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ARTIFICIAL INTELLIGENCE: A FUTURE OF PHARMACEUTICAL INDUSTRIES

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ABSTRACT: Pharmaceutical technology has been using artificial intelligence more and more in recent years. This technology can help save time, money and also very helpful while improving understanding of the links between various formulation and process parameters. To tackle both specific and complex issues, artificial intelligence (AI) leverages human knowledge and gains knowledge from the solutions it generates. Drug development could undergo a revolution thanks to remarkable increases in processing capacity and advances in artificial intelligence. Reduced efficiency and rising R&D expenditures are currently making it difficult for the pharmaceutical industry to continue its medication development programs. Artificial intelligence (AI) has been used more and more in many facets of society, but especially in the pharmaceutical business. The use of AI in several areas of the pharmaceutical business, such as clinical trials, medication repurposing, drug discovery and development, and increasing pharmaceutical production, is highlighted in this article. Moreover, AI boost clinical trials process by identifying suitable candidates and predicting treatment outcomes and maximised efficiency and accuracy. In personalized medicine, AI allow precision treatment by analysing patient data and predicting individual responses to therapies.

INTRODUCTION: Although the notion of artificial intelligence (AI) was first proposed about 1956, significant advancements have been made in the recent 12 to 15 years [1]. In order to give quicker treatments with excellent results, it is beneficial to analyse thousands of medical records and cases [2]. AI uses computer systems that resemble machines to improve human intelligence and procedures. Computer simulation of human intelligence is known as artificial intelligence (AI) [3]. The procedure entails gathering data, formulating usage guidelines, coming to tentative or firm findings, and rapidly self-correcting [4].

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AI has a big impact on the pharmaceutical industry by improving smart production systems, which promote manufacturing, medicine, and related sectors. One aspect of it is the mobilization of computational power that manages data and makes it possible to access data from any location [5]. Its intelligent and sensitive sensors aid in the communication of machine operations, improve manufacturing efficiency, and lower costs [6].

Despite its lengthy history, as previously mentioned, there is currently no accepted definition of artificial intelligence. However, the fundamental idea of artificial intelligence is the use of computer systems to mimic human intelligence.

AI plays a significant part in the drug discovery process, but the lack of sophisticated technology restricts the drug development process and makes it a costly and time-consuming undertaking. AI is able to identify hit and lead compounds, validate drug targets more quickly, and optimize drug

structure design [7]. Data digitalization in the pharmaceutical industry has dramatically increased during the past many years. Thus, the task of learning, analysing and using that information to address complicated medical issues is a consequence of this digitization [8]. By applying personified knowledge, artificial intelligence (AI) is able to tackle both specific and complex problems. The process of developing new drugs could be revolutionized by combining remarkable computational capacity with advances in artificial intelligence [9].

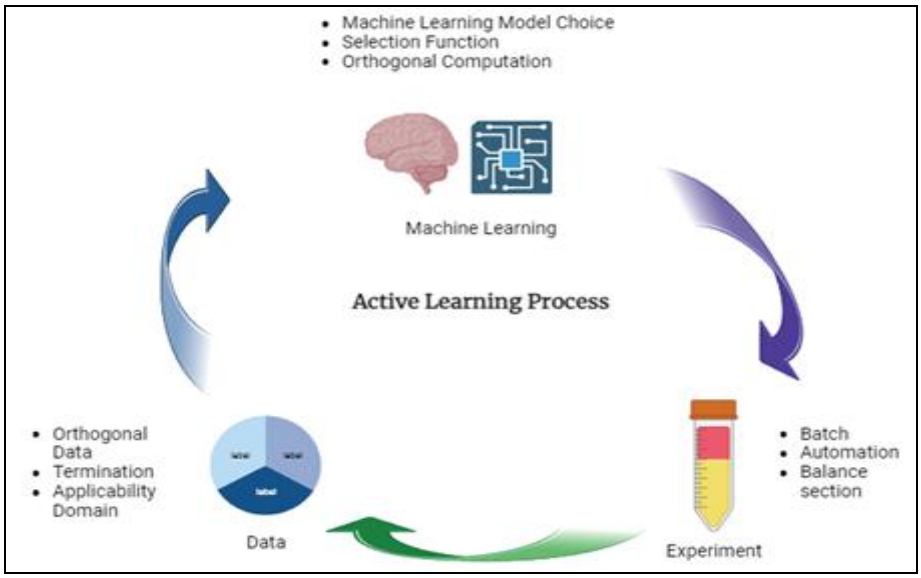

FIG. 1: MACHINE LEARNING IN DRUG DISCOVERY

The usage of AI is encouraged since it can manage massive amounts of data with improved automation. AI makes use of software and systems that are able to analyse and learn from the input data in order to make judgments on their own to complete particular tasks [10]. However, it's important to be aware of certain study gaps. Patient satisfaction with the technology, long-term effects like the effect on medical case reports, and ethical considerations like data privacy and potential biases are some of these [11–12]. Data integration, system upkeep, and usability for patients and medical professionals are a few technological issues [13]. By being aware of these research gaps, scientists may better comprehend how AI is being used in the pharmaceutical and medical system and create solutions that maximize its advantages. Assure ethical use while minimizing its drawbacks [14–15].

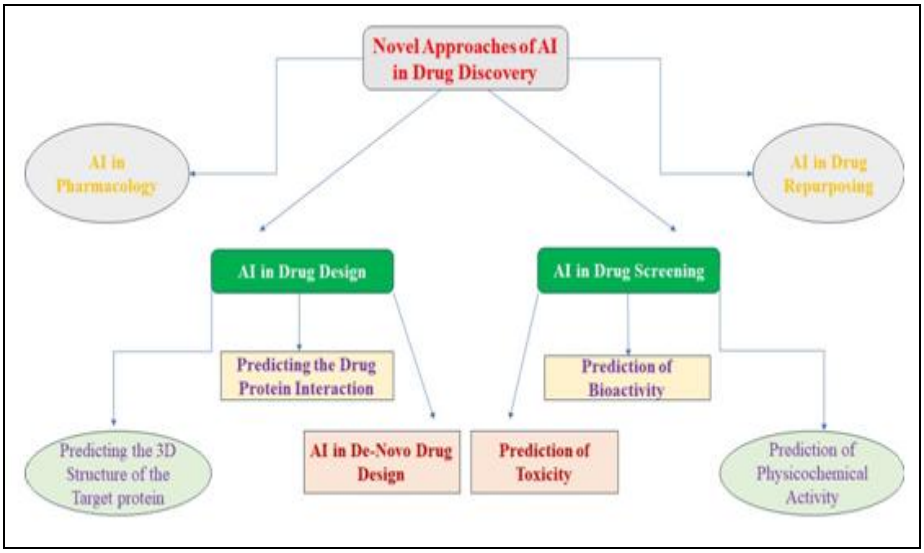

FIG. 2: NOVEL APPROACHES OF ARTIFICIAL INTELLIGENCE IN DRUG DISCOVERY

Classification of Artificial Intelligence:

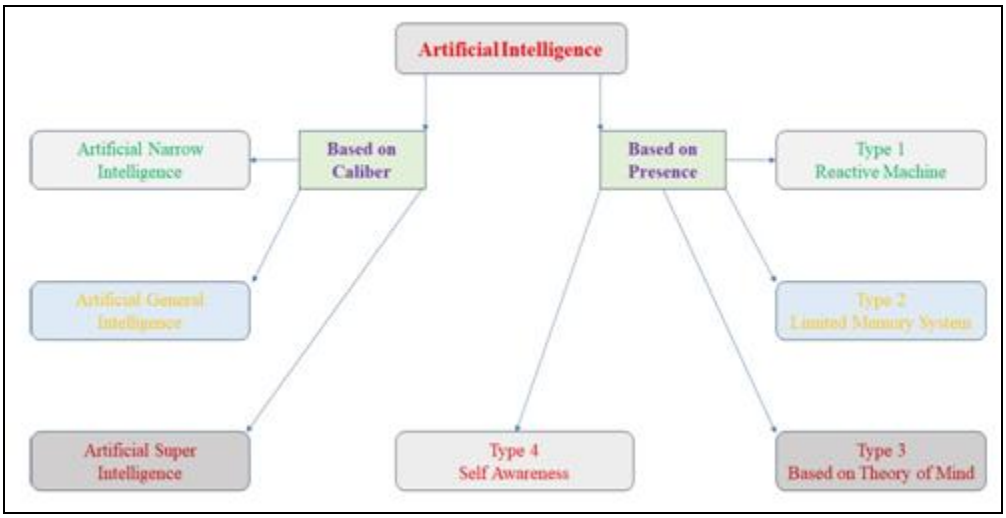

FIG. 3: TYPES OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence can be classified by Two Ways:

A) According to caliber.

B) According to the presence.

According to caliber AI can be classified as [16-18].

A. Artificial Narrow Intelligence (ANI): Sometimes known as weak intelligence, is a system that has been trained to carry out a certain activity, including traffic signalling, chess, driving, or facial recognition It involved in the worklike analysing large datasets to identify potential drug targets, optimizing drug molecule structures, predicting drug efficacy, or identifying suitable patient populations for clinical trials. E.g. SIRI in Apple having personal virtual assistance.

B. Artificial General Intelligence (AGI) or Strong AI: It is also called as Human Level AI. It could simplify human intellectual abilities. Due to this, when it exposed to an unfamiliar task, it could find the solution. It could potentially revolutionize drug discovery, development, and personalized medicine by analysing massive datasets to identify new drug targets, predict drug efficacy and toxicity, optimize clinical trials, and even tailor treatment plans to individual patients based on their unique genetic and medical history. All the things that can be done by humans can be performed by AGI.

C. Artificial Super Intelligence (ASI): It is a brain capacity that is more active than intelligent humans in areas like space, math, and sketching. They range from computers that are only slightly more intelligent than humans to those that are trillions of times more intelligent than humans in every subject, from science to the arts.

According to the presence AI can be classified as [19-20].

A. Type 1: We refer to this kind of AI system as a "reactive machine." For instance, Garry Kasparov, the chess champion, was impacted by the IBM chess software Deep Blue in the 1990s. It lacks the memory to draw on prior experiences, yet it is able to recognize checkers on the chessboard and make predictions. It was created with certain uses in mind and is useless in other contexts. AlphaGo from Google is another example.

B. Type 2: We refer to this kind of AI system as a limited memory system. For current and upcoming issues, this system can draw on prior experiences. This approach alone is used to construct parts of the decision-making processes in autonomous cars. Future activities, such changing lanes by car, are documented using the observations that have been logged. The observations are not kept in the memory for all time.

C. Type 3: The term "theory of mind" refers to this kind of AI system. It implies that every individual has thoughts, goals, and wants that influence their choices. This AI doesn't exist.

D. Type 4: We refer to these as self-awareness. The AI systems possess sentience and self-awareness. If the machine is self-aware, it recognizes the situation and applies the concepts found in other people's minds. This AI doesn't exist. Artificial Intelligence now a day used in various sector. It is also widely used in various branches of pharmaceutical industries.

Artificial Intelligence in Drug Development Process: Artificial intelligence (AI) has been identified as transformational influence on drug development. According to a recent report, big data and machine learning could profoundly affect the health care system and potentially result in a market that generates $100 billion in annual sales [21]. Industry experts predict that drugs developed using AI methods may be 2-3 years from launch but in the longer term will be critical to compete in the pharmaceutical industry. artificial intelligence (AI) in drug development often focus on how AI techniques like machine learning and deep learning can significantly accelerate the process by analyzing large datasets to identify potential drug candidates, predict molecular properties, and optimize drug design, leading to faster and more efficient development with improved efficacy and reduced costs; key areas where AI is applied include virtual screening, target identification, toxicity prediction, clinical trial optimization, and personalized medicine based on patient data analysis.

Artificial intelligence enable drug development process by early drug discovery, molecular design, target identification, clinical trial optimization, real world data analysis, personalised medicine [22].

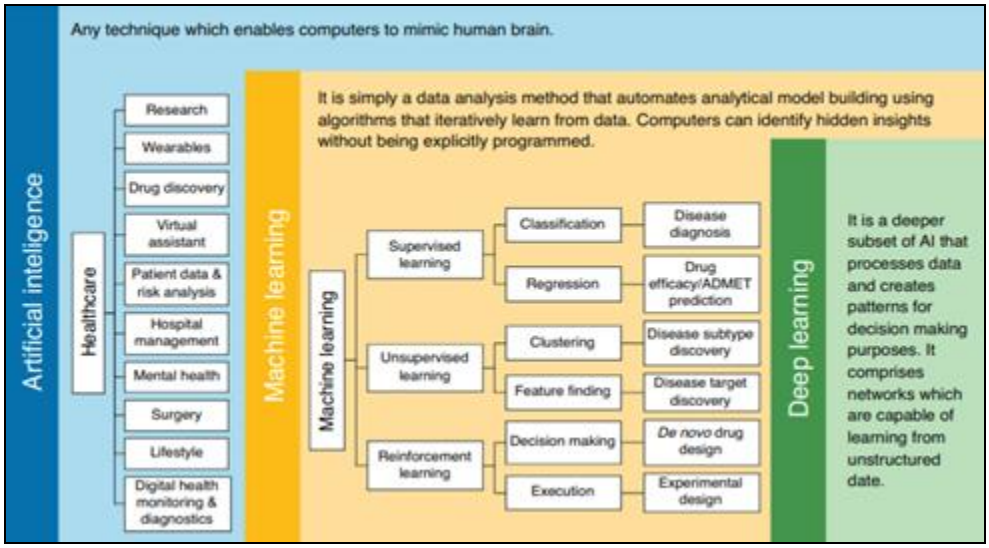

FIG. 4: THE APPLICATIONS OF ARTIFICIAL INTELLIGENCE (AI) AND ITS SUBFIELDS: MACHINE LEARNING AND DEEP LEARNING, IN HEALTHCARE

Much of what is labelled AI in the pharmaceutical industry is closer to machine learning, which is characterized by an algorithmic process whereby computers provide improved feedback. Machine learning is a type of artificial intelligence (AI) application that allows systems to learn from experience and improve without explicit programming [23].The goal of machine learning is to create computer programs that can access data easily and utilize it to learn on their own. More specifically, "machine learning refers to algorithms that can be designed to evaluate and make predictions based on the new and complex features [24].

Artificial intelligence's predictive ability could improve clinical trial success rates and expedite the drug development process, leading to the creation of safer and more effective medicinal medicines. However, there are some issues that need to be addressed when using AI in drug discovery. A primary hurdle entails the imperative acquisition of high-quality and diverse data [25].

Furthermore, ensuring the interpretability of AI models assumes critical importance in securing regulatory endorsement and cultivating trust within scientific and medical communities [26].

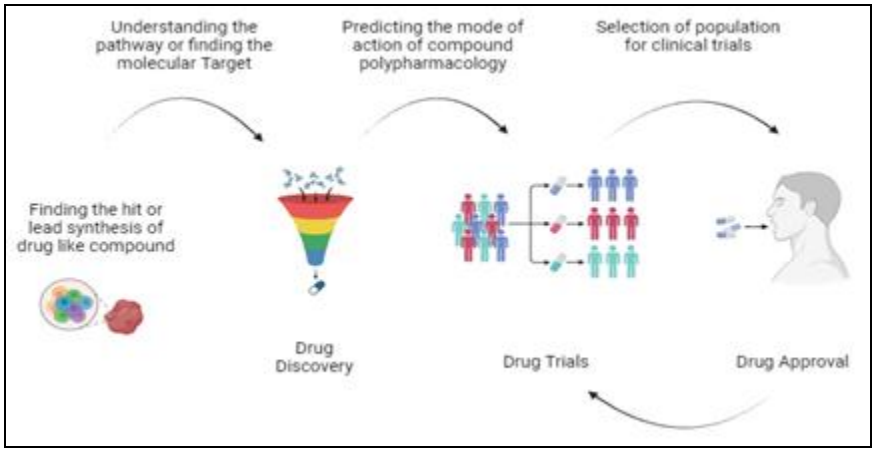

FIG. 5: DRUG DEVELOPMENT PROCESS

Artificial Intelligence in Pharmaceutical Nanotechnology: Specific AI algorithms such as machine learning (ML) allows the ability to compute large data sets while recognizing the complexity within the detailed patterns. The development of therapeutics and diagnostics has advanced significantly in the field of nanomedicine. For example, nanoparticle-modified drug compounds and imaging agents have resulted in markedly enhanced treatment outcomes and contrast efficiency [27].

Similarly to traditional/unaltered combination therapy, medication delivery based on nanomedicine is frequently investigated at set dosages. The fact that pharmacological synergy varies with time, dose, and patient at any given stage of treatment presents a constant problem in all types of drug administration. In order to overcome this obstacle, the development of nanomedicine-mediated co-delivery of numerous therapies has made it possible to integrate nanomedicine with artificial intelligence (AI) to maintain optimization in combinatorial nano-therapy. In a particular domain, such as optimizing drug and dosage parameters in combinatorial nanomedicine administration, AI can successfully leverage the entire potential of nanomedicine [28].

Nanotechnology and artificial intelligence (AI) combine to offer creative answers to problems in the pharmaceutical and medical sciences. Every stage of the pharmaceutical industry that has chosen to use AI has reduced human workload and produced the desired results quickly, opening the door for earlier clinical translation. Examples of this include improving and precisely predicting the properties of materials and their interactions with biological systems, as well as advances in cancer diagnosis, the identification of novel drugs and drug targets, formulation designs, and clinical trials.

Key areas where AI is applied in nanotechnology such as nanomaterial design, image analysis, drug delivery optimization, nonmanufacturing optimization, toxicity prediction. However, the complexity, cost and time-consuming nature of laboratory processes, the large volume of data, and the challenges in data analysis have prompted the integration of artificial intelligence (AI) tools.

AI has been employed in designing, characterising and manufacturing drug delivery nano systems, as well as in predicting treatment efficiency. AI's potential to personalise drug delivery based on individual patient factors, optimise formulation design and predict drug properties has been highlighted. By leveraging AI and large datasets, developing safe and effective DDSs can be accelerated, ultimately improving patient outcomes and advancing pharmaceutical sciences [29].

Artificial Intelligence in Clinical Trials: In addition to costing billions of dollars and taking ten years or longer to reach the market, most medications have the potential to destroy an organization if they fail late-stage trials after generating a lot of speculation. In the future, artificial intelligence (AI) is becoming a more important concept in addressing these problems and appears to be the key to successful drug development.

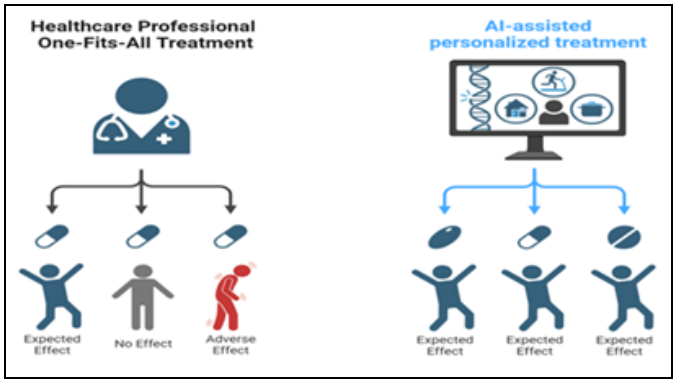

FIG. 6: IMPACT OF AI IN CLINICAL TRIALS

Perhaps the most obvious application of counterfeit consciousness in the pharmaceutical industry is the ability to quickly "perused" an infinite amount of logical data, including research published in diaries, comprehension records, tissue/blood tests, and designs as part of the data to generate experimental hypotheses that can help pharmaceutical companies coordinate the development of new drugs. Instead of using a scattergun approach to screening for concoctions, companies may now develop medications with greater accuracy by taking into account natural markers thanks to the usage of AI in these processes. Therefore, organizations can concentrate on particular symptoms that the medicine is particularly suited to cure. A task that would take a human researcher weeks or months to complete can be completed in a couple of minutes by IBM's artificially intelligent supercomputer (Watson). Through machine learning, Watson, and comparable system's show signs of improvement and speedier at the procedure through advancing their algorithms to incorporate new findings. Eventually, the screening procedure could be sufficiently quick to dissect the whole genome of every patient's individual malignancy and for medications to be customized considering its transformations, on the off chance that they exist. If not, there will be an organization keen on putting that privilege [30].

Innovations in artificial intelligence (AI) have advanced significantly, and a growing number of businesses are concentrating on exploiting these developments to solve business problems while also breaking new ground. There are real-world applications that can help organizations with complex problems, such as comprehending vast amounts of data, enhancing human decision-making, or providing clients with expert advice, even though many people may view computerized reasoning as relics and the realm of science fiction [31].

The time for AI advancements is now. This is a direct outcome of the enormous scale of registration and capacity restrictions, where stockpiling, distributed computing fast, and preparation power are available at affordable prices. This allows for the completion of intricate computations in a matter of seconds rather than weeks. According to Forrester, "man-made brainpower" refers to the theories and skills that attempt to replicate human knowledge through learning and experience. Complex thinking models are included into AI capabilities to address complex problems and provide unexpected answers. Engineers are starting to use AI in the venture area to create subjective figuring frameworks. This decade, artificial intelligence (AI) is advancing quickly, and according to Forrester, it will become a part of how people interact with PCs, devices, wearables, and frameworks on a daily basis to accomplish tasks, get answers, obtain help making decisions, and automate repetitive tasks.AI should eventually drive business development to offer endeavours some assistance with bettering serves their clients, he includes, which makes for a solid driver of appropriation in the undertaking space. AI advancements are accessible for different markets and parts, and offer five consumable business abilities [32].

Artificial Intelligence in Pharmaceutical Manufacturing: The technologies used in pharmaceutical manufacturing are still developing today as the conventional methods, procedures, and business models for pharmaceutical manufacturing are being challenged by the internet of things, artificial intelligence (AI), robots, and sophisticated computers. The industrial manufacturing of pharmaceuticals might become much more agile, efficient, flexible, and high-quality with the use of these technologies. The convergence of Artificial Intelligence (AI) and pharmaceutical manufacturing signifies a pivotal juncture in the industry's evolution, offering unprecedented opportunities to bolster quality control and refine decision-making processes [33].

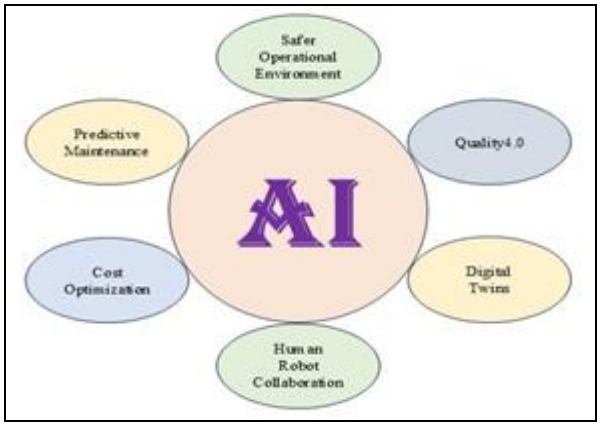

FIG. 7: IMPACT OF AI IN PHARMACEUTICAL MANUFACTURING

The process of producing pharmaceutical drugs is quite complicated, from developing the formulation to the final product. The raw ingredients and process conditions interact in multiple ways during this process. The final product's quality and processability are greatly impacted by these interactions. Over the years, artificial intelligence has become more prevalent in pharmaceutical technology. This technology can help save time and money while improving comprehension of the connections between various formulation and process characteristics. Rapidly developing technologies like fuzzy logic, neural networks, and genetic algorithms may find use in the production and processing of pharmaceuticals. Fuzzy logic is a very effective problem-solving method for controlling and making decisions. From input data, it generates highly helpful rules in the style of "if... so... then." Neuro fuzzy logic is the result of combining fuzzy logic with neural networks. This combination gives the approach greater adaptability and capability and yields potent outcomes [34].

TABLE 1: COMPARISON OF AI AND TRADITIONAL PHARMACEUTICAL MANUFACTURING

Aspect	Traditional pharmaceutical manufacturing	AI in pharmaceutical manufacturing
Quality Control	Manual inspections potential errors	Highly accurate detection and analysis
Efficiency	Labour intensive processes	Automated processes and reduced human intervention
Real Time Monitoring	Periodic checks and delayed responses	Continuous monitoring and rapid response to deviations
Personalised Medicine	Standard treatments patients	Tailored treatments based on individual patient characteristics
Risk Mitigation	Relying on post-production inspections	Early detections of deviations and defects
Innovation	Limited scope for innovation	Facilitates innovation through data driven discoveries

In pharmaceutical manufacturing, artificial intelligence (AI) is used to optimize various processes, including quality control, process monitoring, predictive maintenance, and production scheduling, by analyzing large datasets from manufacturing equipment to identify patterns, predict potential issues and make real-time adjustments, ultimately improving efficiency, reducing waste, and ensuring product quality while adhering to strict regulatory standards.

AI protects the integrity of the product by ensuring constant adherence to strict quality standards. AI has the ability to revolutionize decision-making by utilizing data's analytical capabilities. AI provides stakeholders with useful insights by sorting through large and complicated datasets, directing resource allocation and strategic planning [35].

AI in Drug Design: Identifying and validating therapeutic targets, generating hits to leads, optimizing leads, identifying preclinical candidates, conducting preclinical research, and conducting clinical studies are all steps in it. There has never been as much enthusiasm for artificial intelligence in drug design since the advent of computational chemistry in the late 1980s and early 1990s. We are assured of quick and widespread fixes for the problems of drug design as well as huge productivity gains as we work to develop novel new treatments, seemingly ignoring the lessons of previous past [36-37].

TABLE 2: TYPES OF INFORMATION CONSIDERED BY THE MEDICINAL CHEMIST IN DRUG DESIGN

How the human body works	How drug molecules affect human body
Biological macromolecules	Pharmacological profiles
Cellular signalling pathways	Omics profiles

Anatomy	Structure–activity/property relationships
Physiology	Toxicity profiles
Protein interaction network	Properties
Cellular metabolic pathways	Pharmacokinetic/pharmacodynamic (PK/PD)

A significant part in daily life is played by artificial intelligence (AI). Notable breakthroughs have been made in a wide range of fields, including speech and picture recognition, natural language processing, etc. The strength of this technology in Quantitative Structure-Property Relationships (QSPR) or Quantitative Structure-Activity Relationships (QSAR) is supported by a proliferation of recent applications in property or activity predictions, such as physicochemical and ADMET characteristics.

Owing to the development of machine learning theory and the accumulation of pharmacological data, the artificial intelligence (AI) technology, as a powerful data mining tool, has cut a figure in various fields of the drug design, such as virtual screening, activity scoring, quantitative structure-activity relationship (QSAR) analysis, de novo drug design, and *in-silico* evaluation of absorption, distribution, metabolism, excretion and toxicity (ADME/T) properties. De novo design, which uses artificial intelligence, propels the creation of novel, physiologically active compounds with desired characteristics. The strength of AI in this area is demonstrated by a number of cases. It is possible to combine ease of synthesis with synthesis planning, and increasingly computer-assisted drug discovery is anticipated in the near future [38-39].

CONCLUSION: There are not any medications on the market yet that use AI techniques, but it will probably take another two to three years before one is created. It is interesting to note that specialists firmly believe AI will transform the pharmaceutical sector and medication discovery in the long run. Even while AI can expedite the creation of new drugs, actual studies are still required. AI can also be utilized as a tool in healthcare to support gene therapy or other treatments that are not yet accessible to humans. The term "computational intelligence" refers to a broad range of statistical and machine learning, pattern recognition, logic, and probability theory techniques, as well as biologically motivated methods like neural networks, evolutionary computing, and fuzzy modelling. The various components of AI such as ANN, deep learning, machine learning, genetic programming etc., are being used for rationale design of drug molecules as well as peptides. The AI has also influenced the area of healthcare by playing a major role in clinical research by predicting the adverse effects. The information pertaining to the patient is also being collected through this. Thus, it provides immediate results and test reports that would further aid in the determination of optimum therapy for patient. Therefore, in the upcoming era, the field of Artificial Intelligence can lead to the development of various technologies and software that would help improve the pharmaceutical product development and health management strategies.

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