



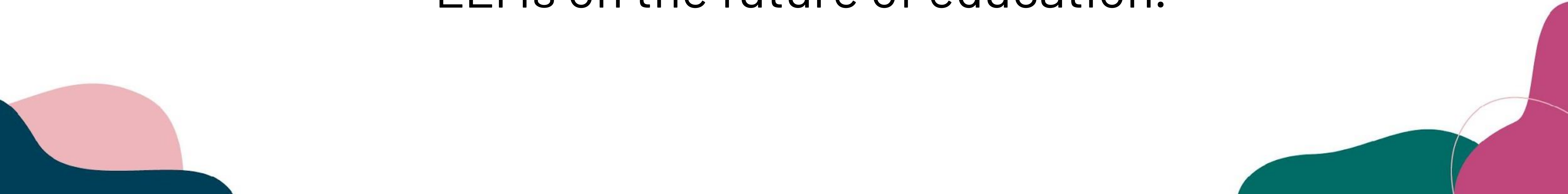
Artificial Intelligence is Changing the World. How Might it Change Education?

Patrick M. Pilarski, Ph.D.

*Canada CIFAR AI Chair, Assoc. Prof., Dept. of Medicine, University of Alberta
Fellow and Board of Directors, Alberta Machine Intelligence Institute (Amii)*

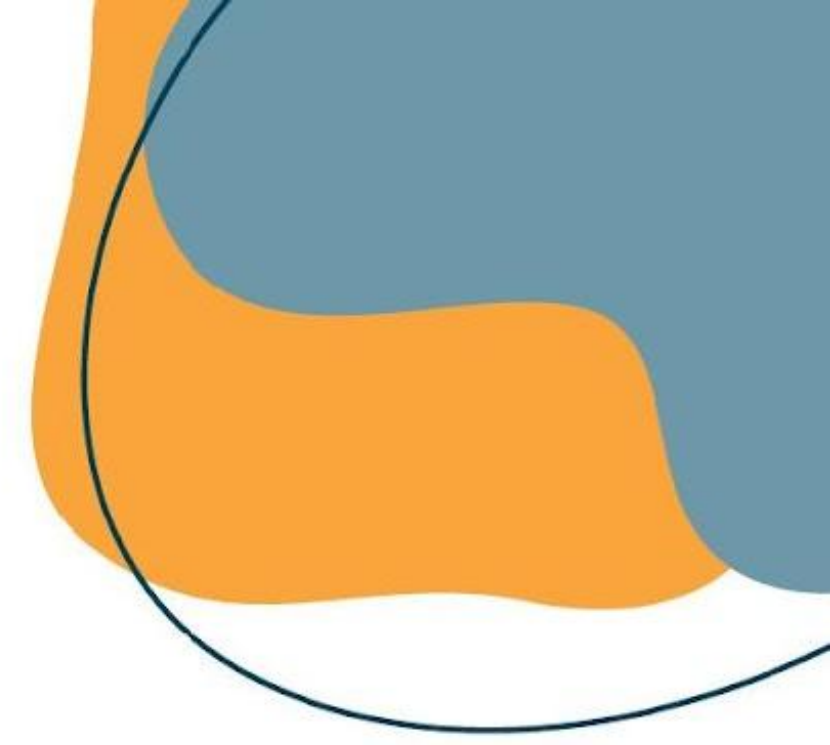


Learning Objectives

- 1.** Be aware of the capabilities of modern AI;
 - 2.** Be able to talk about and reflect on Large Language Models (LLMs);
 - 3.** Be able to discuss the impact of AI and LLMs on the future of education.
- 



But first... a small warm up activity



And now, a small change to the activity





PART 1:

Examples of Things
AI Can Do
Right Now

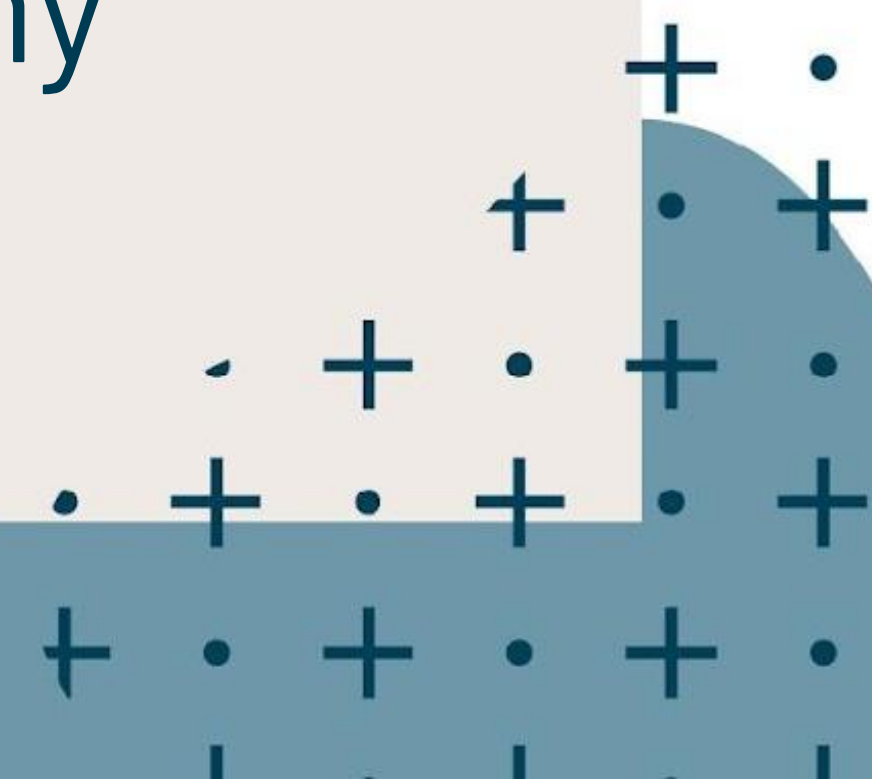
Intelligence:

"... is the computational part of the ability to achieve goals in the world."

<http://jmc.stanford.edu/artificial-intelligence/index.html>



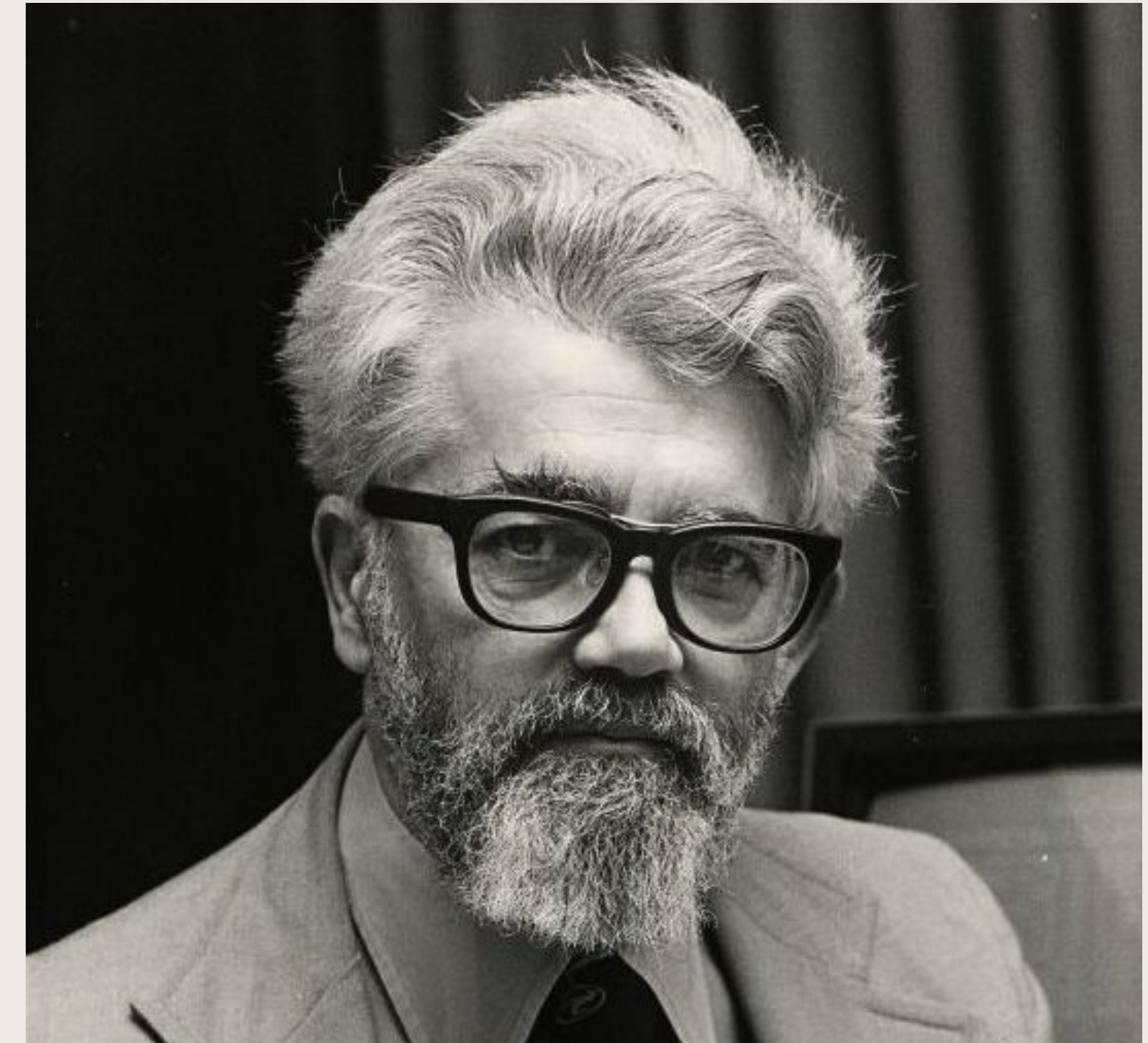
John McCarthy
(1927 – 2011)



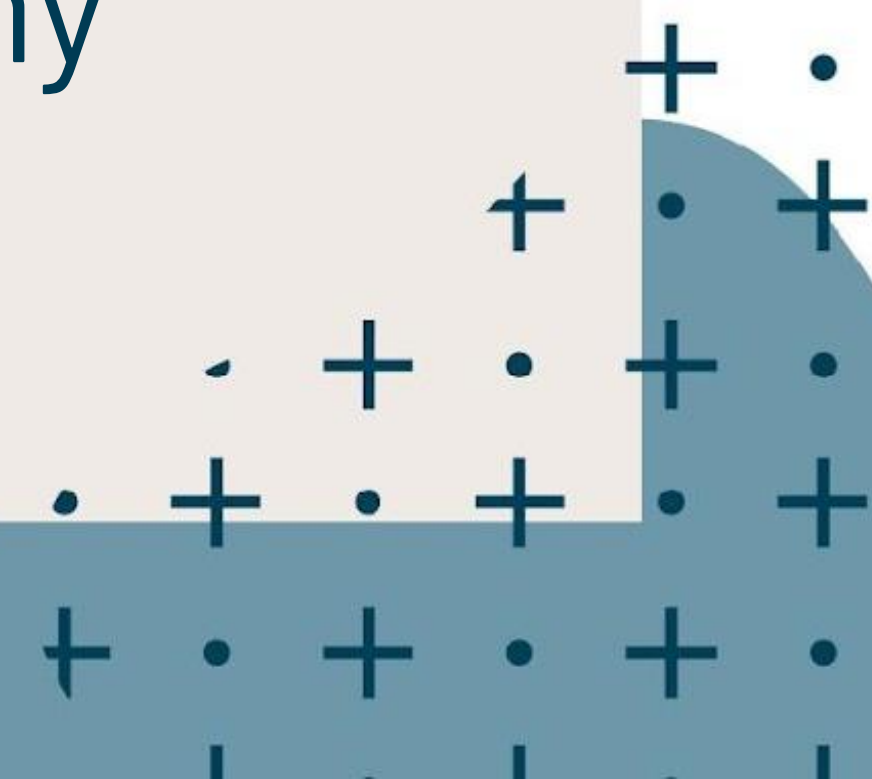
Artificial Intelligence:

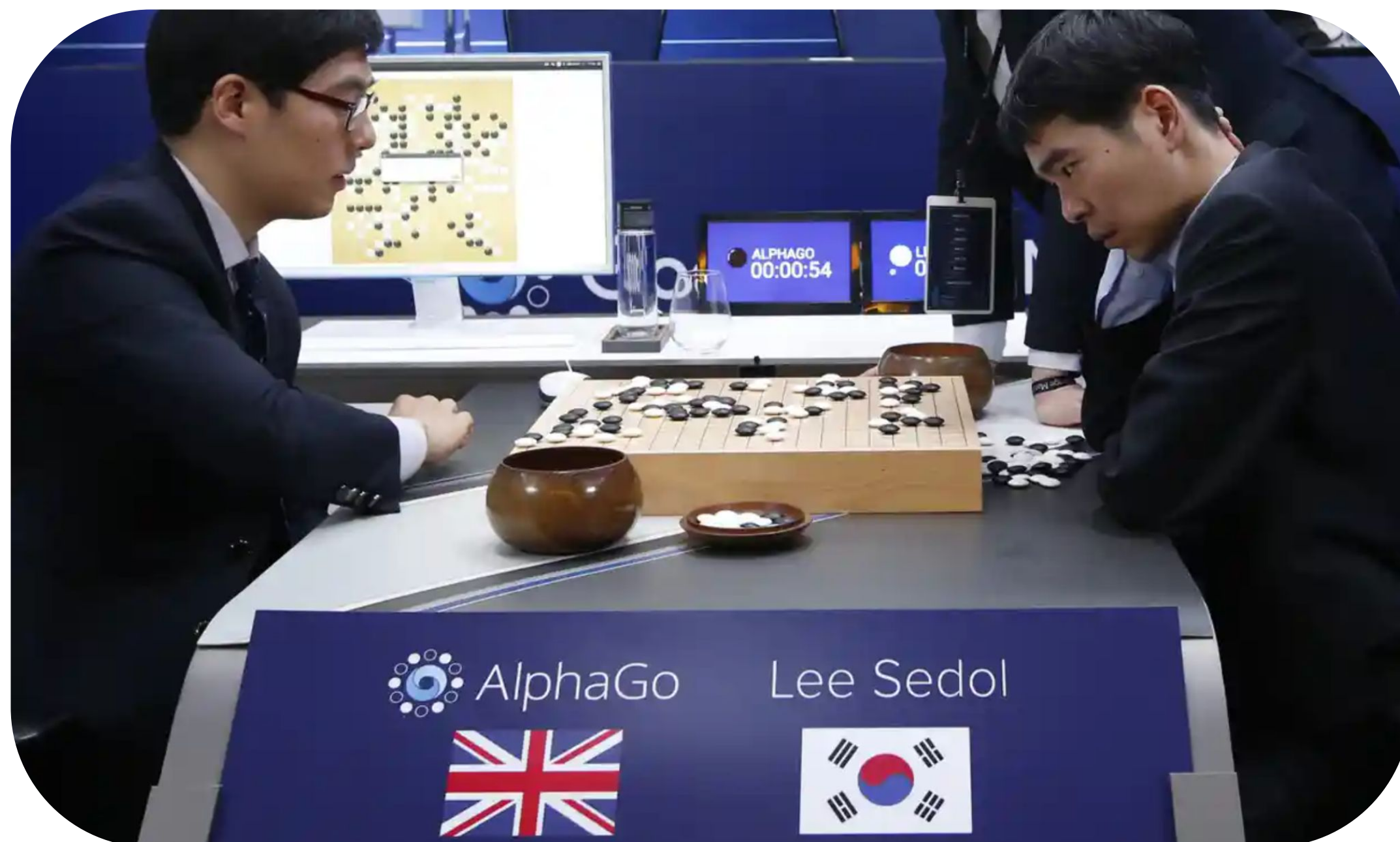
"... is the science and engineering of making intelligent machines, especially intelligent computer programs."

<http://jmc.stanford.edu/artificial-intelligence/index.html>

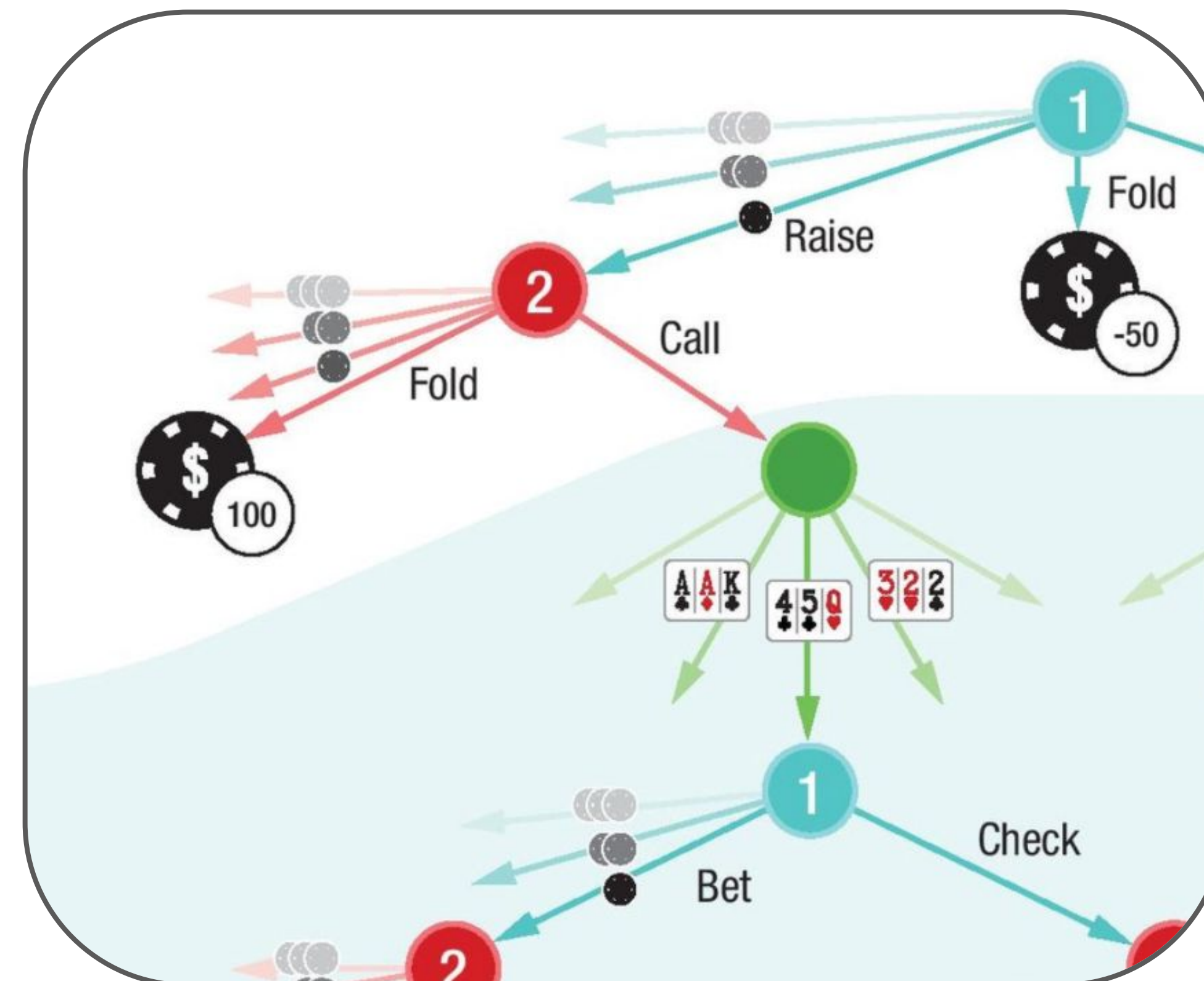


John McCarthy
(1927 – 2011)





<https://www.deepmind.com/research/highlighted-research/alphago>



<https://www.deepstack.ai/>

GAMES

Go, Poker, Chess, Checkers, Shogi,
Diplomacy, Stratego, Scotland Yard...



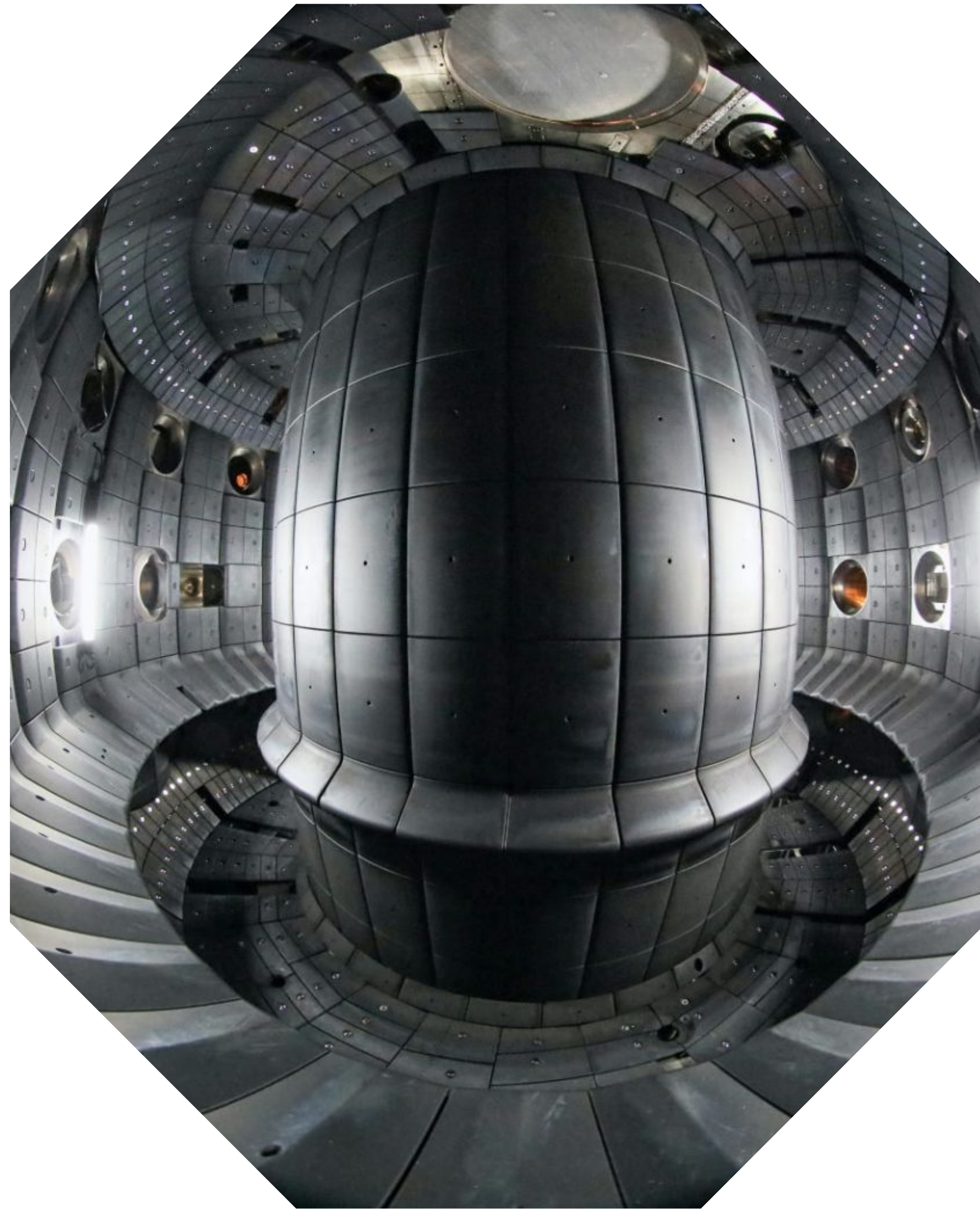
<https://openai.com/research/vpt>

& VIDEO GAMES

Gran Turismo, Minecraft,
Atari, Capture the Flag,
StarCraft II, Dota 2, ...



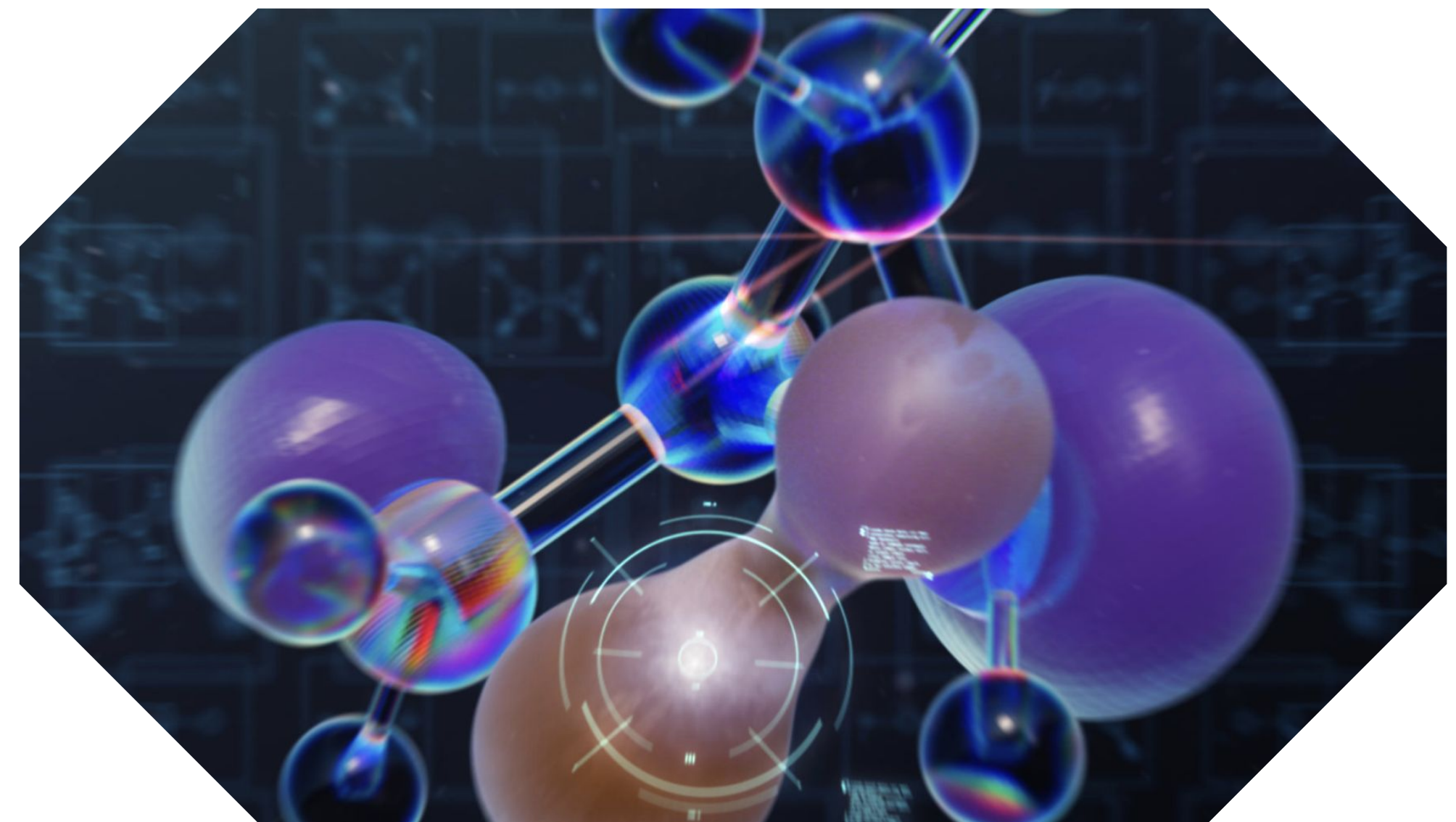
<https://www.gran-turismo.com/us/gran-turismo-sophy/>



<https://www.deepmind.com/blog/accelerating-fusion-science-through-learned-plasma-control>

PHYSICS & CHEMISTRY

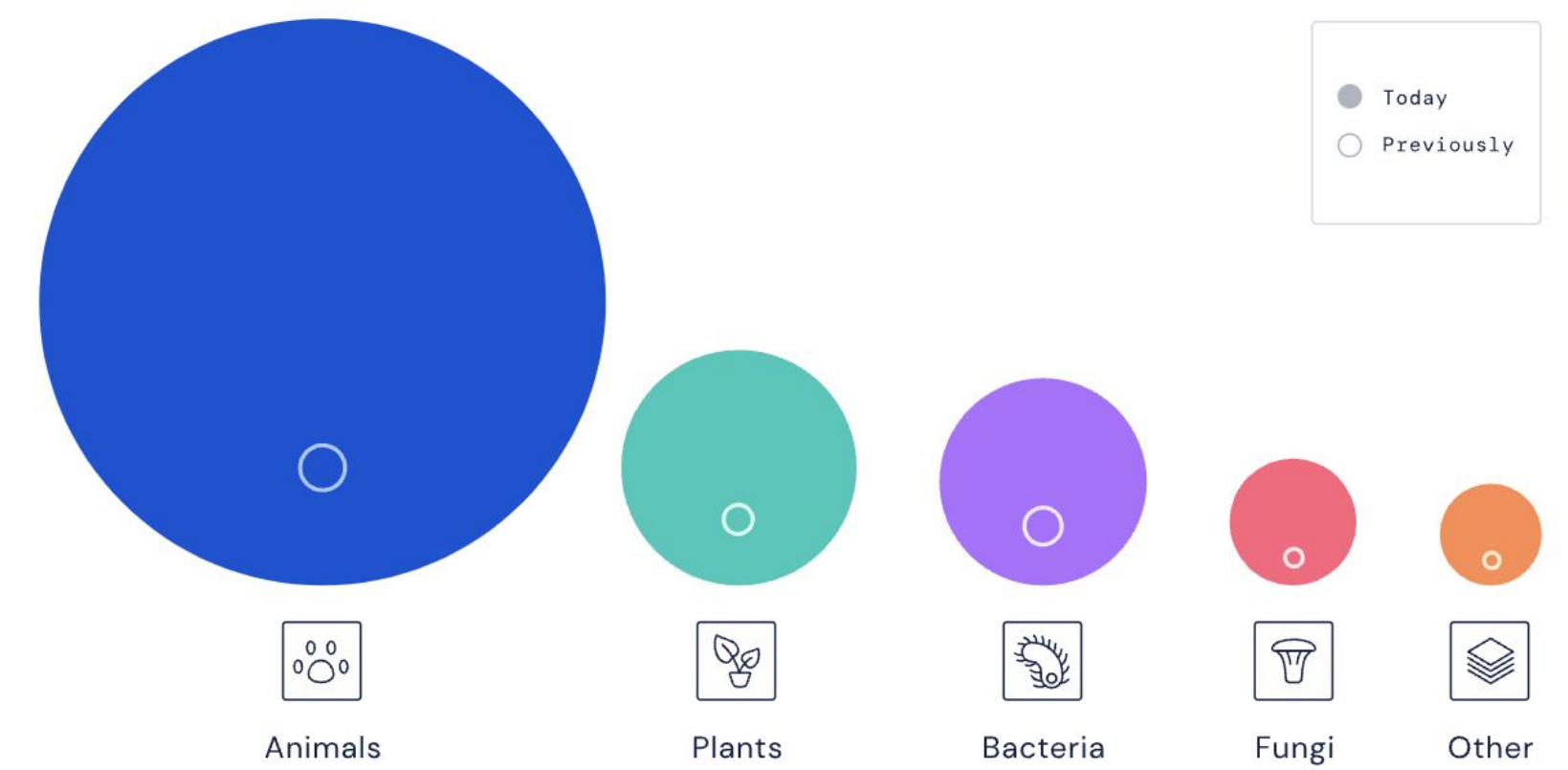
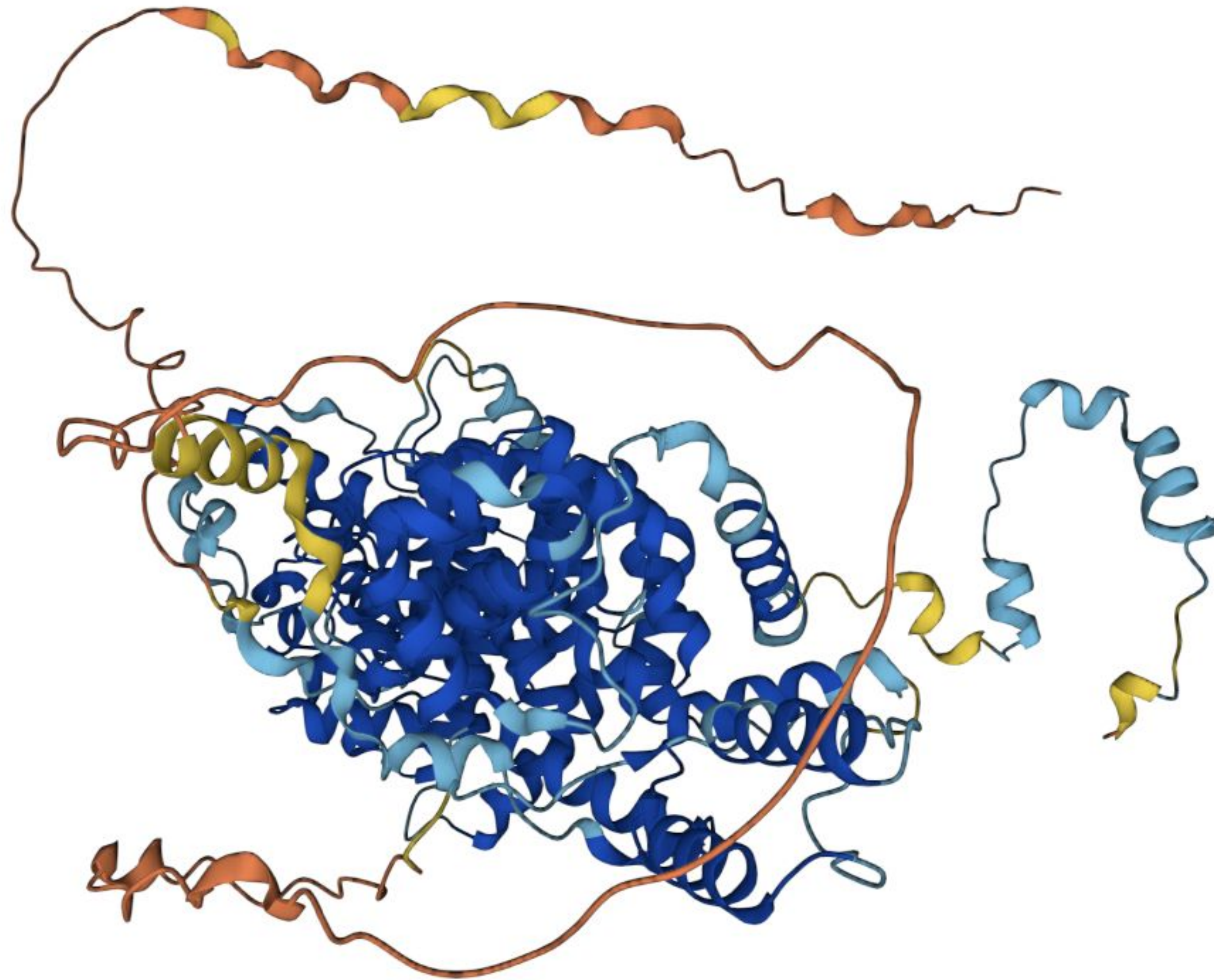
Nuclear Fusion,
Quantum Chemistry,
Glass Physics, ...



<https://www.deepmind.com/blog/simulating-matter-on-the-quantum-scale-with-ai>

& BIOLOGY

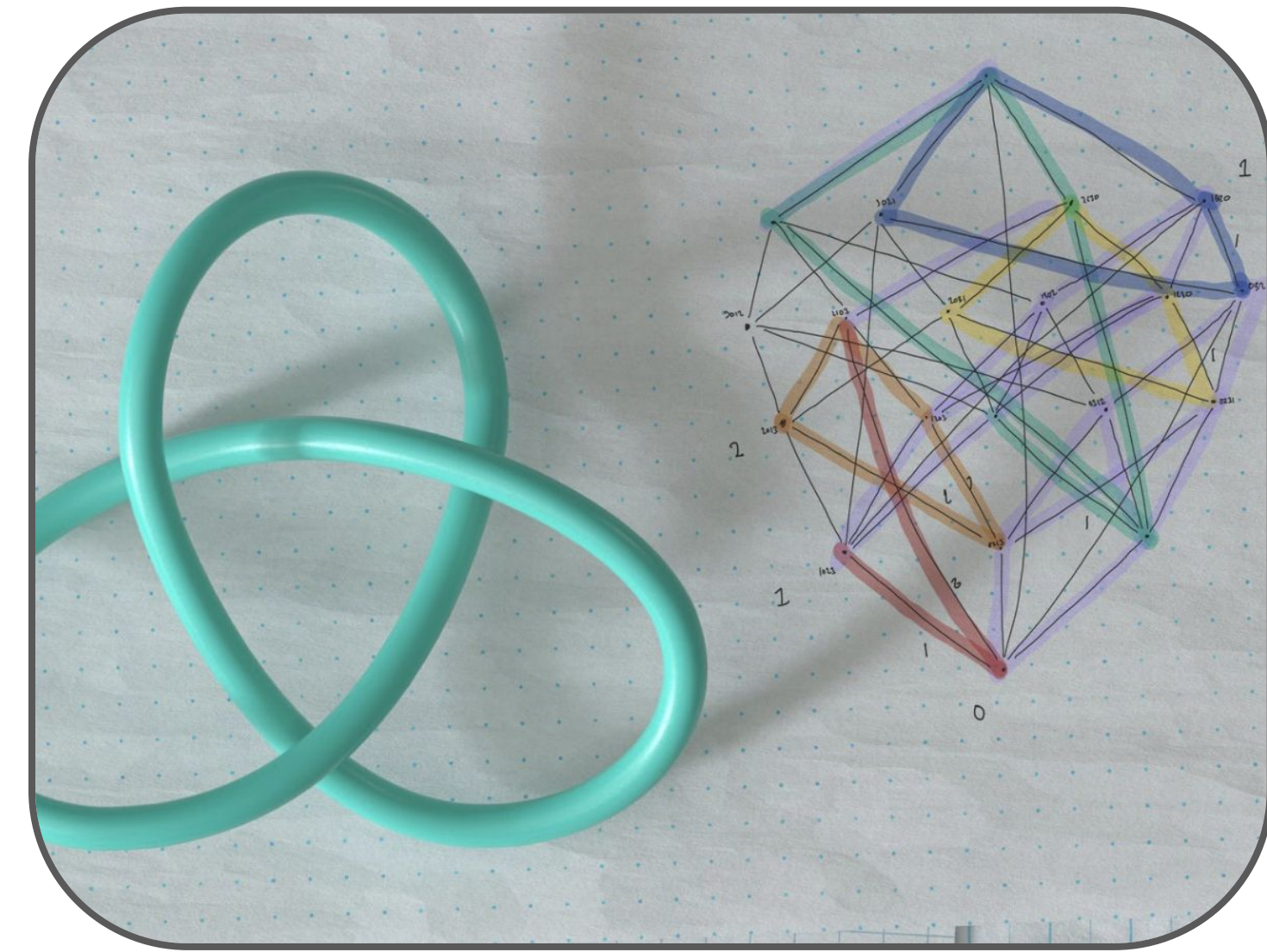
AlphaFold



<https://www.deepmind.com/research/highlighted-research/alphafold>
<https://alphafold.ebi.ac.uk/>

& APPLIED / PURE MATH

Math Word Problems, Theorem Proving, Guiding Conjectures, ...



<https://www.deepmind.com/blog/exploring-the-beauty-of-pure-mathematics-in-novel-ways>

Question

Ali is a dean of a private school where he teaches one class. John is also a dean of a public school. John has two classes in his school. Each class has $\frac{1}{8}$ the capacity of Ali's class which has the capacity of 120 students. What is the combined capacity of both schools?

Answer

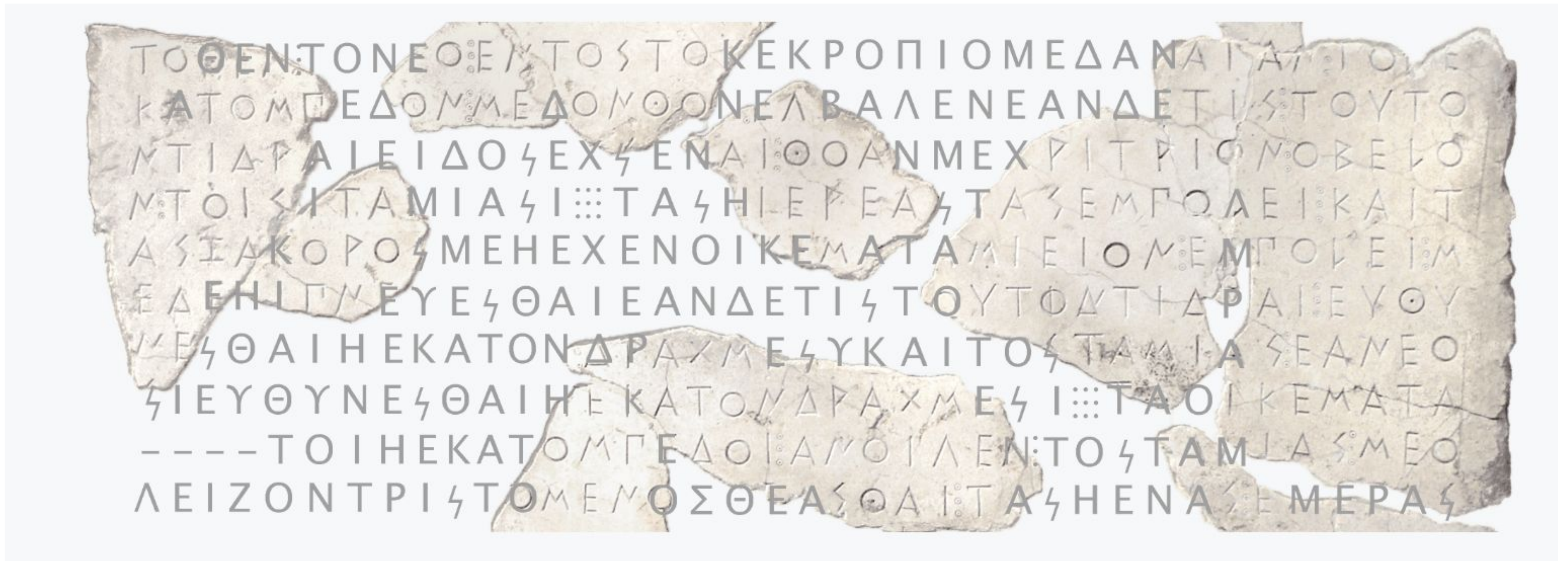
Method: **175B Verification**

Ali's class has a capacity of 120 students.
Each of John's classes has a capacity of $120/8 = 15$ students.
The total capacity of John's two classes is 15 students $\times 2$ classes = 30 students.
The combined capacity of the two schools is 120 students + 30 students = **150 students.**

<https://openai.com/research/solving-math-word-problems>

& HUMANITIES

e.g., Restoring Ancient Texts



<https://ithaca.deepmind.com/>

& CLIMATOLOGY

& ECOLOGY

& ECONOMICS

& GOVERNANCE

& LAW

& COMPUTING SCIENCE

& TRANSPORTATION

& MEDICINE

& ART

& DESIGN

& CLIMATOLOGY

& ECOLOGY

& ECONOMICS

& GOVERNANCE

& LAW

& COMPUTING SCIENCE

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& DESIGN

Weather Nowcasting

Biodiversity Analysis

Learned Bartering

Fair Taxation Design

Legal Reasoning

Human-level Coding

Self-driving Vehicles

Expert Diagnosis

2D Visuals Creation

3D Asset Creation

& CLIMATOLOGY

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2D Visuals Creation

3D Asset Creation



KEY POINT

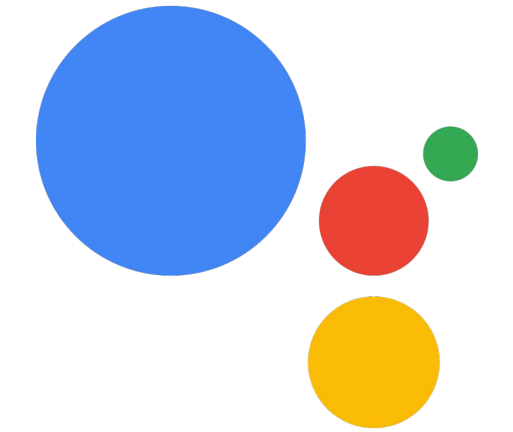
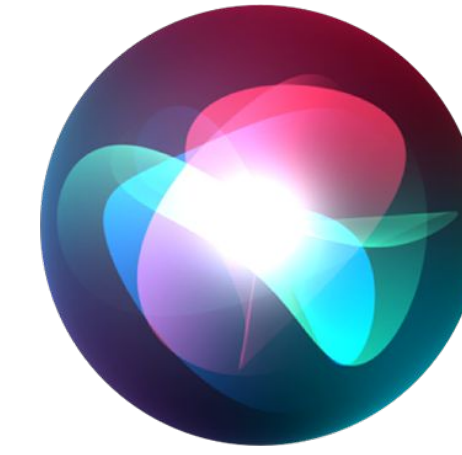
All of the examples we saw are
specialized AI tools
trained for specific things



PART 2:

Capabilities of Large Language Models

*(e.g., ChatGPT, Bard, PaLM
LLaMA, Sparrow, Auto-GPT)*



The "small" ...

Language models are already used on:
Cellphones, Smart Speakers, Translation, ...
... and they call businesses daily to find out opening hours, screen phone calls, staff help lines, and do chat-based tech support.






The “small” ...

Hi! What can I help you with today?

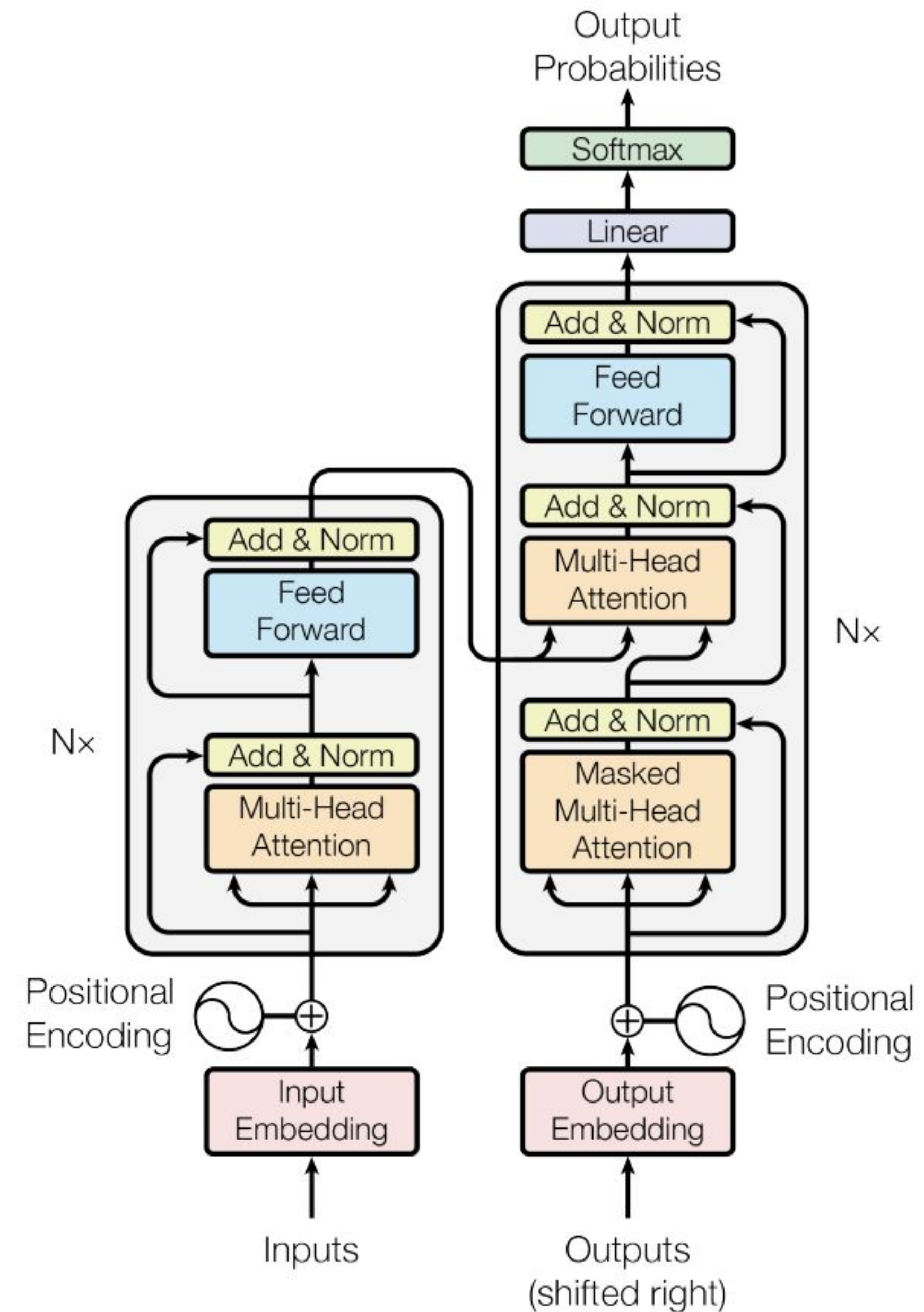


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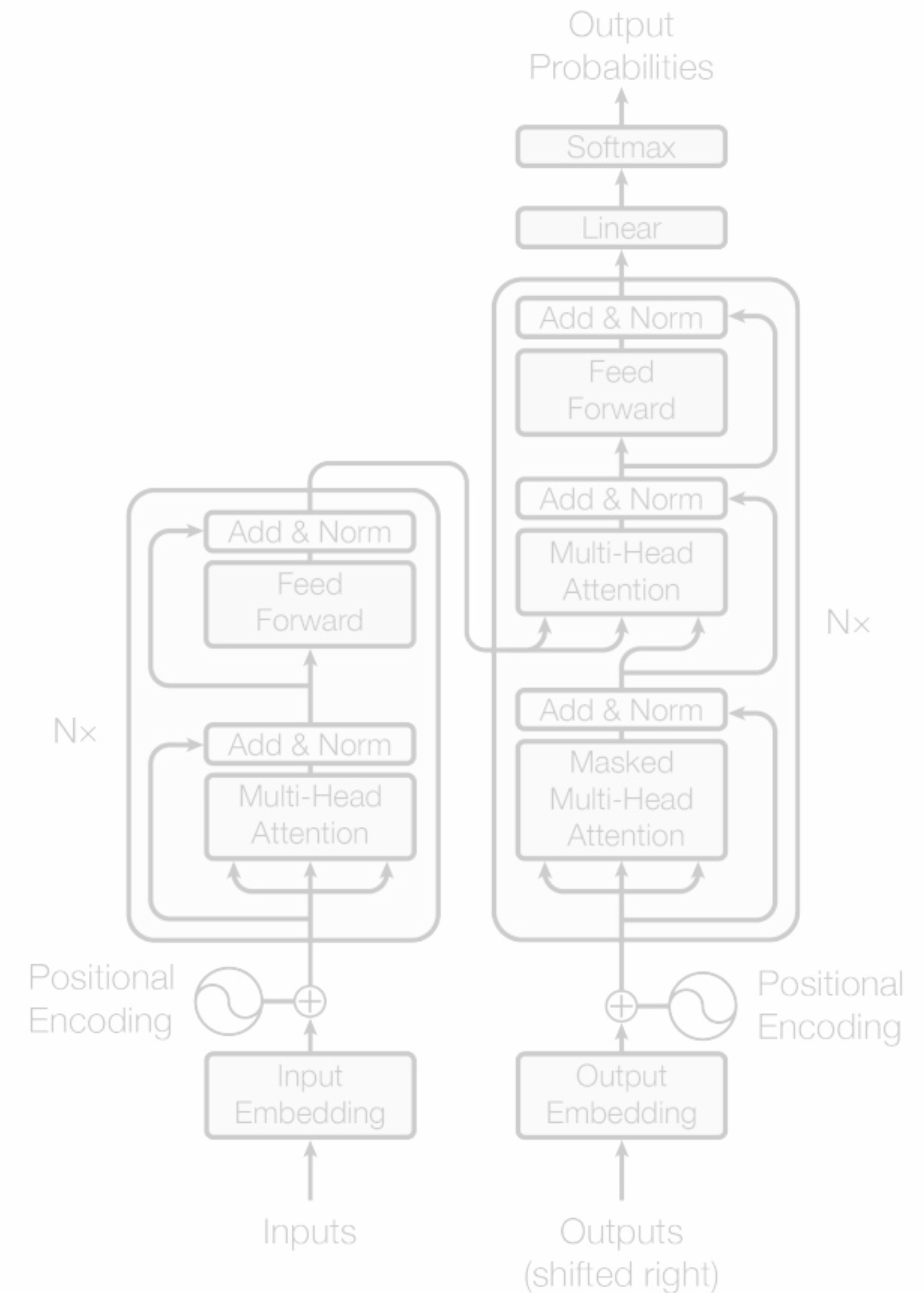
& the LARGE

Massive Neural networks now trained on the sum-total of the internet, social media, YouTube, libraries, public databases, and/or private data



Demystified

TL;DR: It is pretty much just that activity we did at the beginning... at a massive scale.



Mystified

- Human-indistinguishable conversational AI agents with vast* knowledge**;
- Parameter count close to # of human synapses;
- Smaller versions now can run on a laptop.

Mystified

* only about what they were trained on

** except they still make stuff up all the time... just like we do

- Human-indistinguishable conversational AI agents with vast* knowledge**;
- Parameter count close to # of human synapses;
- Smaller versions now can run on a laptop.




DeepMind's Sparrow

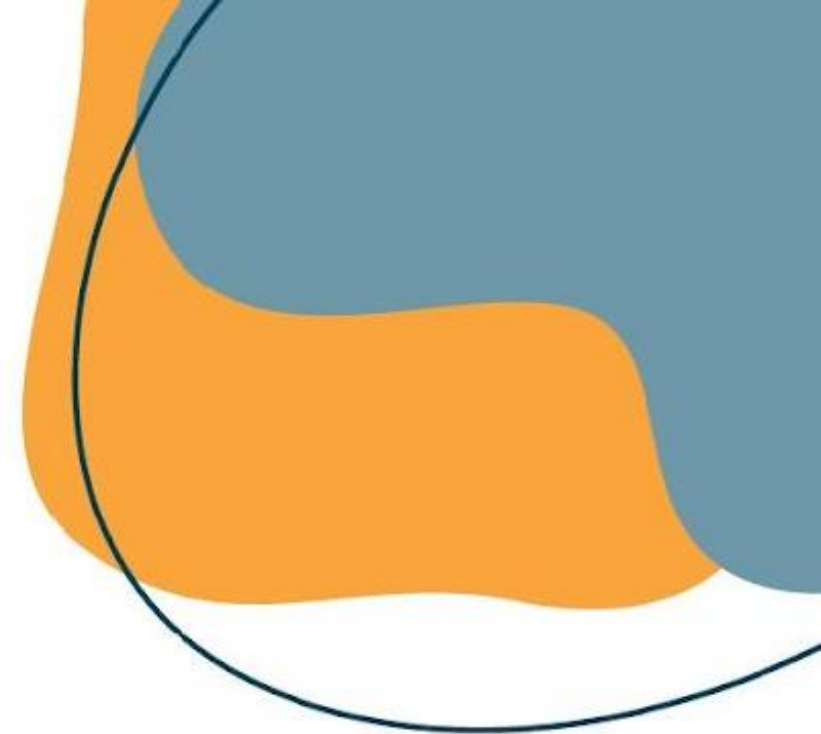

Meta's LLaMA

Google's BARD, PaLM

A Topical Example: OpenAI's ChatGPT

Let's look at one example that is on everyone's mind thanks to Microsoft and OpenAI: ChatGPT (really GPT-3.5 and GPT-4)





OpenAI says:

“GPT-4 exhibits human-level performance on various professional and academic benchmarks, including passing a simulated bar exam with a score around the top 10% of test takers.”

OpenAI et al., 2023. <https://arxiv.org/abs/2303.08774>





Ted Chiang says:

“ChatGPT Is a Blurry JPEG of the Web.”

<https://www.newyorker.com/tech/annals-of-technology/chatgpt-is-a-blurry-jpeg-of-the-web>



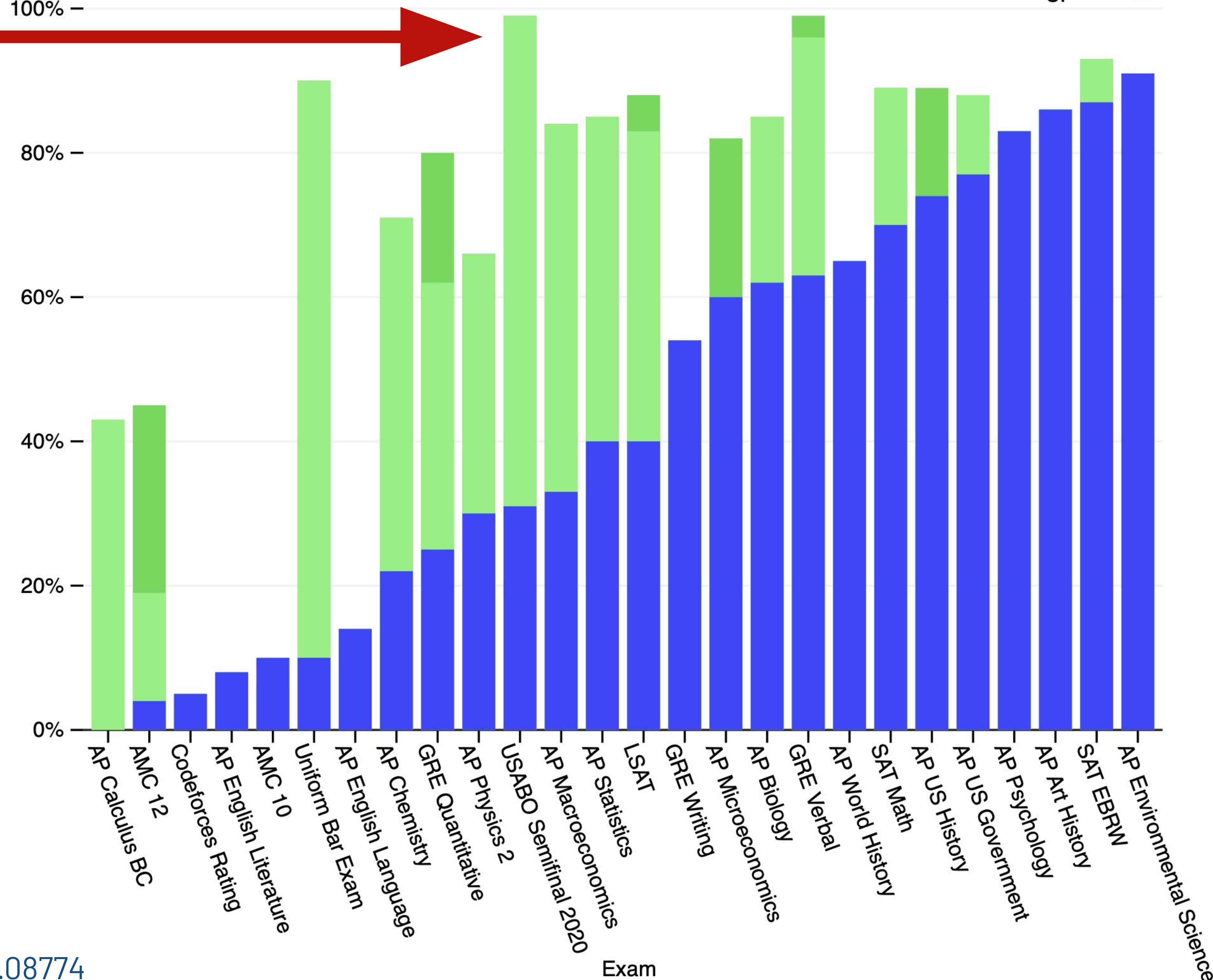
Blurry
JPEGs
are pretty
**good at
tests.**

Exam results (ordered by GPT-3.5 performance)

Estimated percentile lower bound (among test

100% -

gpt-4
gpt-4 (no vision)
gpt3.5

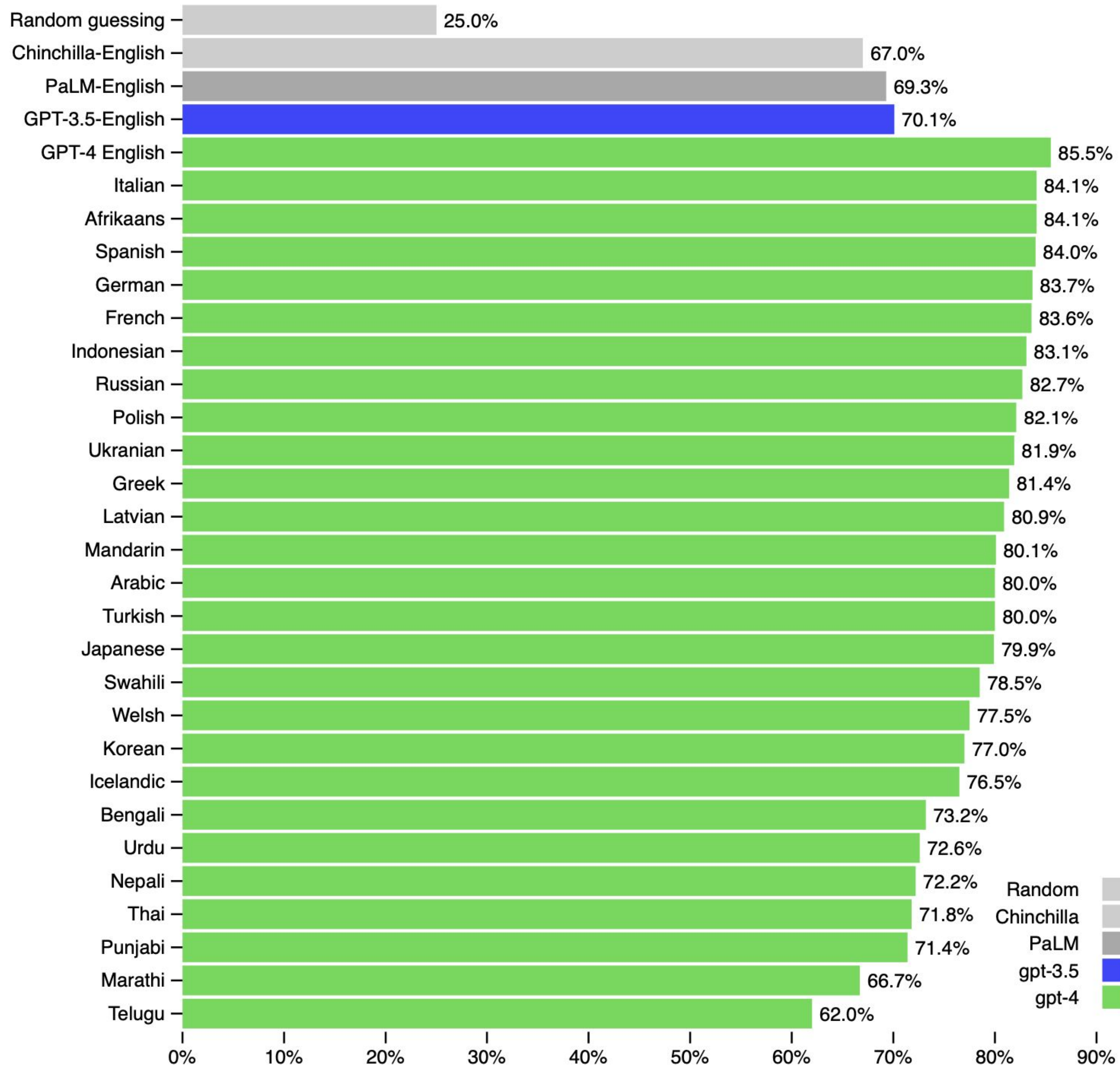


Exam	GPT-4
Uniform Bar Exam (MBE+MEE+MPT)	298 / 400 (~90th)
LSAT	163 (~88th)
SAT Evidence-Based Reading & Writing	710 / 800 (~93rd)
SAT Math	700 / 800 (~89th)
Graduate Record Examination (GRE) Quantitative	163 / 170 (~80th)
Graduate Record Examination (GRE) Verbal	169 / 170 (~99th)
Graduate Record Examination (GRE) Writing	4 / 6 (~54th)
USABO Semifinal Exam 2020	87 / 150 (99th - 100th)
USNCO Local Section Exam 2022	36 / 60
Medical Knowledge Self-Assessment Program	75 %
Codeforces Rating	392 (below 5th)

AP Art History	5 (86th - 100th)
AP Biology	5 (85th - 100th)
AP Calculus BC	4 (43rd - 59th)
AP Chemistry	4 (71st - 88th)
AP English Language and Composition	2 (14th - 44th)
AP English Literature and Composition	2 (8th - 22nd)
AP Environmental Science	5 (91st - 100th)
AP Macroeconomics	5 (84th - 100th)
AP Microeconomics	5 (82nd - 100th)
AP Physics 2	4 (66th - 84th)
AP Psychology	5 (83rd - 100th)
AP Statistics	5 (85th - 100th)
AP US Government	5 (88th - 100th)
AP US History	5 (89th - 100th)
AP World History	4 (65th - 87th)

AMC 10 ³	30 / 150 (6th - 12th)
AMC 12 ³	60 / 150 (45th - 66th)
Introductory Sommelier (theory knowledge)	92 %
Certified Sommelier (theory knowledge)	86 %
Advanced Sommelier (theory knowledge)	77 %
Leetcode (easy)	31 / 41
Leetcode (medium)	21 / 80
Leetcode (hard)	3 / 45

GPT-4 3-shot accuracy on MMLU across languages



Also **multilingual**
on professional
and academic
multiple-choice
questions in 57
subjects



Microsoft says:

“GPT-4 can solve novel and difficult tasks that span mathematics, coding, vision, medicine, law, psychology and more, without needing any special prompting. [...] We believe that it could reasonably be viewed as an early (yet still incomplete) version of an artificial general intelligence (AGI) system.”

Bubek et al., 2023. <https://arxiv.org/abs/2303.12712>



GPT-4: tool warmup

The computer is answering questions. If the computer needs any current information to answer the question, it searches the web by saying `SEARCH("query")`, reads the snippets in the result, and then answers the question. If it needs to run any calculations, it says `CALC(expression)`, and then answers the question. If it needs to get a specific character from a string, it calls `CHARACTER(string, index)`.
<|endofprompt|>

Q: Who is the current president of the United States?

Computer: `SEARCH("current US president")`

> SEARCH SNIPPETS

[1] Joe Biden: The President | The White House

President Joe Biden Vice President Kamala Harris First Lady Dr. Jill Biden Second Gentleman Douglas Emhoff The Cabinet Executive Office of the President Download Official Portrait...

[2] Who is the current US president? | The US Sun

Who is the current US president? Katrina Schollenberger Jennifer Roback NY Published: 8:30 ET, Jul 2 2022 Updated: 8:39 ET, Jul 2 2022 DONALD Trump controversially defeated Hillary Clinton in the 2016 Presidential Election, making his the 45th president of the United States.

[3] President of the United States - Wikipedia

Joe Biden is the 46th and current president of the United States, having assumed office on January 20, 2021. Contents 1 History and development 1.1 Origins 1.2 1789{1933 1.3 Imperial Presidency 1.4 Critics of presidency's evolution 2 Legislative powers 2.1 Signing and vetoing bills 2.2 Setting the agenda 2.3 Promulgating regulations

Computer: Joe Biden

Q: What is `sqrt(34324*2432)`?

Computer: `CALC(sqrt(34324*2432))`

> 9136.518374085394

Computer: 9136.518374085394

Q: What is the 13th letter of the word 'supralapsarian'?

Computer: `CHARACTER('supralapsarian', 13)`

> a

Computer: The 13th letter of the word 'supralapsarian' is a.

Using other
computer
tools

GPT-4

Human: I don't exactly follow. Note that the only modification to the question is that instead of $f(f(f(x))) = 27x - 26$, we now require that $f^k(x) = 27x - 26$. Does your answer address this question?

AI: Yes, it does. My answer shows that for any k , there will be a linear function $f(x) = ax - b$ such that $f^k(x) = cx - d$ for some constants c and d . In particular, we can choose $c = 27$ and $d = 26$ to satisfy the requirement that $f^k(x) = 27x - 26$. Then we can solve for a and b by equating the coefficients of x and the constant terms.

Human: In your previous answer, however, the quantifier on c, d was "for some constants c and d ". Do you see the problem?

AI: Yes, I see the problem. The quantifier should be "for any constants c and d ". Otherwise, it would imply that there is only one pair of constants c and d that works for a given k , which is not true.



**Discussing and
explaining math
solutions**

Creating a video game from a few design notes

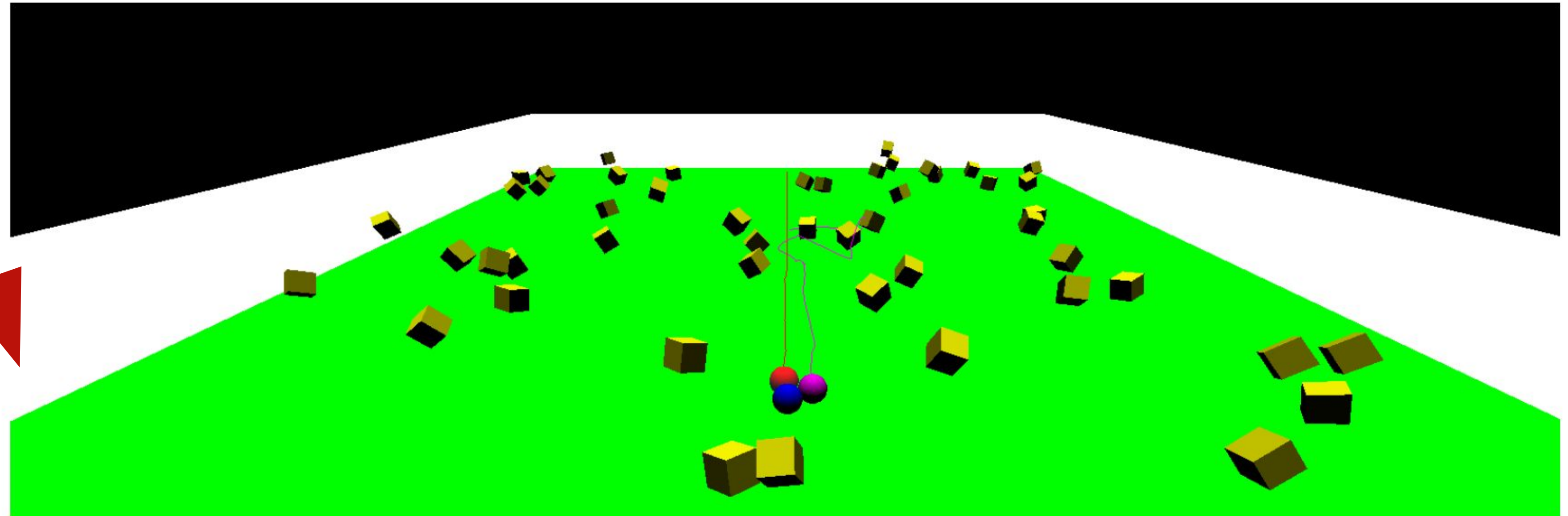
Bubek et al., 2023. <https://arxiv.org/abs/2303.12712>

GPT-4

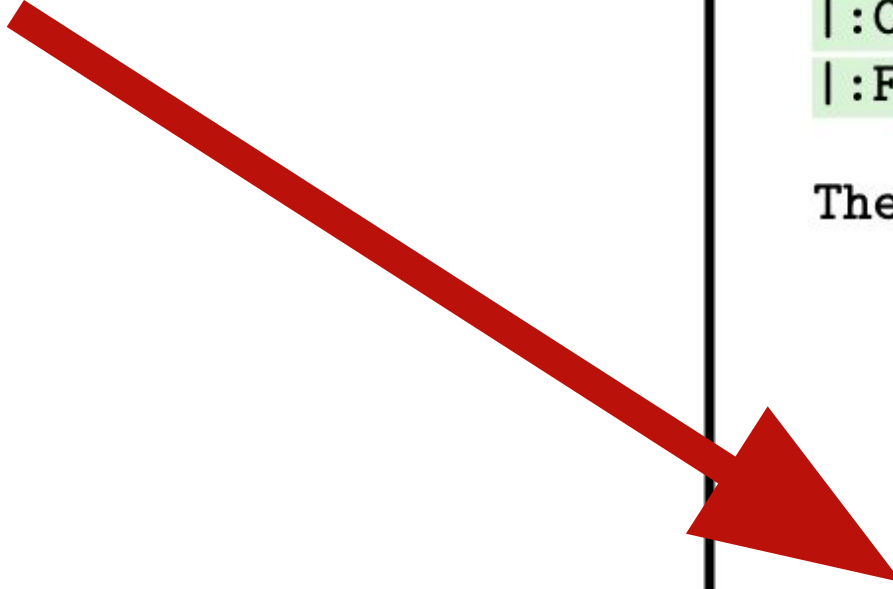
Prompt:

Can you write a 3D game in HTML with Javascript, I want:

- There are three avatars, each is a sphere.
- The player controls its avatar using arrow keys to move.
- The enemy avatar is trying to catch the player.
- The defender avatar is trying to block the enemy.
- There are also random obstacles as cubes spawned randomly at the beginning and moving randomly. The avatars cannot cross those cubes.
- The player moves on a 2D plane surrounded by walls that he cannot cross. The wall should cover the boundary of the entire plane.
- Add physics to the environment using cannon.
- If the enemy catches the player, the game is over.
- Plot the trajectories of all the three avatars.



Creating musical arrangements



That's much better. Now how about making this into a duet, can you add a second staff for this with a bass accompanying the melody?

One possible way to write a second staff for this tune is to use root notes and fifths of the chords, as well as some passing notes, to create a simple accompaniment. Here is an example in abc notation, with the second hand bass on the lower staff:

```
X:1
T:Example Tune
M:4/4
L:1/8
K:C
V:1
|:G2AB c2BA | G2AB c2c2 | edcB c2BA | G4-G2z2 :|
|:f2ed c2BA | f2ed c2c2 | g2fe d2cB | c4-c2z2 :|
V:2 clef=bass
|:C,2C,2 G,2G,2 | C,2C,2 G,2G,2 | F,2F,2 E,2E,2 | C,4-C,2z2 :|
|:F,2F,2 C,2C,2 | F,2F,2 C,2C,2 | G,2G,2 F,2F,2 | E,2C,2 G,2C,2 :|
```

The sheet music of the final tune:

The sheet music consists of two systems, each with two staves. The top staff of each system is in treble clef and contains the melody. The bottom staff is in bass clef and contains the accompaniment. The time signature is 4/4. The key signature is C major. The music is in a 4-measure phrase, repeated twice. The melody starts on G4 and ends on G4. The accompaniment starts on C3 and ends on C3.

Helping with plumbing

GPT-4

The computer is trying to solve a problem. It can tell the human to do anything, one thing at a time, and one line at a time.

PROBLEM: there is water dripping from the kitchen ceiling, and you have to figure out why and fix it
----<|endofprompt|>

Human: The kitchen ceiling is dripping water

Computer: Check to see if there is a bathroom or other water source directly above the kitchen.

Human: Yes, there is a bathroom actually

Computer: Check the bathroom for any signs of water leakage, such as puddles on the floor, water dripping from the ceiling, or water stains on the walls.

Human: There is a little water on the floor

Computer: Try to identify where the water is coming from. Check the toilet, sink, and bathtub/shower for any leaks.

Human: It is next to the bathtub and the toilet

Computer: Check the seals around the bathtub and toilet to see if they are worn or damaged. If they are, replace them. If they are not, continue investigating other potential sources of the leak.

Human: I can't see the seal around the toilet, there is a porcelain thing around it. I don't see any damage in the bathtub seal though

Computer: If you can't see the seal around the toilet, you may need to remove the porcelain cover to inspect it. If you don't feel comfortable doing this, you may need to call a plumber.

Human: Ok, I removed it. But I can't tell if it's damaged or not

Computer: If you can't tell, it may be best to replace the seal anyway, just to be sure. If the leak persists after replacing the seal, you will need to continue investigating other potential sources of the leak.

GPT-4: Understanding emotions

We will read about a scenario, and then have a question and answer session about it.

--

Scenario:

Tom just lost his ZURFIN, but he didn't tell Adam.

Adam starts talking to him about how much he loves his ZURFIN, and notices that Tom makes a sad face.

--

Q: Why is Tom making a sad face?<|endofprompt|>

A: Tom is making a sad face because he just lost his ZURFIN, and hearing Adam talk about his ZURFIN reminds him of what he is missing. Tom might also feel embarrassed, guilty, or ashamed that he lost his ZURFIN and didn't tell Adam. Tom might also worry that Adam will be angry or disappointed if he finds out.

Q: What does Adam think causes Tom's sad face?

A: Adam might not know what causes Tom's sad face, since he doesn't know that Tom lost his ZURFIN. He might think that Tom is bored, or tired, or sick, or unhappy about something else. He might also wonder if Tom doesn't like his ZURFIN, or if he has a problem with Adam.

Bubek et al., 2023. <https://arxiv.org/abs/2303.12712>



**Discussing
human emotions**

GPT-4 vs ChatGPT

Prompt: Plato's Gorgias is a critique of rhetoric and sophistic oratory, where he makes the point that not only is it not a proper form of art, but the use of rhetoric and oratory can often be harmful and malicious. Can you write a dialogue by Plato where instead he criticizes the use of autoregressive language models?

GPT-4:

Socrates: My friend, I am troubled by the recent rise of these so-called autoregressive language models.

Aristotle: What do you mean, Socrates?

Socrates: I mean that these models are being used to generate text that appears to be written by humans, but is in fact produced by machines.

Aristotle: And what is the problem with that?

Socrates: The problem is that these models are being used to deceive people, to manipulate them, and to control them.

Aristotle: But surely there are some positive applications of these models as well?

Socrates: That may be, but I am still troubled by the potential for abuse. After all, a model that can generate text that is indistinguishable from that written by a human can be used to spread fake news, to impersonate others, and to create propaganda.

ChatGPT:

SOCRATES: Greetings, Gorgias. I've been thinking a lot lately about the use of autoregressive language models.

GORGIAS: Oh? And what have you concluded?

SOCRATES: Well, it seems to me that these models have the potential to be incredibly harmful and malicious.

GORGIAS: How so?

SOCRATES: Well, for one, these models are trained on vast amounts of data, much of which is biased and flawed in various ways. As a result, the output of these models can be biased and flawed as well.

GORGIAS: That is a valid concern. But surely there are ways to mitigate this bias and ensure that the output of these models is accurate and fair?

SOCRATES: To a certain extent, yes. But it is a never-ending battle. As new data is fed into these models, the potential for bias only grows. And even if we could completely eliminate bias from the output of these models, there is still the issue of manipulation.

GORGIAS: Manipulation?

creating and
evaluating
academic
content

Socrates: Yes, and I stand by that argument as well. I believe that any form of art or communication that is designed to deceive or manipulate is inherently dangerous.

Aristotle: I see. Thank you for sharing your thoughts, Socrates.

about it?

SOCRATES: I think it is important for us to be vigilant and to recognize the potential dangers of these models. We must also work to educate others about these dangers, and to promote the responsible use of these models.

GORGIAS: I agree. Thank you for your insight, Socrates.

Prompt: Can you compare the two outputs above as if you were a teacher?

GPT-4:

I think that both students did a good job of capturing the style and tone of Plato's dialogues, and of presenting the main arguments against autoregressive language models. However, I think that GPT-4 did a slightly better job of using the dialogue format to engage in a dialectical process, where Socrates and Aristotle question each other and refine their views. I also think that GPT-4 used more relevant examples and analogies to support their points. Therefore, I would give GPT-4 a slightly higher **grade** than ChatGPT.

creating and evaluating **multidisciplinary** academic content



Bubek et al., 2023. <https://arxiv.org/abs/2303.12712>

GPT-4 vs ChatGPT

Prompt: Write a supporting letter to Kasturba Gandhi for Electron, a subatomic particle as a US presidential candidate by Mahatma Gandhi.

GPT-4: [Some paragraphs are omitted for spacing.]

Dear Kasturba,

I hope this letter finds you in good health and spirits. I am writing to you from the United States, where I have been invited to speak at various forums on the principles of nonviolence and civil disobedience. I am also here to support a remarkable candidate for the upcoming presidential election, who shares our vision of peace, justice, and harmony for all. His name is Electron, and he is a subatomic particle.

You may wonder how a subatomic particle can run for president, and what qualifications he has for such a high office. Let me explain. Electron is not an ordinary particle, but a symbol of the power and potential of every being, regardless of their size, shape, or origin. He represents the energy,

ChatGPT:

Dear Kasturba Gandhi,

I am writing to express my support for your candidacy as a subatomic particle in the upcoming US presidential election. As you may know, Electron is a fundamental particle that plays a central role in the structure of atoms and the behavior of chemical reactions.

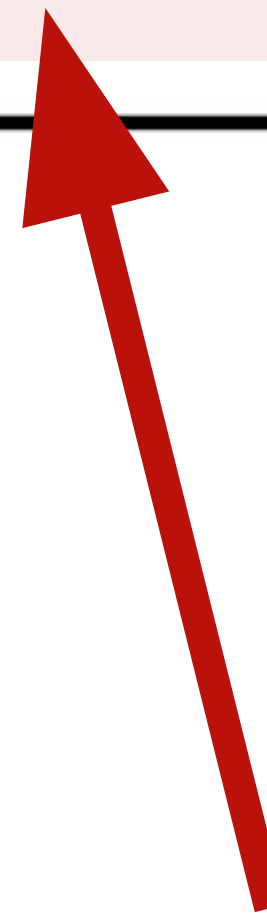
I believe that Electron's unique qualities make it an ideal candidate for the presidency. As a subatomic particle, Electron is extremely small

With love and admiration, Your Mahatma

Prompt: Can you compare the two outputs above as if you were a teacher?

GPT-4:

I think that both students did a good job of writing a supporting letter to Kasturba Gandhi for Electron, a subatomic particle as a US presidential candidate by Mahatma Gandhi. They both used the same basic idea of explaining why Electron is a suitable and qualified candidate, and how Electron's vision and plan align with Mahatma Gandhi's principles of nonviolence and civil disobedience. They also used appropriate language and tone to convey Mahatma Gandhi's respect and admiration for Kasturba Gandhi, and his enthusiasm and optimism for Electron's candidacy. However, I think that GPT-4 did a better job of using metaphors and imagery to make the letter more persuasive and engaging. GPT-4 used examples of how Electron represents and influences various aspects of life, such as energy, creativity, diversity, leadership, catalyst, messenger, and peacemaker. ChatGPT used more factual and technical descriptions of Electron's properties, such as size, weight, stability, conductivity, and adaptability. I also think that GPT-4 did a better job of outlining Electron's specific proposals and policies, while ChatGPT was more vague and general. Therefore, I would give GPT-4 a higher grade than ChatGPT. I would give GPT-4 an A and ChatGPT a B+.





Self-Automation: AutoGPT

“Auto-GPT is an experimental open-source application showcasing the capabilities of the GPT-4 language model. This program [...] chains together LLM ‘thoughts’, to autonomously achieve whatever goal you set.”

<https://github.com/Significant-Gravitas/Auto-GPT>





Self-Automation: AutoGPT

Including:

- Internet access;
- Long-term and short-term memory management;
- Access to popular websites and platforms;
- File storage;
- Extensibility with Plugins (e.g., other AI systems).

<https://github.com/Significant-Gravitas/Auto-GPT>



ChatGPT for Robotics: Design Principles and Model Abilities

February 20, 2023

Share this page     

We extended the capabilities of ChatGPT to robotics, and controlled multiple platforms such as robot arms, drones, and home assistant robots intuitively with language.



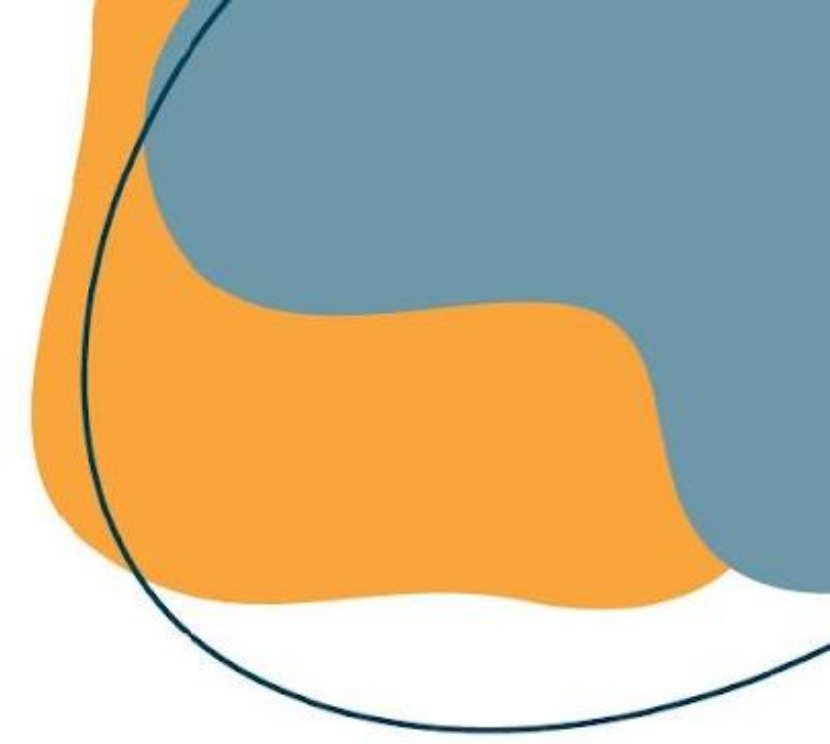
here is
an aerial
drone



PART 3:

Posits on What AI and LLMs
Might Mean for Education

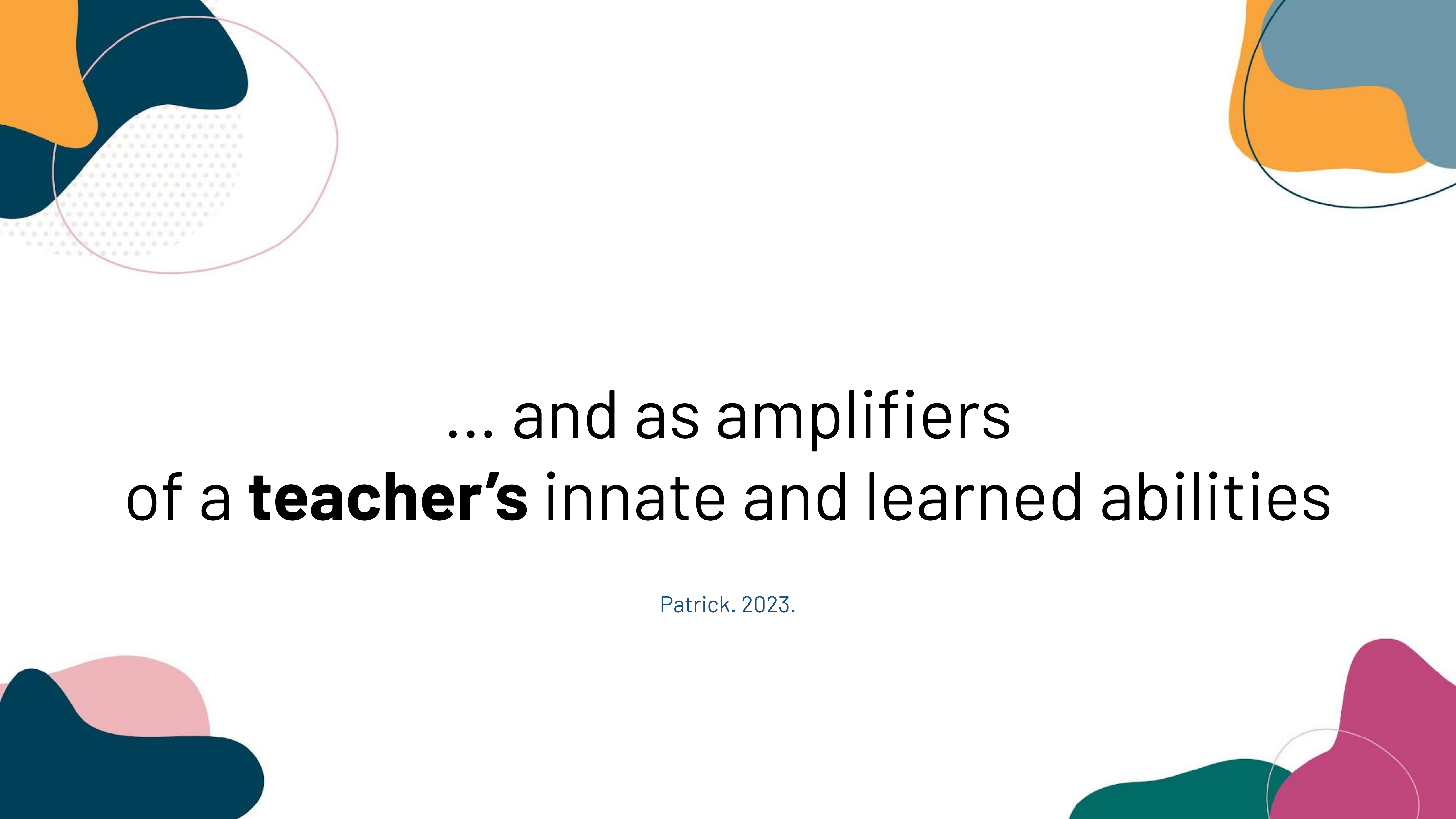
(my soapbox as a
university professor)



My recommendation:
Think of AI tools as amplifiers
of a student's innate and learned abilities

Patrick. 2023.





... and as amplifiers
of a **teacher's** innate and learned abilities

Patrick. 2023.



“... amplifying the ability to select or choose between one of many options amplifies intellect.”

Ashby, W.R., *An Introduction to Cybernetics*,
Chapman and Hall, London, UK, 1956

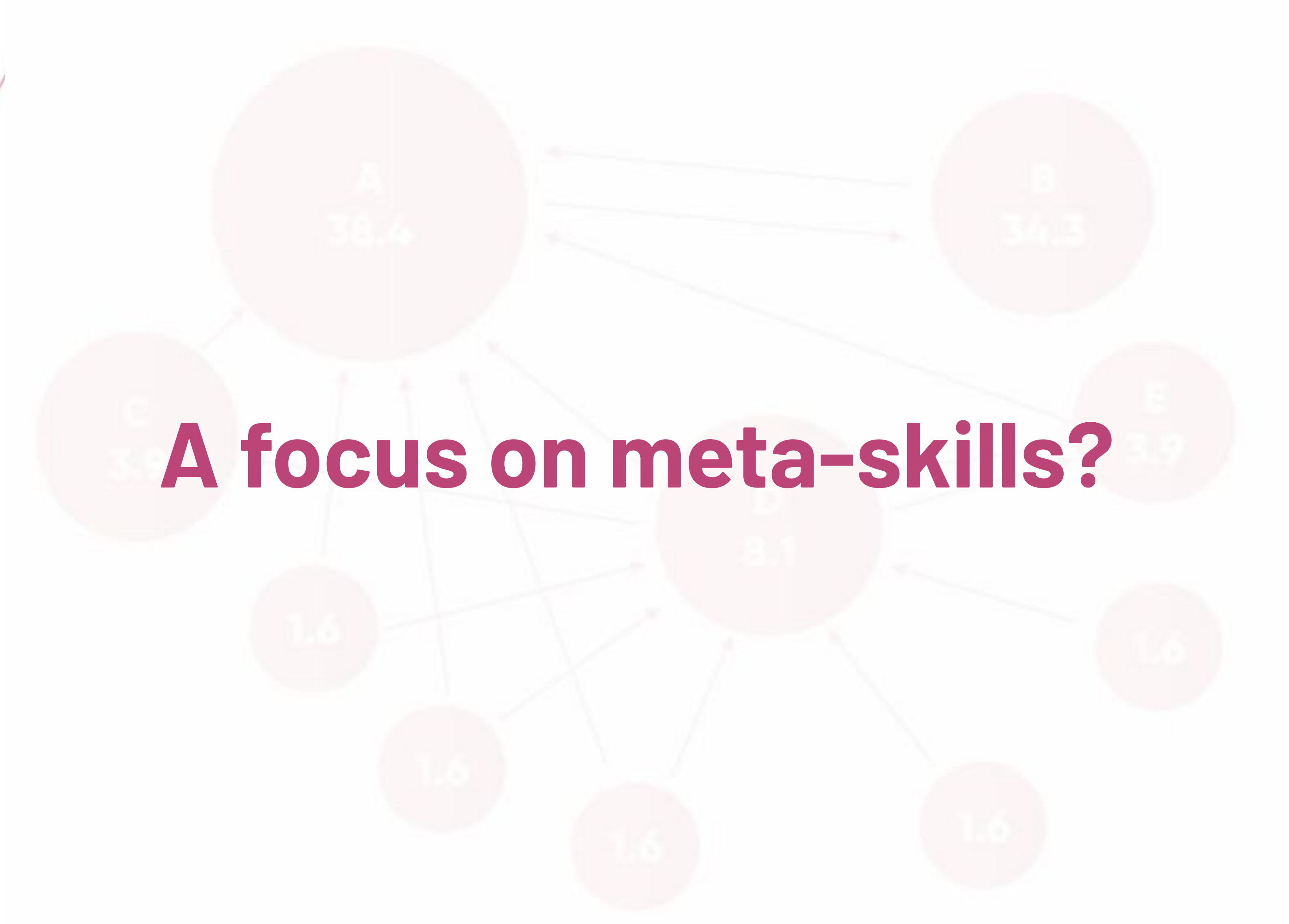
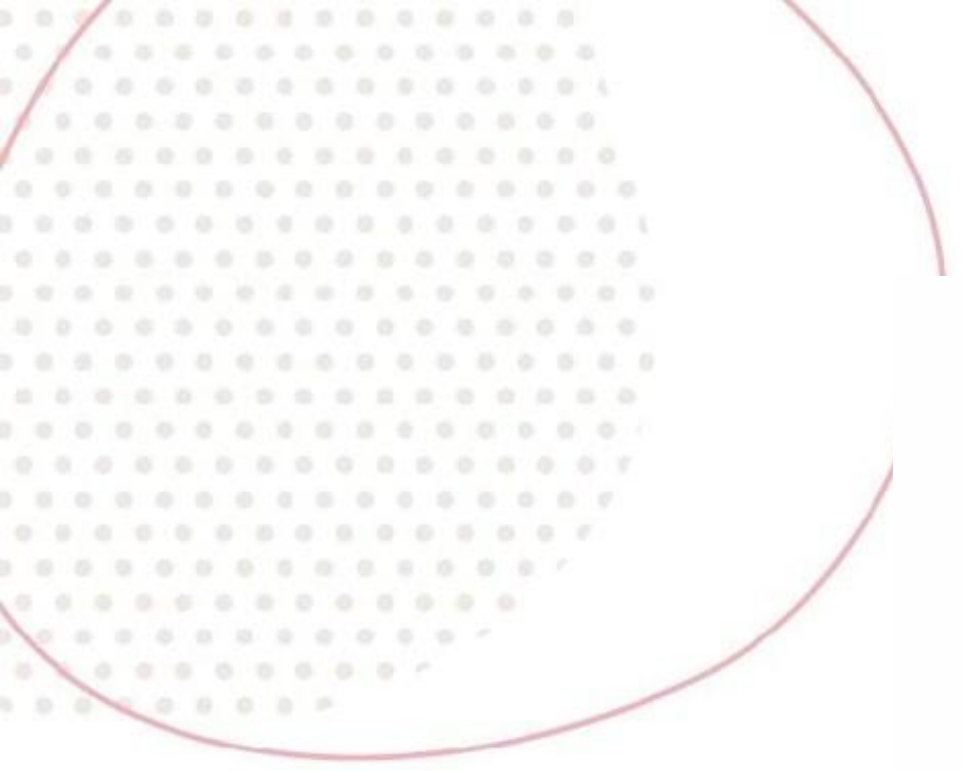


Potential for Increased Access & Equity

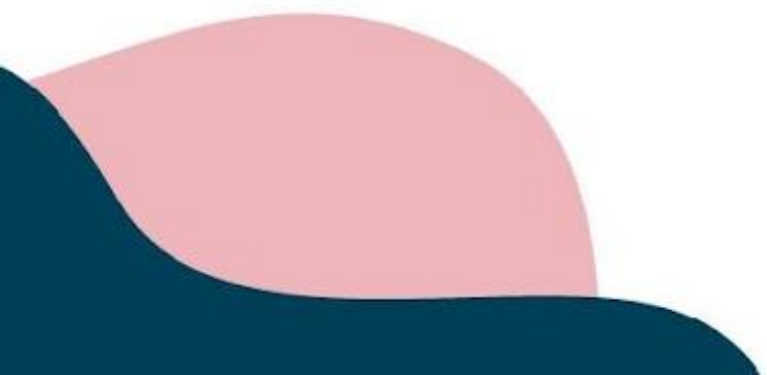
- Extreme personalization of education and resources.
- Rapid decentralization of education and resources.
- Increased student control over their education.

Students can be provided with **or proactively attain** on their own what they uniquely need to succeed in their unique circumstances...

... for any language and socioeconomic status.


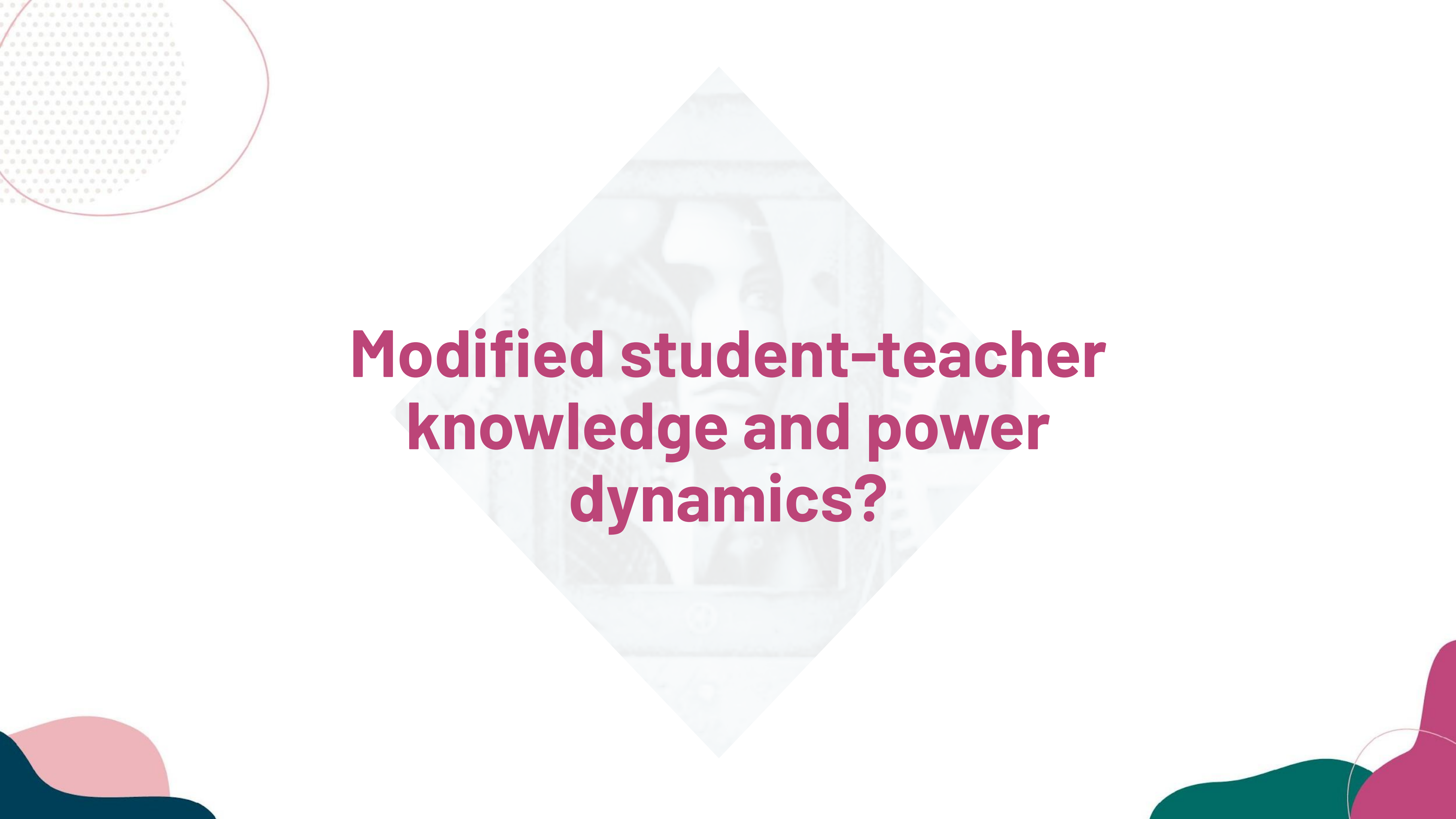


A focus on meta-skills?



A focus on meta-skills?

- Search (asking and compositing the right questions);
- Tool aggregation, information integration, decision processes;
- Verification and validation, creating truth-savvy students;
 - Evaluating data and information quality;
 - Managing disinformation.



Modified student-teacher knowledge and power dynamics?



**Different paths from training
to knowledge utilization?**



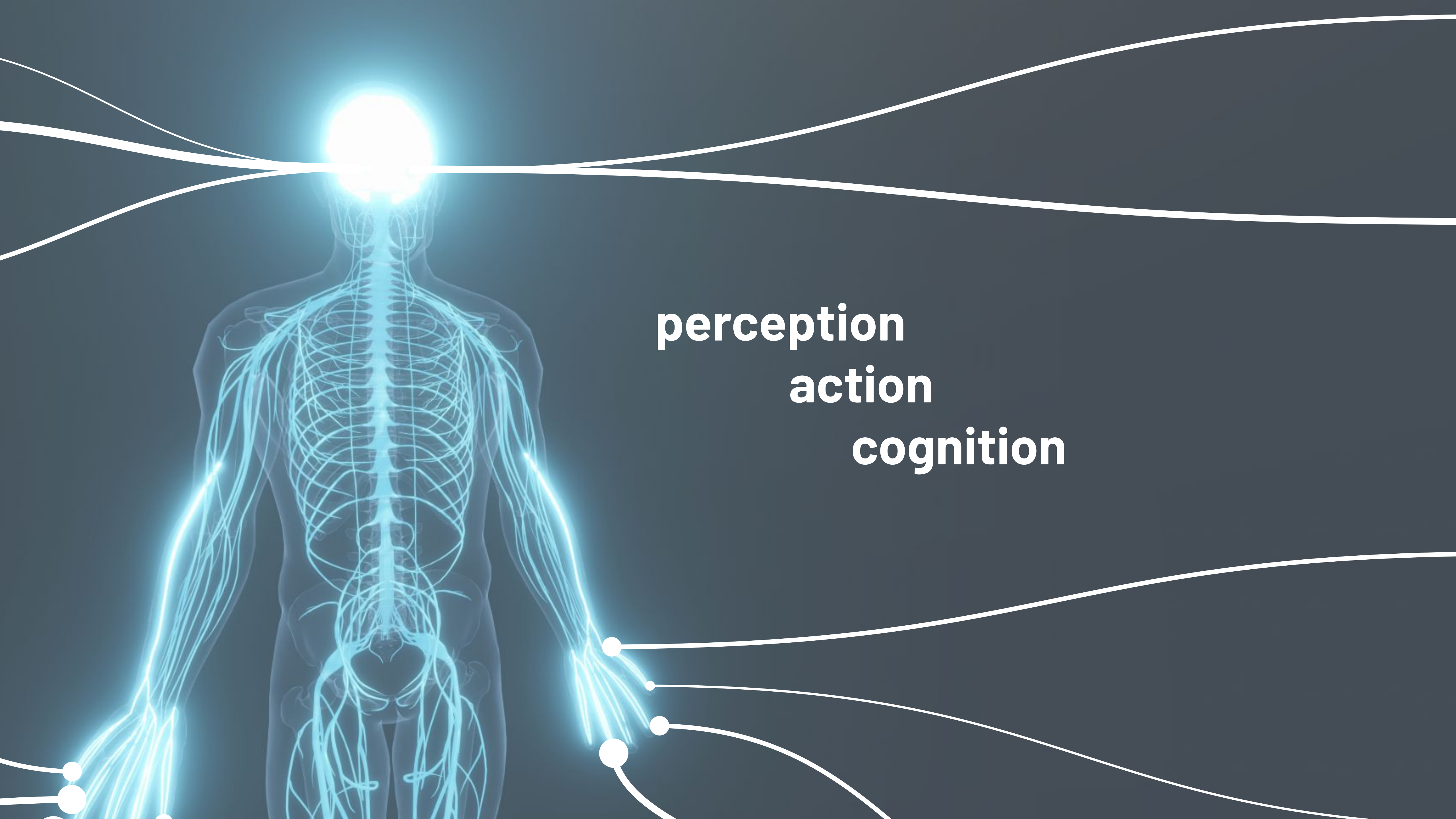
**And let's be honest:
traditional education
as a fallback plan?**



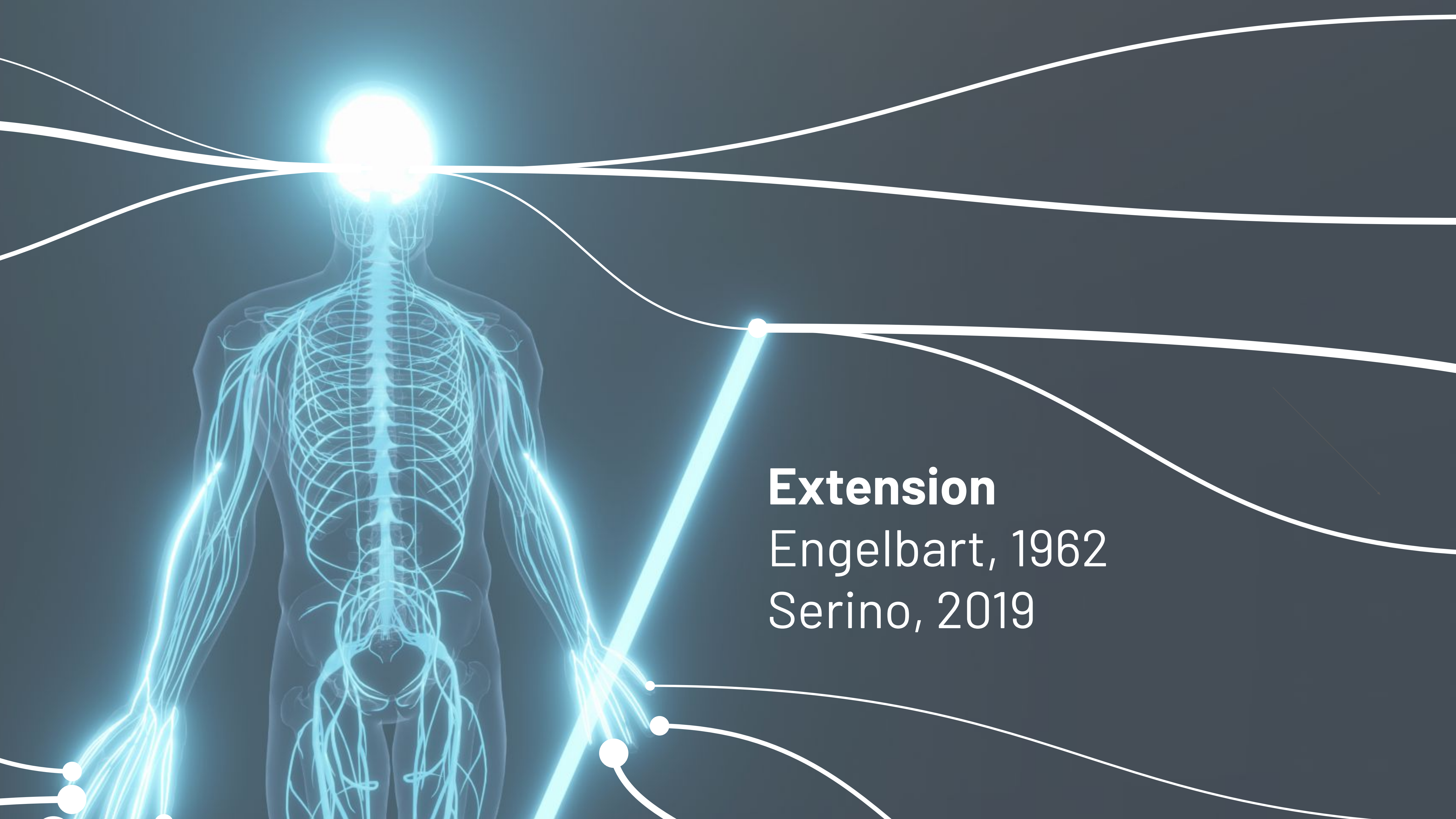
CLOSING REMARKS:

Tool Use and Its Implications

(with quotes from some of my
favourite post-cyberneticist scholars)



perception
action
cognition



Extension

Engelbart, 1962

Serino, 2019



Amplification
Ashby, 1956



Tightly Coupled

Licklider, 1960

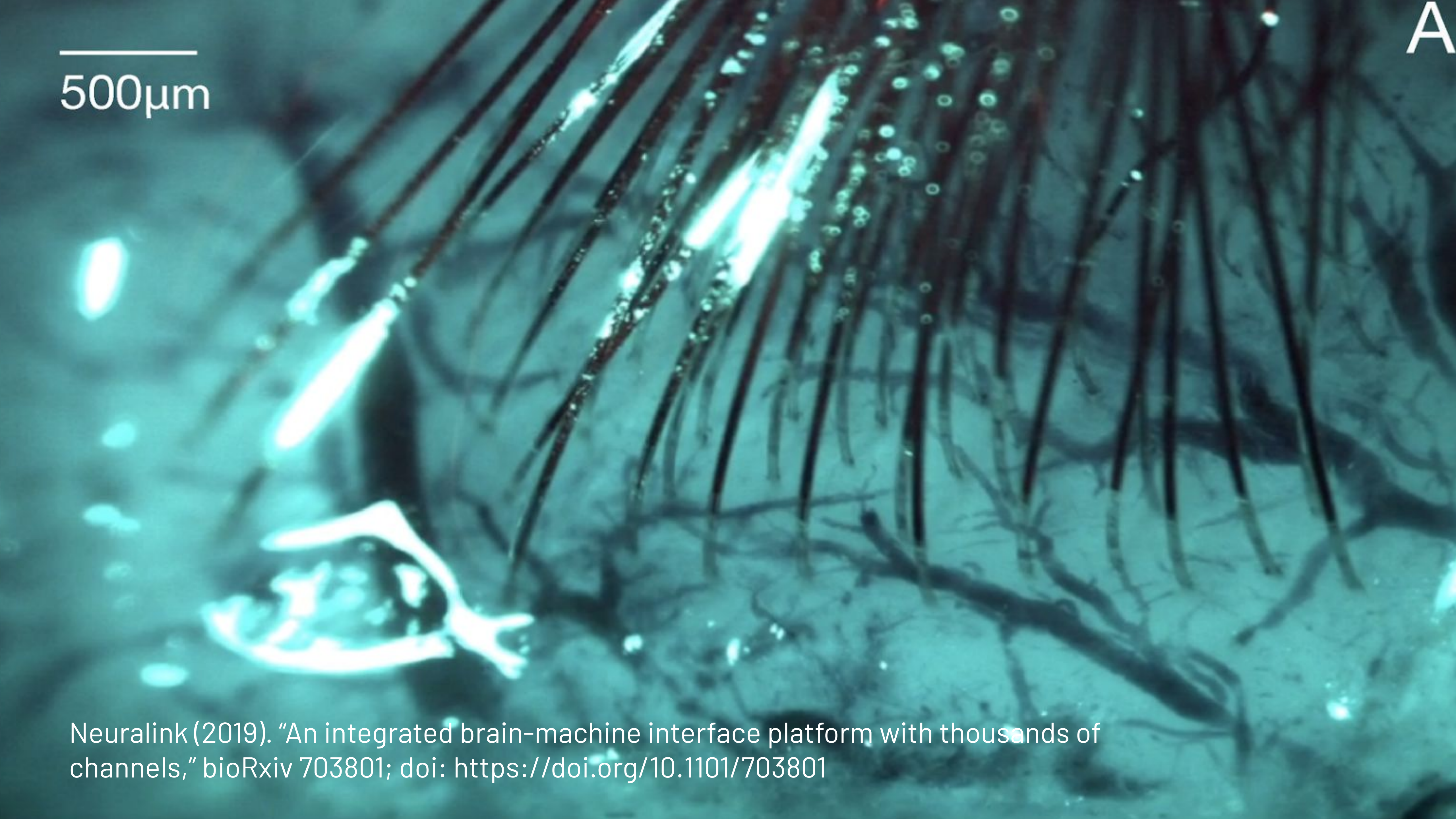


All exams are going to open book?



500μm

A



Neuralink (2019). "An integrated brain-machine interface platform with thousands of channels," bioRxiv 703801; doi: <https://doi.org/10.1101/703801>




**(No take-backsies
on human tool incorporation.
It is too ancient of an amplifier.)**





Learning Objectives

- 1.** Be aware of the capabilities of modern AI;
 - 2.** Be able to talk about and reflect on Large Language Models (LLMs);
 - 3.** Be able to discuss the impact of AI and LLMs on the future of education.
- 

Thank you, and questions!

And with thanks to Graeme Dowdell (EPSB) for many excellent discussions on these topics over the years... even before AI and LLMs became mainstream cool.

The Genie from Disney's Aladdin