Applications of artificial intelligence in Healthcare and medicine

Introduction

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To be discussed

What is AI?

When AI was entered to medical literature?

What is new and not new about AI?

Which aspects of medicine and health was affected by AI?

What I have done until know

- ✓ Prediction of physicochemical properties of drugs using SVM, ANN, Classification methods etc
- ✓ Feature selection using GA based methods, clustering algorithms, etc
- ✓ Image analysis for the quantification of experimental results using CNN
- ✓ Drug effect prediction using supervised and unsupervised methods
- ✓ Drug-target interaction studies using molecular modeling methods
- ✓ Target discovery using various ML methods based on fingerprint similarity search methods
- ✓ Drug repurposing
- ✓ Solvent Design based on the combination of molecular modeling and machin learning methods
- ✓ Cryopreservation medium design (combined MD and ML)
- ✓ Biomaterial design
- ✓ Formulation Design
- ✓ Integration of chemometrics with biological evaluations
- ✓ Fine tuning and Rag of LLMs for the database generation

Using MATLAB, Knime, Python

What is AI about?

Replacing Us?

Equipping Us?

What is AI about?

Equipping Us

with smarter tools to tackle challenges like medication errors, personalized treatments, and even global health crises.

AI complements human capabilities rather than replacing them

What is Artificial Intelligence (AI)?

AI refers to machines or software that simulate human intelligence.

What is Artificial Intelligence (AI)?

AI involves tasks like learning, decision-making, and pattern recognition.

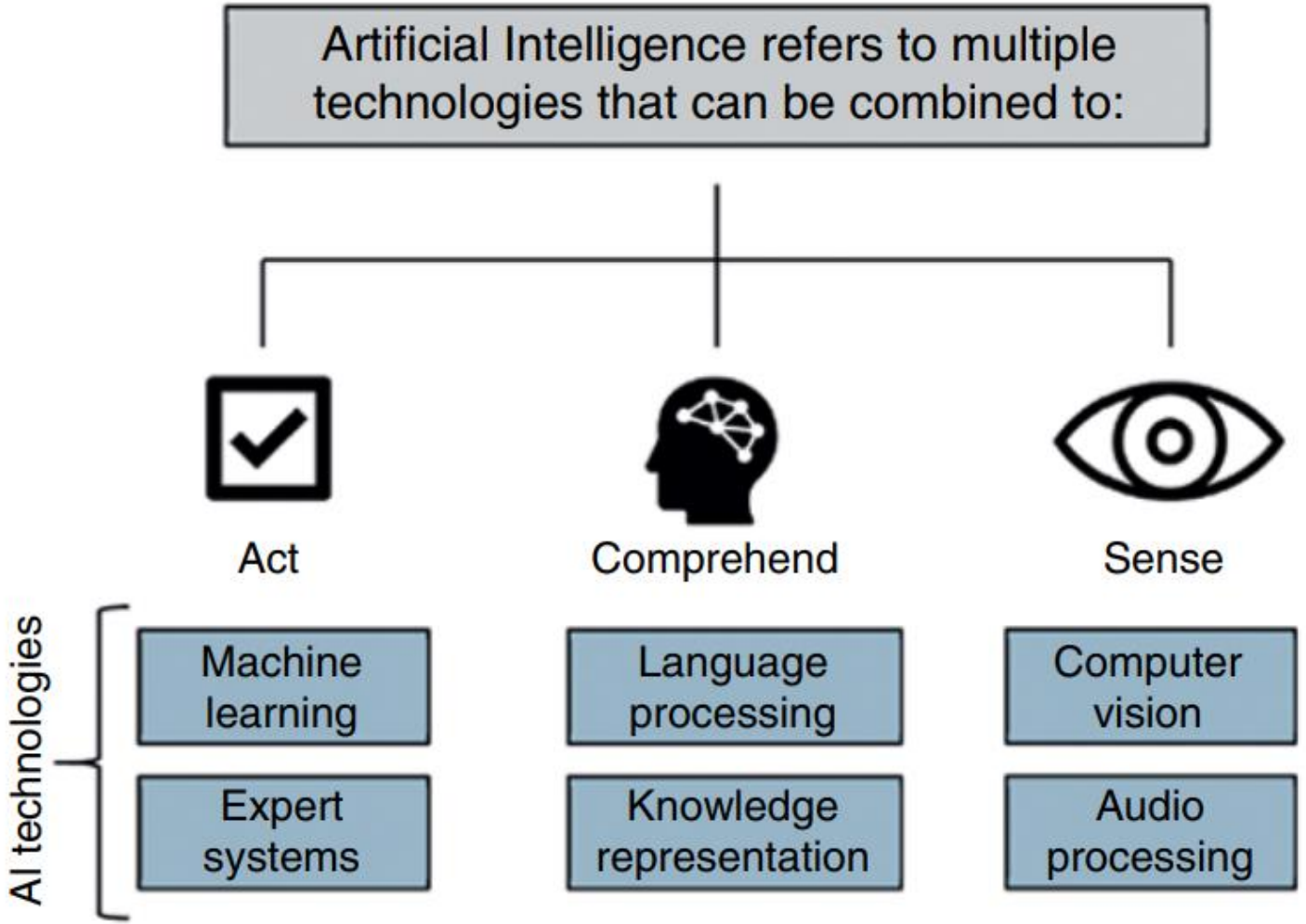


FIGURE 1.2 *(source: Accenture)*[16]

The ability of AI systems to recognize objects has improved markedly to the point where the best systems now exceed human performance

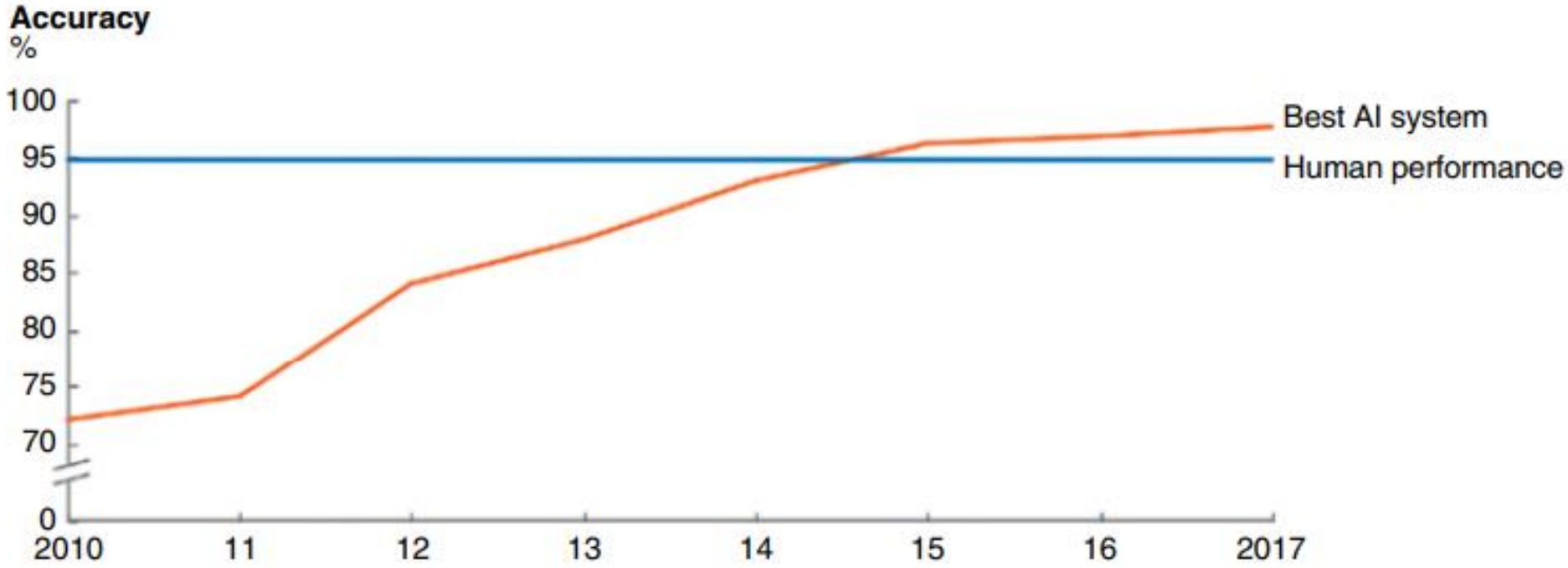
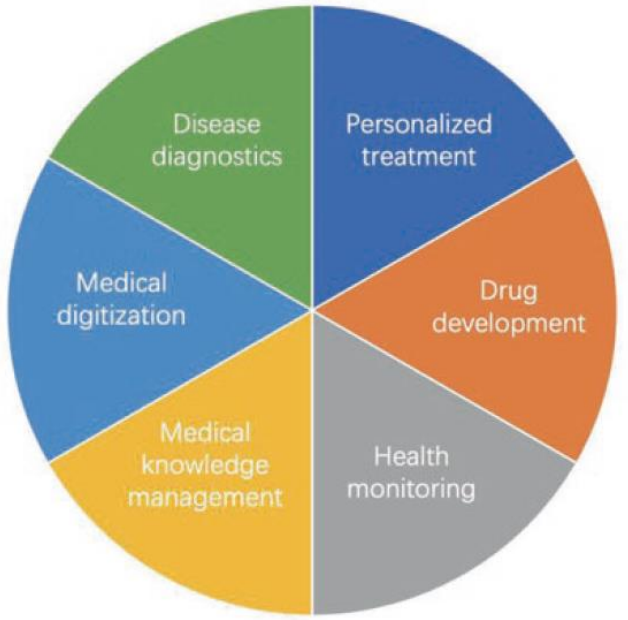


FIGURE 1.6 ***(source: McKinsey Global Institute analysis/****https://www.mckinsey.com/~/media/mckinsey/featured%20insights/artificial%20intelligence/notes%20from%20the%20ai%20frontier%20applications%20and%20value%20of%20deep%20learning/notes-from-the-ai-frontier-insights-from-hundreds-of-use-cases-discussion-paper.ashx)*[23]

AI in healthcare and medicine

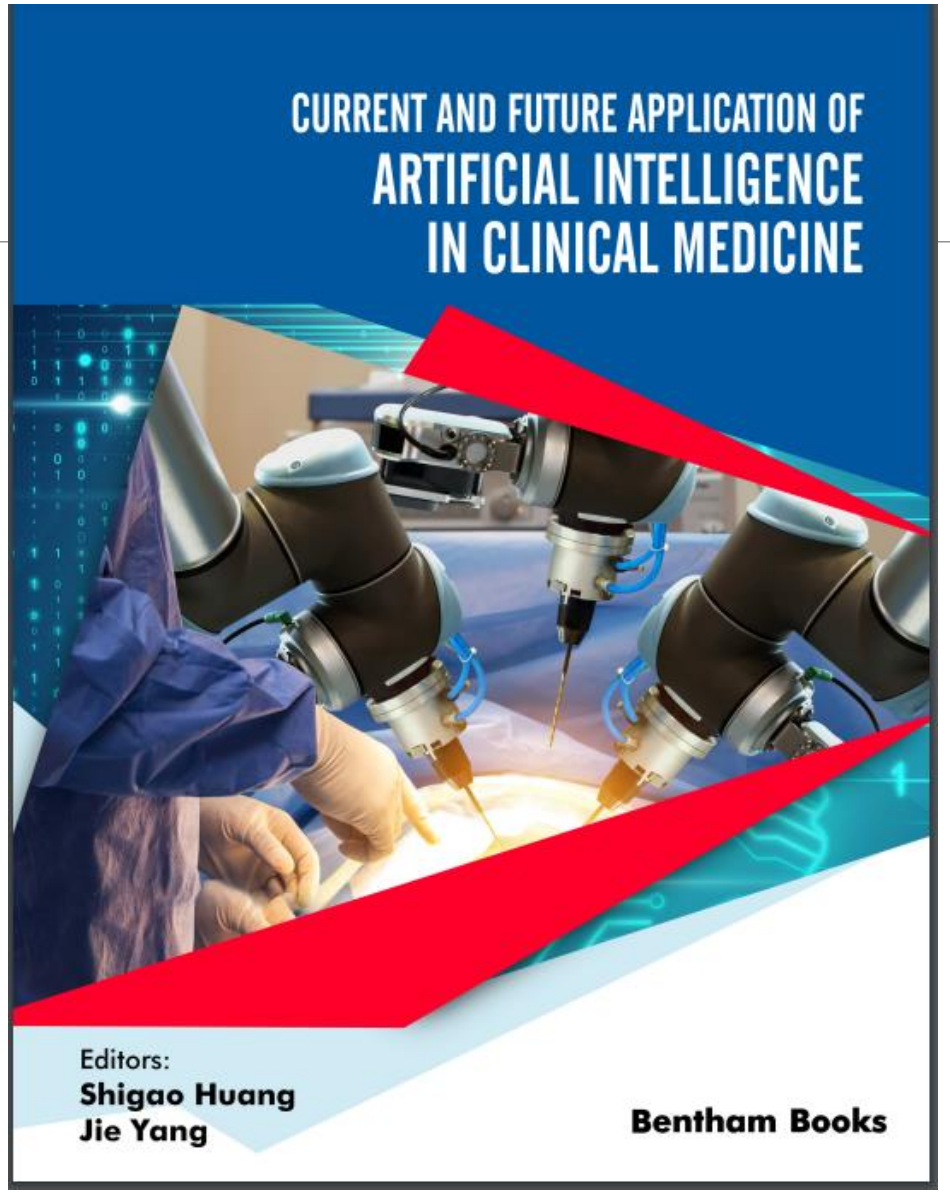
Physical: integration of hardware and advanced AI software (facilitated by internet of medical things)

- Drug discovery and pharmacotherapy
- Diagnosis
- Treatment
- Management and education
- Care delivery and management
- Selfcare, prevention, wellness
- Research
- Ethical and legal challenges
- Technical challenges



Virtual: ML algorithms: Software

“In 2019, the Chinese Academy of Sciences published its core magazine “the Internet Weekly” and listed the TOP 100 AI cases, “ [9], 17 of which are directly relevant to the application of AI in the medical and public health industry, as shown in Table 1”



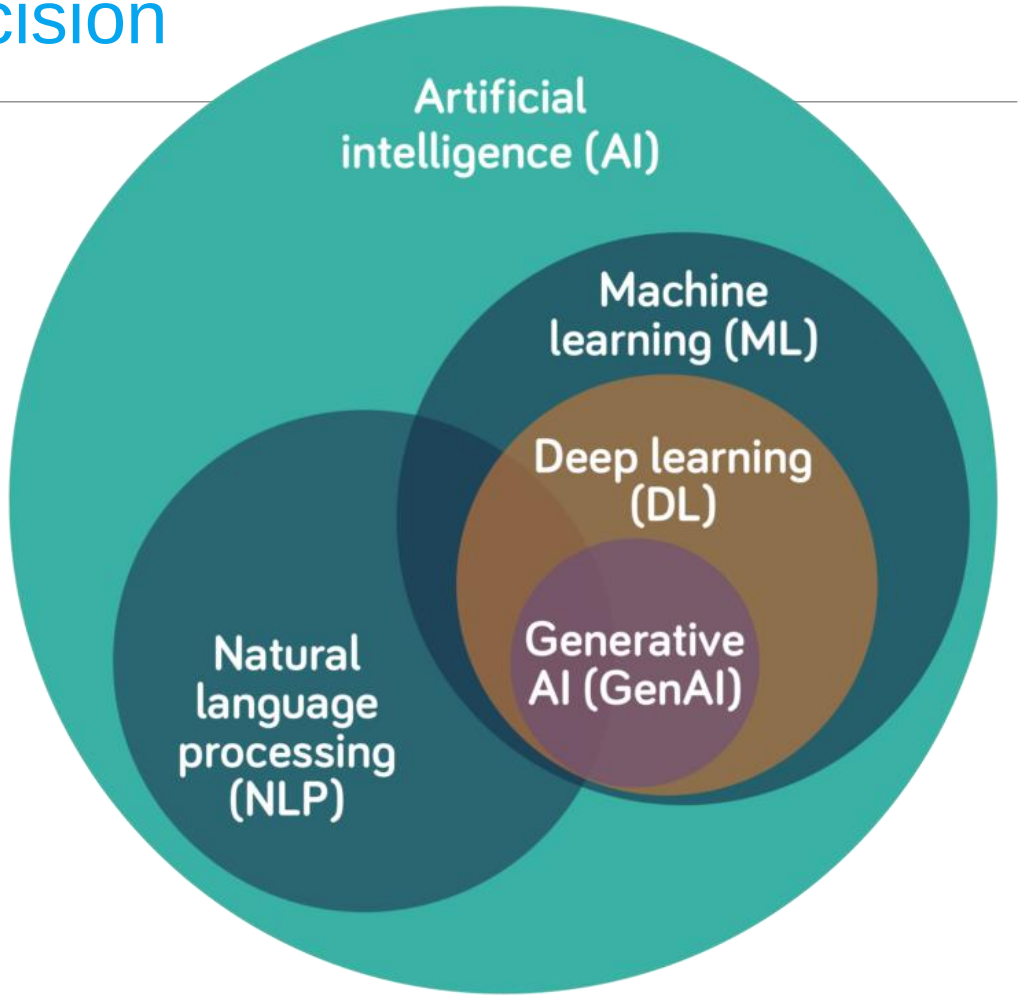
17%

No.	Procurement	Tender	Case
1	Health Commission of Ningbo	YiduCloud	Ningbo Comprehensive Surveillance and Service Platform
2	Tianjin Diabetes Screen and Transfer Platform	VoxelCloud	VoxelCloudRetina Disease Screening
3	Guangzhou Baiyun Airport	CloudWalk	AI Epidemic Prevention and Detection
4	Shanghai Jiaotong University	Ping An Healthcare & Technology Company	One Minute Doctor by Ping And Good Doctor
5	First Affiliated Hospital of Kunming Medical University	HiAR	AR/5 COVID-19 3D Digital Internet-based Remote Consultation System
6	The Fifth Affiliated Hospital of Sun Yat-Sen University	Huiyi Huiying	Dr. Turing COVID-19 AI Screening System
7	China-Japan Friendship Hospital	Deepwise	Computer Aided Diagnosis for Micro Pulmonary Nodules
8	Peking University Shougang Hospital,Wuhan Huoshenshan Hospital, Beijing Haidian Hospital, Zhengzhou Qiboshan Hospital	Cheetah Mobile	AI Robot Medical Solution for COVID-19
9	Renji Hospital,School of Medicine, Shanghai Jiaotong University	Kyee Group	Mobile Medical Solution
10	Sichuan Province People's Hospital	PereDoc	AI Smart Medical Integral Solution
11	Obstetrics & Gynecology Hospital of Fudan University	Wondersgroup	AI Clinical Aided Solution for Advanced Aged Pregnancy
12	Changsha Public Security Bureau	Centrin Ciyun	NLP-based Medical Corpus Recognition Application
13	Linyi Shandong Energy Mining Group Co. Ltd	Luculent	AI-enabled Equipment Management and Diagnose Platform
14	Central Hospital of Qinghe County	Xueyang Technology	AI Early Warning Solution for Myocardial Infarction and Apoplexy
15	Haidian Administrative Service Hall, Haidian Mudanyuan Subway Station	Megvii	AI-enabled Temperature Screening Solution

What is AI?

Input data → **AI model** → output decision

- **Artificial Intelligence (AI)** as the broadest category.
- **Machine Learning (ML)**, which is a subset of AI focused on learning from data.
- **Deep Learning (DL)**, a more advanced subset of ML, focusing on complex neural networks.
- **Natural Language Processing (NLP)**, which deals with how machines understand and process human language, and can be applied across AI, ML, and DL.
- **Generative AI (GenAI)**, which is a specific application of AI that focuses on creating new content, like text, images, or music.



Analytics continue to evolve, increasing in maturity over time

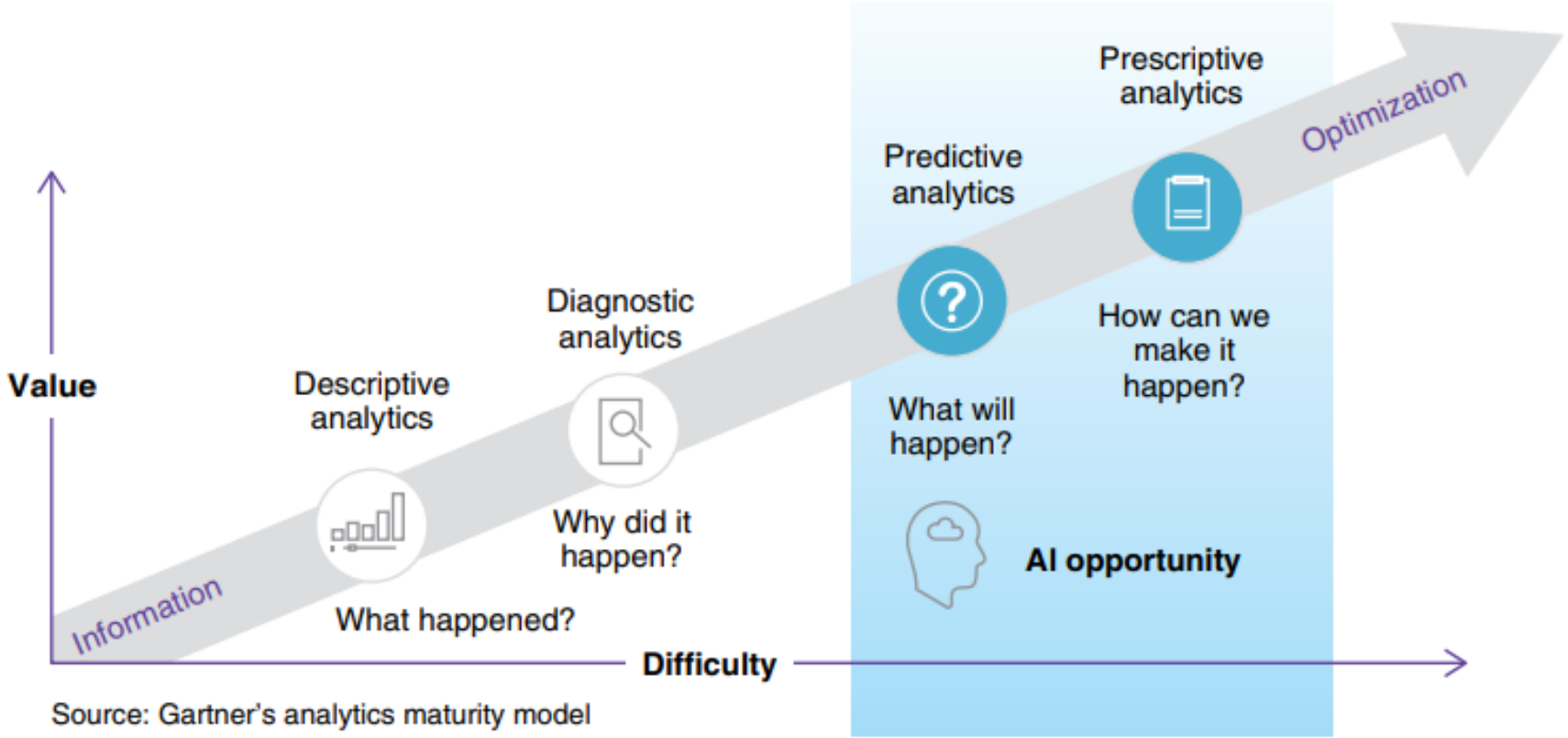


FIGURE 1.7 *(source: Gartner/McKinsey & Company)*[24]

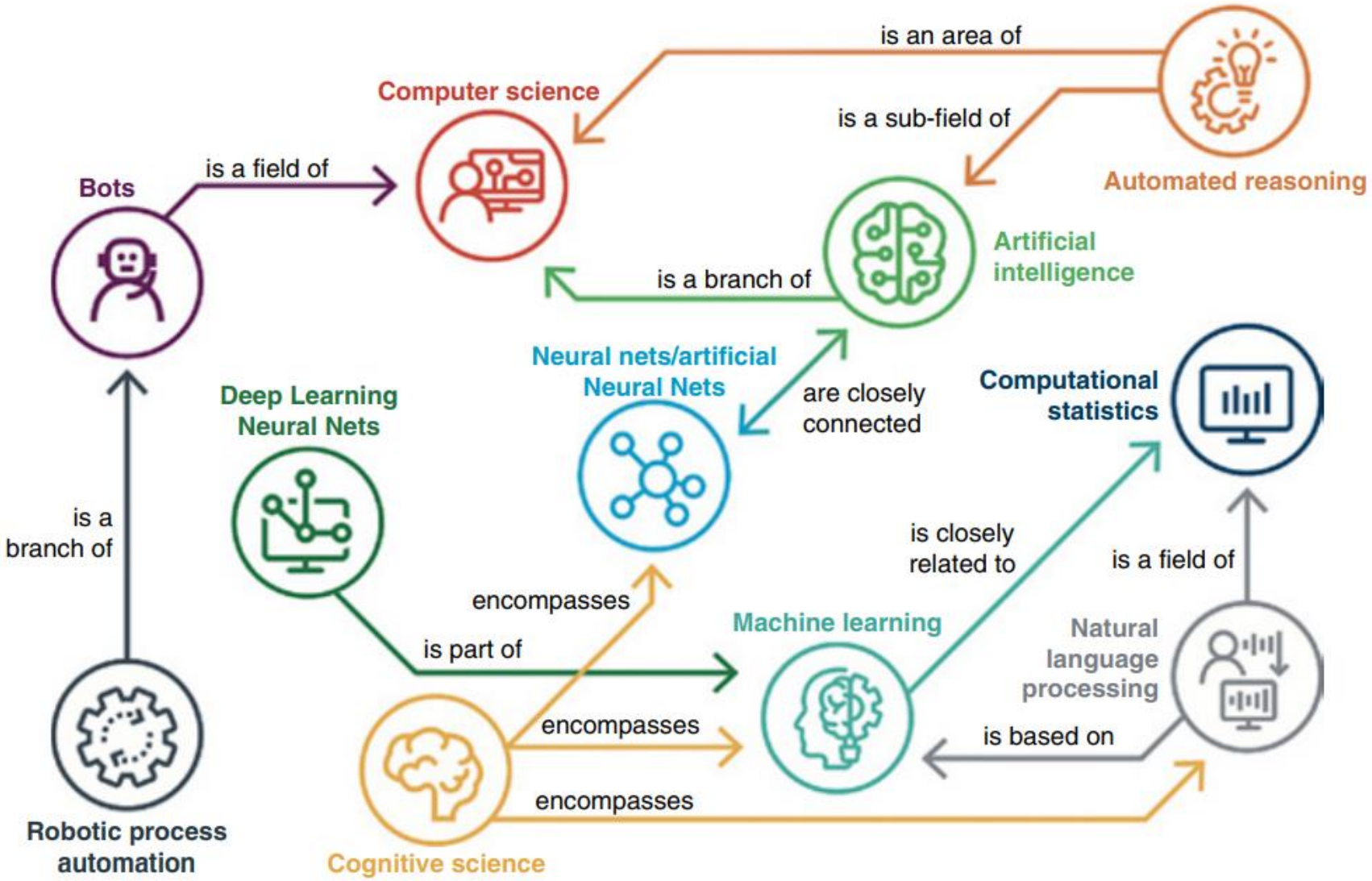
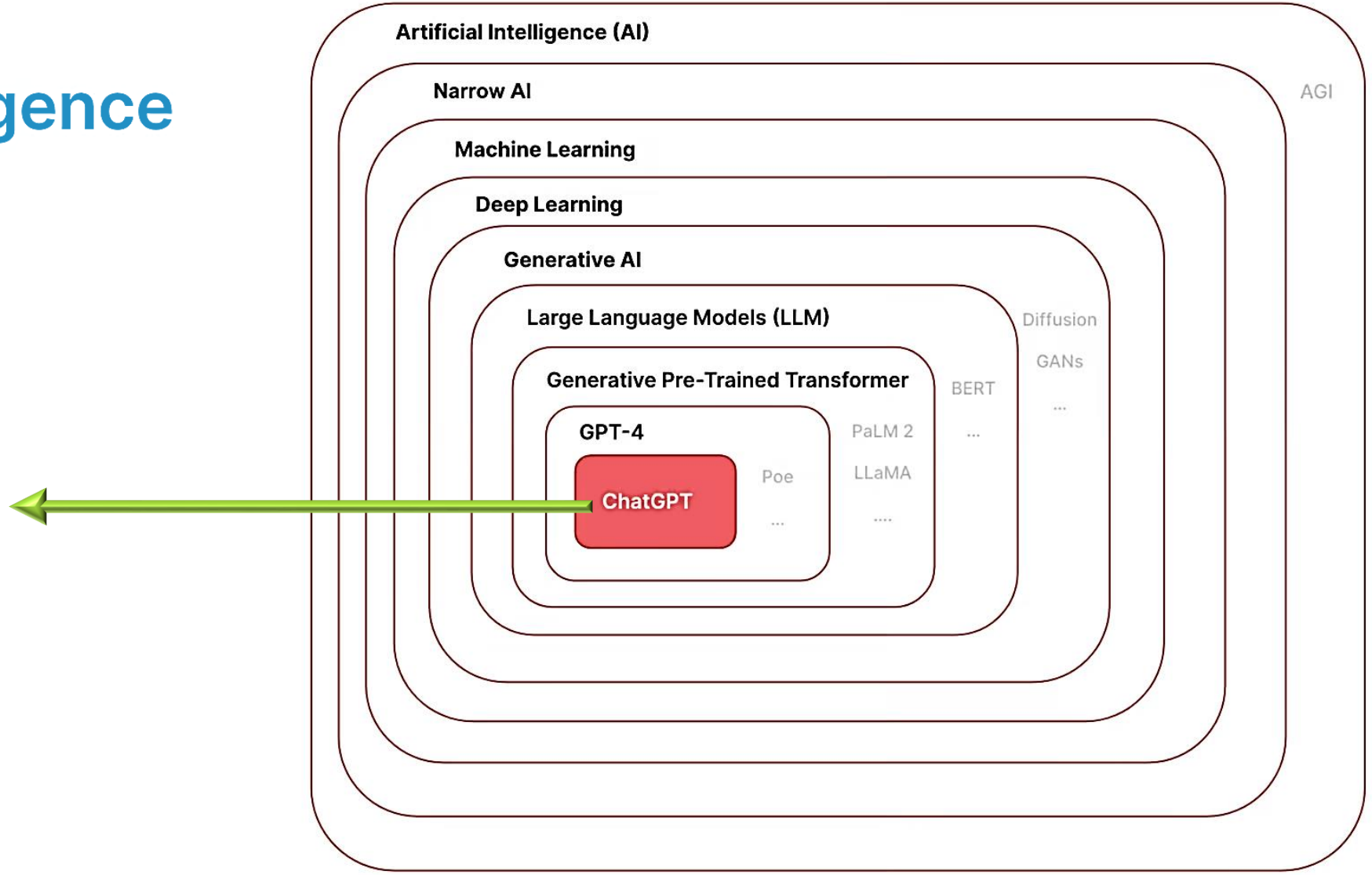


FIGURE 1.4 *(source: IQVIA)*[19]

Artificial Intelligence Taxonomy

What else?



https://www.gptechblog.com/5-diagrams-to-help-you-understand-generative-ai/

How AI works?

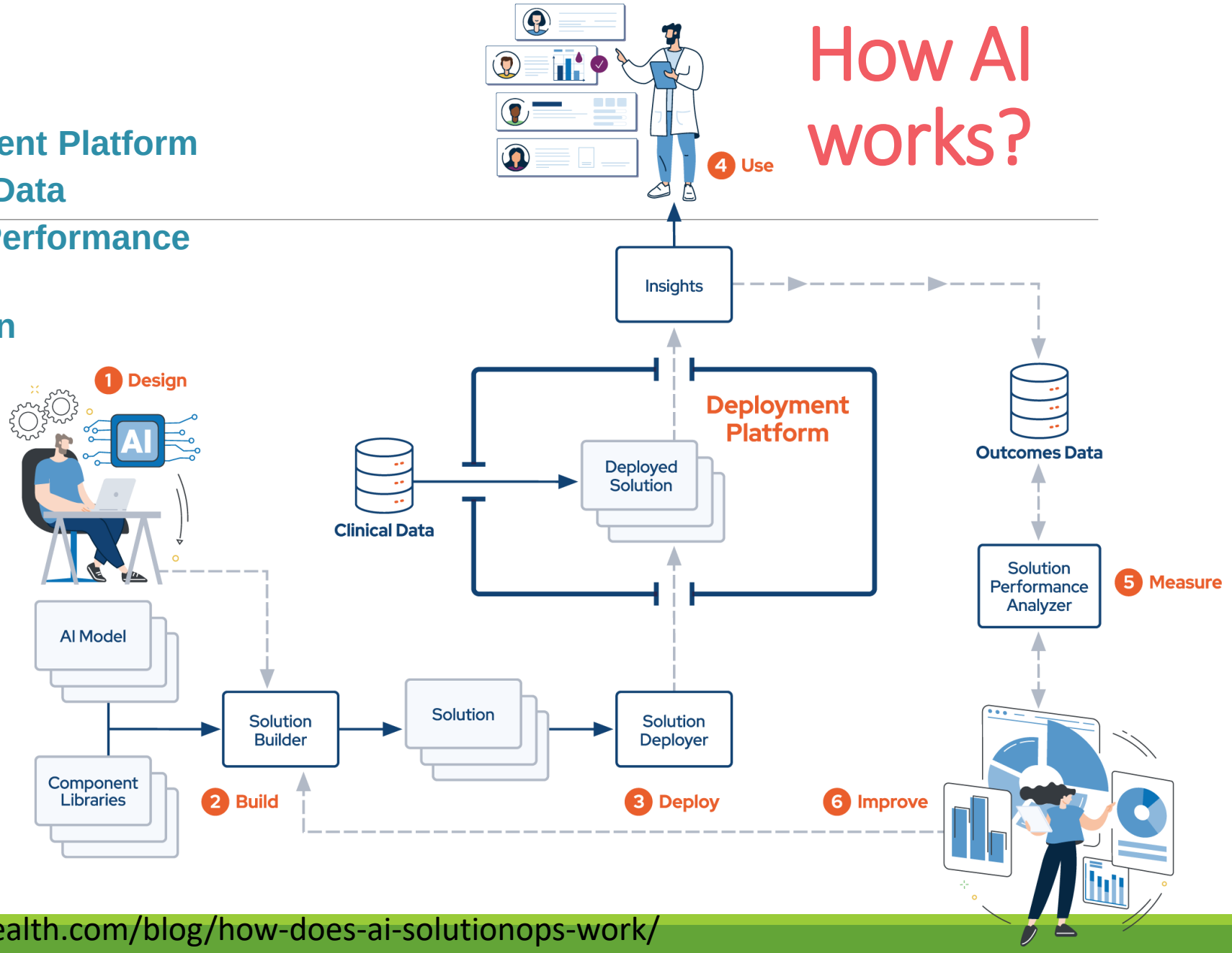
A: Foundation
- Clinical Data
- AI Model
- Component Libraries

B: Development
- Solution Builder

C: Deployment
- Solution
- Solution Deployer
- Deploy

D: Analysis
- Insights
- Development Platform
- Outcome Data
- Solution Performance Analyzer

E: Optimization
- Improve
- Measure

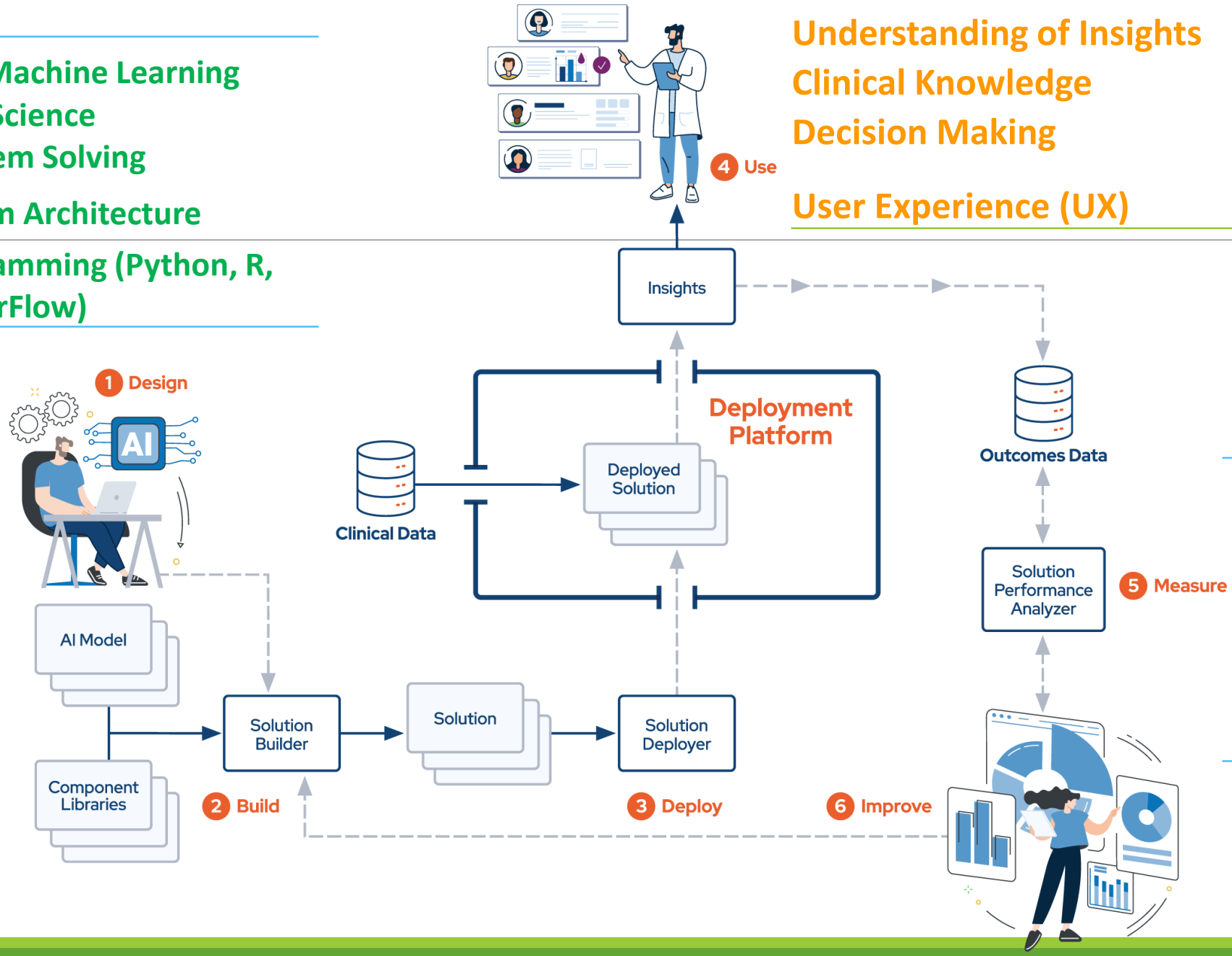


https://lucemhealth.com/blog/how-does-ai-solutionops-work/

AI & Machine Learning
Data Science
Problem Solving
System Architecture
Programming (Python, R, TensorFlow)

Understanding of Insights
Clinical Knowledge
Decision Making
User Experience (UX)

Necessary skills!

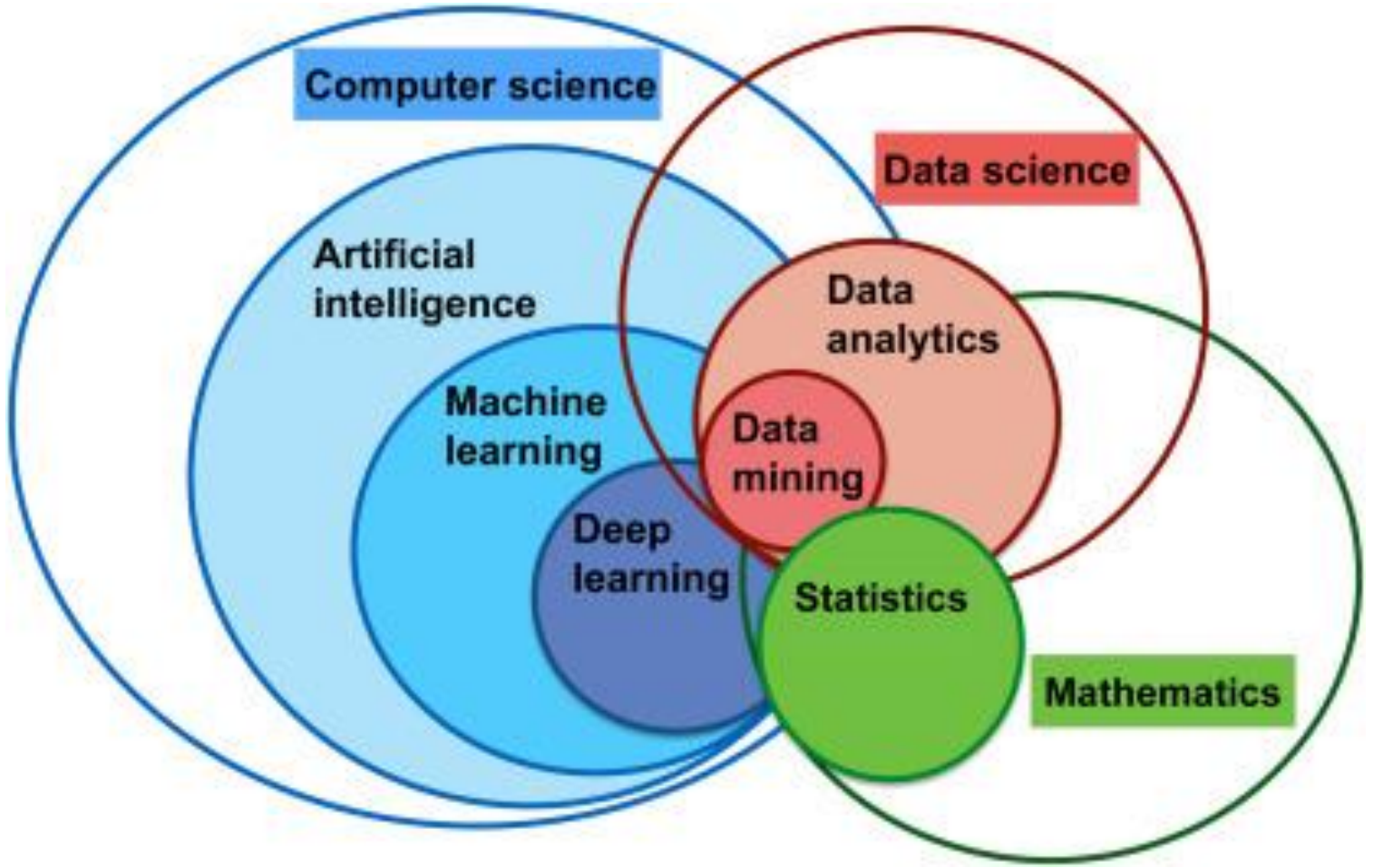


Performance Analysis
Data Analytics
Optimization
Technical Expertise
Iteration & Testing

Are

you
or
your company
or
your data

AI-ready?



AI-ready	Key Requirements	Examples	Applications/Outcomes
Persons	- Technical skills (Python, data analysis) - AI literacy - Adaptability - Critical thinking	Data scientists, healthcare professionals, lifelong learners	Enhanced decision-making, career growth, effective collaboration with AI tools
Companies	- Robust data infrastructure - AI talent - Ethical AI practices - AI strategy	Google, Amazon, hospitals using AI diagnostics	Improved efficiency, innovation, personalized customer experiences
Universities	- AI curriculum - Research labs - Interdisciplinary programs - Ethics training	MIT, Stanford, University of Toronto	Cutting-edge research, AI-skilled graduates, ethical AI development
Governments	- AI policy frameworks - Digital infrastructure - AI education initiatives - Ethical governance	EU (AI Act), Singapore (National AI Strategy), U.S. (AI research funding)	Public-sector AI adoption, ethical regulation, economic growth

The Story of AI

What's new and what's not new?

AI Doctor

The Rise of Artificial Intelligence in Healthcare

A Guide for Users, Buyers, Builders, and Investors

Ronald M. Razmi, MD

WILEY

Contents

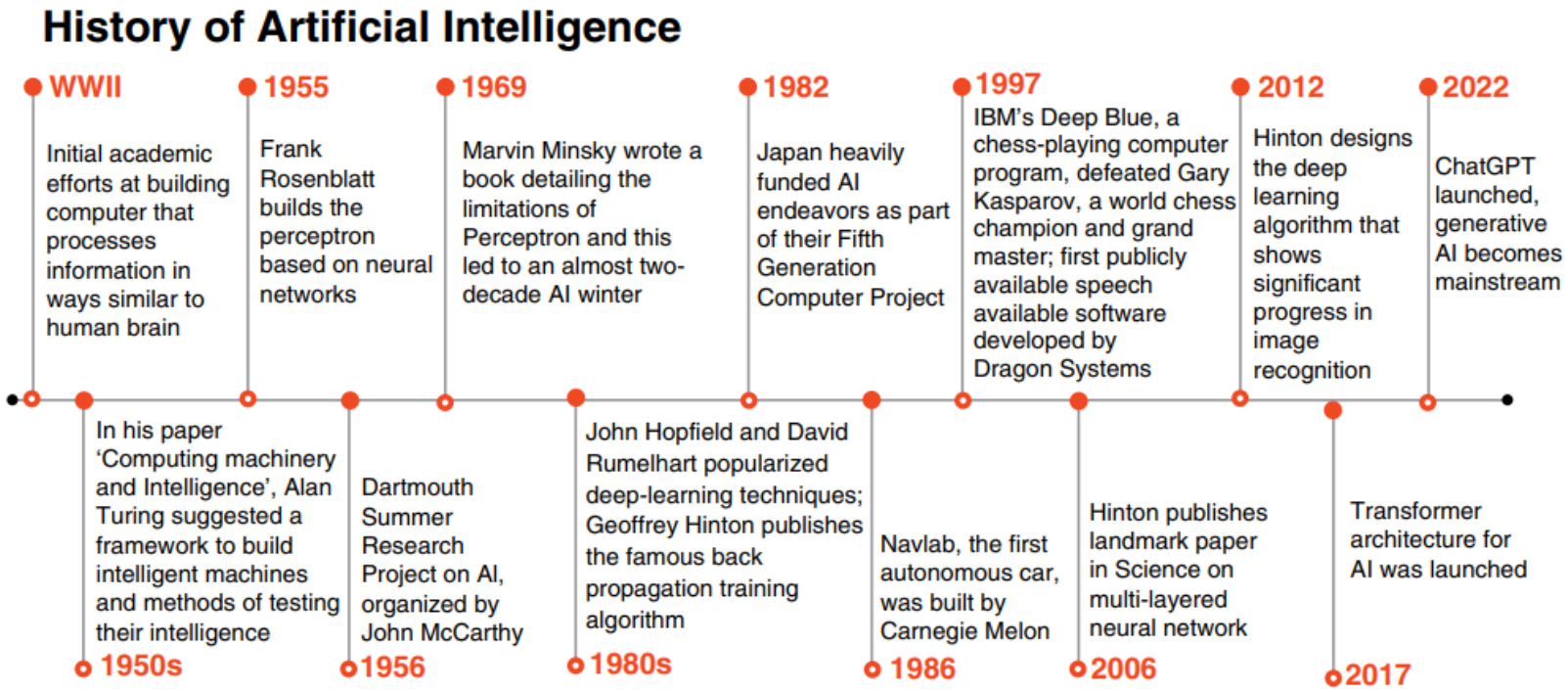


FIGURE 1.1 ***(source: original research[14])****: 1936–1969: Early progress, 1969–1986: AI winter, 1986: Hinton's paper on back propagation in neural networks, 1997–2012: Progress in AI methodologies: 1997 IBM beat Kasperov, 2007 ImageNet, 2011 IBM beat Jeopardy, 2012–Present: Rapid progress in deep-learning applications*

William B. Schwartz, M.D.

Beginning in the 1970s, Schwartz developed an interest in medical decision-making, and was an early researcher into artificial intelligence applications to medicine.

"Medicine and the computer: the promise and problems of change. Use and Impact of Computers in Clinical Medicine" N Engl J Med 1970; 283:

> Rapid advances in the information sciences, coupled with the political commitment to broad extensions of health care, promise to bring about basic changes in the structure of medical practice. Computing science will probably exert its major effects by augmenting and, in some cases, largely replacing the intellectual functions of the physician.

A victim of Alzheimer forgetfulness

Why AI in medicine and healthcare

"Artificial intelligence (AI) is a new **technical discipline** that uses computer technology to **research** and **develop** the **theory, method, technique**, and **application system** for the **simulation, extension, and expansion of human intelligence**"

Current Medical Science
DOI https://doi.org/10.1007/s11596-021-2474-3 41(6):1105-1115,2021

Application of Artificial Intelligence in Medicine: An Overview

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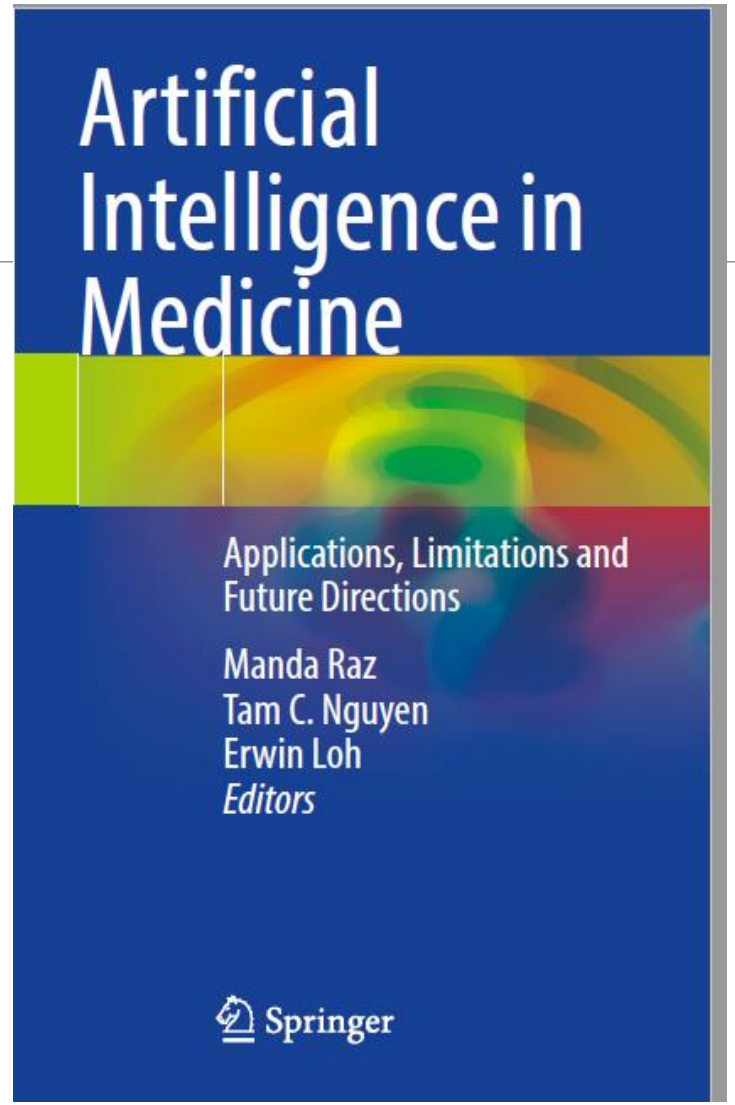
AIM refers to the specialized application of AI technology within the medical domain



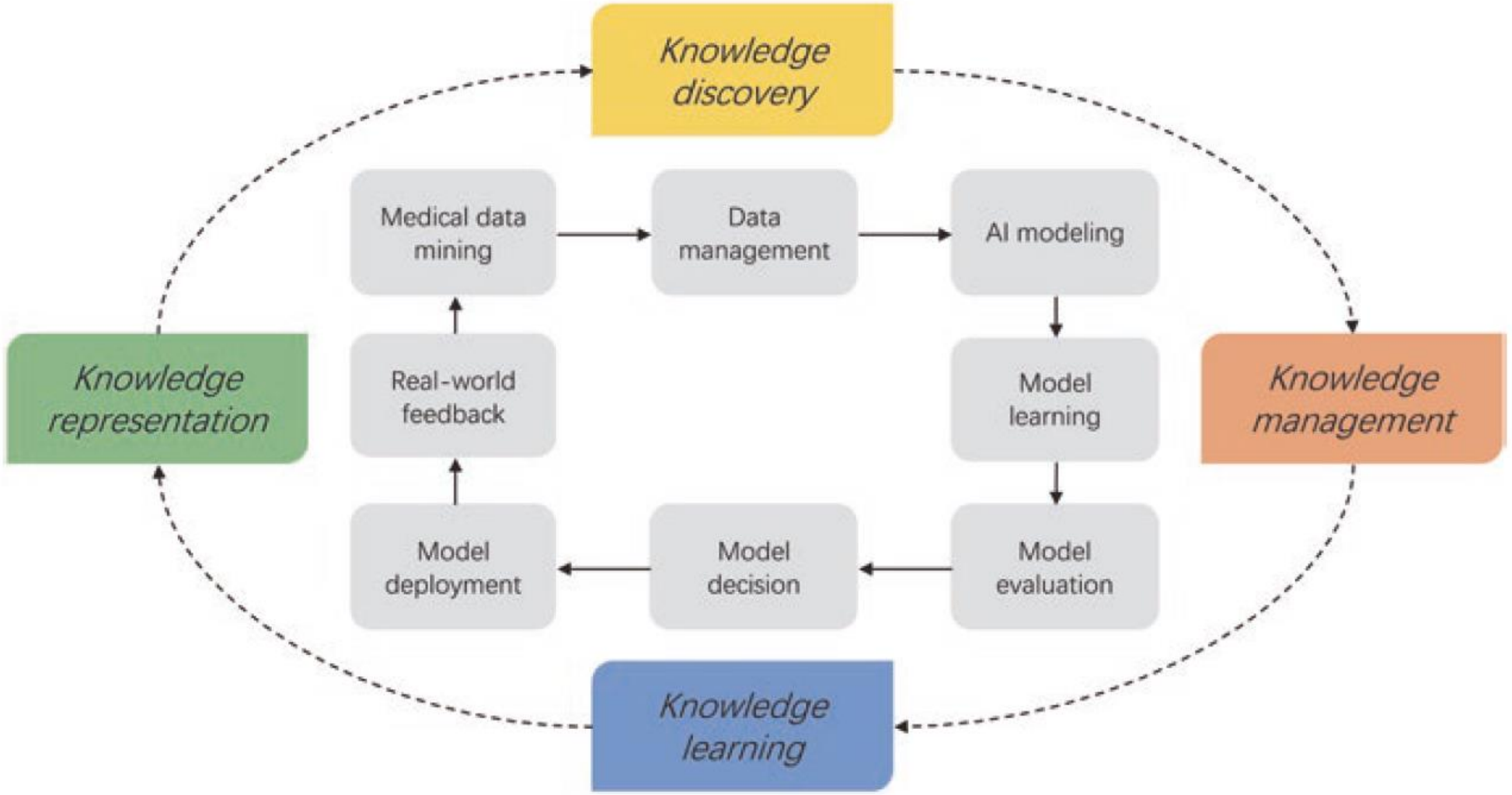


Fig. 1 Knowledge life circle in a typical AIM application

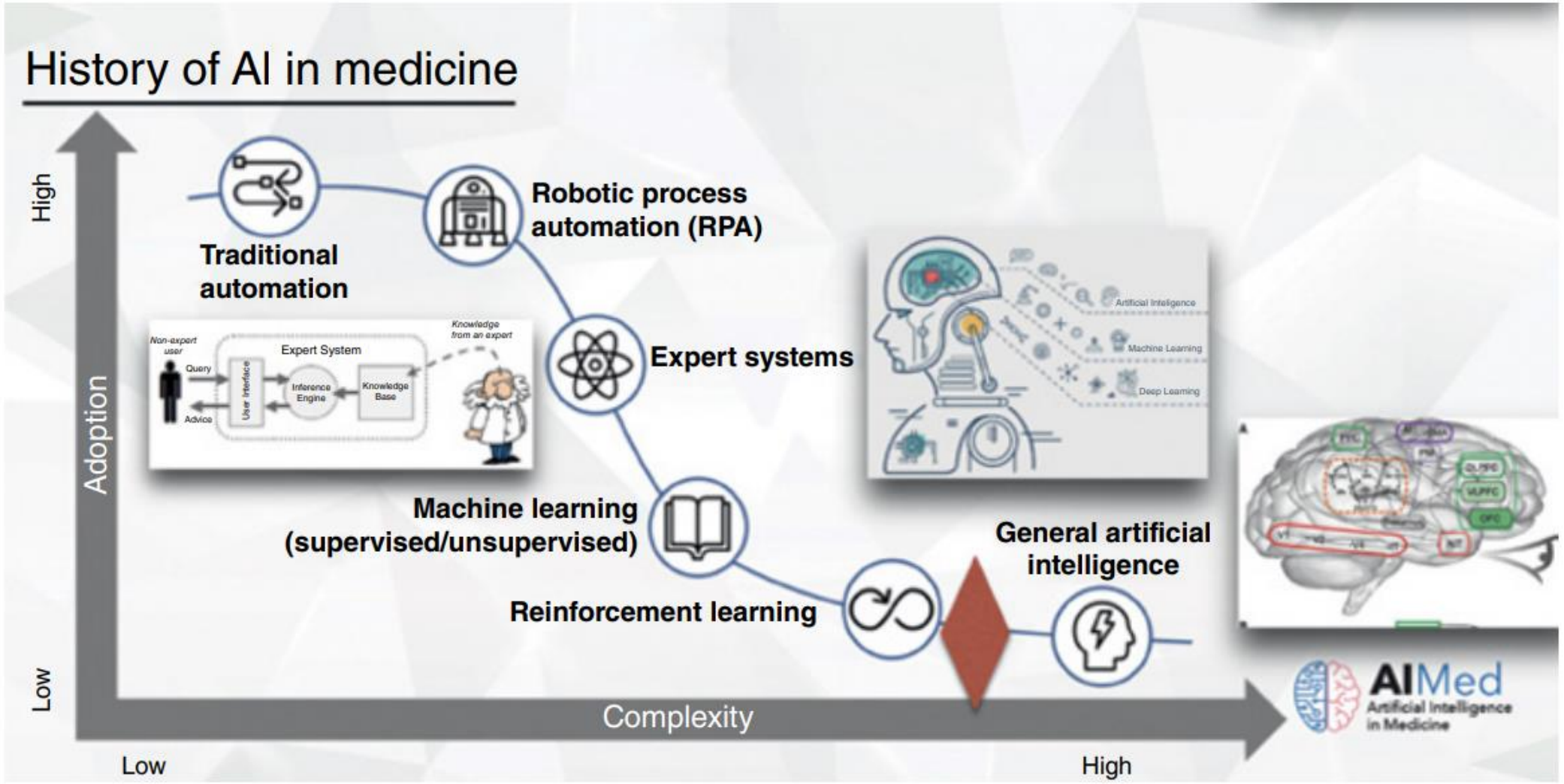


FIGURE 1.9 *(source: HIMSS 2019[26])*

Spectrum of algorithms underpinning AI (excerpt)

	Expert systems	Traditional machine learning	Frontier machine learning
Summary	Human-programmed, static program to perform a single, deterministic task	Algorithms mathematically proven to make an optimum or best prediction based on data they are trained with	Algorithms with the same characteristics as traditional machine learning (learn from and improve predictions through data) but with greater autonomy and less explainability
Period of major breakthroughs	1980s–1990s	2000s	2010s–present
Autonomy	Low, program is entirely dependent on human-provided information	Medium, generally humans guide the model to take into account certain features and to remove "noisy" outlier data	High, generally the model decides on feature selection and weighting and has to account for outlier data independently
Explainability	High	Medium	Low, "black box"

FIGURE 1.8 ***(source: Rock Health[25])***

History of AI
In medicine and healthcare context

1956-2006

Year	Milestone	Key Developments and Impact	Companies Involved
1956	The Birth of AI	The term "Artificial Intelligence" was coined at the Dartmouth Conference. AI as a field of study was formally established.	Dartmouth College, John McCarthy (Founder of AI)
1960s-70s	Early AI Programs and Expert Systems	Development of ELIZA (early chatbot) and MYCIN (expert system for diagnosing blood infections). AI research focused on symbolic reasoning and rule-based systems.	MIT, Stanford, IBM
1980s	Expert Systems and Neural Networks Revival	Rise of expert systems for industrial and medical use. Backpropagation algorithm revived interest in neural networks.	Symbolics, IBM, Xerox
1997	Deep Blue Defeats Garry Kasparov	IBM's Deep Blue defeated world chess champion Garry Kasparov, marking a significant milestone in AI's problem-solving abilities.	IBM
2006	The Revival of Deep Learning	Geoffrey Hinton and others helped popularize deep learning, particularly through the use of neural networks with multiple layers (deep learning).	Google, Stanford, NVIDIA

2006-2018

Year	Milestone	Key Developments and Impact	Companies Involved
2012	Breakthrough with AlexNet	AlexNet won the ImageNet competition, dramatically improving image recognition and demonstrating the power of deep learning and GPUs.	University of Toronto, NVIDIA, Google
2016	AlphaGo Defeats Lee Sedol	DeepMind's AlphaGo defeated world champion Go player Lee Sedol, showcasing AI's ability to handle complex, intuitive games and strategic thinking.	DeepMind (Google), NVIDIA
2017	Introduction of Transformers (Attention Mechanism)	The "Attention is All You Need" paper introduced transformer models, revolutionizing natural language processing (NLP) and setting the foundation for models like GPT and BERT.	Google, OpenAI, Microsoft, Facebook
2018	AI Begins Widespread Industrial Adoption	AI technologies like GPT-2 and AlphaZero demonstrated the ability to transform industries. Significant strides in NLP, deep reinforcement learning, and AI-powered products.	OpenAI, Google, IBM, Microsoft

2018-2021

Year	Milestone	Key Developments and Impact	Companies Involved
2019	GPT-2 and BERT Revolutionize NLP	OpenAI's GPT-2 and Google's BERT advanced natural language generation and understanding, creating more human-like AI text generation models.	OpenAI, Google, Microsoft, Facebook
2020	GPT-3 Released by OpenAI	GPT-3 became the largest language model at the time, capable of generating human-like text, programming code, and handling a variety of tasks.	OpenAI, Microsoft
2020-2021	AI in Healthcare during COVID-19	AI played a major role in drug discovery, diagnostics, and vaccine research during the COVID-19 pandemic, proving its ability to assist in global crises.	Moderna, Pfizer, IBM, Google, DeepMind
2021	AI's Role in Autonomous Systems and Healthcare	AI advancements in autonomous vehicles and personalized medicine, AI-assisted surgery, and diagnostic tools led to real-world applications gaining momentum.	Tesla, Waymo, IBM, Google, Microsoft, NVIDIA

From 2023

Year	Milestone	Key Developments and Impact	Companies Involved
2023	AI in Multi-Modal Applications	The rise of multi-modal AI systems that integrate text, image, and video data (e.g., GPT-4, CLIP) led to more holistic AI models that understand and create across various mediums.	OpenAI, Google, Microsoft, Meta, NVIDIA
2018-2023	AI in MEdicine	Companies began implementing AI and machine learning in optimizing clinical trial processes, improving drug storage management, and automating supply chain.	Extencia, Atomwise, Ion Labs, Veeva Systems, Zebra Medical Vision

From 2023

Year	Milestone	Key Developments and Impact	Companies Involved
2024	AI in Personalized Medicine and Clinical Trial Optimization	AI is being increasingly used to tailor clinical trials and personalized treatments based on patient data, enabling better precision in drug development and trial designs.	Google Health, IBM, Medtronic
2025	AI for Real-Time Monitoring	AI-enabled real-time tracking and monitoring solutions for drug storage and clinical trials are now being widely adopted. AI systems optimize logistics, inventory, and compliance.	Amazon, Microsoft, Palantir, IBM

From 2023

Year	Milestone	Key Developments and Impact	Companies/Institutions Involved	Healthcare Applications
2024	AI-Powered Stroke Solutions	AI tools like Aidoc's stroke solution reduced door-to-puncture time by 38 minutes, significantly improving outcomes for acute stroke patients.	Aidoc, SNIS	Emergency care and stroke management 1
2024	AI in Chronic Disease Management	AI-driven remote monitoring tools became widespread, enabling continuous tracking of chronic conditions like diabetes and hypertension.	Kaiser Permanente, various telehealth providers	Chronic disease management and remote patient monitoring 29

From 2023

Year	Milestone	Key Developments and Impact	Companies/Institutions Involved	Healthcare Applications
2024	AI in Mental Health	AI applications in mental health care emerged, providing early diagnosis and personalized therapy plans through digital therapeutics.	Various digital health companies	Mental health diagnostics and treatment 69
2024	EU AI Act Implementation	The EU AI Act came into force, regulating high-risk AI systems in healthcare, ensuring transparency, accountability, and reliability.	European Union	Regulatory compliance and ethical AI use 9
2025	AI-Powered Medical Imaging	AI-enhanced diagnostic tools became standard in over 70% of U.S. hospitals, improving early detection of diseases like breast cancer.	Google DeepMind, various radiology departments	Radiology and diagnostic imaging 10

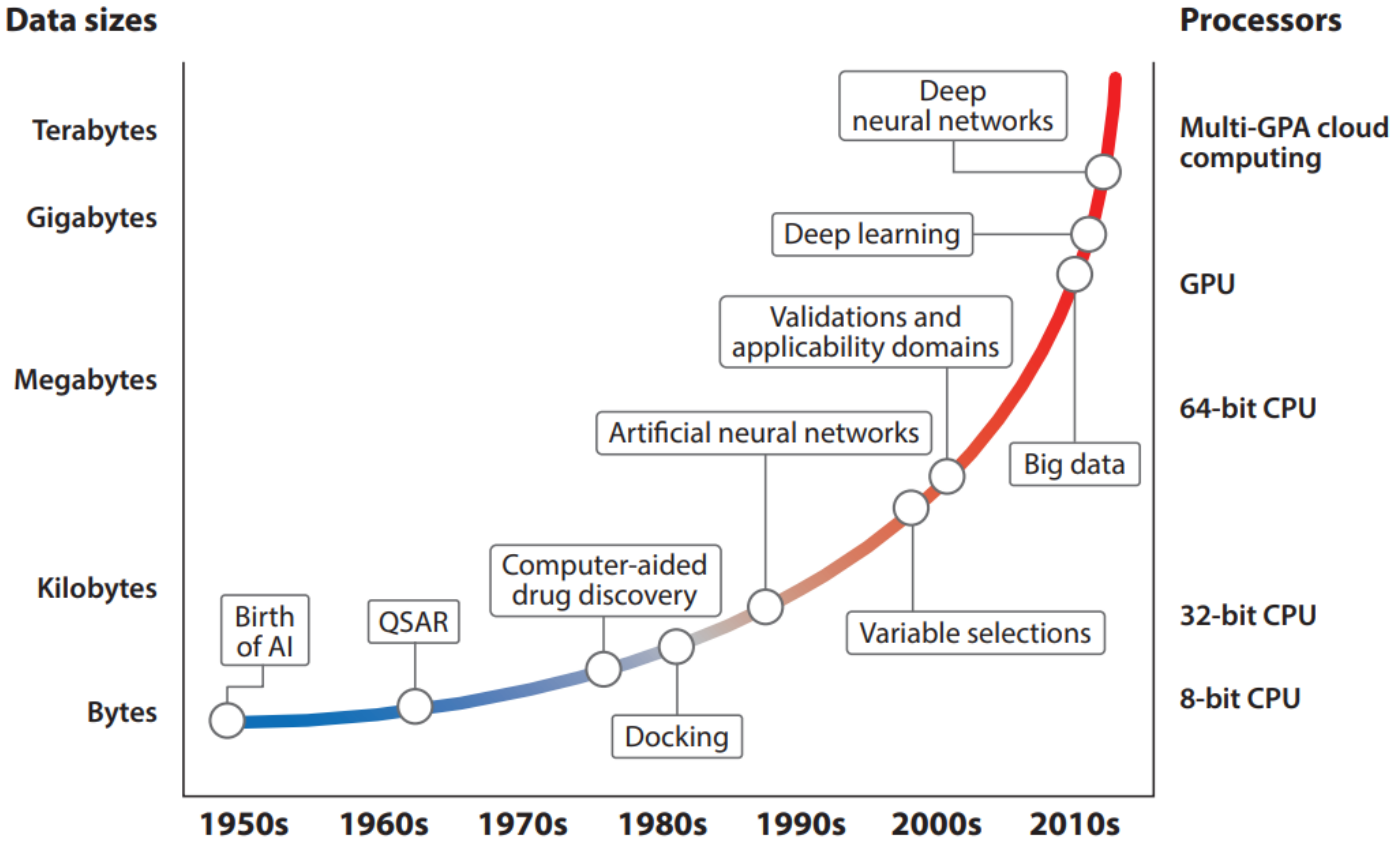
From 2023

Year	Milestone	Key Developments and Impact	Companies/Institutions Involved	Healthcare Applications
2025	Personalized Medicine	AI tools like DeepMind's AlphaFold helped develop treatments tailored to individual genetic profiles, particularly for rare diseases.	DeepMind, various biotech firms	Personalized treatment plans and precision medicine 10
2025	AI in Robotic Surgery	AI-powered robotic systems advanced surgical precision, though fully autonomous surgical robots faced regulatory hurdles.	Intuitive Surgical, Medtronic	Surgical procedures and rehabilitation 10

What will be the next

Year	Milestone	Key Developments and Impact	Companies/Institutions Involved	Healthcare Applications
2025	AI in Administrative Tasks	Virtual assistants like Amazon Clinic and Microsoft's AI-driven Copilot streamlined administrative tasks, such as pre-authorization processes and patient scheduling.	Amazon, Microsoft	Hospital management and administrative efficiency 10
2025	AI in Predictive Analytics	AI-driven predictive models improved early diagnosis of conditions like sepsis and heart disease, reducing hospital stays and readmission rates.	Deloitte, various healthcare providers	Predictive analytics and patient outcomes 26

Why AI is highlighted recently?



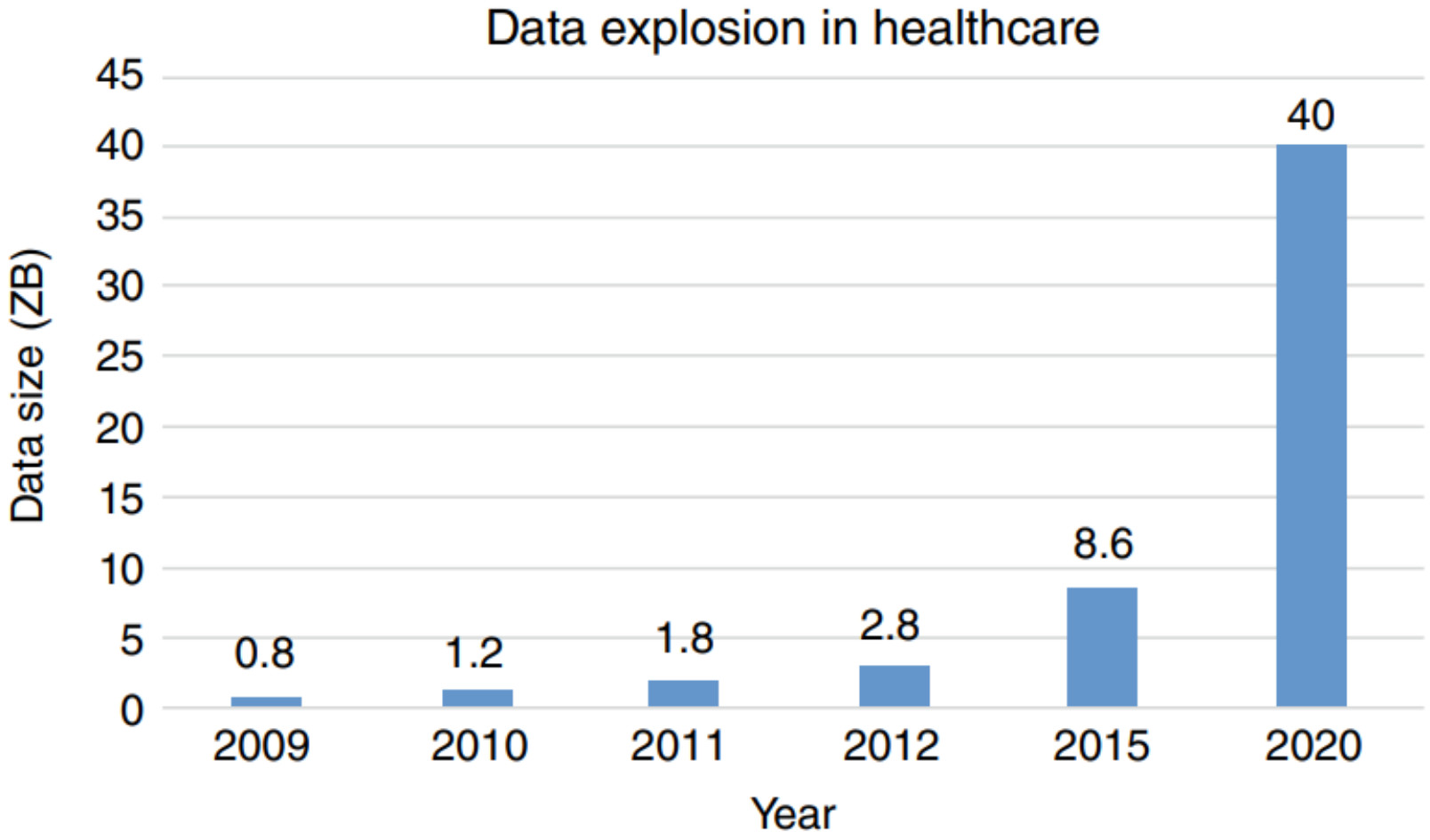


FIGURE 2.1 Big data in health care: Applications and challenges
(source: Hang et al.[1])

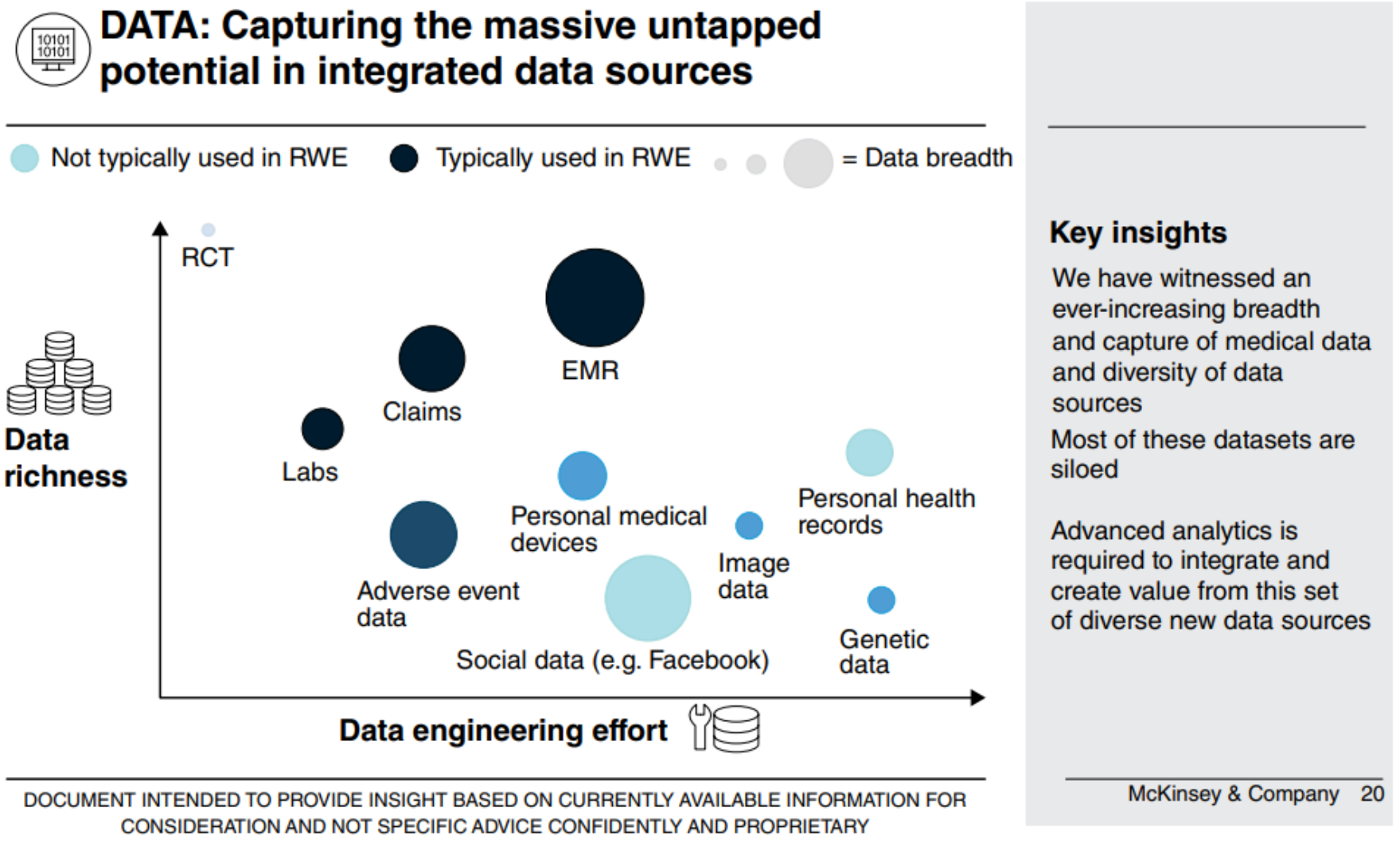


FIGURE 2.2 *(source: McKinsey & Company)*

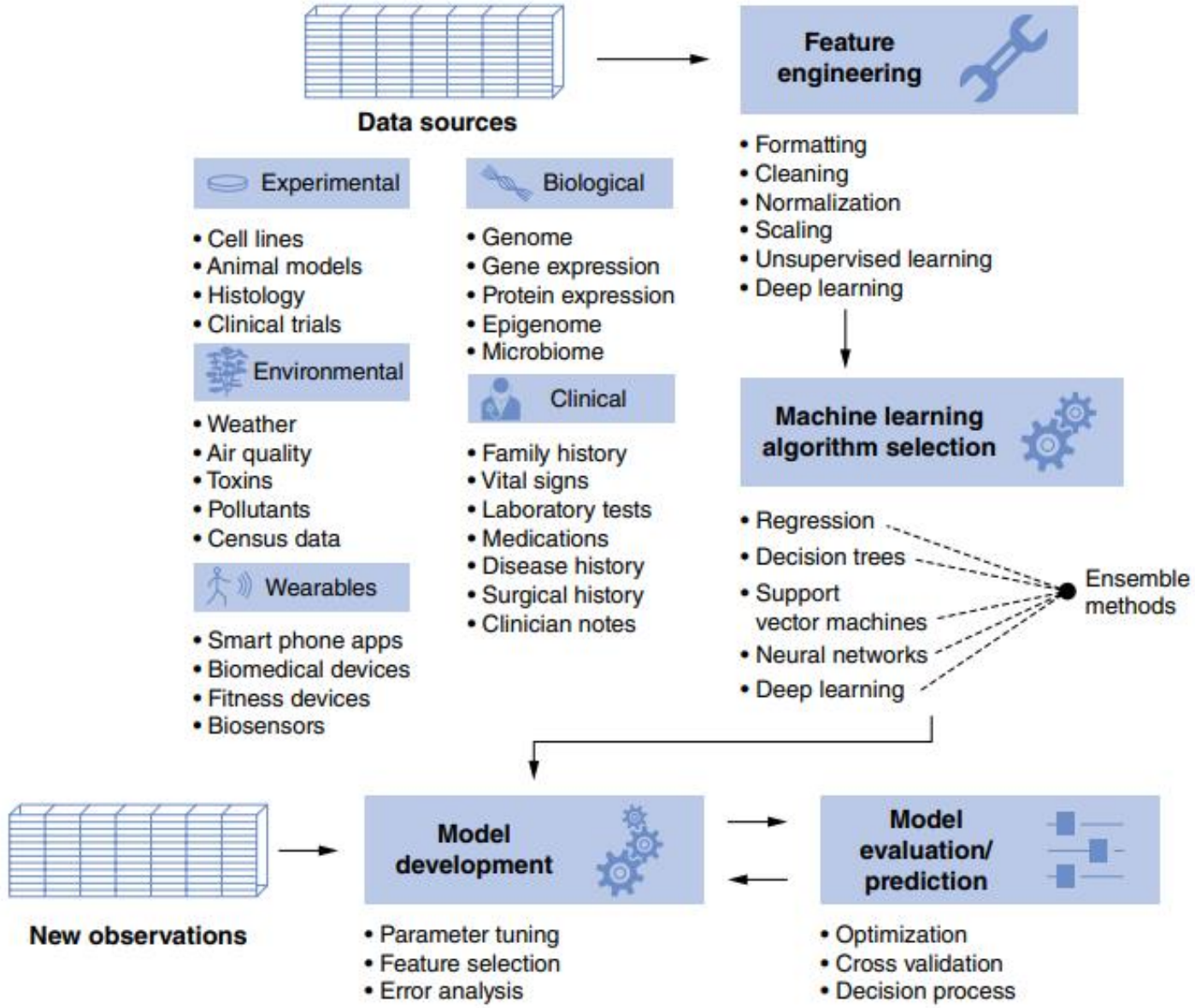


FIGURE 1.12 **Developing AI medical models using variety of data sources** ***(source: Johnson et al.[39]/Elsevier/CC BY 4.0)***

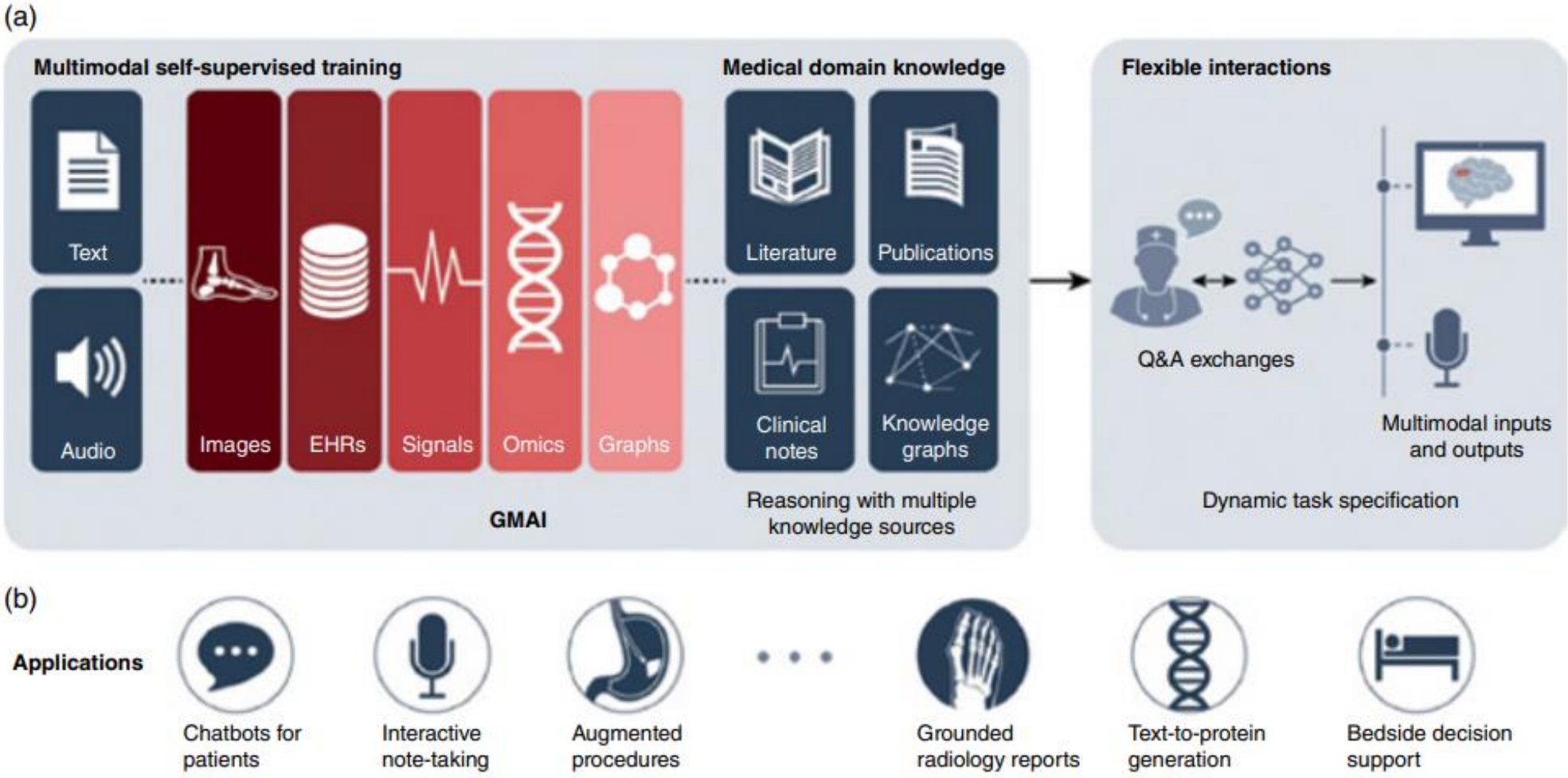


FIGURE 1.13 **Foundation Models for Generalist Medical Artificial Intelligence** *(source: Moore et al.[43]/Springer Nature)*

Barriers to AI in medicine

Short-term

Training data and real-world data are often different leading algorithm to wrong conclusions

Machine learning also doesn't have the same ability to weigh the costs and consequences of false positives or negatives the way a doctor would: they can't "err on the side of caution" like a human.

Machine learning algorithms, especially those in the black box category, need some way to assess their own confidence in their predictions. Without attaching some degree of certainty, the machine learning application lacks a necessary "fail-safe."

Medium-term

Trusting a program becomes even more dangerous over time as the training dataset gets older and clashes with the inevitable reality in medicine of changing practice, medications available, and changes in disease characteristics over time.

Machine learning can influence medical research: it can make "self-fulfilling" predictions that may not be the best course of action but over time will reinforce its decision making process.

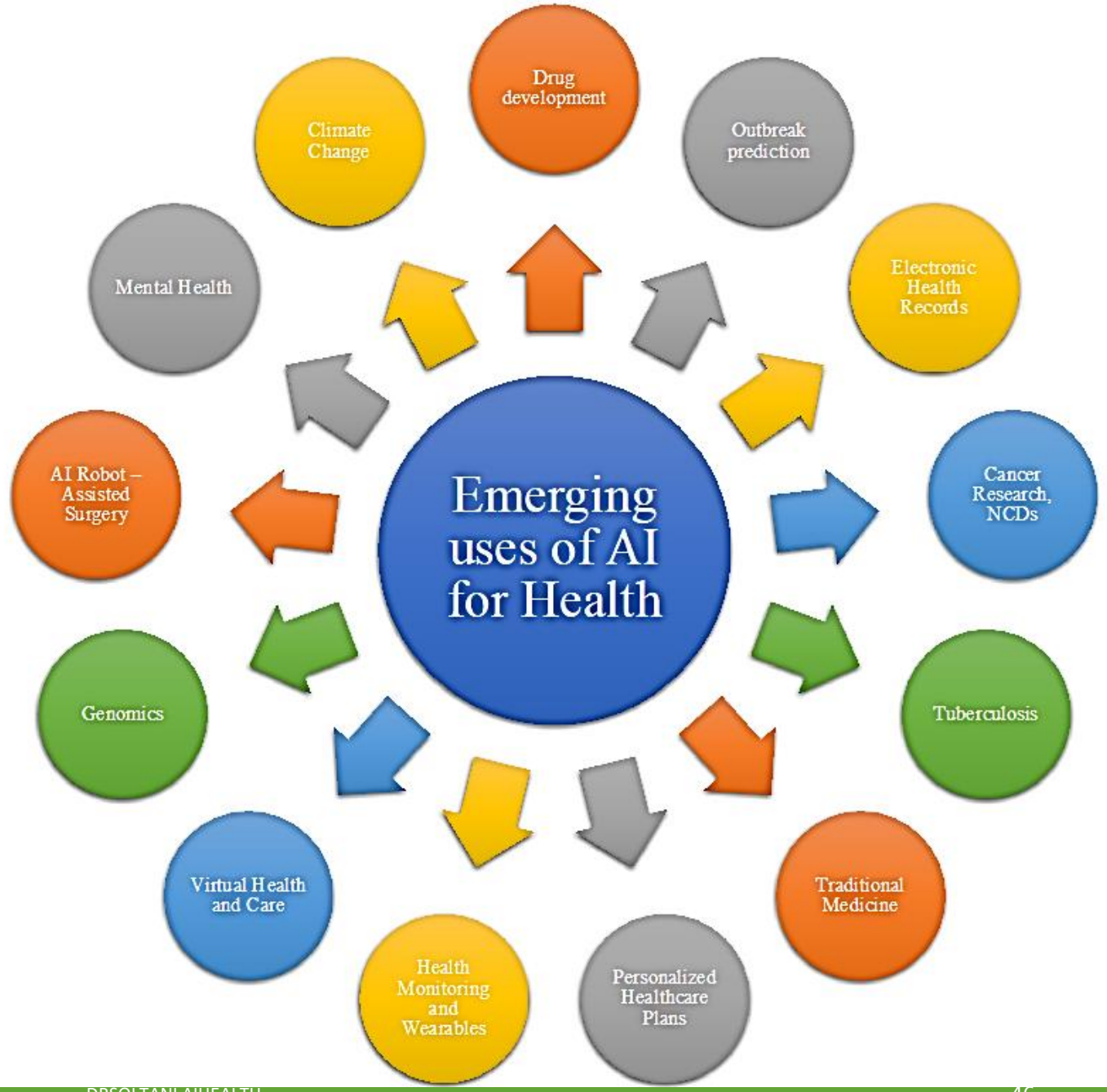
Long-term

Machine learning algorithms are trained on fairly narrow datasets and unlike humans are unable to take into account the wider context of a patient's needs or treatment outcomes

They can "game the system," and learn to deliver results that appear successful in the short term but run against longer term goals.

A continuously learning autonomous system will eventually experiment with pushing the boundaries of treatments in an effort to discover new strategies, potentially harming patients.

WHO


Emerging uses of AI for Health
Drug development
Outbreak prediction
Electronic Health Records
Cancer Research, NCDs
Tuberculosis
Traditional Medicine
Personalized Healthcare Plans
Health Monitoring and Wearables
Virtual Health and Care
Genomics
AI Robot – Assisted Surgery
Mental Health
Climate Change

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Ethics and Governance of Artificial Intelligence for Health

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Artificial intelligence (AI) has enormous potential for improving health outcomes and helping countries achieve universal health coverage. However, for AI to have a beneficial impact on people's health, ethical considerations and human rights must be placed at the centre of its design, development and use. Adapted from the core contents of the Guidance on Ethics & Governance of Artificial Intelligence for Health, this course introduces entry-level knowledge to policymakers, AI developers and designers, and health care providers who are involved in designing, developing, using and regulating AI systems for health.

Photo credit: Getty Images / miriam-doerr

Self-paced

Language: English

Health topic

Enroll me for this course

Conclusion

Applications of Artificial Intelligence in Healthcare and Medicine

- **AI in Healthcare**: AI is transforming healthcare by enhancing diagnostics, treatment, drug discovery, and patient management.
- **Key Areas Impacted**:
  - **Diagnosis**: Improved accuracy and speed in disease detection.
  - **Treatment**: Personalized medicine and optimized treatment plans.
  - **Drug Discovery**: Accelerated development of new therapies.
  - **Patient Care**: Enhanced care delivery and management.
- **Challenges**: Ethical, legal, and technical hurdles remain, but ongoing advancements are addressing these issues.
- **Future Outlook**: AI will continue to revolutionize (evolves?) healthcare, making it more efficient, personalized, and accessible.

Thanks for your attention

Share your comments:

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