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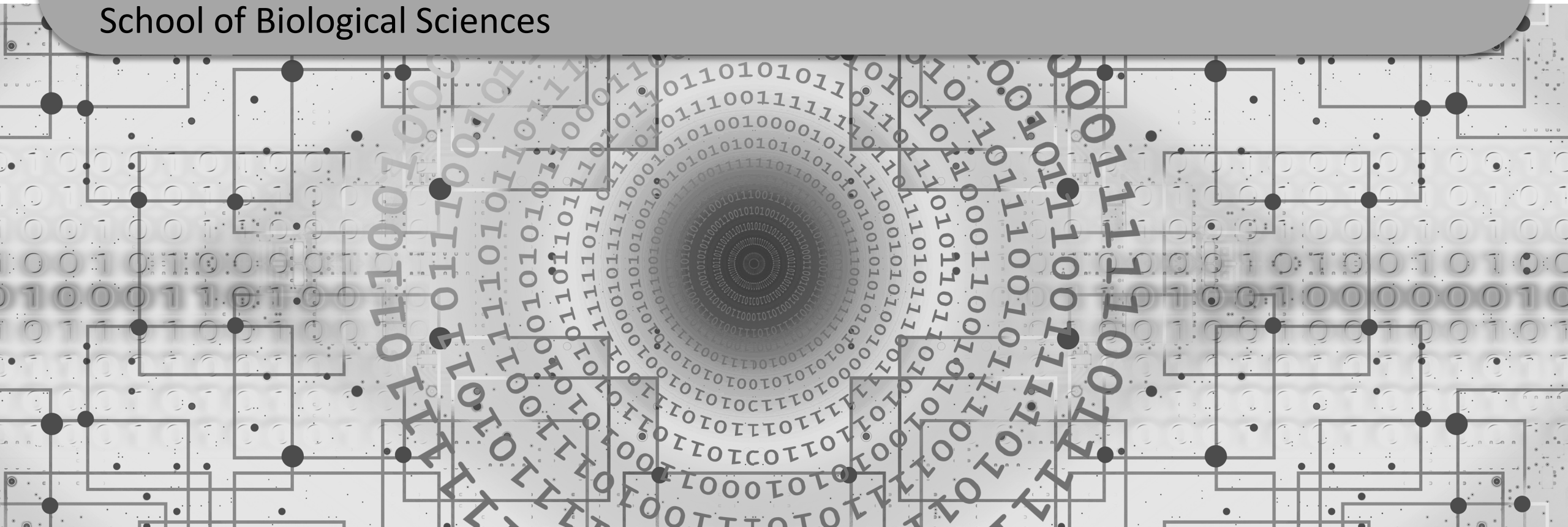
Artificial Intelligence and Society

BS0004 Introduction to Data Science

Dr Wilson Goh
School of Biological Sciences



Learning Objectives

By the end of this lecture, you should be able to:

- Explain Artificial Intelligence (AI).
- Explain the underlying technology behind AI in the form of a neural network.
- Explain how artificial intelligence (may) impact your daily lives.
- List some societal/ ethical considerations involved in the use of AI technology.
- Explain how co-evolution with AI is important --- using biotechnology education as an example.

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What is AI?

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What is Artificial Intelligence?

Artificial intelligence (AI) = "Machine Intelligence":

- Superhuman ability to spot and pick out patterns in large volumes of data.
- Enabling computers and machines with some properties of traditional "human intelligence": memory, sight, speech and language interpretation, basic problem solving.
- Does not include advanced reasoning and common sense!

"Intelligent agents/ devices" demonstrate intelligence as:

- Perceive their environment and take actions to achieve their goals.
- Mimic "cognitive" functions such as "learning" and "problem solving".

AI-capabilities of modern machines:

- Successfully understand human speech (Google Home).
- Compete at the highest level in strategic game systems (such as Chess and Go).
- Autonomously operating vehicles (Tesla Driverless Car).
- Intelligent routing in content delivery networks and military simulations. (Amazon 1-hour delivery system).

Ultimately: Problem-solving engines and tools that augment and enhance human activities/ abilities.

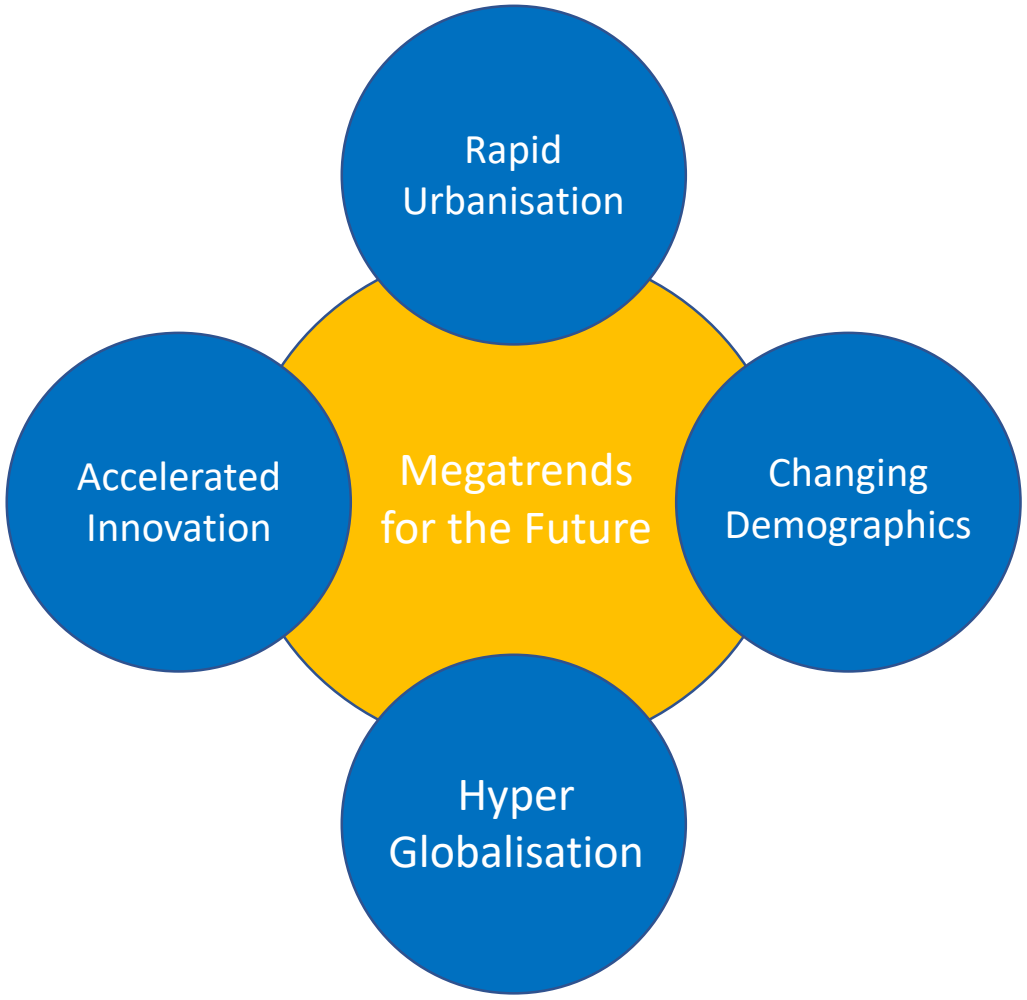
Watch the Video

Watch this YouTube video to appreciate what the fourth industrial revolution entails.

Artificial Intelligence

AI is a key component of the fourth industrial revolution:

- Billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge.
- Heavy implementation of emerging technologies with high potential of disruptive effects, including:
  - Internet of Things
  - Artificial Intelligence
  - Robotics
  - Blockchain
  - Personalised Medicine/ Smart Healthcare
  - Autonomous Vehicles and Systems
  - 3-D Printing
  - Nanotechnology
  - Quantum Computing



Google DeepMind’s AlphaZero

- Computer programme (algorithm) developed by Alphabet-owned AI research company DeepMind.
- Self-learning machine that beats all humans and other machines in the three most complex strategy board games Chess, Go and Shogi.
- Special learning capabilities and huge computing powers support and train neuronal networks → AlphaZero trained solely via "self-play”, learns successively based on the game rules and criteria for successful moves.
- Dynamically calculates only most promising moves in deep neural nets using reinforcement learning algorithms.
- Development could lead to universal strategic learning machine.

Source: Channel, A. C. (2017, December 06). Google Deep Mind Alpha Zero Sacs a Piece Without "Thinking" Twice. Retrieved from https://www.youtube.com/watch?v=NaMs2dBouoQ

Examples of AI Applications

Google Maps: Web mapping service, offers satellite imagery, street maps, 360° panoramic views of streets (Street View), real-time traffic conditions (Google Traffic), and route planning for traveling by foot, car, bicycle, or public transportation. Planned improvements to the app, using AI self-learning algorithms, include:

- Creating Street View-style visual guides for step-by-step directions overlaid onto the real world, as viewed through the smartphone camera.
- Integrating computer vision platform Google Lens into Maps, allowing to see pop-ups highlighting restaurants and other locations in real time.
- Including visual features of an environment (e.g., storefront displays, street signs) for geolocation and route mapping through new Visual Positioning System (VPS).

Semantic Scholar

Developed by Allen Institute for AI, Seattle.

By Source (WP:NFCC#4), Fair use, https://en.wikipedia.org/w/index.php?curid=57380532

- System to identify scientific papers most relevant to a particular problem.
- Applies AI to try to understand the context of recurring phrases to rank the relevance of papers (→ achieves better results than Google Scholar that relies on citations in other papers or the frequency of recurring phrases).
- Trained for its task, the system can now identify 368,071 topics and 6,756,863 relationships between topics in the 38 million papers available to it → finds the ones most pertinent to your needs.

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How does AI work?

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Two Main Types of AI

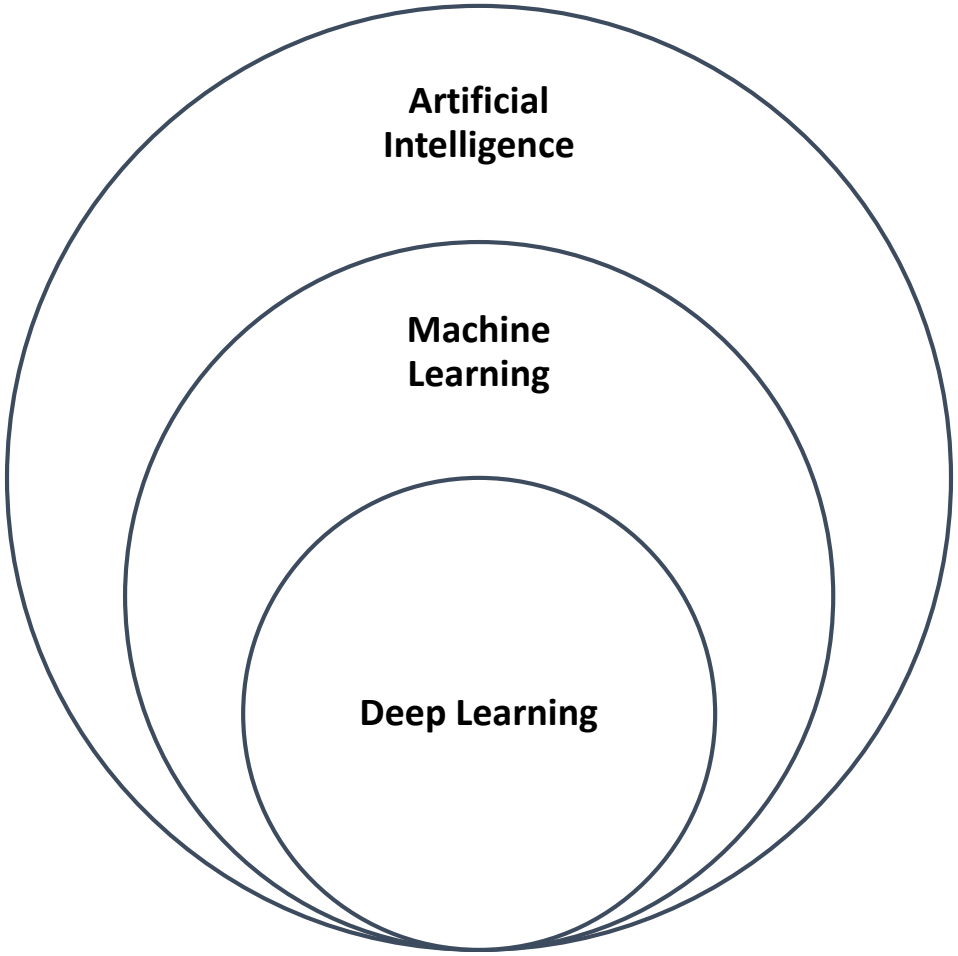
Specialised AI

- An intelligence that is task-specific; cannot do anything else.
- Also known as Narrow AI.
- Examples include AIs for playing chess, driving cars and identifying cancers on X-Rays.

Generalised AI

- An intelligence that is non-task specific; can be adapted for multiple purposes.
- Mostly an idea for now.
- Closest thing --- Deepmind's AlphaZero, that was able to conquer the games of Go, Chess and Shogi without any prior instructions.

The AI Technical Landscape



Supervised Learning

A machine learning algorithm learns from a labelled dataset rules and patterns that will allow it to predict labels for unlabeled datasets.

Unsupervised Learning

A machine learning algorithm learns from a dataset rules and patterns that will allow it to group the dataset based on similar characteristics.

Reinforcement Learning

A reinforcement learning algorithm learns to navigate an environment given a certain reward function.

Most Current Generation AI is Dependent on Data

Well-curated data (based on data analysis and classification/ categorisation) is crucially required to train machines for AI-supported applications.

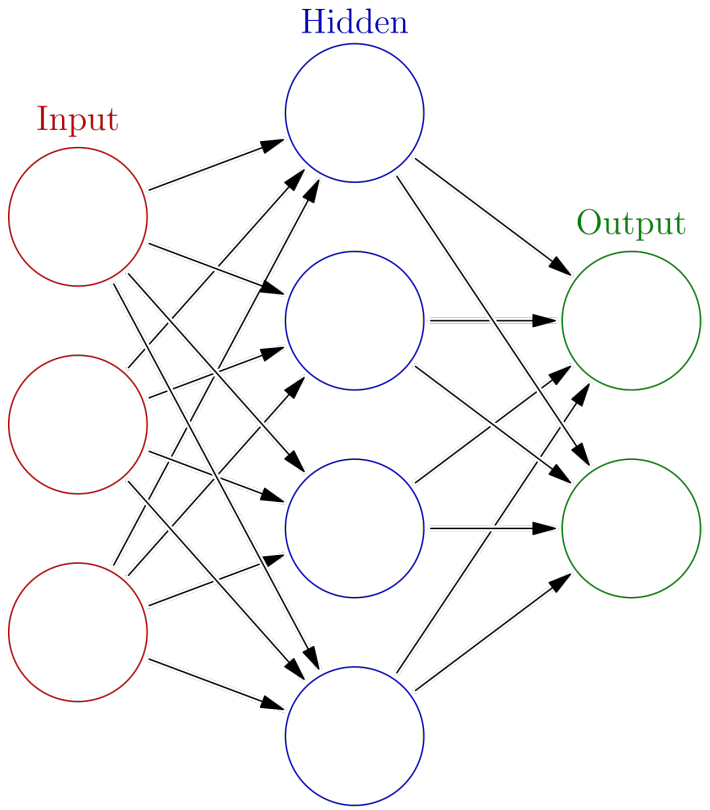
- Uses computational statistical and mathematical optimisation techniques to give computer systems the ability to "learn" (e.g., progressively improve performance on a specific task) from data, without being explicitly programmed.
- Constructs algorithms that can learn from and make predictions based on data = predictive analytics → build analytical models from sample inputs → allow researchers, data scientists, engineers, and analysts to produce reliable, repeatable decisions and results and uncover hidden insights through learning from historical relationships and trends in the data.
- Employed in a range of computing tasks (e.g., email filtering, detection of network intruders, computer vision) where designing and programming explicit algorithms with good performance is difficult or infeasible.
- Because AI helps to provide insight from large data feeds, it is a very important tool in the data science arsenal.

AI technologies, including the learning algorithms, are always built based on training datasets. In other words, AI is data dependent.

Artificial Neural Networks

Artificial Neural Networks: AIs are inspired from the architecture of the brain. Successful applications of AI rely on **Artificial Neural Networks:**

- Collection of connected units or nodes (= artificial neurons), which model neurons in biological brain.
- Signals from one artificial neuron to another are transmitted via connections (equivalent to synapses in biological brain).
- Artificial neurons receiving a signal can process it → signal additional connected artificial neurons.
- Algorithms use artificial neural networks to calculate complex functions based on fed-in data.



Source: Glosser.ca - Own work, Derivative of File:Artificial neural network.svg, CC BY-SA 3.0, commons.wikimedia.org/w/index.php?curid=24913461

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AI in your Daily Lives

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Examples of AI Applications from Everyday Life

Most current AI technologies focus on solving specific tasks where AI can surpass humans (in speed/ pattern recognition ability/ accuracy):

- Photo-tagging on social media
- Chatbots
- Language translation
- Digital assistants like Apple's Siri and Amazon's Alexa

Other areas with increasing AI applications:

- Internet (of Things)
- Communication and networking (e.g., dating services)
- Sensory devices
- Energy management
- Manufacturing and Construction
- Robotics
- Infrastructure and Transport (autonomous vehicles)
- E-commerce (customer profiling –> tailored suggestions and advertising)
- Medicine and Health systems
- Banking and financial (customer profiling/ loans etc).

Capabilities (and Limitations) of AI Today

Capabilities

- Analysing available data and pattern recognition.
- Performing specific tasks like humans such as cooking specific meals.
- Rapid progress in specialised AI.
- Machines will reach (and exceed) human performance on more and more tasks.

Limitations

- Make inferences or judgements.
- Develop new output possibilities beyond what it is programmed to do → cannot replace a chef in the very near future.
- Exhibit broadly applicable intelligence comparable to or exceeding that of humans (not for the next 20 years at least).
- Surpass human intelligence "as long as computers are made with processor chips".
- Work like a human brain, because it is all fast logic calculations, comparisons, statistics and programming, programmed by humans (Prof Nadia Thalmann, IMI). But the gap between AI and humans could narrow considerably "if biotechnology improves over time". "We can imagine having robots, for example, built with real cells and organs … then if robots are bio-robots, the difference between humans and robots capacity will be lesser and lesser," she said.

Internet of Things

Perhaps not in the too distant future…

Internet of Things

Where we are now..

Near future: Internet of Intelligent Things (appliances with embedded intelligence and learning capabilities; extreme learning machines, smart materials and sensors, moving data centres [e.g., cars, trains, humans, robots]).

Future: Society of Intelligent Things: Coexistence of intelligence of living things and non-living things (machine intelligence).

Skynet?

Example: AI-powered smart surveillance camera networks: allow multiple cameras to "work together" to recognise a person or object from different angles in real time → improve public safety, transportation, healthcare, manufacturing etc.

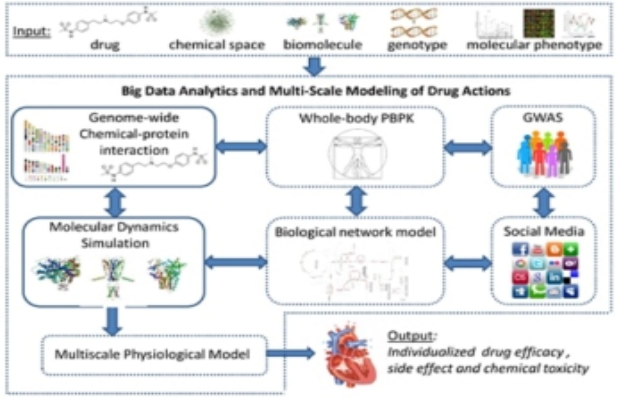
Biology/ Biomedicine is the Next Frontier for Data Science

The Next Big Thing in Data Science is …. Biology

Posted by William Vorhies on June 19, 2018 at 7:55am View Blog

Summary: *Computational Synthetic Biology (CSB) is likely to be both the next big thing and perhaps most important field to exploit data science. As the name implies, this lies at the intersection of data science and biological research. Big advancements and big investments are already starting to occur here. Data scientists with deep learning skills will want to check this out.*

And the next big thing in data science is *(wait for it)* – biology! Actually **Computational Synthetic Biology (CSB)** sometimes referred to as 'computational systems biology' or simply 'synthetic biology'.



From the biological researcher's perspective CSB broadly refers to the design and fabrication of biological components and systems that don't already exist in the natural world or to the redesign and fabrication of existing biological system.

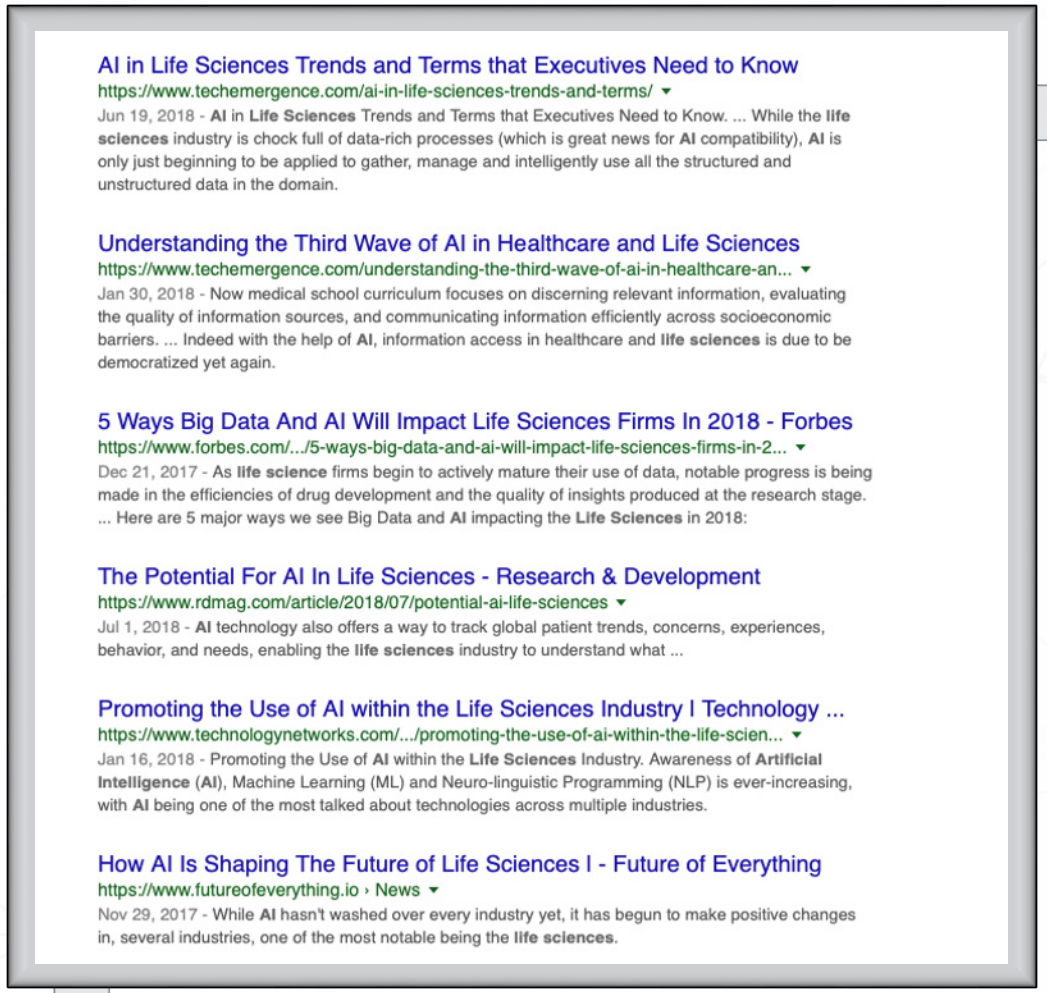
To the data scientist and particularly the start-up world CSB is a newly emerging field that will capitalize on advances in deep learning.

Depending on your personal sense of priority, CSB will remarkably accelerate cures to some of mankind's most intractable diseases or be the foundation for the next generation of unicorns in the time frame of 5 to 7 years.

Perhaps the better way to frame this is which would you rather be working on, facial recognition to label your friends faces in Facebook, creating chatbots for that travel platform, or working to cure cancer and extend quality human lifetimes.

Source: https://www.datasciencecentral.com/profiles/blogs/the-next-big-thing-in-data-science-is-biology

AI Features Prominently as a Key Tool for Driving Biomedical Data Science



AI in Life Sciences Trends and Terms that Executives Need to Know
https://www.techemergence.com/ai-in-life-sciences-trends-and-terms/
Jun 19, 2018 - **AI** in **Life Sciences** Trends and Terms that Executives Need to Know. ... While the **life sciences** industry is chock full of data-rich processes (which is great news for **AI** compatibility), **AI** is only just beginning to be applied to gather, manage and intelligently use all the structured and unstructured data in the domain.

Understanding the Third Wave of AI in Healthcare and Life Sciences
https://www.techemergence.com/understanding-the-third-wave-of-ai-in-healthcare-an...
Jan 30, 2018 - Now medical school curriculum focuses on discerning relevant information, evaluating the quality of information sources, and communicating information efficiently across socioeconomic barriers. ... Indeed with the help of **AI**, information access in healthcare and **life sciences** is due to be democratized yet again.

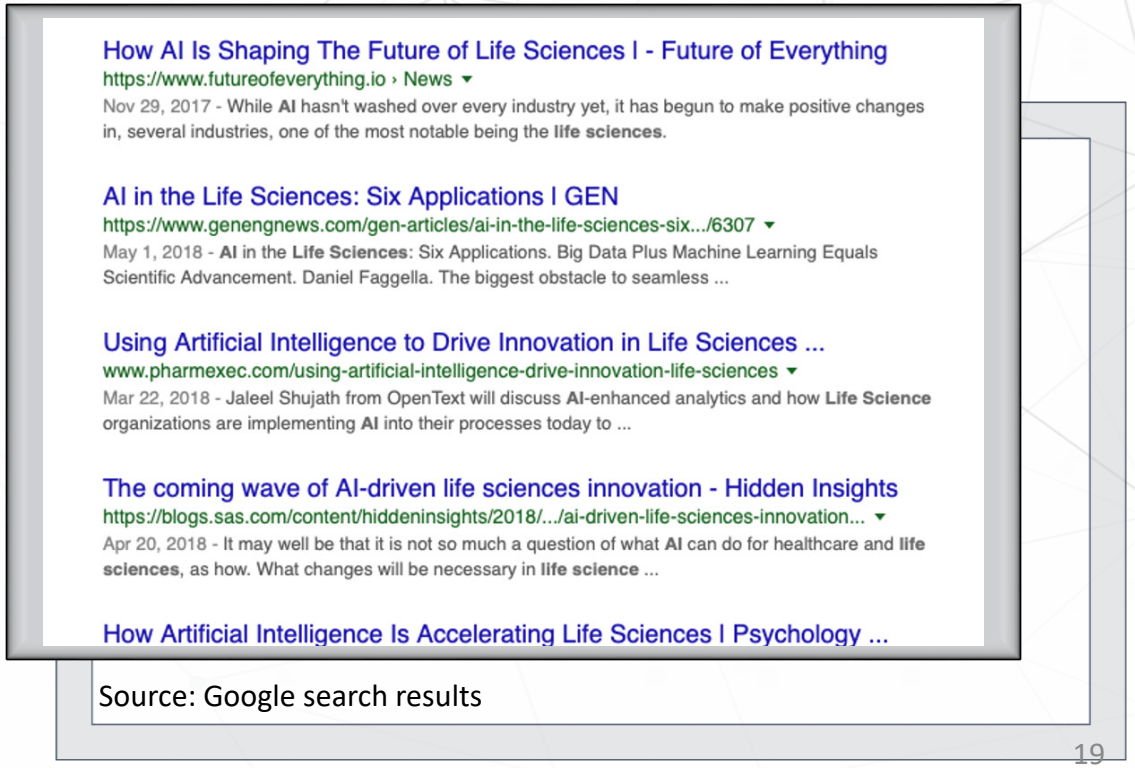
5 Ways Big Data And AI Will Impact Life Sciences Firms In 2018 - Forbes
https://www.forbes.com/.../5-ways-big-data-and-ai-will-impact-life-sciences-firms-in-2...
Dec 21, 2017 - As **life science** firms begin to actively mature their use of data, notable progress is being made in the efficiencies of drug development and the quality of insights produced at the research stage. ... Here are 5 major ways we see Big Data and **AI** impacting the **Life Sciences** in 2018:

The Potential For AI In Life Sciences - Research & Development
https://www.rdmag.com/article/2018/07/potential-ai-life-sciences
Jul 1, 2018 - **AI** technology also offers a way to track global patient trends, concerns, experiences, behavior, and needs, enabling the **life sciences** industry to understand what ...

Promoting the Use of AI within the Life Sciences Industry | Technology ...
https://www.technologynetworks.com/.../promoting-the-use-of-ai-within-the-life-scien...
Jan 16, 2018 - Promoting the Use of **AI** within the **Life Sciences** Industry. Awareness of **Artificial Intelligence** (**AI**), Machine Learning (ML) and Neuro-linguistic Programming (NLP) is ever-increasing, with **AI** being one of the most talked about technologies across multiple industries.

How AI Is Shaping The Future of Life Sciences | - Future of Everything
https://www.futureofeverything.io › News
Nov 29, 2017 - While **AI** hasn't washed over every industry yet, it has begun to make positive changes in, several industries, one of the most notable being the **life sciences**.

Source: Google search results



How AI Is Shaping The Future of Life Sciences | - Future of Everything
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AI in the Life Sciences: Six Applications | GEN
https://www.genengnews.com/gen-articles/ai-in-the-life-sciences-six.../6307
May 1, 2018 - **AI** in the **Life Sciences**: Six Applications. Big Data Plus Machine Learning Equals Scientific Advancement. Daniel Faggella. The biggest obstacle to seamless ...

Using Artificial Intelligence to Drive Innovation in Life Sciences ...
www.pharmexec.com/using-artificial-intelligence-drive-innovation-life-sciences
Mar 22, 2018 - Jaleel Shujath from OpenText will discuss **AI**-enhanced analytics and how **Life Science** organizations are implementing **AI** into their processes today to ...

The coming wave of AI-driven life sciences innovation - Hidden Insights
https://blogs.sas.com/content/hiddeninsights/2018/.../ai-driven-life-sciences-innovation...
Apr 20, 2018 - It may well be that it is not so much a question of what **AI** can do for healthcare and **life sciences**, as how. What changes will be necessary in **life science** ...

How Artificial Intelligence Is Accelerating Life Sciences | Psychology ...

Source: Google search results

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Societal Considerations Involved in the use of AI Technology

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Anti-terrorism or Terrorism Tool?

Source: Consulting, CS. “MICRO DRONES KILLER ARMS ROBOTS - AUTONOMOUS ARTIFICIAL INTELLIGENCE - WARNING !!” *YouTube*, YouTube, 16 Nov. 2017, www.youtube.com/watch?v=TlO2gcs1YvM.

Social Control in China

NBRbizrpt. (2017, June 19). Airports roll out facial recognition technology. Retrieved from https://www.youtube.com/watch?v=bTX-fbNDG8Q

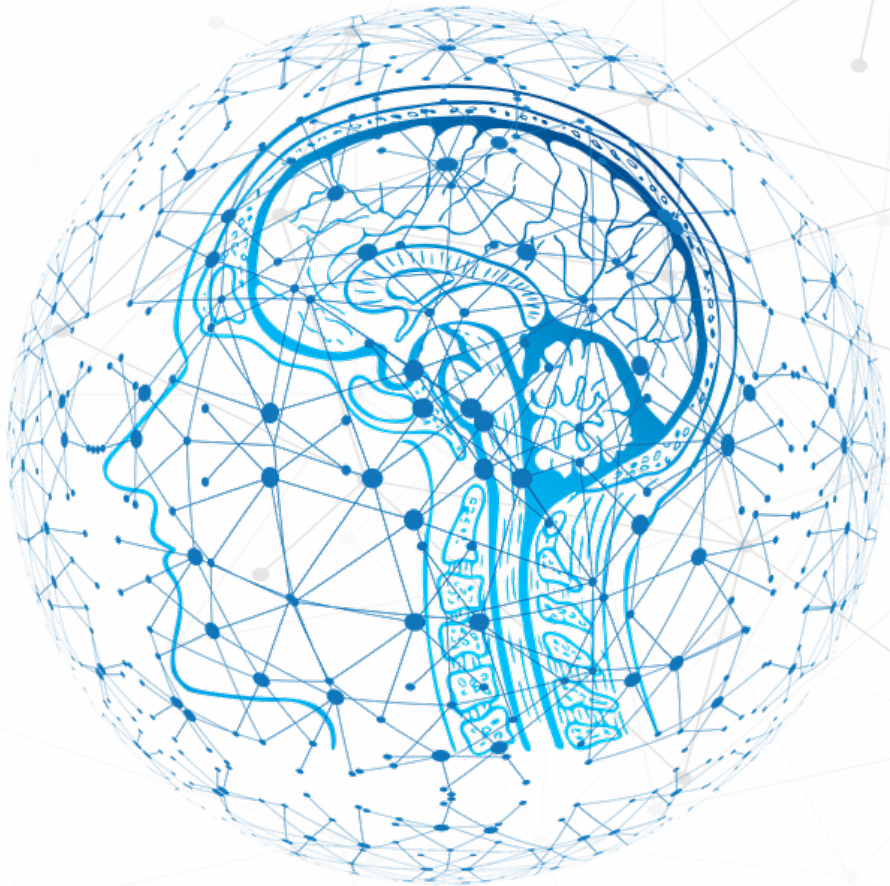
Is this scenario worth considering for now?

By Source, Fair use,
https://en.wikipedia.org/w/index.php?curid=22186885

Probably not!

Be Realistic

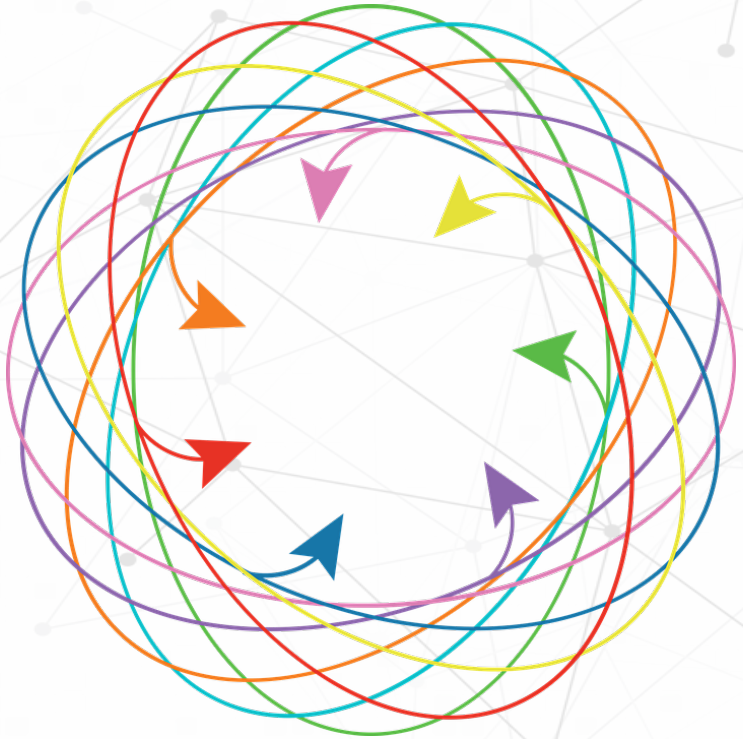
It is more useful to think of AI as computer systems or algorithms which have the capacity to replace human decision-making in both the public and private spheres.



What is more likely for now?

- AI systems will operate *“invisibly”,* automating information flows between different stakeholders inside the background processes that directly affect our lives.

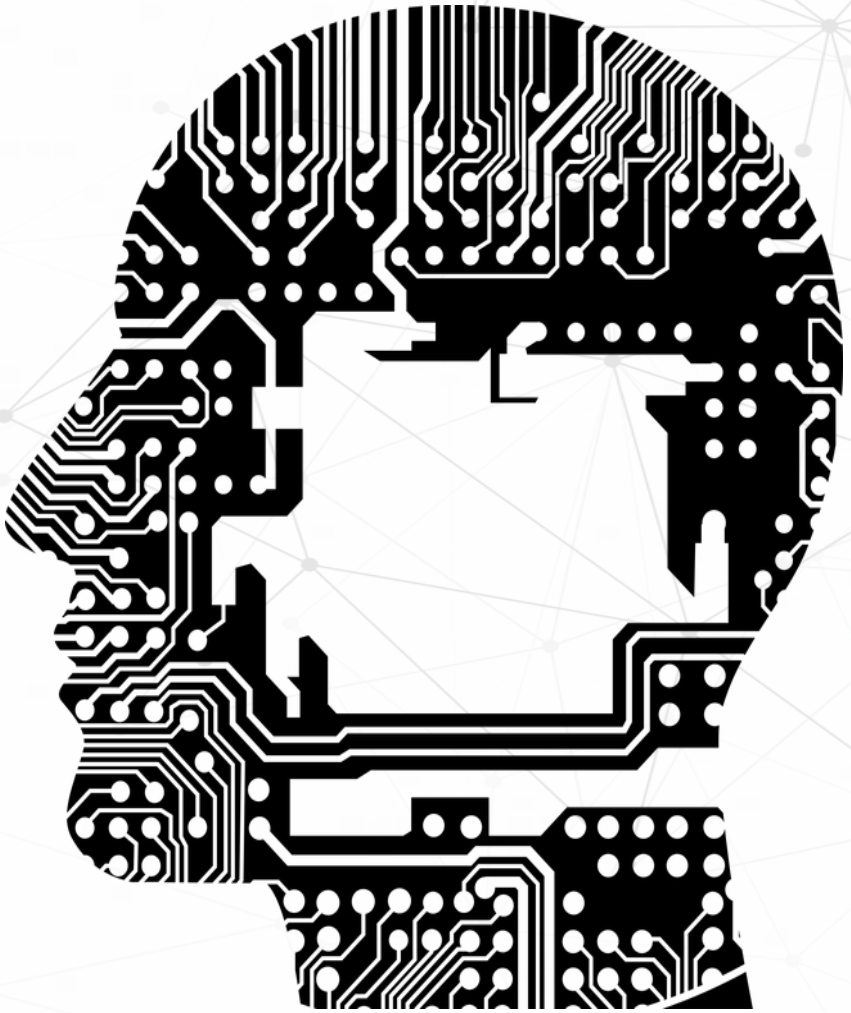
- This can range from seemingly benign processes such as the posts we see on Facebook *(not so benign after recent scandals), or* the movie recommendations we get on Netflix, to more consequential processes such as credit rating and predicting recidivism rates for individuals.



Impact on the Labor Market

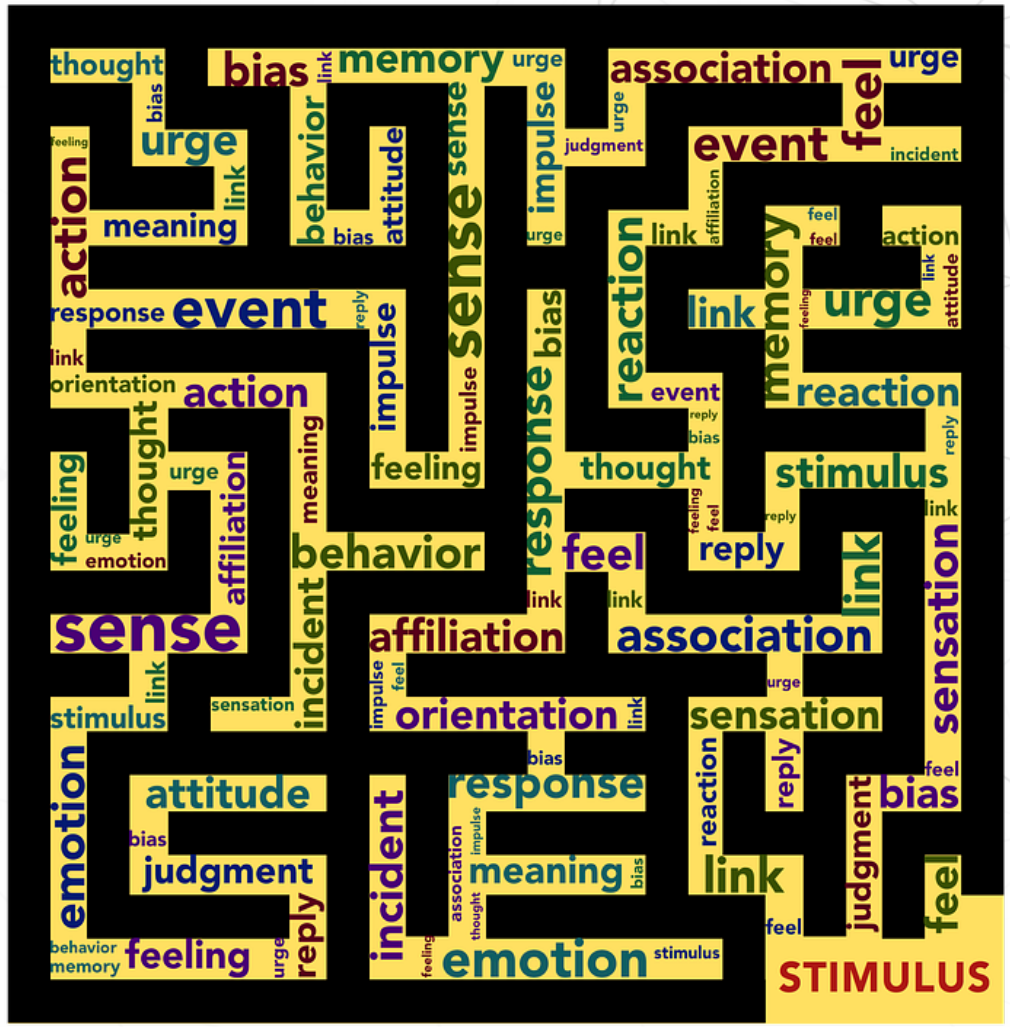
Will the AI take over your job?

Probably not.



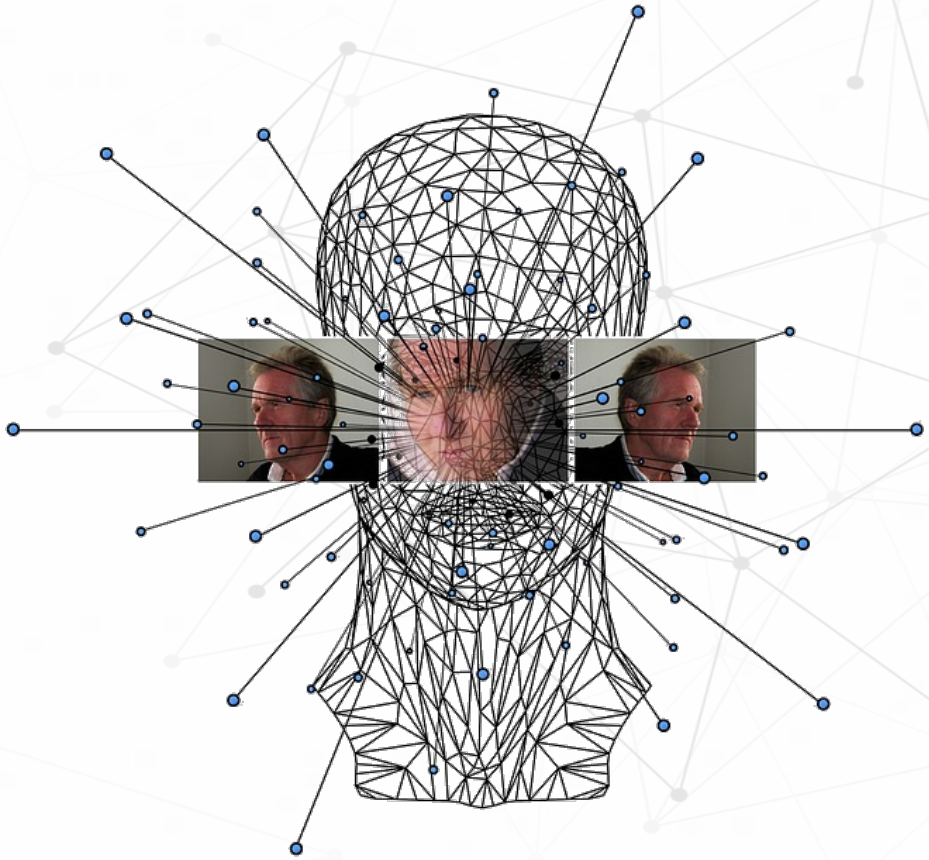
Bias in AI Systems

AI systems can potentially reinforce biases existing in society today.



AI, Politics and Governments

- AI provides a range of advanced pattern recognition tools that, if built on top of this *"surveillance"* apparatus, would significantly reduce the costs of government oppression, destabilise existing sociopolitical arrangements, and erode notions of objective truth.
- Recent examples include Cambridge Analytica.



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Co-evolution with AI

Examples using Biotechnology Education

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What do we mean by co-evolution?

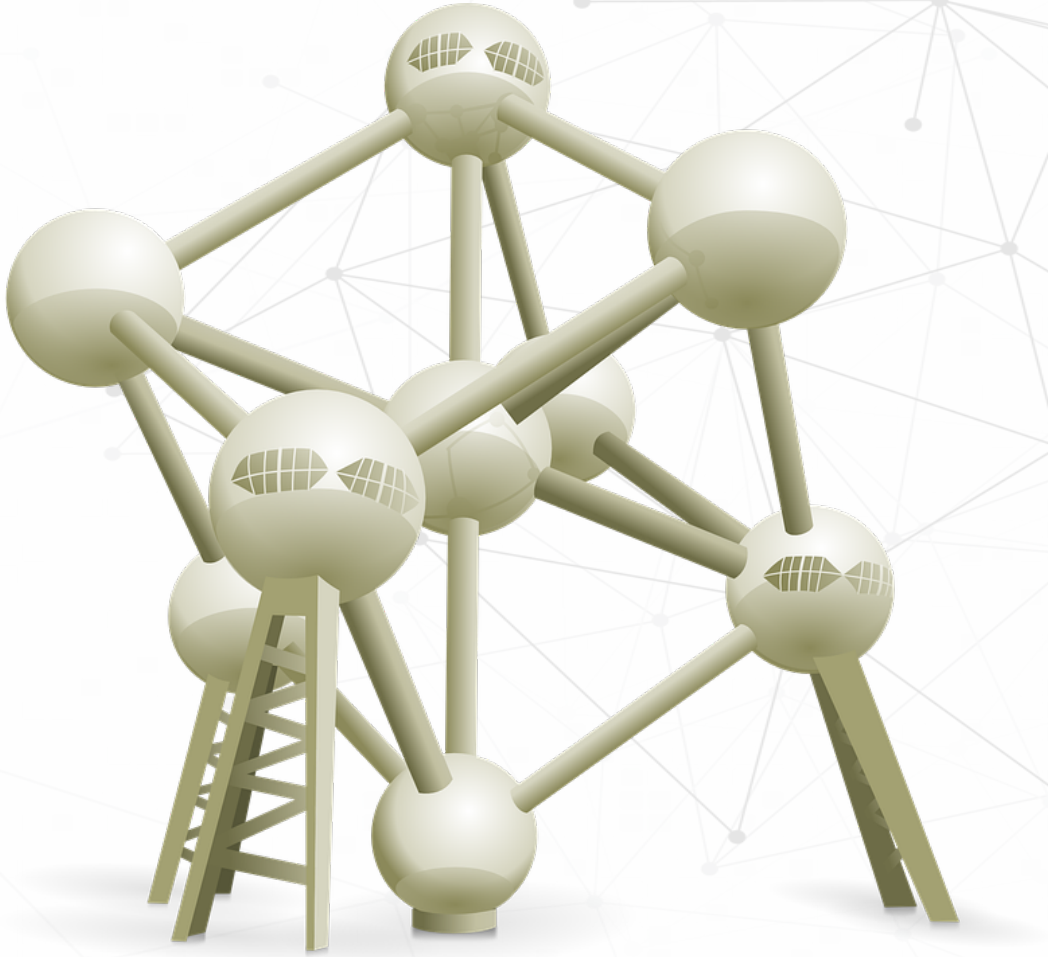
- New AI technologies are powerful.
- But if we really want to tap on these technologies effectively, we also need to co-evolve to keep pace with these new developments.
- In other words, smarter tools need “smarter” humans.
- Let us look at biotechnology education as an example.

Biotechnology is Built on an Interdisciplinary Network of Knowledge

- Biotechnological innovation depends on drawing meaningful connections within vast knowledge networks via synergistic co-learning, discussions and collaborations amongst inter-disciplinary specialists.

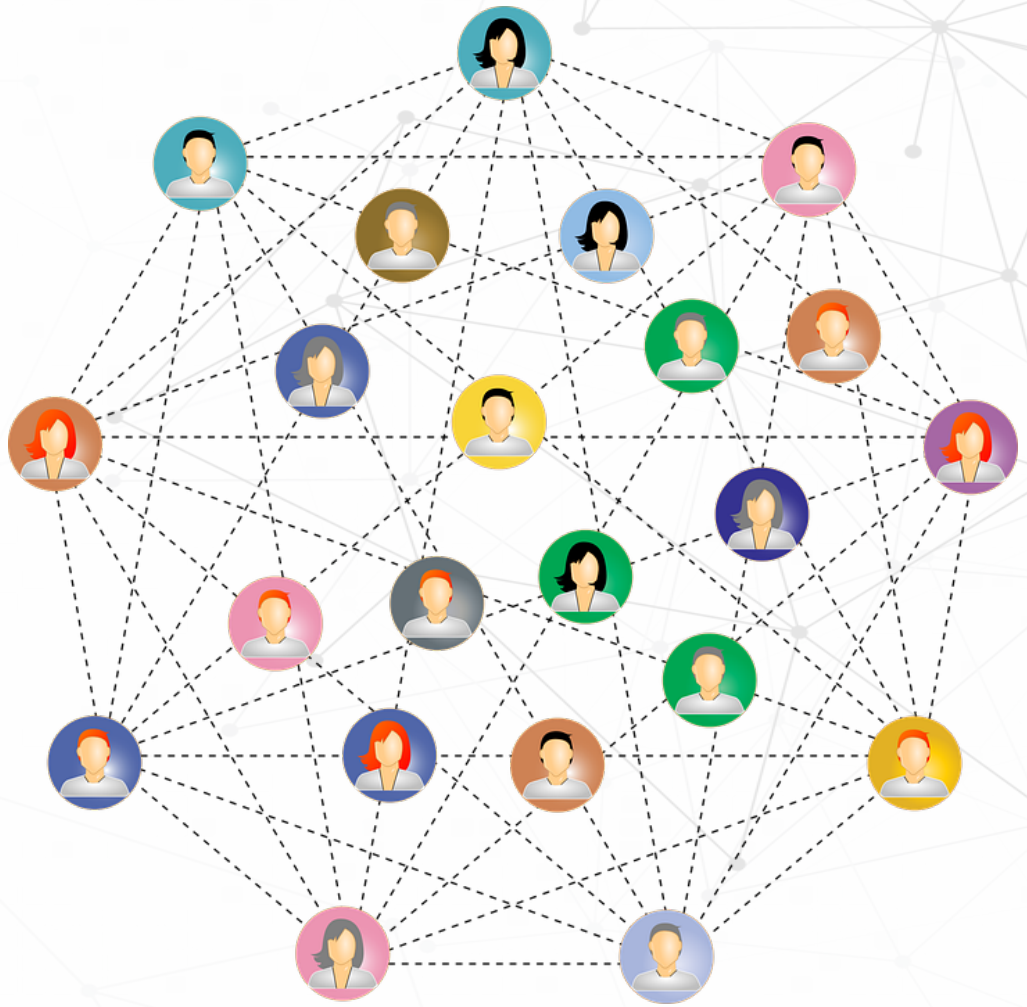
- If you want to draw meaningful links successfully. You may do the following:
  - Learn faster and more efficiently.
  - Have an AI help you make these interesting knowledge connections (suggestions).

https://linkinghub.elsevier.com/retrieve/pii/S0167779918302622



AI for Learning

- AI should not be perceived merely as a tool for advancing biotechnology, but also for more *effectively learning* it in two notable ways:
  - Help you learn faster via facilitating adaptive learning (AL).
  - helping make meaningful links by modeling knowledge as networks and identifying potentially interesting connections.



Adaptive Learning AI

- AI-driven adaptive learning technologies involves the use of advanced data analytics to profile users, predict behaviours, and provide specific mitigations for altering behaviours towards desired outcomes.
- AL collects real-time information on the learner's engagement with the teaching material. It then provides personalisation of the learning experience depending on one's prior knowledge, learning style, real-time performance on assignments, etc.
- The personalisation aspect could involve dynamic difficulty adjustment of the source material for online-based learning.

Examples of Adaptive Learning AI

Institutional Adoption Example	Technology Deployed
Pearson Education **Nanyang Technological University (Lee Kong Chian Medical School)**	IBM-Watson (Element and Enlight): https://www.ibm.com/watson/education What it is: Tools for real-time classroom monitoring and curriculum planning with an AI backend.
University of New South Wales	Smart-Sparrow: https://www.smartsparrow.com/ What it is: Adaptive online learning platform for providing customised learning experience via their adaptive pathways, feedback and analytics modules.
University of Arizona	Knewton (Alta): https://www.knewton.com/ What it is: An integrative platform that consolidates data science, statistics, psychometrics, content graphing, machine learning, tagging, and infrastructure to enable upscaled personalised learning.
Colorado Technical University	Intellipath What it is: A smart learning platform that allows students to direct their learning, while also capable of strengths analysis and 'change' how the course progresses in order to best address those personal learning needs.

Forging Links within Knowledge Networks

- AI technologies are evolving, and are being taught to “think” without being fed large amounts of data.
- Can rapidly peruse scientific publications.
- Generate hypotheses automatically.
- The implication is that AI can make the links within knowledge networks and then teach this insight to a human learner who now need only to invest significantly less time.
- This is aided by:
  - Reinforcement Learning (Learning that does not require perfect or large amounts of data).
  - Deep Learning (Facilitates complex decision-making by modelling AI as neural networks, not unlike the neural connections found in the human brain).

Examples of AI-driven Knowledge Modelling

Semantic Scholar
https://www.semanticscholar.org/

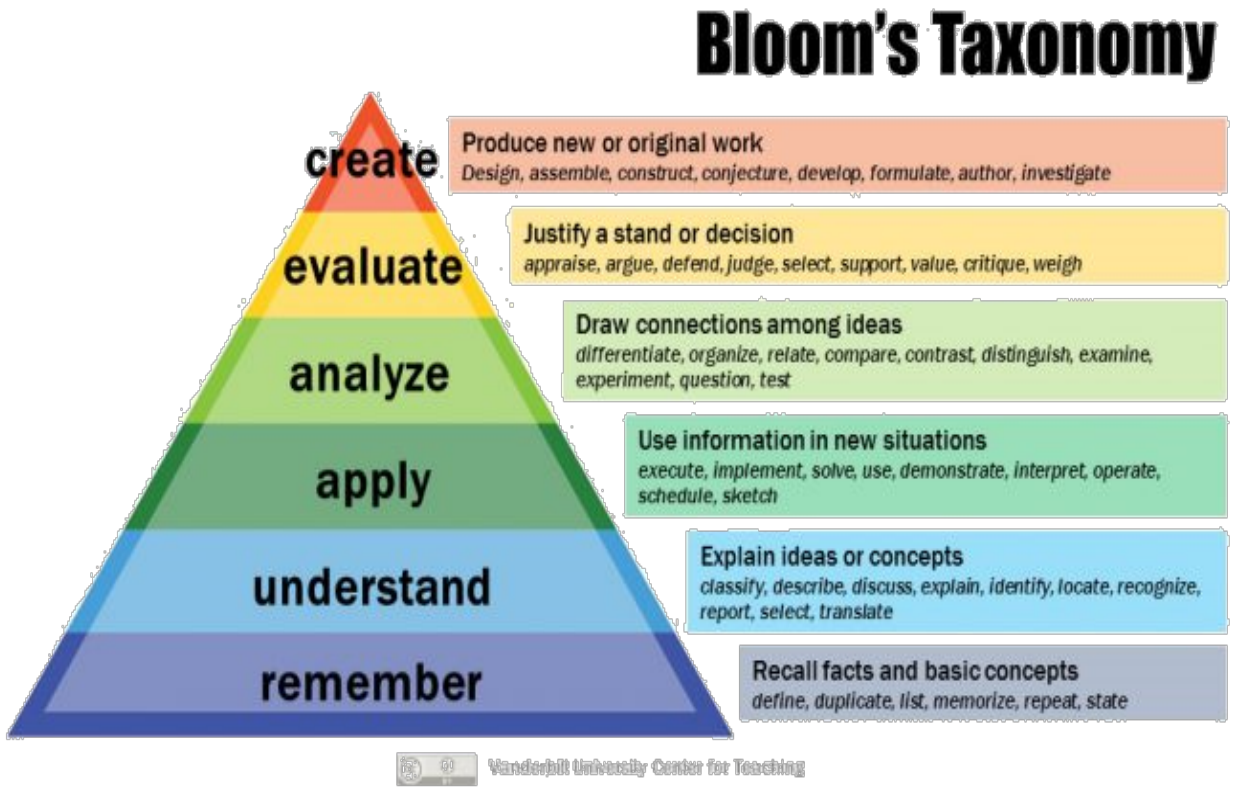
What it is: It is an AI-powered search engine that reads, extracts information and categorises findings from published research papers. It is meant to provide meaningful evaluation of a paper's worth via meta-analysis. It is hoped that it would become advanced enough to become a hypothesis engine that can guide scientists towards the bigger picture or to adopt alternative perspectives towards problem-solving.

Knowledge Integration Toolkit (KnIT)
https://dl.acm.org/citation.cfm?id=2623667

What it is: It is an automated hypothesis generator (from text-mining of scientific literature) and is based on IBM Watson. One of its earliest (and promising) deployments is in predicting links and interactions between proteins via data-mining. This accelerates work on understanding the functional properties of proteins without excessive involvement in reading the literature or performing experiments.

Levels of Learning

- Having AIs do the heavy lifting for us seems like a great situation to be in. But where's the gap?
- There are many different levels of learning (from the superficial to the deep).
- Realistically, the AI can help you with levels 1 to 3. But can the AI help make you smarter? Going beyond level 4 will be a bottleneck, even if you are learning faster and more efficiently at the basic levels.



Smarter Tools Need “Smarter” Humans

- Achieving levels 1 to 3 faster means more time for education practices to work on promoting creative thinking and problem solving.
- Achieving scientific advances has little to do with superficial memorisation. It requires the ability to “actionate” and ”build on top” of the knowledge (Bloom’s taxonomy levels 4 onwards).
- Even with AI-enabling, the gap between theory and action will persist as this ultimately is a human problem. AI can help smoothen learning processes via AL, or provide new ideas. The “step-up” lies in cultivating self-reliant individuals with a penchant for deep learning and creative “action-ation”.
- Addressing the “theory-practice” gap ultimately still lies in high impact pedagogical practices.

Summary

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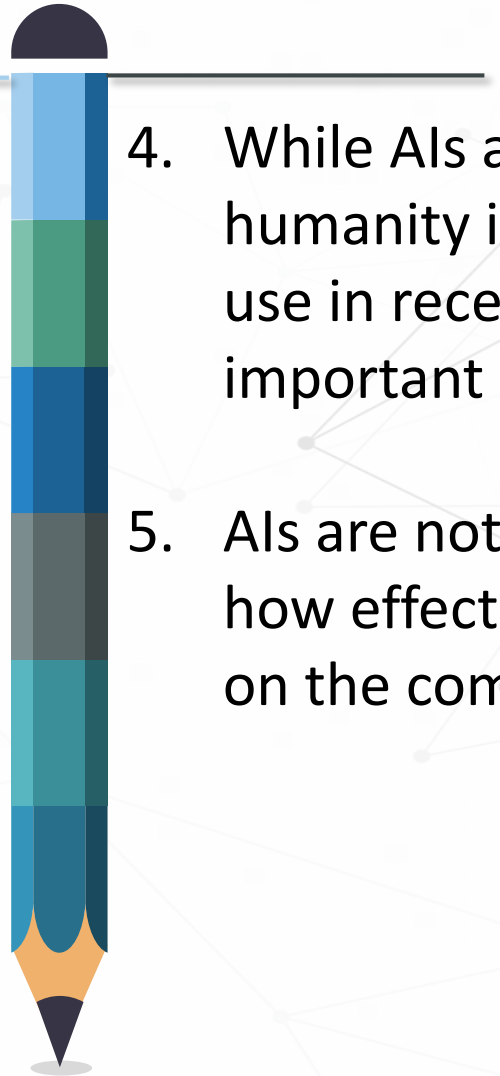
Key Takeaways from this Topic

1. An Artificial Intelligence (AI) is a program that can learn autonomously from data in order to effect a response.
2. AI architectures are modelled after human brains.
3. Applications running with an AI backend are endemic in our everyday lives.



4. While AIs are unlikely to obliterate humanity in the near future, its ab/use in recent times does raise important questions.
5. AIs are not omnipotent: Ultimately, how effective these are will depend on the competence of the user.