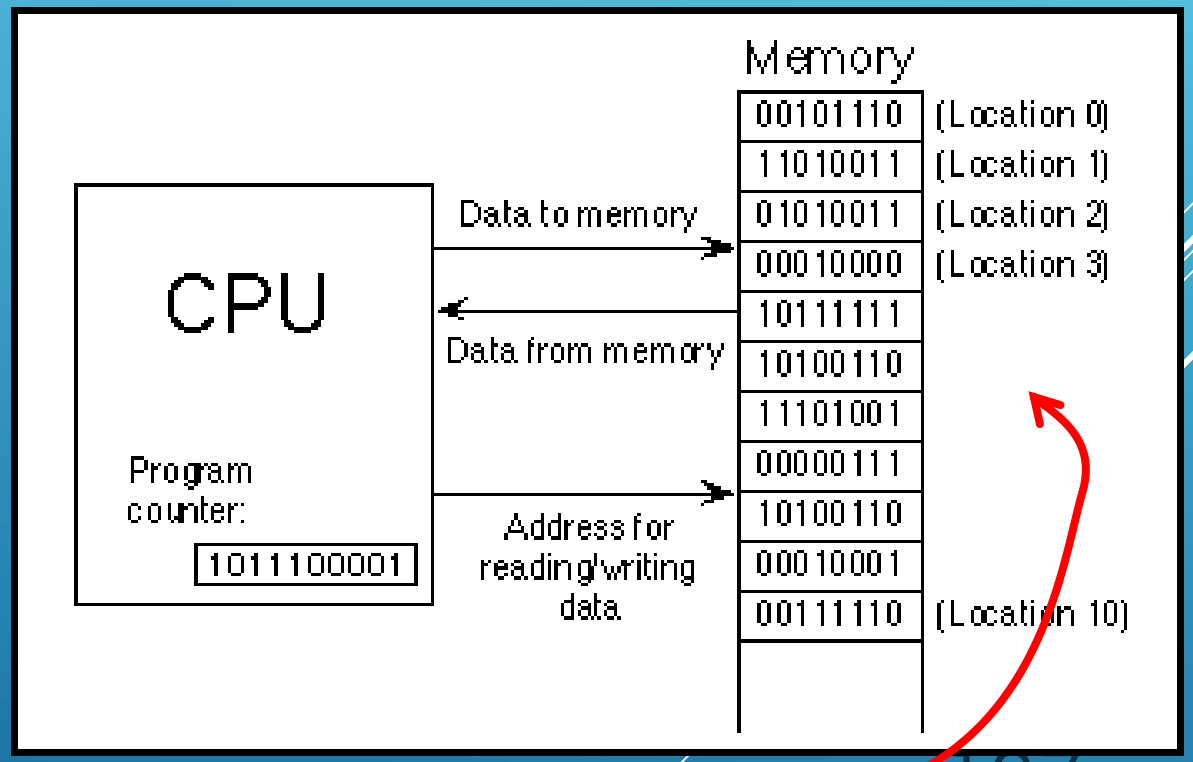


# SYMBOLIC COMPUTER PROGRAM ('GOFAI') IS TURNED INTO 1'S AND 0'S AND CPU PROCESSES IT

$$King(John) \wedge Greedy(John) \Rightarrow Evil(John)$$

```
if king and greedy:
    print(f'{x} is an evil king')
else:
……..
```

PYTHON COMPILER



# QUIZ – QUESTION 1.

# WHAT IS REINFORCEMENT LEARNING?

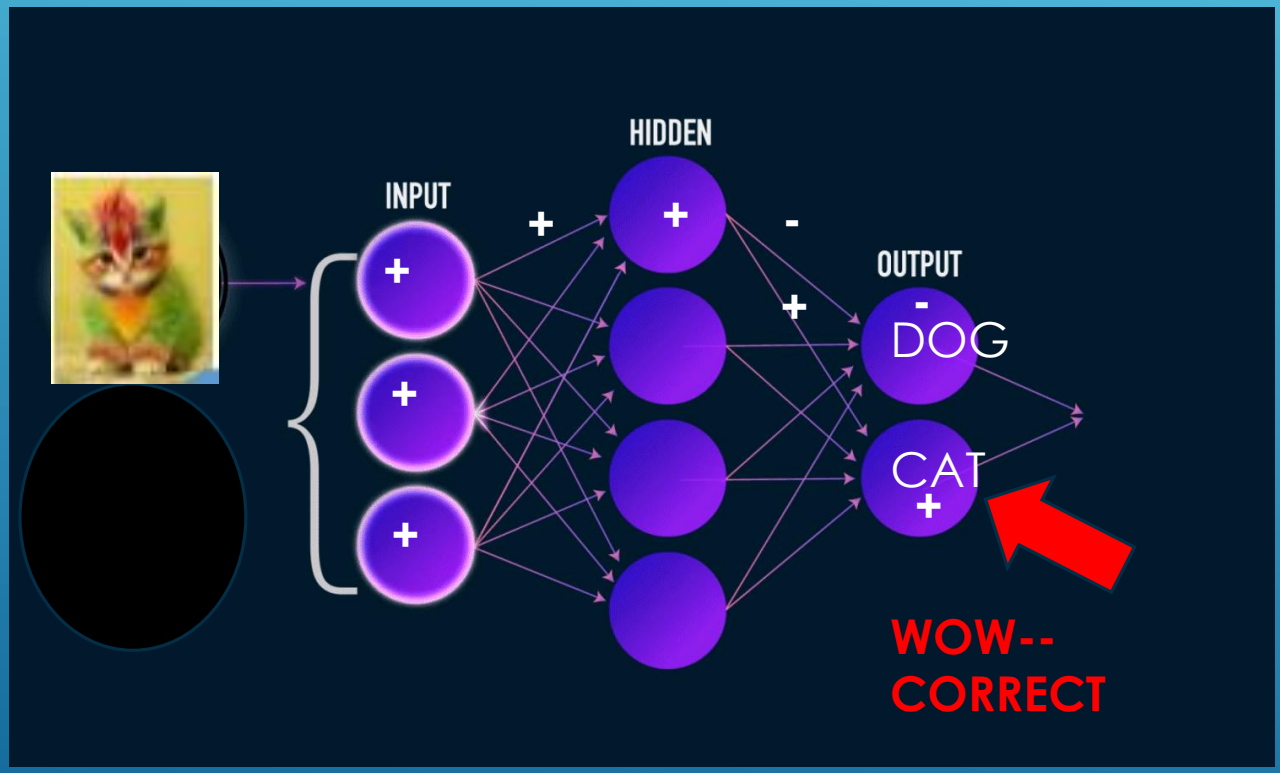
# REINFORCEMENT LEARNING

-NETWORK ('AGENT') TRIES TO MAXIMIZE THE REWARD

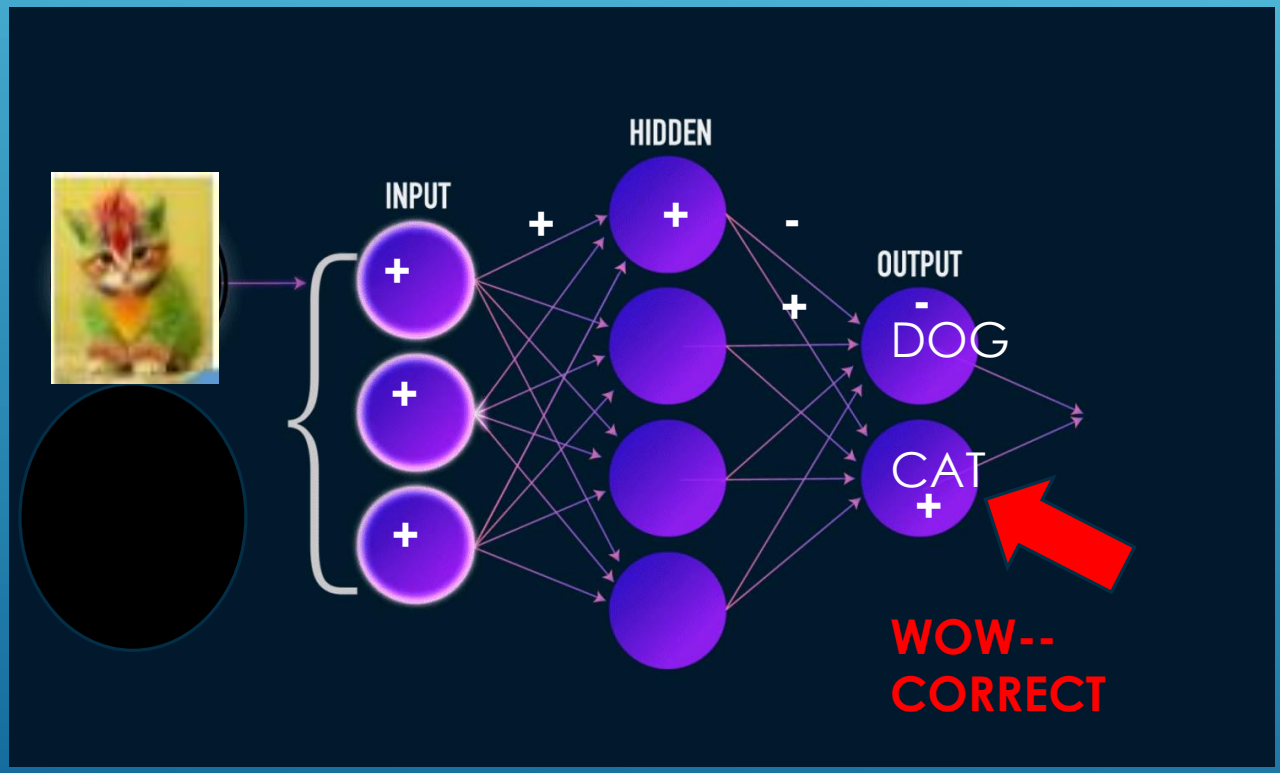
EG, PLAYS CHESS/SHOGI/GO AGAINST ITSELF MILLIONS AND MILLIONS OF TIMES


Deepmind 2017: Alphazero – superhuman performance in chess, shogi & go

# QUIZ – QUESTION 2.
# WHAT KIND OF SYSTEM IS SHOWN BELOW?

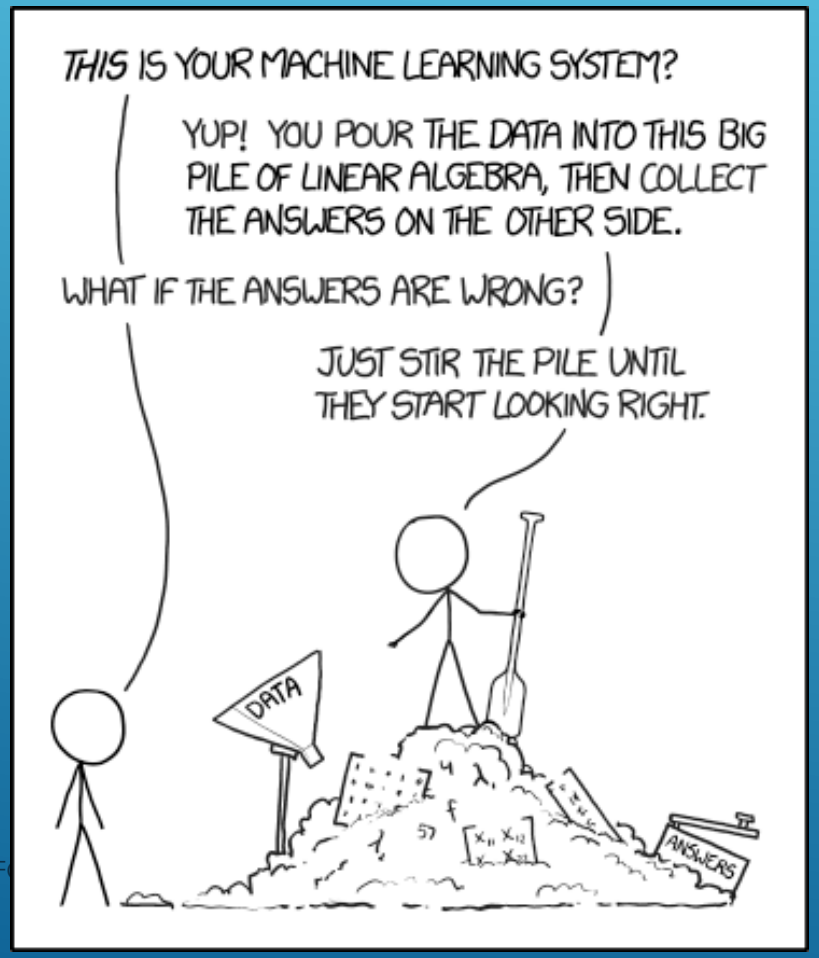


# **DEEP LEARNING** TO RECOGNIZE ALL SORTS OF CATS AND DOGS




*"Connectionism"*
*"Neural Network"*
*"Deep Learning Network"*

# **DEEP LEARNING** CAN **RECOGNIZE** OR **ASSOCIATE** ALL KINDS OF INFORMATION – IMAGES, FACES, SPEECH, DATA, ETC OR MARKETING DATA……



# QUIZ – QUESTION 3.
# WHAT KIND OF COMPUTER SYSTEM HANDLES THE LOGIC SHOWN BELOW?

$\forall x\ \text{King}(x) \wedge \text{Greedy}(x) \Longrightarrow \text{Evil}(x)$ ← *axiom*

*("All greedy kings are evil")*

*Therefore can infer:*

$\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Longrightarrow \text{Evil}(\text{John})$

# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE ("GOFAI") "SYMBOLIC AI"

$\forall x\ \text{King}(x) \wedge \text{Greedy}(x) \Rightarrow \text{Evil}(x)$ ← *axiom*

*("All greedy kings are evil")*

*Therefore can infer*:

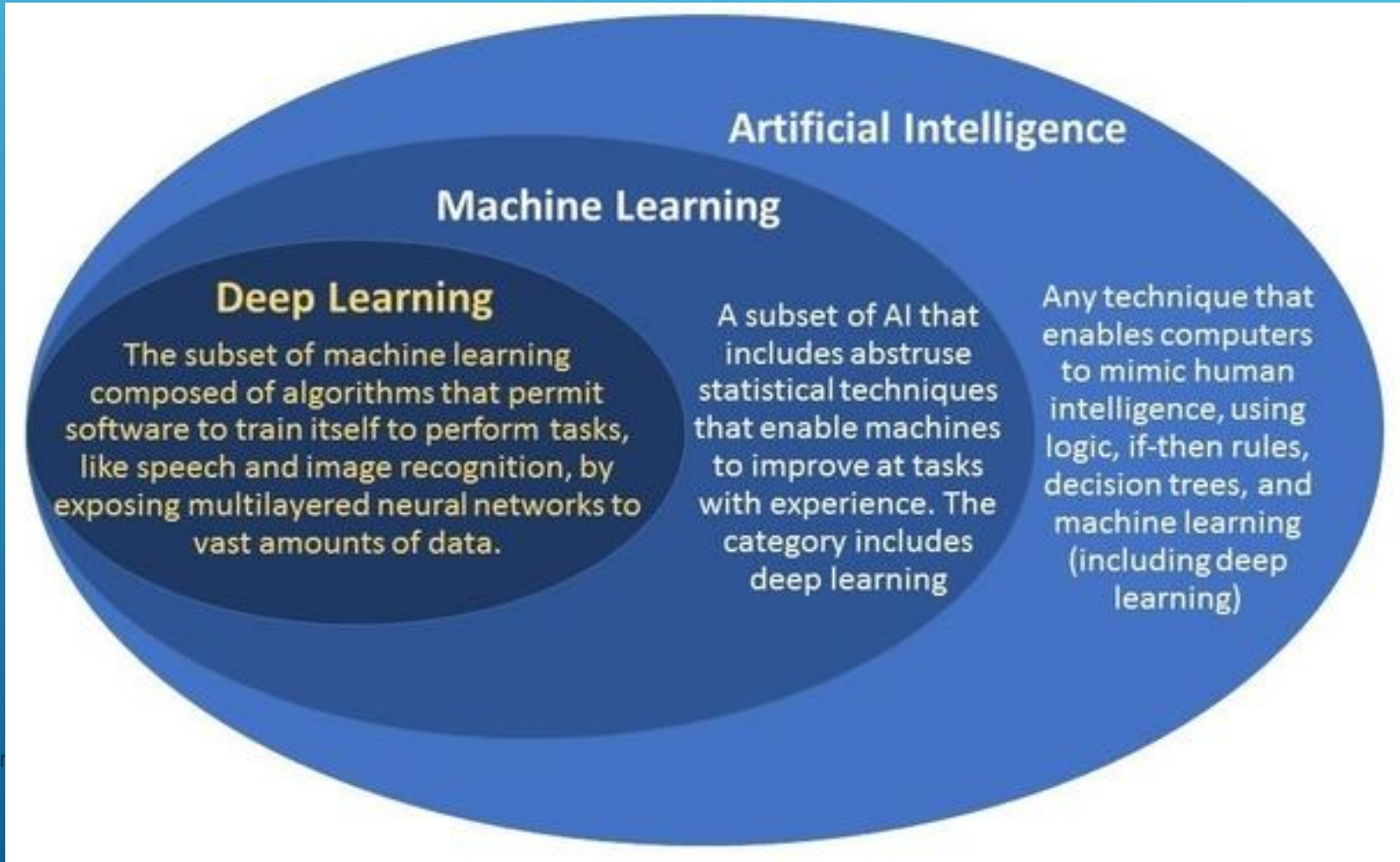
$\text{King}(\text{John}) \wedge \text{Greedy}(\text{John}) \Rightarrow \text{Evil}(\text{John})$

# GOOD OLD FASHIONED ARTIFICIAL INTELLIGENCE
# "GOFAI" == "SYMBOLIC AI"

```
yes_synonyms = ['y', 'Y', 'yes', 'Yes', 'T', 'true']
x = input('What is the name of the person? ')
king = input(f'Is {x} a king? ')
if king in yes_synonyms:
    king = True
else:
    king = False
greedy = input(f'Is {x} greedy? ')
if greedy in yes_synonyms:
    greedy = True
else:
    greedy = False
if king and greedy:
    print(f'{x} is an evil king')
else:
    print(f'We cannot infer that {x} is an evil king')
```

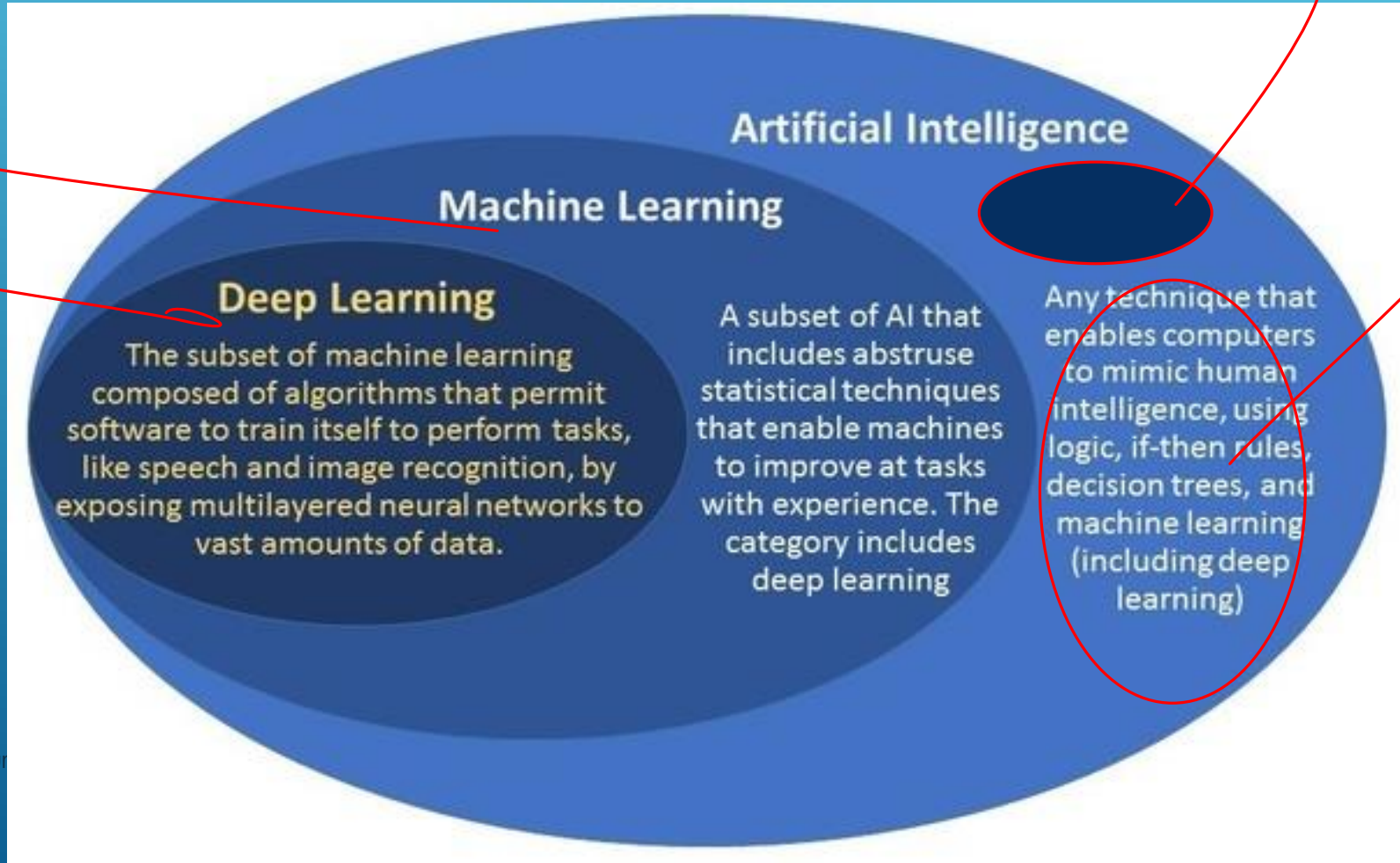
```
C:\Users\howar>kings.py
What is the name of the person? Sebastian
Is Sebastian a king? yes
Is Sebastian greedy? yes
Sebastian is an evil king
```

# Quiz – question 4
# Where are Neural Networks in the diagram below?
# Where is Symbolic (GOFAI) in the diagram below?



# Neural networks

# Symbolic AI



# LEARNING OBJECTIVES

- 1. **Real understanding of what AI is:**
- **1a. Deep Learning and Reinforcement Learning**
- 1b. Field of Artificial Intelligence (AI)
- **1c. Neuro-Symbolic Gap**
- 2. **How will AI in next decade (or two) affect my patients' lives?**
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- 5. **Discussion**

# WE HAVE COVERED :

-DEEP LEARNING (**NEURAL** NETWORKS AI)
*ASSOCIATIONS, RECOGNITION (IMAGES, SPEECH, ETC….)*
*BIG SUCCESSES!!*

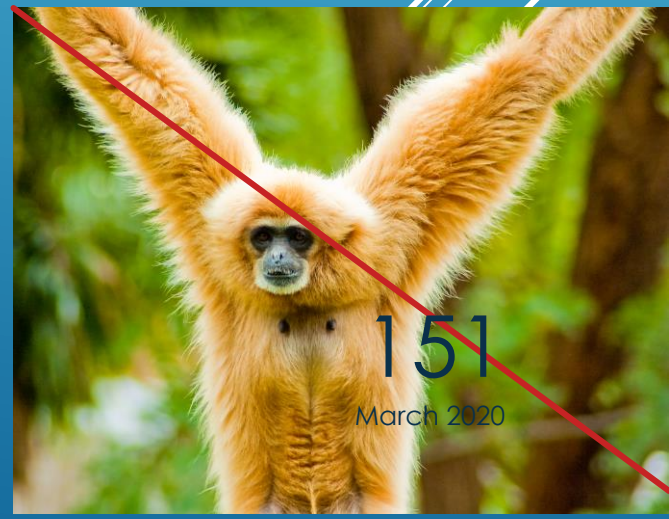
-**SYMBOLIC** AI
*LOGIC*
*BIG FAILURES!! EG, EXPERT SYSTEMS -> AI WINTERS!!*

# The *Neural Symbolic Gap*


- **Neural Network** – phenomenal image processing and reinforcement learning
- **Child** – phenomenal causal symbolic learning with few examples (eg, Gopnik)


Goodfellow,I.J., Shlens,J. and Szegedy,C. (Google Mountainview), Explaining and Harnessing Adversial Examples, ICLR 2015.

# It’s still a Panda – and the 3 year old boy would know this!! (and…. 3 year old only needs 1 or 2 photos for training, not 1000s)



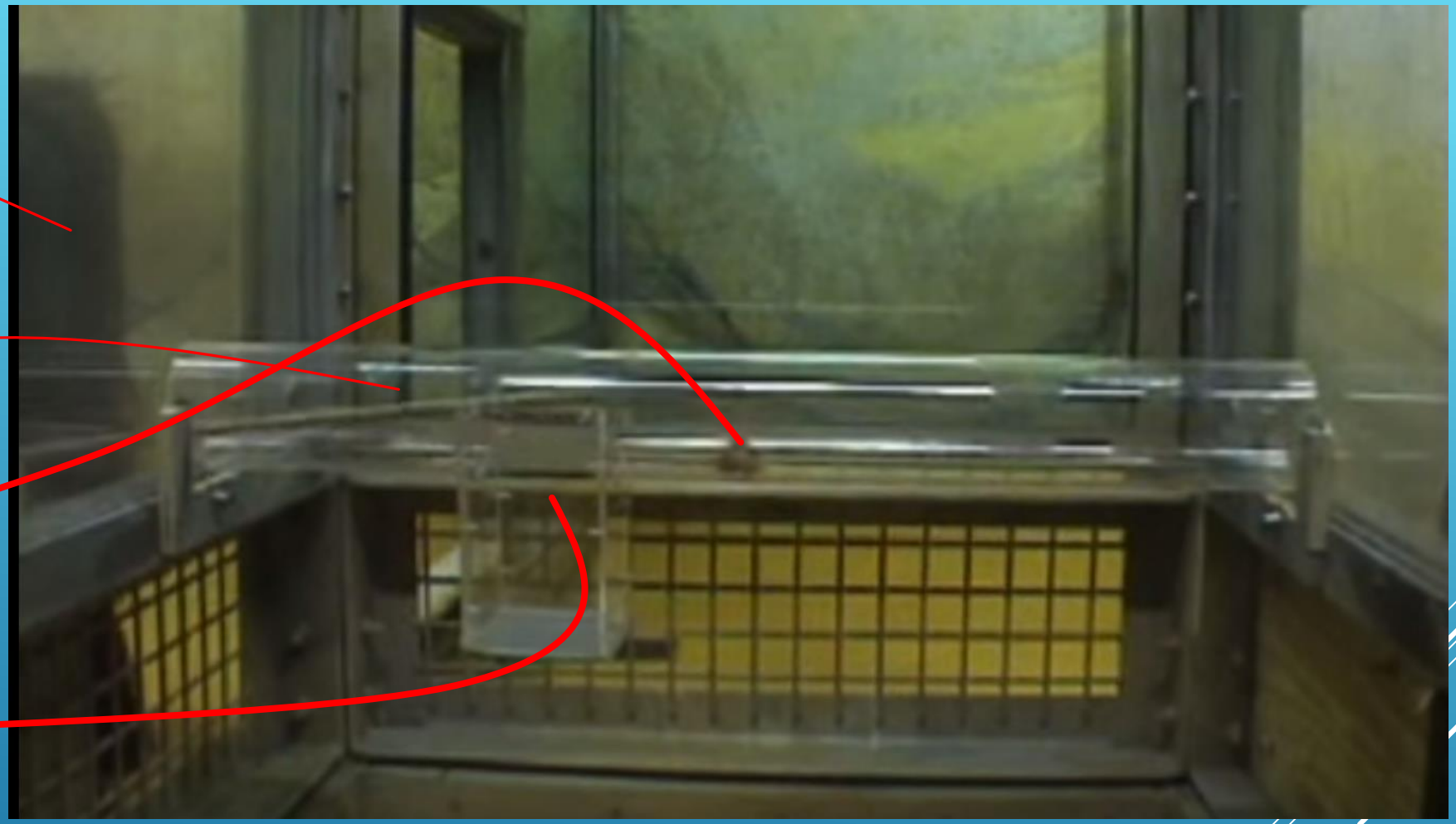

| Deep Learning Neural Network | 3 Year Old Human Child |
| --- | --- |
| Pattern Recognition<br>→Recognize the World | Model Building +also Pattern Recognition<br>→Explain the World |
| Need 1000's examples for learning | A few examples enough |

Chimpanzee (behind plexiglass)

Stick to push or pull food

Food

Gravity trap



# Chimpanzees **do not** have full causality

Deep Learning has zero Understanding
**Deep Learning gets more powerful by brute force**

Compute for Deep Learning has been doubling q3 months
300,000x increase in computing power the last few years
NOT SUSTAINABLE -- There is a deep flaw in deep learning

Humans have causality.

Animals do not. ← *associations*

Deep Learning does not. ← *associations*

**Humans** (me☺) learn to drive with 5 hours of driving in a driver's ed course. I do not need to be programmed with every possible scene on the road – I can figure it out (eg, bag on road).

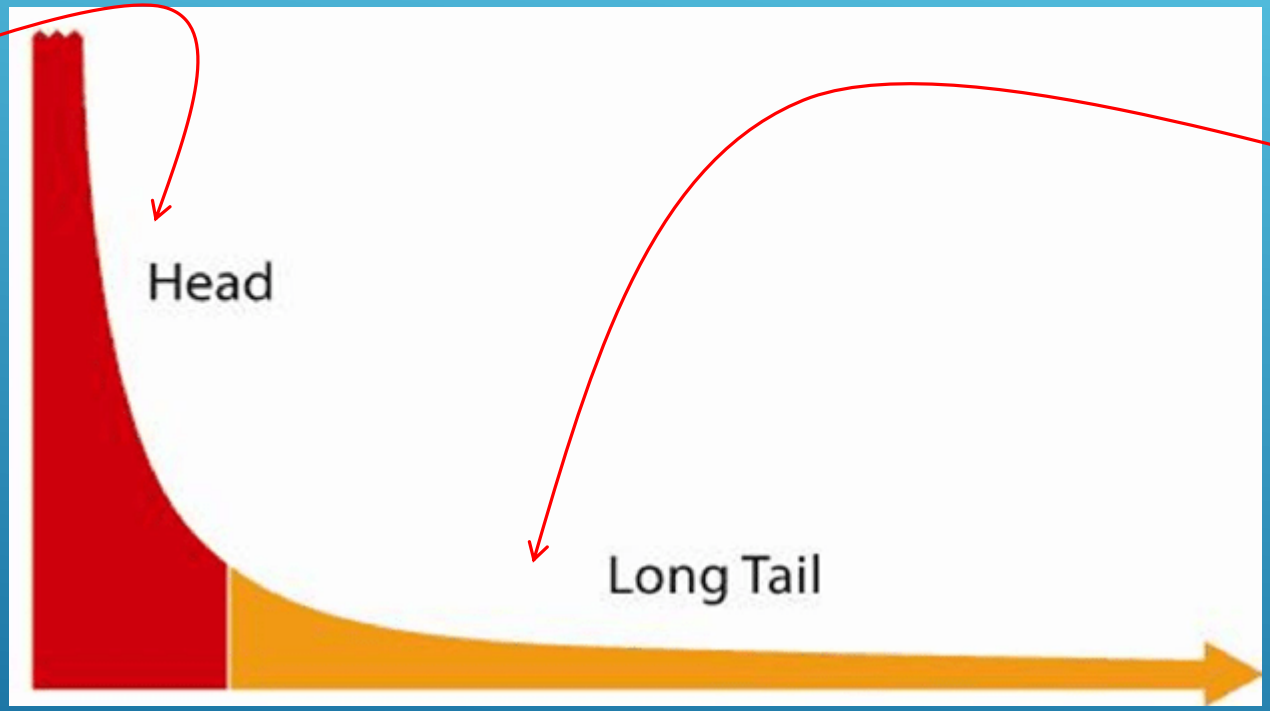
**Deep Learning autonomous driving system** – must get training data showing *everything* since **it cannot causally reason**
Eg, Tesla has about a billion miles of driving experience of its cars as training data now.

# Classic example: unless explicitly programmed, an autonomous driving system will follow road and drive off a cliff (because it understands nothing!!)

(programmers add symbolic rules to autonomous driving systems and probably this one has been added already)

# Without causality need loads and loads of experience to see everything: **'long-tail problem'**

Reasonable number of examples make up 99% of examples will see in the world




Last 1% or .1% are HUGE NUMBER of possible examples

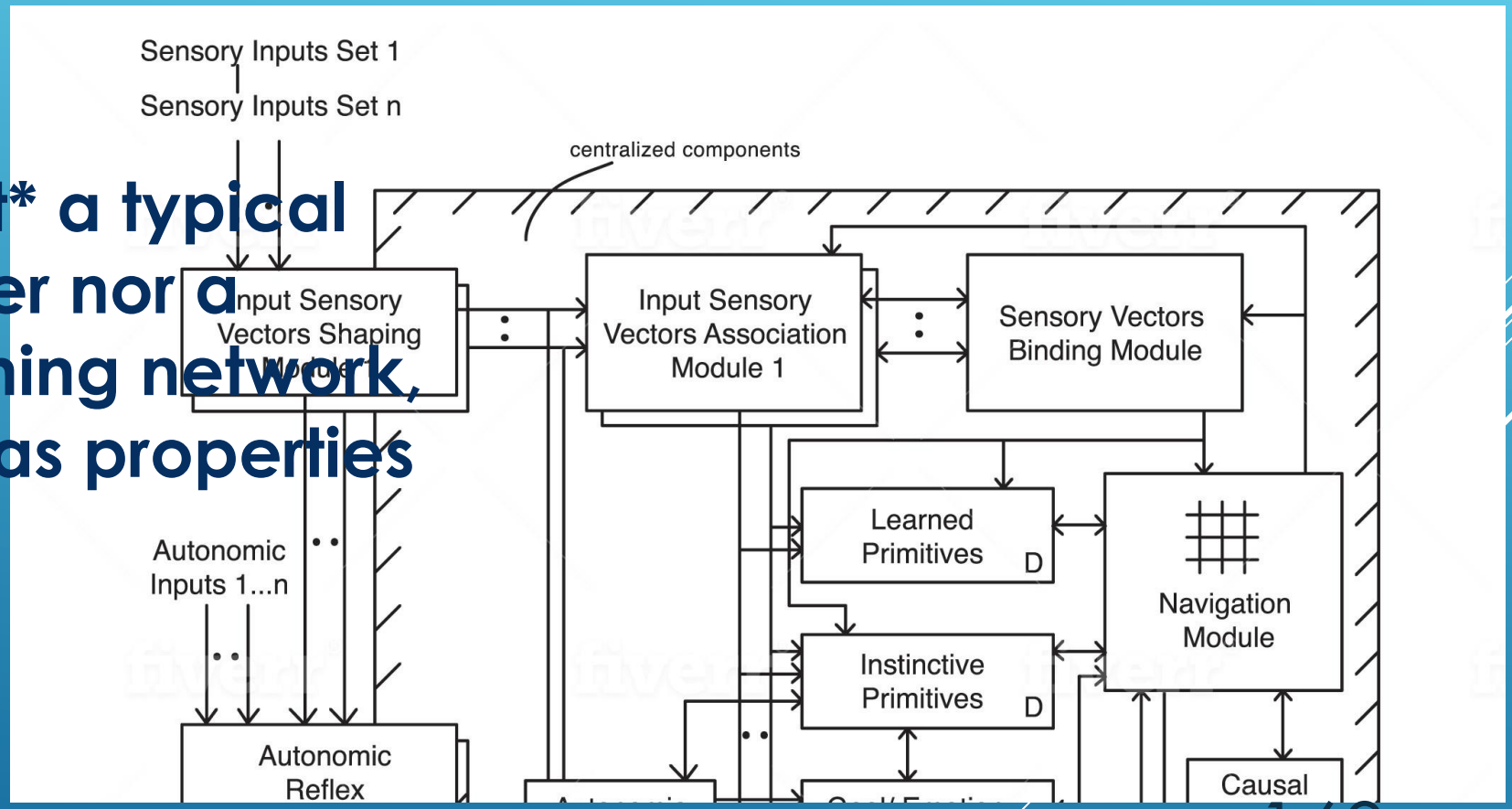
# March 18, 2018 – Uber self driving car kills Elaine Herzberg in Tempe, Arizona

-Uber's system never had training with image of pedestrian pushing bike across the *middle* of the street

-Volvo normal system: did detect (6secs) but ignored

# CAUSAL COGNITIVE ARCHITECTURE 1 – SCHNEIDER (IN PRESS)

**System that is *not* a typical symbolic computer nor a typical deep learning network, but instrinsically has properties of both**



# Organizations Focused on Developing AGI


Musk, Altman, MS $1B


Fei-Fei Li (ImageNet)


1000+, Google


Ben Goertzel, AGI Conf

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# THIS DECADE (MY OPINION)

-**OTHER FACTORS** OF **MORE IMPORTANCE**, EG, GLOBALIZATION, COVID-19, ETC

-**IMPROVEMENTS IN OFFICE AUTOMATION AND FACTORY AUTOMATION (EVEN WITHOUT AI)** WILL AFFECT JOBS (IN GOOD AND BAD WAYS)
-DEEP LEARNING CAN SPEED THIS UP


# "**SENSE OF POWERLESSNESS** – WORRY…"
# → RECORD LEVELS OF INEQUALITY, LOWER SOCIAL MOBILITY

-EVIDENCE –USA 500WORKER FACTORIES NOT USING MANY ROBOTS BUT TROUBLE FINDING SPECIALIZED WORKERS

**"HYPE ABOUT ROBOTS"**

**"FOCUSED OUR ATTENTION IN THE WRONG PLACE"**

-HOWEVER, TECH USE IN **HIGH SKILL JOBS** MAKES THESE JOBS MORE PRODUCTIVE & PAYING VS **LOW SKILL JOBS**

-**MIDDLE SKILL JOBS** EASIER TO AUTOMATE & OFF-SHORE

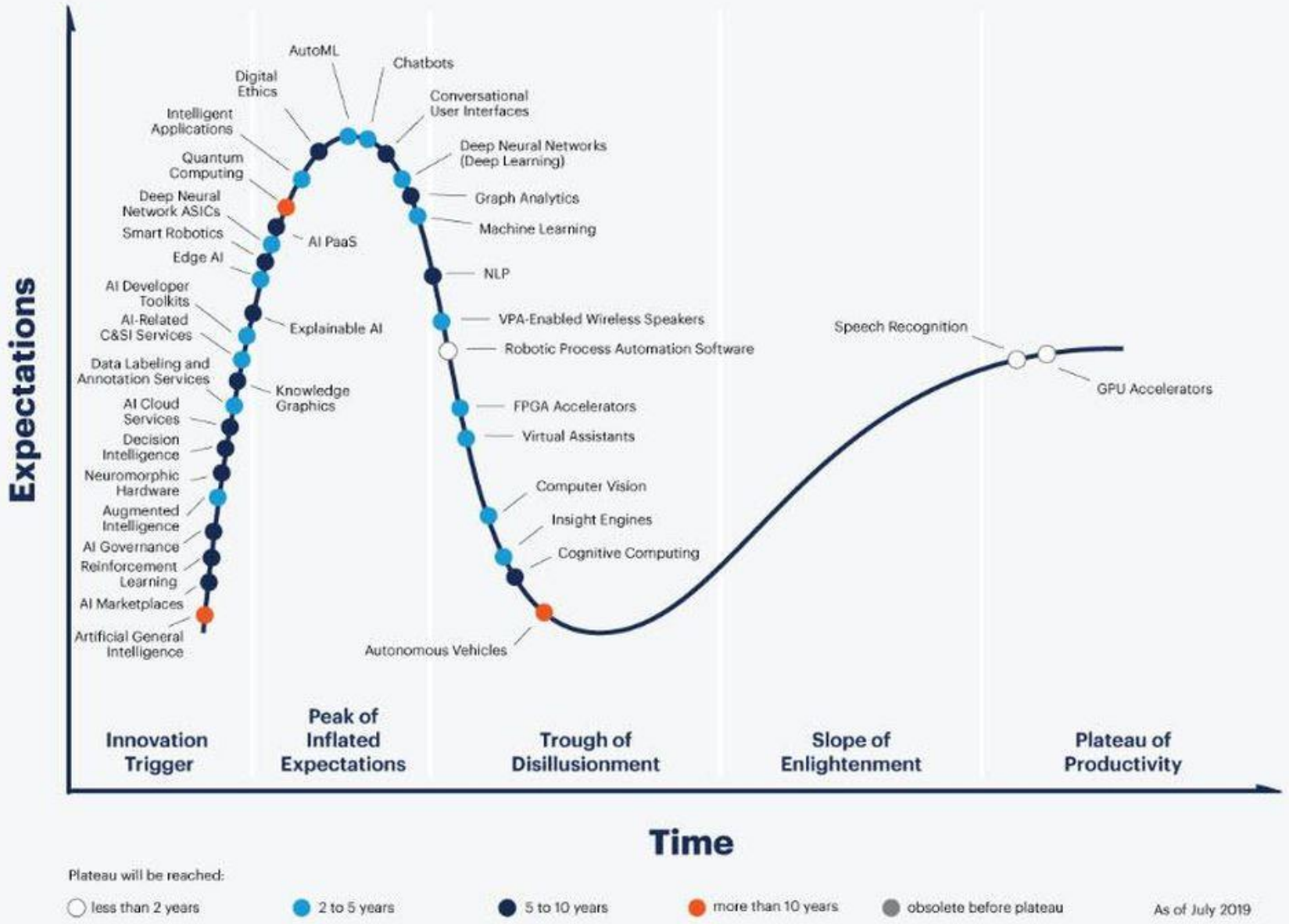
→**NEED TO FIX IMBALANCE** BETWEEN WORKERS HELPED AND HURT BY **NEW ECONOMY**

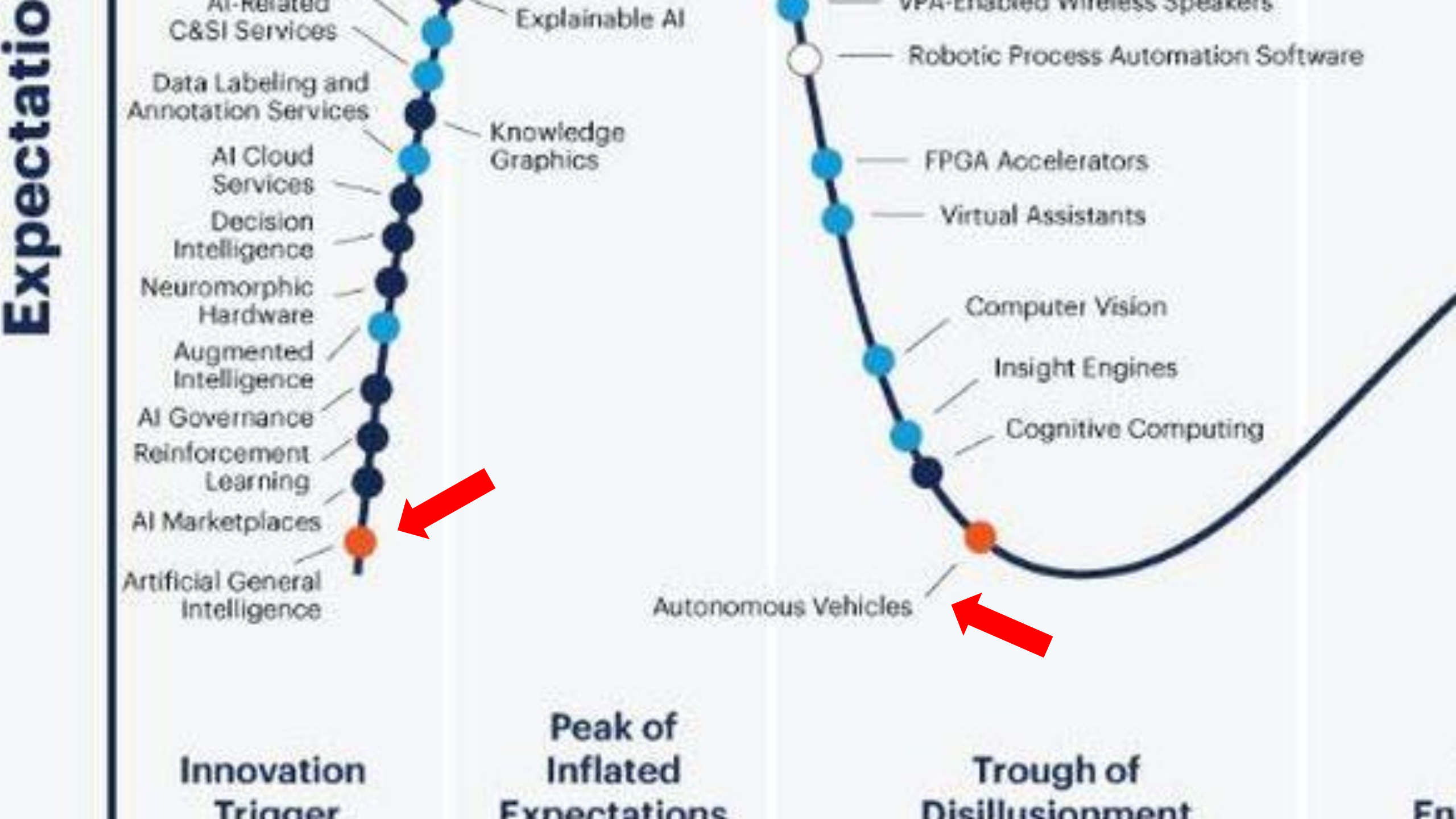
→ **NOT REALLY DUE TO AI AT THIS POINT**

# AI -- NEXT DECADE

*"It's tough to make predictions, especially about the future"*
--Yogi Berra

# Gartner Hype Cycle for Artificial Intelligence, 2019




Expectation
AI-Related C&SI Services
Explainable AI
Data Labeling and Annotation Services
Knowledge Graphics
AI Cloud Services
Decision Intelligence
Neuromorphic Hardware
Augmented Intelligence
AI Governance
Reinforcement Learning
AI Marketplaces
Artificial General Intelligence
VPA-Enabled Wireless Speakers
Robotic Process Automation Software
FPGA Accelerators
Virtual Assistants
Computer Vision
Insight Engines
Cognitive Computing
Autonomous Vehicles
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment

# NEXT DECADE (MY OPINION)

-ONCE THE **NEURO-SYMBOLIC GAP IS SOLVED**, AI SYSTEMS SHOULD BE ABLE TO DO THE WORK ALMOST ANY WORKER CAN DO

-**MASSIVE JOB SHIFTS AND REPLACEMENTS**, UNLIKE ANYTHING IN THE PAST

**-TIME OF STRESS FOR OUR PATIENTS WITHOUT APPROPRIATE SOCIETY PROGRAMS IN PLACE**

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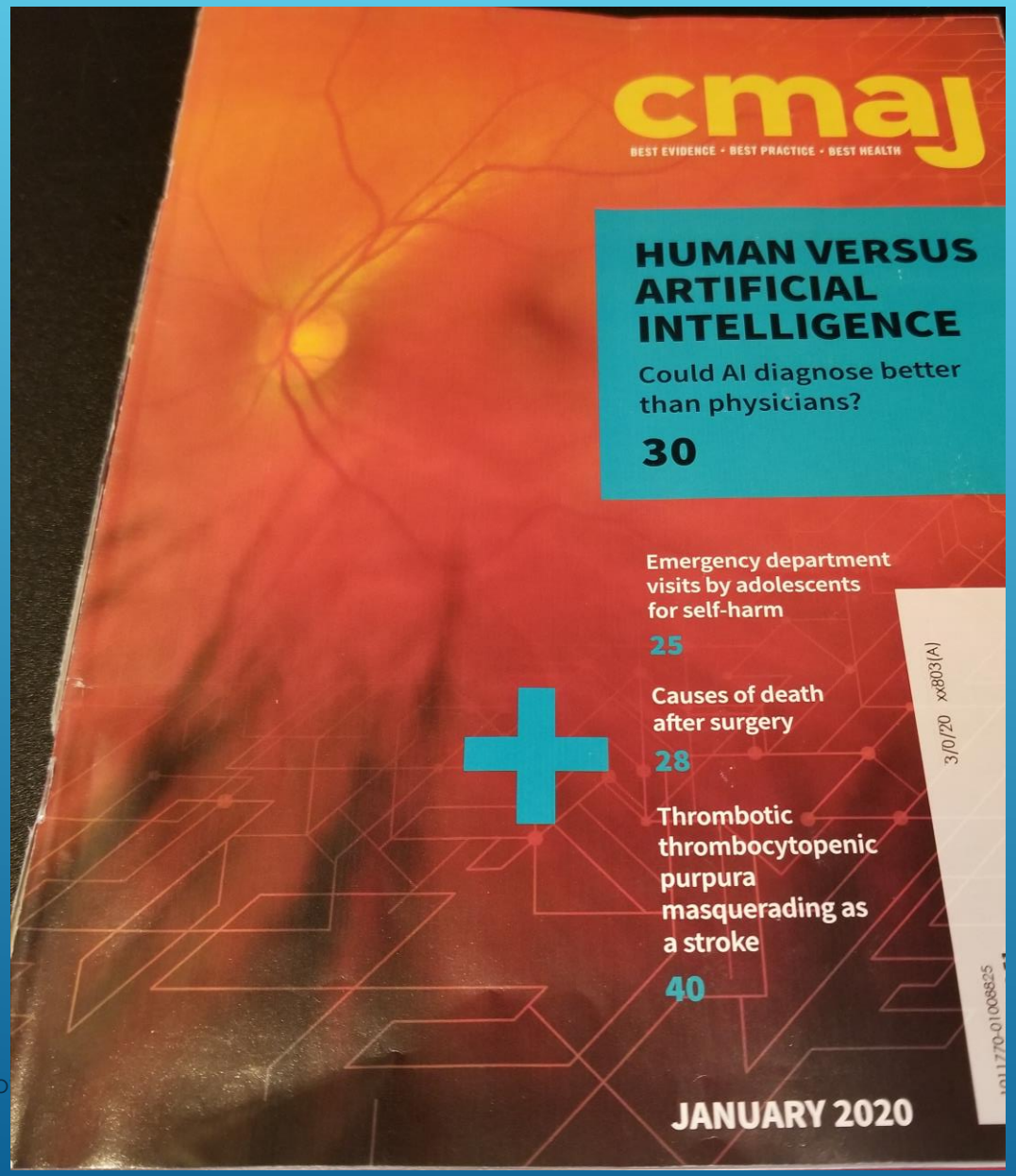
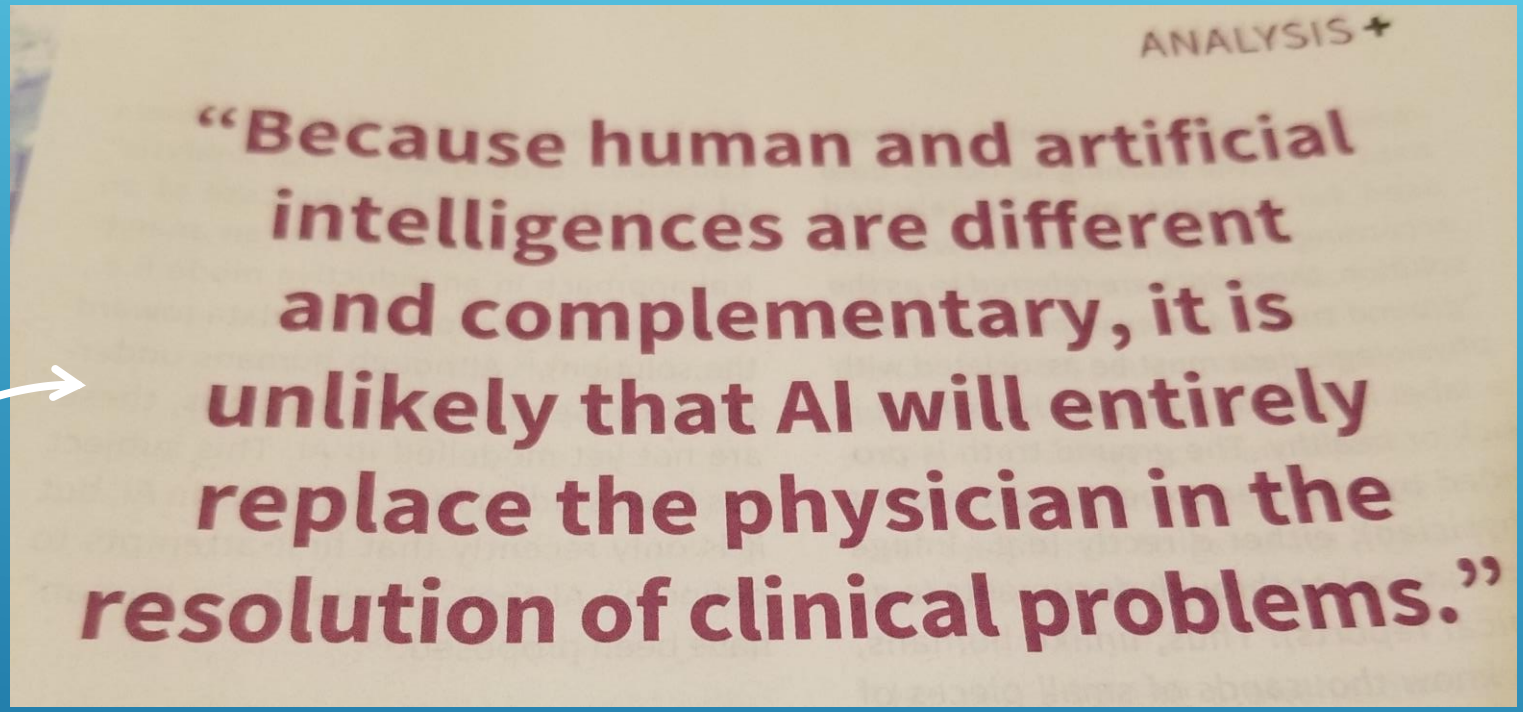
# MEDICAL AI SYSTEMS

-NO UNDERSTANDING OF WHAT THEY ARE DOING
-NO/POOR CAUSALITY
-THEY CAN'T EVEN EXPLAIN WHAT THEY ARE DOING

# COVER STORY OF JANUARY 2020 PRINT CMAJ



# THE ARTICLE TALKED ABOUT INTELLIGENCE IN HUMANS AND MACHINES IN VAGUE WAYS….



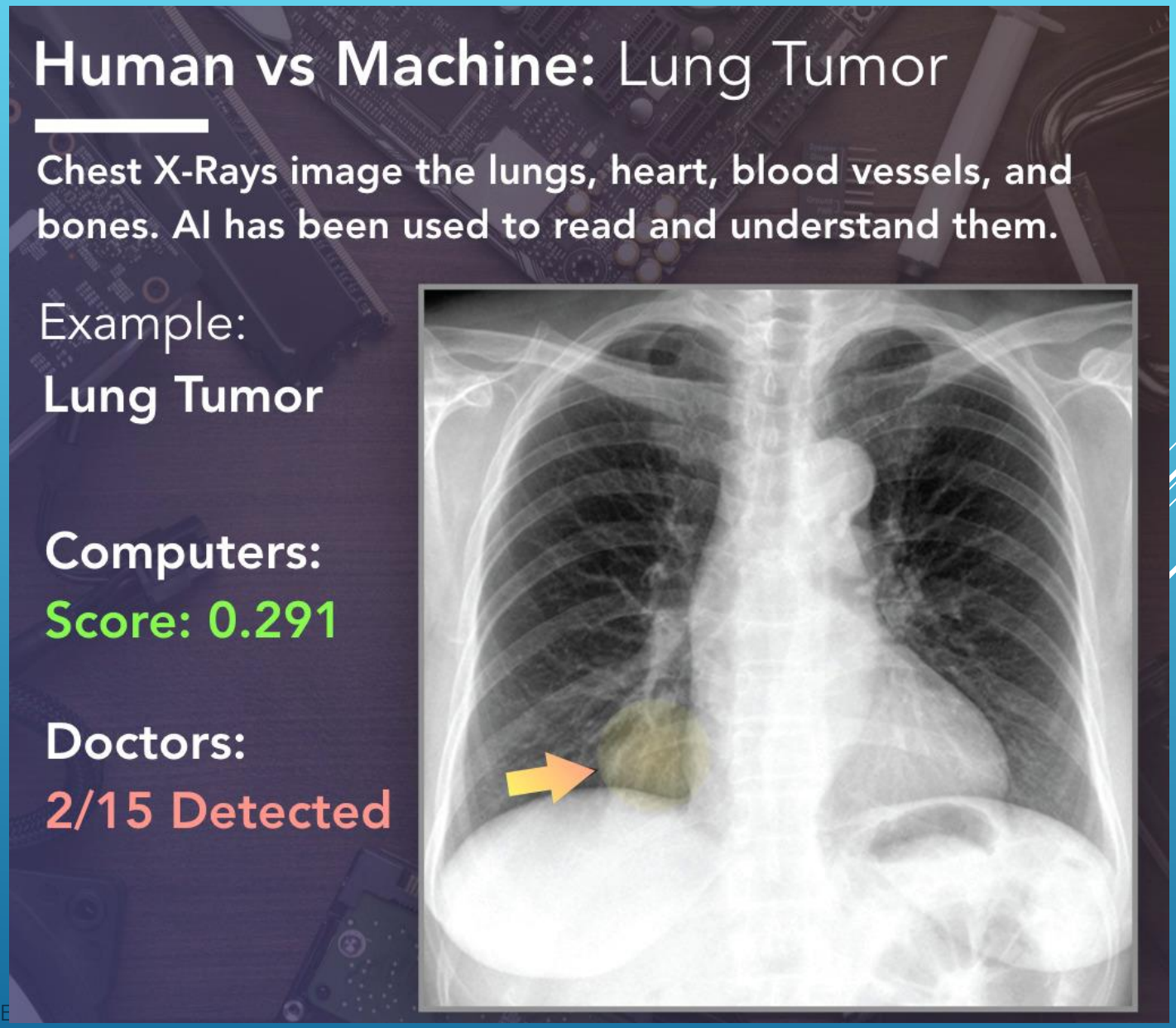

My view:

-current AI contains **no model** of the world, **no causal** reasoning

-instead functions as a **massive association machine**

# **DEEP LEARNING FOR RADIOLOGY** (REQUIRES MILLIONS XRAYS AS TRAINING DATA)

-USEFUL 3AM IN ER
-USEFUL SCREENING
-BUT…. NO CAUSALITY
*CLINICAL CORRELATION*
*DISEASE PROGRESSION*
*TEAM COLLABORATION*



# DEEPMIND RETINAL SCANS DIAGNOSIS

Traditional AI

**INPUT**
(Image)

**BLACK BOX**

**OUTPUT**
(Diagnosis)

DeepMind's Framework

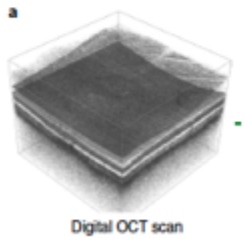
**INPUT**
(Image)

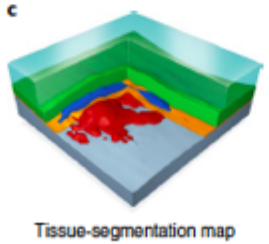
1
*Segmentation network*

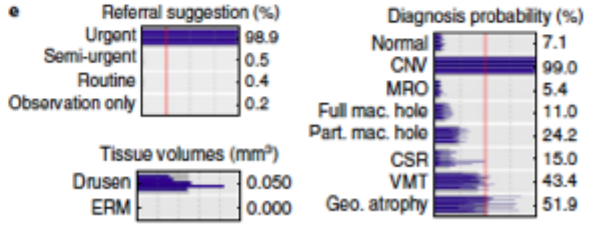
**TISSUE MAP**
(with labels for anatomy, pathology, artefacts)

2
*Classification network*

**OUTPUT**
(Referral suggestion + Diagnosis)



# **A DEEP LEARNING APPROACH TO ANTIBIOTIC DISCOVERY** – STOKES ET AL (MIT), CELL 2020

-TRAINED A **DEEP NEURAL NETWORK** CAPABLE OF PREDICTING MOLECULES WITH ANTIBACTERIAL ACTIVITY

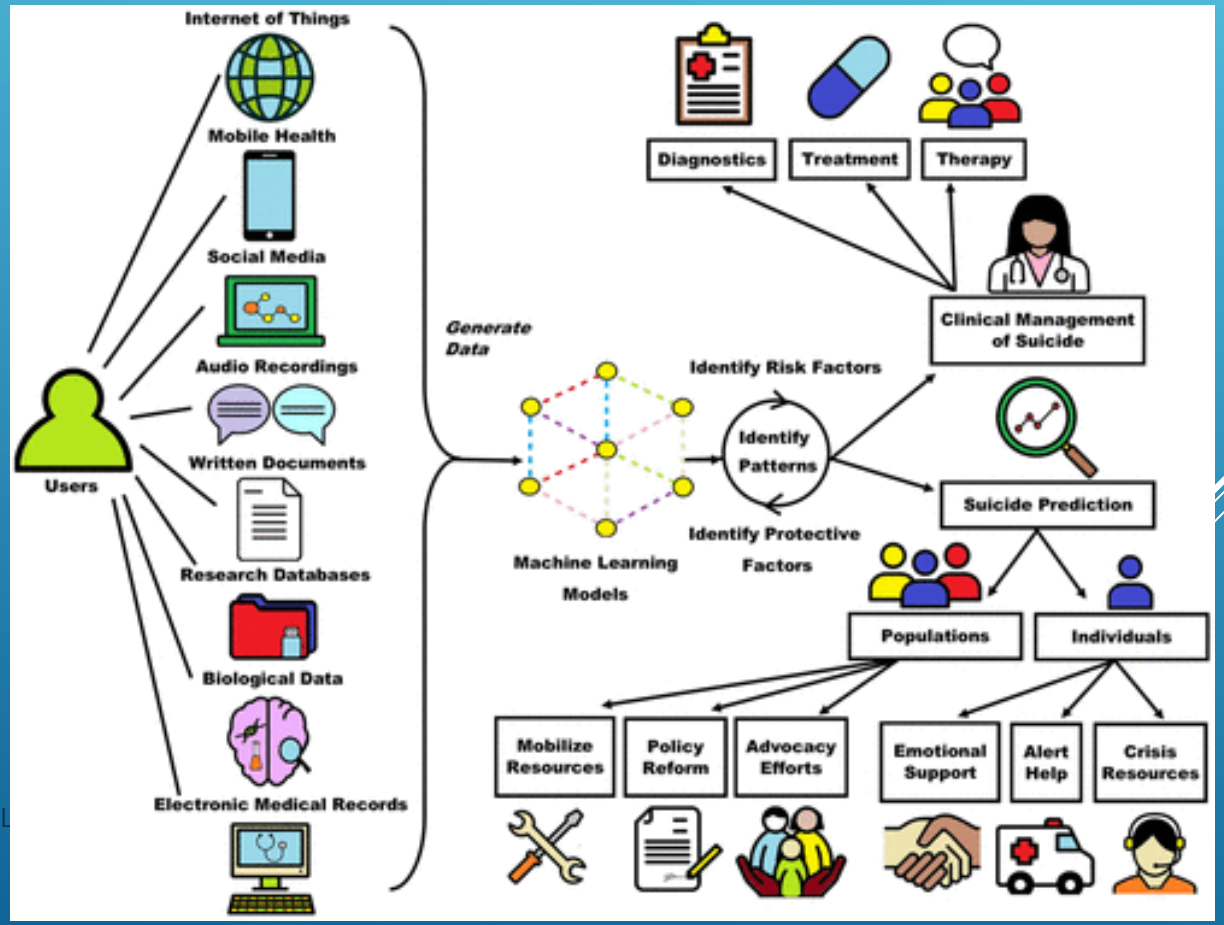
-**PREDICTIONS** ON MULTIPLE **CHEMICAL LIBRARIES**

-**DISCOVERED A MOLECULE**—HALICIN—THAT IS STRUCTURALLY DIVERGENT FROM CONVENTIONAL ANTIBIOTICS AND DISPLAYS BACTERICIDAL ACTIVITY

Artificial Intelligence in Medicine
Volume 103, March 2020, 101785
The impact of machine learning on patient care: A systematic review
Ben-Israel  and colleagues - Neurosurgery, University of Calgary

*“Despite the expanding use of machine learning (ML) in fields such as finance and marketing, its application in the daily practice of clinical medicine is almost non-existent.”*

# Dr Sidney Kennedy, University of Toronto
# Machine Learning in psychiatry
# -predict escitalopram treatment outcome from EEG
# -predict relapse, increased risk of suicidal behavior

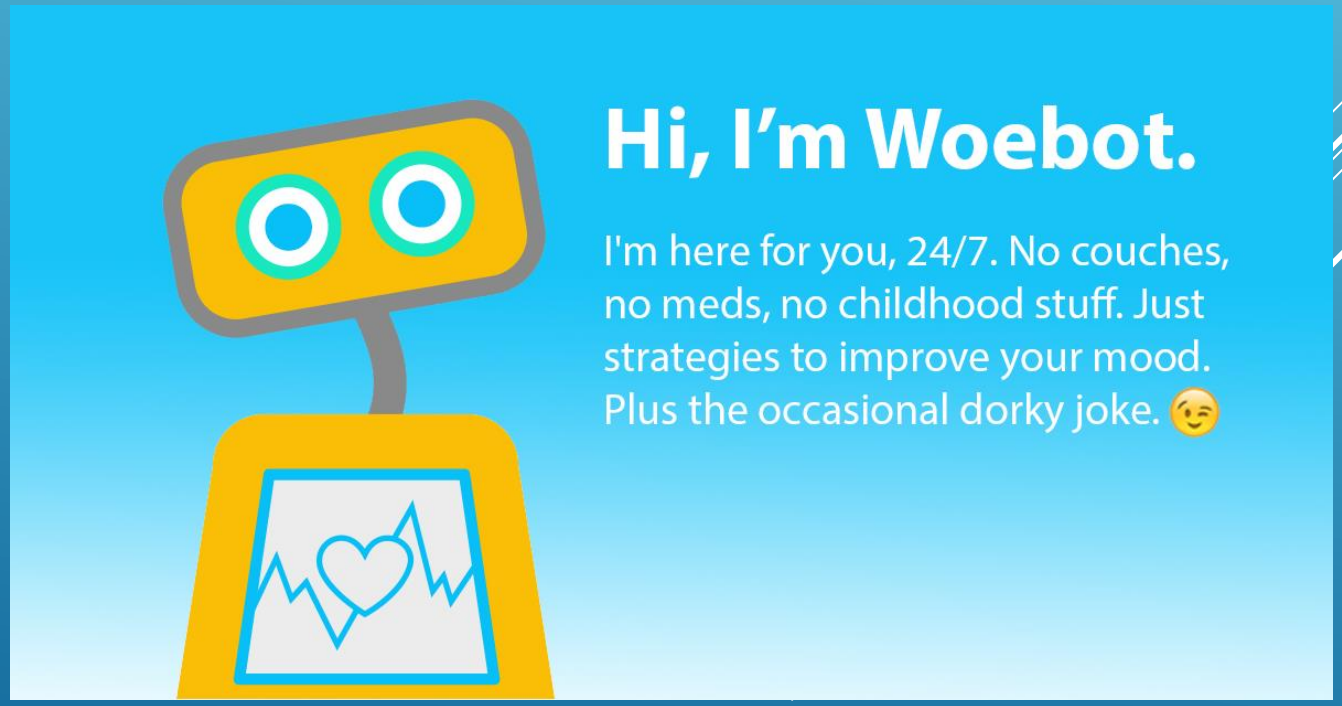


# Brain activity can help predict who'll benefit from an antidepressant

Amit Etkin,Stanford University

# AI Therapists

-OFFERS PROMISE OF THERAPY FOR ALL AT LOW COST
-ONLINE CBT
-CHATBOTS: "SIRI, I FEEL DEPRESSED"
-CHATBOTS, EG, WOEBOT



# Computer-Assisted CBT ('CCBT') for Depression

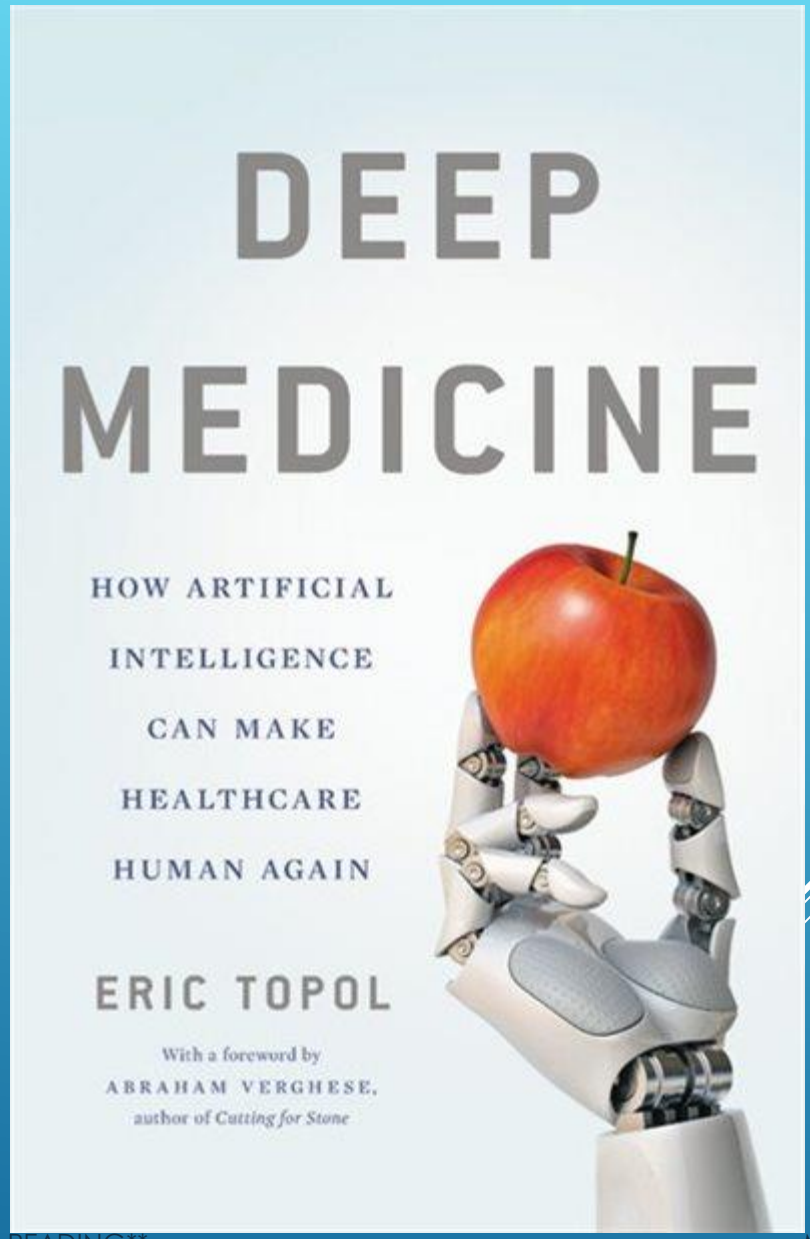
-JESSE WRIGHT ET AL, 2019, J CLIN PSYCHIATRY
-META-ANALYSIS  40 RCT STUDIES CCBT FOR DEPRESSION
-CCBT WITH MODEST SUPPORT FROM CLINICIAN EFFECTIVE
-CCBT FULLY SELF-GUIDED MUCH LESS EFFECTIVE
(TYPES, AMOUNT AI IN CCBT STUDIED??)

# →AT THIS POINT IN TIME AI **CANNOT** REPLACE DOCTORS -- **NOT TECHNICALLY POSSIBLE**

-**BETTER SOFTWARE** CAN IN THEORY **REDUCE** HEALTH CARE **STAFF** HOWEVER, AND DEEP LEARNING CAN SPEED THIS UP (DEPENDS ON FIELD)

# DR ERIC TOPOL

-CARDIOLOGIST
-SCRIPPS, LA JOLLA
-DEVELOPED T-PA, ANTI-CLOT MEDS
-PROPONENT OF AI IN MEDICINE



# LEARNING OBJECTIVES

- 1. **Real understanding of what AI is:**
- **1a. Deep Learning and Reinforcement Learning**
- 1b. Field of Artificial Intelligence (AI)
- 1c. Neuro-Symbolic Gap
- 2. **How will AI in next decade (or two) affect my patients' lives?**
- 3. **How will AI affect my practice of medicine including psychotherapy?**
- 3a. How is AI affecting medicine at present?
- **3b. How will AI affect medicine in the next decade?**
- 4. **How will AI affect the future of mankind?**
- 5. **Discussion**

# NEXT DECADE (MY OPINION)

-ONCE THE **NEURO-SYMBOLIC GAP IS SOLVED**, AI SYSTEMS SHOULD BE ABLE TO DO THE WORK ALMOST ANY HEALTHCARE WORKER CAN DO

-HUMANS PROVIDE **OVERSIGHT** (FOR A WHILE….) OF AI HEALTH SYSTEMS

# NEXT DECADE (MY OPINION)

HUMANS PROVIDE EMPATHIC & **EXISTENTIAL LIAISON** TO AI HEALTH SYSTEMS

**→THUS KEY FOR PSYCHOTHERAPY**

Even if technology is great, will this work?

# LEARNING OBJECTIVES

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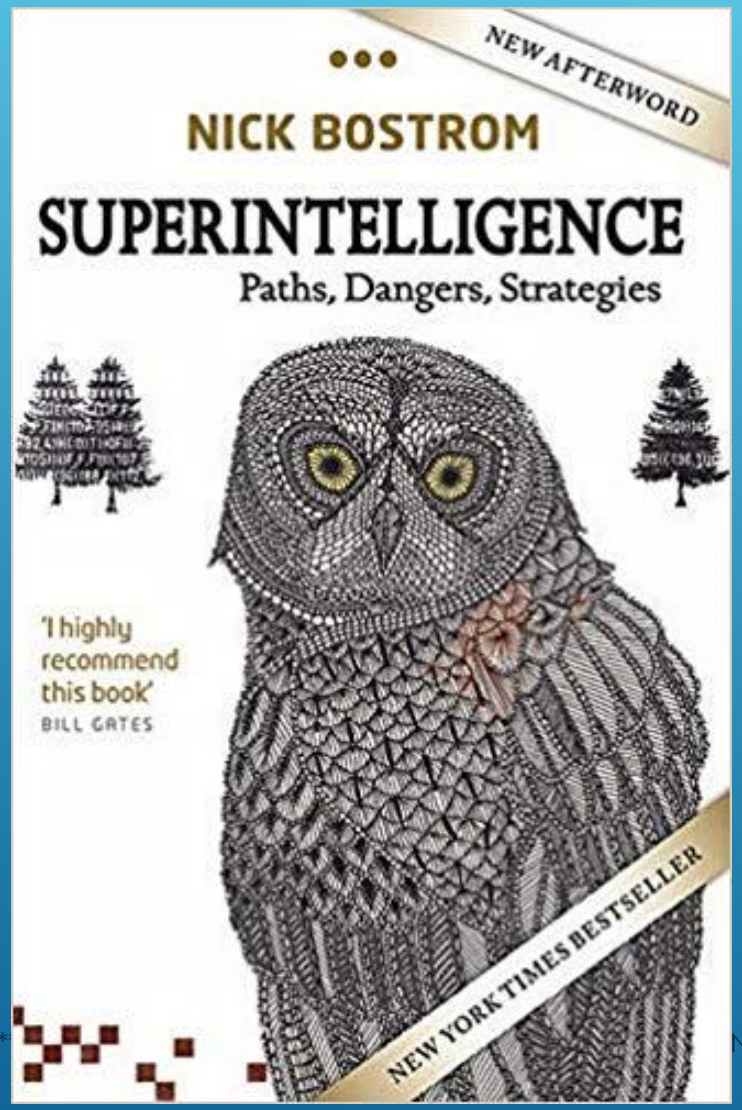
# DEEP LEARNING ALL AROUND US NOW: LONDON POLICE SURVEILLANCE CAMERAS WITH FACIAL RECOGNITION

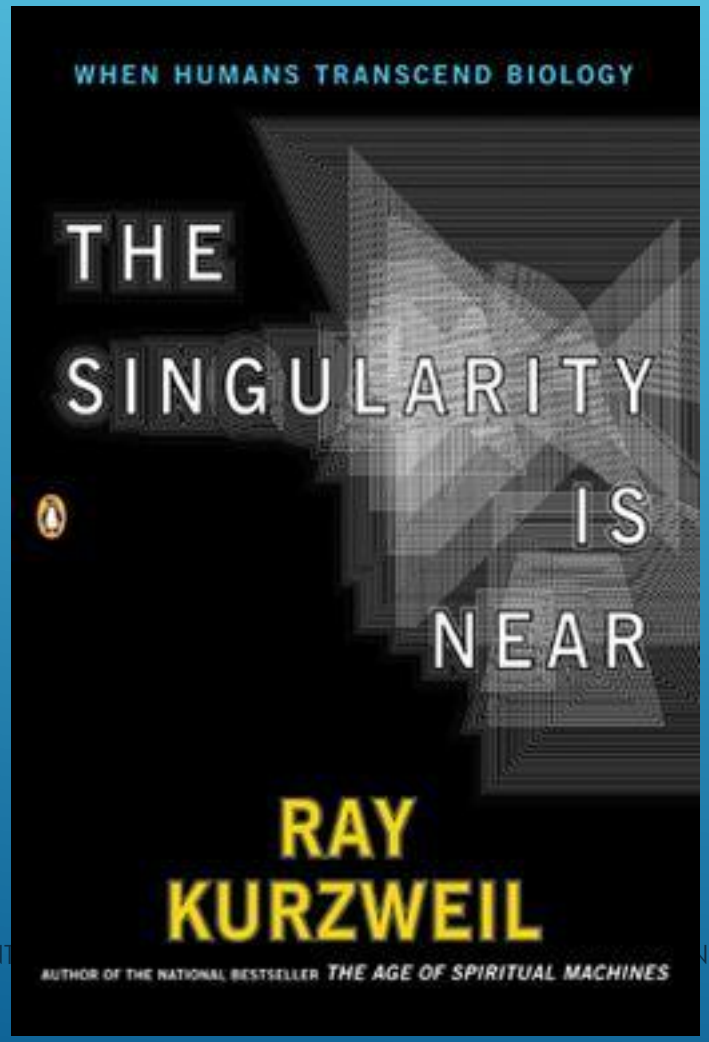
## PSYCHOLOGY OF CONSTANT SURVEILLANCE??

# Bostrom – SuperIntelligence



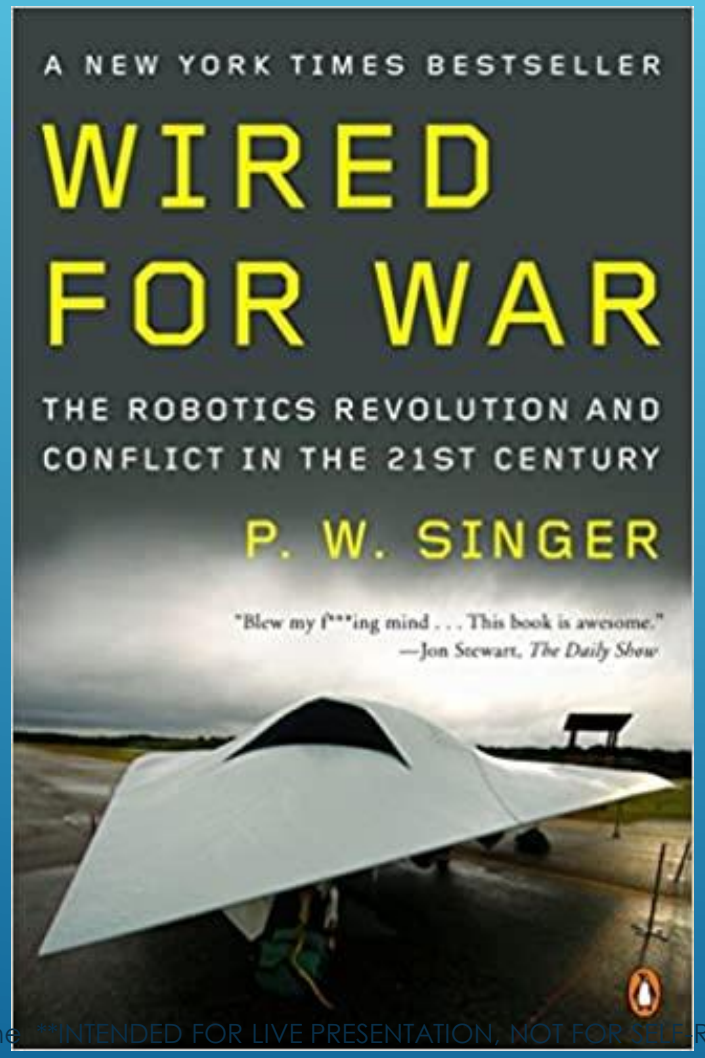
## Could an AI Paperclip Maximizer machine turn the earth into paperclips?

# Kurzweil – AI Exceeding Human Intelligence and Merging with Humans




The Future of Intelligence
MIT Tech Conference
February 20, 2016
Ray Kurzweil
KurzweilAI.net
The Future of I
MIT Tech Conference
February 20, 2016
Ray Kurzweil
KurzweilAI.net
MIT TECH CONFERENCE

# SINGER'S 2009 BOOK – WIRED FOR WAR



# 2017 ASILOMAR AI PRINCIPLES

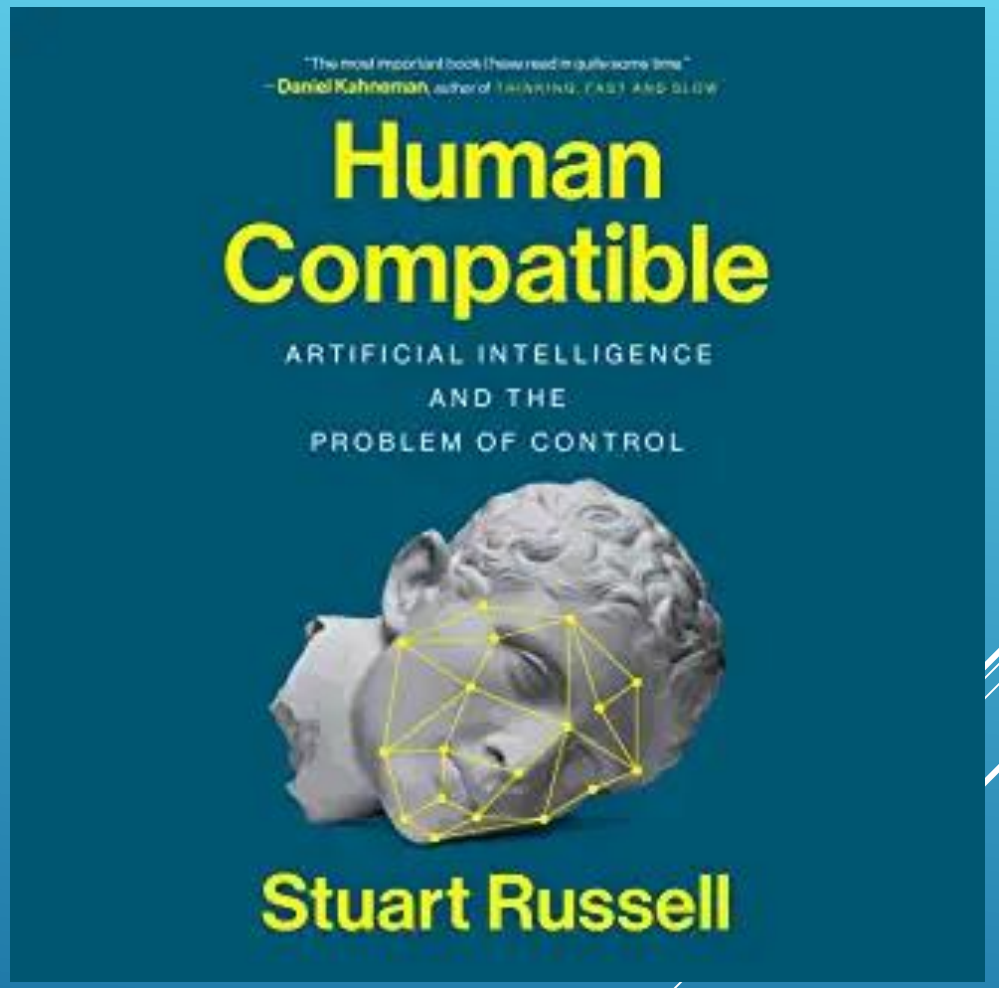
#1- The goal of AI research should be to create not undirected intelligence, but **beneficial intelligence**.

#6- AI systems should be **safe and secure**.. **verifiably so..**

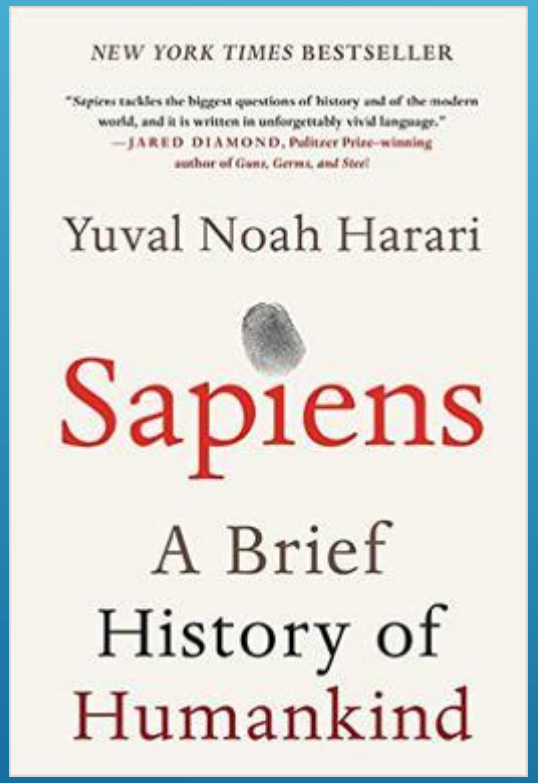
#23- **Superintelligence** should only be developed.. for the **benefit of all humanity** rather than one state.

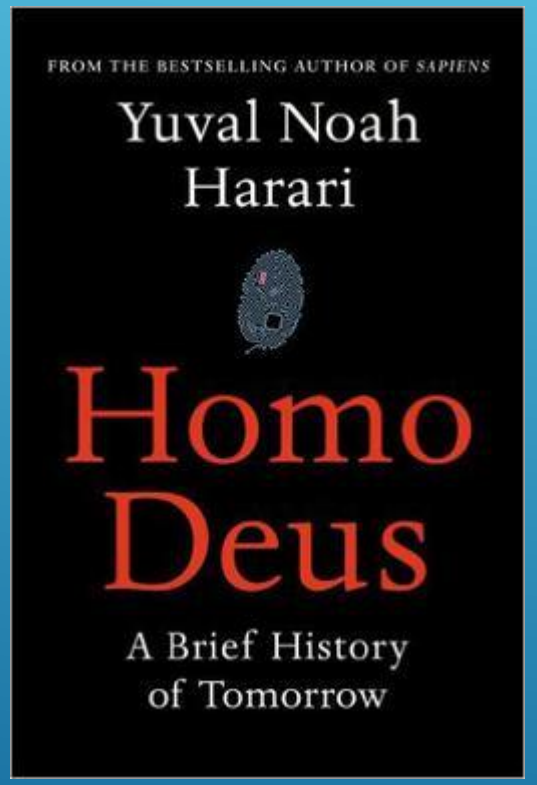
# Provably Beneficial AI

The only objective of the machine is human well being, or the satisfaction of human preferences



-Continued technological powers.
-We lose meaning in our lives
-Replacement of *H sapiens* with *H deus*



**RIGHT NOW**

– AI (= DEEP LEARNING) IS A PHENOMENAL COMPUTER SCIENCE TECHNIQUE

– LIKELY TO **IMPROVE OUR LIVES**

– TERMINATOR NOT POSSIBLE

**FUTURE**

– THAT'S ANOTHER STORY

-- **AI SAFETY** CONCERNS

# OK…. WE'VE MADE IT….

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# Artificial Intelligence and the Future of Medicine/Mankind

Thank You

howard.schneider@gmail.com