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Popular Article

Artificial Intelligence and Machine learning in Life Science

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Abstract:

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn. These machines can perform tasks that typically require human intelligence, such as recognizing speech, making decisions, solving problems, understanding language and visual perception. Artificial Intelligence (AI) is rapidly transforming the educational landscape, impacting both the teaching to administrative tasks. AI can generate quizzes, flashcards, study notes and digital textbooks within seconds, saving demonstrators time and providing students with additional resources. It can also create adaptive content that adjusts to a student's learning progress and interests. Artificial Intelligence (AI) is also revolutionizing treatment and diagnosis process in veterinary, medical education and its biotechnological aspect through the model preparation by offering tools like 3D models, virtual reality (VR), and augmented reality (AR). These technologies provide dynamic, interactive learning experiences, enhancing the morphological, biotechnological and medical understanding which can be utilized in research and diagnostics. While AI presents significant benefits, challenges like data requirements, potential biases and ethical considerations need careful addressing. Machine Learning (ML) is a subset of AI where computers analyze data to learn patterns and make predictions without being explicitly programmed. Artificial intelligence and machine learning are revolutionizing the life sciences by accelerating drug discovery, automating genomic sequencing analysis, and predicting complex protein structures.

Keywords: Artificial Intelligence, Teaching, Solving and Problems

Introduction:

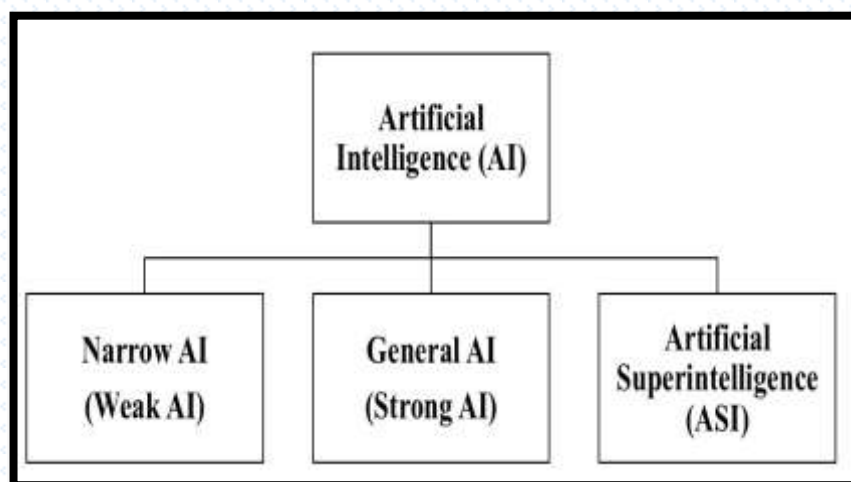
Artificial Intelligence (AI) can be defined as the simulation of human cognitive processes such as reasoning, learning, problem-solving and decision-making by machines and computer systems (McCarthy, 2006). It represents one of the most dynamic and transformative technologies of the modern

era, influencing almost every aspect of human life, from education and agriculture to biotechnology and medical sciences. At its core, AI involves designing systems that can analyse data, recognize patterns, adapt to new information and perform tasks traditionally requiring human intelligence.

Based on its scope and capabilities, AI has been broadly categorized into three types: **Narrow AI** focuses on performing specific tasks such as virtual assistants like Siri and Alexa; **General AI** refers to machines with human-like intelligence capable of performing diverse functions across multiple domains and the hypothetical stage of Artificial Superintelligence (ASI)-where AI could surpass human intelligence in nearly all fields. The functioning of AI follows a systematic process that begins with data collection, followed by data processing, model training, algorithmic learning, evaluation, prediction, deployment and continuous monitoring to ensure accuracy and reliability. With such wide-ranging applications, AI has become an essential tool not only for technological advancement but also for reshaping the fields of anatomical sciences, biotechnology and medical research.

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn which can be categorized into numerous types: Source: (Mc. Carthy, 2006)

Machine Learning (ML) requires human intervention, means developers must manually select and extract specific features from raw data (e.g., teaching an algorithm to recognize a car by defining its wheels, windows, and headlights) however **Deep Learning (DL)** eliminates manual feature engineering and the algorithms ingest



raw data (like images or audio) and automatically discover the features required for accurate classification on their own, thus if we assume the Artificial Intelligence (AI) as the overarching umbrella of smart systems, **Machine Learning** is a branch of AI that learns from data, and **Deep Learning** is a more advanced branch of ML that utilizes layered "**neural networks**" inspired by the human brain.

AI in medicine works by analysing massive amounts of **clinical data** using **machine learning algorithms** to identify hidden patterns, predict diseases and assist with treatments. Rather than replacing doctors, AI acts as a powerful tool to augment human expertise, speed up diagnoses, and automate administrative duties.

Artificial intelligence analyses massive amounts of patient data and medical imagery to detect diseases faster and more accurately. It then uses this information to assist doctors in suggesting personalized treatments and accelerating the development of new drugs. AI is actively being used across

hospitals and clinics globally. Here are some of the most prominent, real-world examples categorized by their clinical application-Diabetic Retinopathy Screening, Stroke & Fracture Triage, Faster MRI Scans, Heart Rhythm Monitoring, Digital Stethoscopes, Cancer Care Chatbots and Accelerating Clinical Trials etc.

Process of AI workflow:

The process of the AI can be represented by following diagram:



Fig. 1. Photograph showing the Artificial Intelligence workflow

1. **Data Collection:** Gather large amounts of data from various sources.
2. **Data Processing:** Clean and organize the data for analysis.
3. **Model Selection and Training:** Choose a suitable model (e.g., neural network) and train it using the data to learn patterns.
4. **Algorithm Implementation:** Use algorithms (e.g., supervised learning, unsupervised learning) to help the model learn and make decisions.
5. **Model Evaluation:** Test the model's performance using metrics like accuracy and precision.
6. **Prediction and Decision Making:** Use the trained model to make predictions or decisions based on new input data.
7. **Deployment and Integration:** Integrate the model into applications or systems for real-time use.
8. **Monitoring and Maintenance:** Continuously monitor and update the model to ensure it performs well over time (Mc Carthy, 2006)

How does AI works:

At its core, Artificial Intelligence (AI) works by analysing massive amounts of data to identify patterns, make predictions, and solve problems. Instead of relying on rigid, step-by-step human

instructions, AI learns from experience—refining its accuracy every time it processes new information.

Potential Benefits of AI:

1. **Enhanced Data Analysis:** AI can process and analyse massive datasets quickly, identifying hidden patterns and insights that humans might miss.
2. **Improved Decision-Making:** By providing accurate predictions and real-time insights, AI supports businesses and individuals in making informed choices.
3. **Cost Reduction:** Automation of repetitive tasks reduces the need for manual labour, lowering operational expenses.
4. **Personalization:** AI enables customized recommendations in shopping, entertainment, and education, improving user experience.
5. **Healthcare Improvements:** From diagnosing diseases to drug discovery and patient monitoring, AI enhances healthcare efficiency and outcomes.
6. **Safety Enhancements:** AI systems in vehicles, factories, and workplaces help reduce accidents through predictive monitoring and automation.
7. **Innovation:** AI fosters new technologies, products, and services, opening opportunities in various sectors like robotics, biotech, and energy.
8. **24/7 Operation:** Unlike humans, AI systems can operate continuously without fatigue, ensuring higher productivity.
9. **Scalability:** AI solutions can be expanded easily to handle increasing workloads without significant additional costs.
10. **Predictive Maintenance:** AI predicts equipment failures before they occur, reducing downtime and repair costs.
11. **Enhanced Customer Service:** Chatbots and virtual assistants provide instant responses, improving service efficiency and customer satisfaction.
12. **Environmental Benefits:** AI supports smart energy management, climate modeling, and sustainable agriculture, helping protect the environment.
13. **Accessibility Improvements:** AI tools such as speech recognition, text-to-speech, and computer vision empower differently-abled individuals.
14. **Fraud Detection:** AI detects suspicious patterns in financial transactions, protecting businesses and

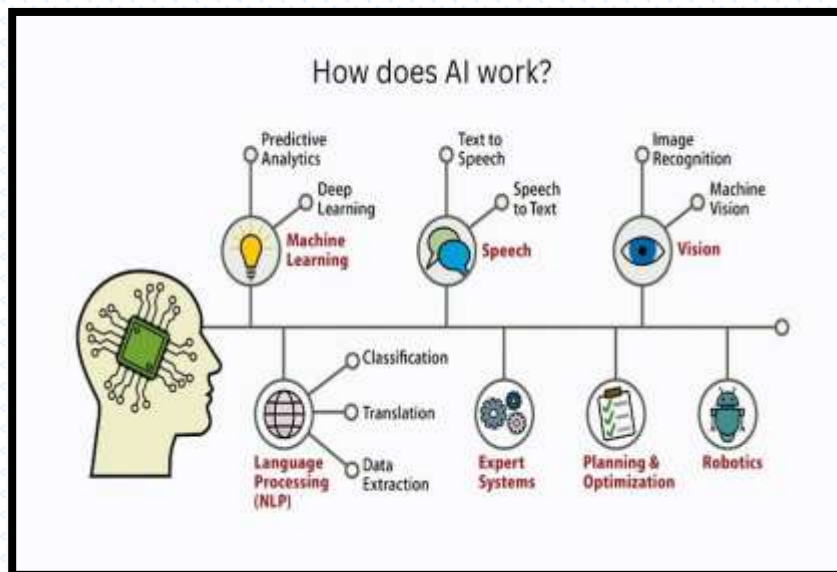


Fig. 2 Photograph showing the How the Artificial Intelligence works.

individuals from fraud (Goodfellow, Bengio & Courville, 2016 and Zhang *et. al.*, 2023).

Current Trends in AI:

- 1. Advanced Content Creation:** AI models generate high-quality text, images, music, and video. Tools like OpenAI's GPT-4 and similar models are widely used for creative tasks.
- 2. Deepfake Technology:** Improved methods for creating realistic deepfakes, leading to both innovative applications and concerns about misinformation.
- 3. Adaptive Robots:** Robots with enhanced capabilities for complex tasks in manufacturing, healthcare, and domestic settings.
- 4. Environmental Monitoring:** Advanced tools for tracking and managing environmental impacts.
- 5. Enhanced Safety Features:** More robust systems for self-driving cars, including improved sensors and real-time decision-making algorithms (Schwab, 2017).

Future Scenarios in AI:

- 1. Development of AGI:** The potential for creating AI with human-like cognitive abilities that can understand, learn, and apply knowledge across various domains.
- 2. Emergence of ASI:** Theoretical advancements leading to AI surpassing human intelligence in all areas, with implications for society and ethics.
- 3. Symbiotic Relationships:** AI systems working closely with humans to enhance capabilities and decision-making in various fields.
- 4. New Forms of Art and Entertainment:** AI-driven innovation in art, music, and entertainment, leading to new creative expressions and experiences.
- 5. Ubiquitous AI:** Increased integration of AI in everyday life, from smart homes and personal assistants to enhanced public services and infrastructure (Mittelstadt; *et.al* 2016).

Historical Evolution of AI in Biotechnology and Medical Science:

1. Evolution of AI in Biotechnology:

- AI applications in biotechnology date back to the late 20th century.
- Significant advancements in computational biology and bioinformatics. (Goodfellow, Bengio & Courville, 2016).

2. Milestones in Medical Science Aided by AI:

- Early adoption of AI in medical imaging and diagnostic tools.
- Breakthroughs in AI-assisted surgical techniques and robotic surgery (Jiang, *et. al.*, 2017)

3. AI's Role in Drug Discovery/Development

- AI algorithms analyze vast datasets to identify potential drug candidates.
- Machine learning models predict drug efficacy and potential side effects.
- Accelerates the traditionally lengthy and costly drug discovery process (Engkvist, *et.al.*, 2018).

4. Application of AI in Genomic Research:

- AI helps in sequencing genomes and understanding genetic variations.
- AI tools analyze genetic data to identify mutations linked to diseases.
- Facilitates the development of gene therapies and personalized medicine. (Libbrecht, *et.al.* 2015).

5. Case Studies of AI in Genomics:

- DeepMind's AlphaFold predicts protein structures, aiding genomic research.
- IBM Watson Genomics assists in identifying cancer mutations and treatment options.

6. AI in Crop Genomics and Trait Prediction

- AI analyzes genomic data to predict traits like yield, disease resistance.
- Example: John Deere's Blue River Technology uses AI for precise crop management.

7. Role of AI in Enhancing Crop Yields and Resistance

- AI optimizes planting schedules, irrigation, and pest control.
- Example: Syngenta uses AI for breeding high-yield crops. (Schwab, 2017).

8. Examples of AI-driven Innovations in Sustainable Agriculture

- Precision agriculture: AI-driven drones and sensors for monitoring crop health.
- Smart farming: AI applications in soil health monitoring and climate impact assessments (A. L. & Kohane, 2018).

9. AI enhances animal productivity by optimizing breeding, monitoring health, improving feed efficiency.

- This leads to increased yields, better animal welfare, and reduced costs.
- Health Monitoring: Detects early signs of illness.
- Optimized Breeding: Selects best breeding pairs.
- Feed Efficiency: Optimizes nutrient intake.
- Behavioral Analysis: Monitors for abnormal behavior
- Environmental Monitoring: Maintains optimal conditions.
- Disease Prediction: Anticipates and prevents outbreaks (Brian, *et al.* 2020)

10. Treatment Customization

- AI analyzes patient data (genetic, clinical, lifestyle) to tailor treatments.
- AI enables personalized treatment plans by analyzing patient data and customizing therapies.
- Predictive analytics used for tailoring treatment plans to individual patients for better health outcomes.
- Success stories of AI-driven personalized medicine showcase improved patient care and treatment efficacy through tailored therapies. Topol, (2014)

11.Enhanced Diagnosis:

- Use of AI in radiology enhances image recognition accuracy and aids in disease diagnosis.
- AI brings advancements in medical imaging with reduced diagnostic errors and improved interpretation. AI-driven medical imaging offers enhanced accuracy and efficiency in diagnosing diseases for better patient care.
- AI Medical Imaging Diagnostics (Litjens, *et al.* 2017).

12.Early Detection

- AI systems enable early disease detection through screening and predictive diagnostics.
- Machine learning models support accurate disease diagnosis and proactive healthcare management.
- Real-world examples highlight the success of AI in diagnosing diseases early, improving patient outcomes and survival rates.
- AI Disease Diagnosis Early Detection. Obermeyer & Emanuel (2016).

AI-driven research methodologies revolutionize biotech practices, leading to breakthroughs in healthcare innovations:

❖ Enhancements in Biotechnological Research through AI:

- AI aids in data analysis, modeling, and simulation in biotech research.
- Accelerates research timelines and enhances experimental accuracy.

❖ Collaborative AI Research Projects:

- The Human Genome Project utilized AI for data analysis.
- AI-driven research initiatives like the Allen Institute for AI (AI2) collaborate across disciplines. Vieira., *et.al* (2016).



Fig. 3 Advantages of AI in Biotech and Medical Science

❖ Increased Efficiency and Accuracy

- Automation reduces time spent on repetitive tasks, enhances precision.
- Example: AI in high-throughput screening of compounds

❖ Cost Reduction and Resource Optimization

- AI lowers R&D costs, optimizes resource use.
- Example: AI-driven drug discovery reduces development time and cost.

❖ Enhancing Research Capabilities and Innovation

- AI enables new research methodologies, accelerating innovation. e.g AI in large-scale genomics projects, facilitating new discoveries (Makridakis, 2017).



Fig. 4. Future Trends in AI for Biotechnology and Medical Science

❖ Emerging Trends in AI Applications

- AI in telemedicine, wearable health tech, robotics in surgery.
- Innovations in AI for mental health and rehabilitation technologies.

❖ Potential for AI to Revolutionize Biotech and Medical Fields

- Vision for AI transforming research and clinical practices.
- Example: AI systems integrating diagnostics, treatment planning, and patient monitoring (Topol, 2019).

❖ Predictions for the Next Decade

- Expert forecasts: AI's impact on research, clinical practices.
- Expected milestones: AI advancements in precision medicine, global health initiatives.

Challenges and Limitations:

Ethical Considerations and Data Privacy:

- Concerns about patient data security, informed consent. (Mittelstadt; *et.al* 2016).
- Ethical issues: Bias in AI algorithms, transparency in decision-making.

Technical Limitations:

- Challenges in achieving high algorithm accuracy, reliability.
- Need for high-quality, diverse datasets to train AI models

Regulatory Issues:

- Navigating regulatory frameworks for AI in healthcare.
- Compliance with standards like GDPR, HIPAA for data protection. European Commission (2020).

Key Area of Transformation:

- **Drug Discovery & Development:** AI models (like Generative AI and Deep Learning) predict how molecules will interact with disease targets, drastically reducing the time and cost required to bring life-saving drugs to market.
- **Genomics & Multi-Omics:** ML algorithms process massive genomic datasets to identify disease-causing variants, unravel cellular heterogeneity, and map out complex biological networks.
- **Protein Folding:** Structural biology has been completely transformed by AI models (such as AlphaFold) capable of accurately predicting 3D protein structures from amino acid sequences.
- **Clinical Trials & Diagnostics:** Natural Language Processing (NLP) helps extract real-world evidence from medical records, optimizing patient recruitment for trials and refining disease diagnostics.
- **AI in Data Collection:** In the AI-driven cancer treatment process, the first step involves data collection and imaging, where patient data is gathered through various medical imaging techniques such as CT scans, MRIs, X-rays, and digital pathology, along with other diagnostic tests. AI in radiographic imaging automates the extraction of quantitative data, reducing human error and variability, especially for complex tumors. It improves image segmentation, registration, and visualization, enhancing 3D image analysis despite challenges like data complexity and noise (**Lewis *et al.*, 2019**). AI systems in medical imaging outperform human observers, improving the accuracy and speed of cancer detection, as demonstrated by systems like Quant X for breast cancer. Digital pathology, evolving with AI, reduces labour-intensive workloads and enhances efficiency, enabling high-resolution digital imaging for better analysis and remote consultations (**Patel *et al.*, 2023**).

AI in Diagnosis:

Clinicians often rely on personal knowledge and experience for diagnosing diseases, which

can lead to potential inaccuracies due to the human brain's limitations in handling large data sets. A deep convolutional neural network (DCNN) model enhanced thyroid cancer diagnostic accuracy through ultrasound image analysis, showing improved specificity compared to skilled radiologists (**Li et al., 2019**). AI has also been effective in reducing unnecessary surgeries and improving detection and classification accuracy across various cancers, such as lung, breast, and colorectal cancers. However, further validation in diverse geographic settings and through clinical trials is necessary to confirm these findings. AI has become integral in advancing oncology by improving cancer categorization. For instance, AI-driven DNA methylation analysis has been pivotal in reclassifying cancers with high accuracy, potentially transforming prognosis and therapy options. Further, ML/DL has successfully classified various cancer types such as prostate adenocarcinoma, colon adenocarcinoma, breast invasive carcinoma, kidney renal clear cell carcinoma (KIRC), and lung adenocarcinoma (LUAD) based on comprehensive data analysis. Techniques like supervised ML using artificial neural networks (ANNs) have enabled precise differentiation between acute lymphoblastic leukaemia and acute myeloid leukaemia, leveraging microarray gene expression patterns (**Zhang et al., 2023**). Recent studies have demonstrated the effectiveness of AI in predicting cancer types and survival rates with accuracy exceeding traditional methods. AI models not only aid in customizing treatment plans based on individual patient profiles but also enhance the accuracy of clinical follow-up plans, thereby improving patient outcomes and reducing unnecessary healthcare interventions. By harnessing AI, researchers can accelerate discoveries, improve treatment outcomes and enhance agricultural productivity, ultimately mitigating the impact of *Pseudomonas*-related diseases, while promoting healthier environments and advancing clinical, pharmaceutical, and agricultural research. Systems powered by AI-trained models using machine learning (ML) and deep learning (DL) such as deep colony are currently being used in clinics. These advancements underscore AI's potential to revolutionize cancer care by leveraging complex data to inform more precise diagnostic and therapeutic decisions.

Conclusion:

AI technologies have the potential to help address important health challenges. In AI the different opportunities and applications have presented specifically in the field of biotechnology. So, it is a very important intellectual mission in today's time. Thus, it benefitting economy by helping evolution of work and it increase a business efficiency and also reduce probability of human error and study historical data to cuts costs. Artificial intelligence (AI) is the creation of intelligent systems that execute tasks requiring human intelligence to function. The application of AI in bioscience including clinical, agricultural, and pharmaceutical research has revolutionized over the years amplifying productivity and improving delivery time. This information explores AI-driven advancements in biological sciences, including genomics, machine learning-based antimicrobial resistance prediction, personalized medicine, AI-assisted drug discovery, precision agriculture and plant disease detection, examining AI's transformative potential,

addressing challenges and outlining further directions.

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