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Integrating Artificial intelligence in Pharmacy

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ABSTRACT

The field of computer science is vaster than what humans predict. Artificial intelligence is one of the revolutionary innovation which is programed to exhibit the intelligence through various software in built in a machine and this requires investment is a greater amount. The artificial intelligence uses algorithm which is a set of huge data, recognized by the machine and start to sort and display the output by recognizing the patterns in built within the system. The accuracy and amount of data generated is the strength of the Artificial intelligence. To generate the best data AI needs the training to change the algorithm and the patterns. To in built the best data to be generated by AI, the competition between the industry have also been increased.

Artificial Intelligence :-

The goal of the computer science field of artificial intelligence (AI) is to build computers or systems that are capable of carrying out activities that call for intellect similar to that of humans. Among these activities include problem-solving, experience-based learning, pattern recognition, language comprehension, decision-making, and even modeling some aspects of human behavior. From simple automation to sophisticated machine learning (ML) algorithms and intricate neural networks that enable systems with speech recognition, picture analysis, and autonomous control, artificial intelligence (AI) technology has expanded quickly. Narrow AI, often referred to as weak AI, and general AI, also referred to as strong AI, are the two main categories into which AI is frequently separated. Virtual personal assistants such as Siri or Alexa, who comprehend voice instructions but are restricted to a set of predefined skills, are examples of narrow artificial intelligence (AI) that is made to do specific jobs. However, this is still primarily a theoretical aim. In contrast, general AI would have a larger comprehension and reasoning ability similar to human intelligence, allowing it to do a wider range of activities and adapt to new ones. AI is currently being used in a wide range of fields, including healthcare (helping with drug discovery and diagnostics), finance (helping with algorithmic trading and fraud detection), and entertainment (powering recommendation engines). Many of these applications rely on artificial intelligence (AI) technologies, particularly machine learning (ML), natural language processing (NLP), and computer vision, which are pushing the limits of speed, accuracy, and scalability. AI's ascent presents both fascinating possibilities and difficulties. AI presents ethical questions about privacy, security, bias, and the future of employment, even while technology has the potential to significantly improve productivity and decision-making. The question of how to guarantee that AI systems are developed responsibly and applied in ways that benefit society is a topic of continuous discussion as they get more complex.

History of Artificial intelligence :-

Over the course of several decades, significant developments in a variety of disciplines, including computer science, mathematics, neuroscience, and linguistics, have contributed to the history of artificial intelligence (AI). An outline of the main phases of AI development is provided below:

Early Foundations (1940s – 1950s) Alan Turing and the Turing Test (1950): British mathematician Alan Turing, known as the father of computer science, proposed the idea of machines that could as a way to ascertain whether a machine might display intelligent behavior that was indistinguishable from that of a person, the Turing Test was developed. First Neural Networks (1943) by neuroscientist Warren McCulloch and mathematician Walter Pitts created the first mathematical model of a neural network, setting the stage for modern neural networks. Invention of the Term "Artificial Intelligence" (1956): At the Dartmouth Conference, organized by John McCarthy, the term "artificial intelligence" was officially coined. This event is considered the birth of AI as a research field. Early AI Programs and Hype (1950s – 1970s) Logic Theorist (1955) was one of the first AI programs designed to mimic human problem-solving by proving mathematical theorems. General Problem Solver (1957): Newell and Simon also developed the General Problem Solver, a computer program aimed at mimicking human reasoning. Perceptrons and Early Neural Networks (1958) Frank Rosenblatt developed the Perceptron, an early neural network model designed for pattern recognition. However, limited computational power and theoretical challenges slowed its progress.

The First AI Winter (1970s) Decline in Funding and Interest The limitations of AI became apparent as it struggled with complex tasks. This period saw a loss of funding and enthusiasm, leading to what is known as the "AI Winter." Critique from Marvin Minsky and Seymour Papert: Their book "Perceptrons" (1969) highlighted limitations in neural network capabilities, particularly with the single-layer perceptron, which couldn't solve non-linear problems. This contributed to a slowdown in neural network research. Expert Systems and Knowledge-Based AI (1980s) Development of Expert Systems:

In the 1980s, AI experienced renewed interest with the rise of expert systems, which used "if-then" rules to simulate human expertise in areas like medical diagnosis and mineral exploration. Key systems included MYCIN (medical diagnosis) and XCON (configuration of computer systems). Commercial Interest and Investment: Businesses saw value in expert systems, leading to an increase in investment and commercial applications. Rise of Machine Learning Theory: Researchers began exploring machine learning, probabilistic reasoning, and decision trees as approaches beyond expert systems. The Second AI Winter (Late 1980s – Early 1990s) Limitations of Expert Systems: Expert systems required extensive manual knowledge input, making them costly and rigid. As these limitations became apparent, interest in AI declined again, leading to another AI Winter. Lack of Computational Power: The lack of powerful computers to handle complex AI tasks also contributed to the slowdown. Revival with Machine Learning and Data-Driven AI (1990s – 2010s) Growth of Machine Learning: Researchers turned to machine learning, which allowed AI systems to learn from data rather than rely on rule-based programming. Data Availability and Improved Algorithms: The rise of the internet and digital storage provided large datasets that AI could analyze, fostering machine learning advancements. Breakthroughs in Neural Networks: In the late 2000s, improvements in hardware (like GPUs) and techniques such as deep learning, popularized by researchers like Geoffrey Hinton, Yann LeCun, and Yoshua Bengio, renewed interest in neural networks. Modern AI Revolution (2010s – Present) Deep Learning: Breakthroughs in deep learning have led to advancements in areas like image and speech recognition. In 2012, AlexNet, a deep learning model, won the ImageNet competition, demonstrating the power of neural networks for visual tasks. Natural Language Processing (NLP): Advances in NLP, particularly with the introduction of transformer models (like BERT, GPT, and T5), enabled AI to understand and generate human language at an unprecedented level. AI in Everyday Life: AI-powered applications, from virtual assistants (like Siri and Alexa) to recommendation engines on streaming platforms, became part of daily life. Ethics and Responsible AI: The rapid growth of AI led to increased focus on ethical considerations, privacy, bias, and AI's impact on society, with calls for regulations and responsible use. The Future of AI Generative AI: Generative models like GANs (Generative Adversarial Networks) and transformers continue to push the boundaries of AI by generating realistic images, text, and other content. Autonomous Systems: AI research in robotics, self-driving cars, and healthcare aims to create systems capable of autonomous decision-making and learning. Artificial General Intelligence (AGI): Some researchers are exploring AGI—AI systems with human-level understanding and adaptability—though this remains a distant and highly debated goal.

In today's environment, artificial intelligence (AI) is extremely useful due to its many benefits across a variety of industries. The following are some of the main justifications for utilizing Al:

1. Increased Productivity and Efficiency Al is able to automate time-consuming and repetitive procedures so that humans can concentrate on more intricate or imaginative parts of their work. This increases output and lowers human error, producing quicker and more precise results.
2. Analysis of Data and Creation of Insights Al is very good at swiftly analyzing large volumes of data and identifying correlations and patterns that people might overlook. It is especially helpful for drawing conclusions from large amounts of data in industries like marketing, customer service, healthcare, and finance.
3. Better Ability to Make Decisions Real-time data analysis using Al algorithms can yield insights that improve decision-making. Al, for example, helps companies manage risk, forecast consumer preferences, and optimize supply chains—all of which help them make better strategic decisions.
4. Customization and Client Experience Al makes mass personalization possible, enabling businesses to customize their goods and services to suit the tastes of specific customers. This is typical in customer service, where Al-driven chatbots offer prompt and precise assistance, and in e-commerce, where Al fuels recommendation engines.
5. Al can lower operating expenses by automating chores and streamlining procedures. For example, predictive maintenance reduces downtime and saves businesses money on repairs by preventing equipment breakdowns in manufacturing.
6. New Capabilities and Innovation By making it possible for whole new goods and services that otherwise would not have been feasible, Al is fostering innovation. Al has enabled innovations such as language translation applications, sophisticated medical diagnostics, and autonomous cars.
7. Improved Security and Safety Al systems can enhance security (e.g, fraud detection in financial transactions or surveillance for threat identification) and transportation (e.g, self-driving automobiles), safeguarding people and property.
8. Resolving Complicated Issues Al can solve problems that were previously impossible, such as finding novel medicinal compounds or optimizing energy usage, thanks to its capacity to handle enormous datasets, identify intricate patterns, and learn from vast volumes of information.
9. Ongoing Education and Development A subset of Al called machine learning (ML) enables systems to get better with time by using data and experience. Because of their versatility, Al systems gain value over time as their accuracy and efficacy increase.
10. Worldwide Scalability Businesses may reach and serve a larger audience while preserving quality and consistency by implementing Al solutions across a range of sectors and geographical areas.

The Role of AI in a Post-COVID WORLD :-

Artificial intelligence (AI) has become more and more important in the post-COVID era, changing industries, improving healthcare, and altering social standards. Due to the pandemic's acceleration of digital adoption, Al is essential in a number of crucial areas:

1. Healthcare and Biomedical Research :- Early detection and predictive analytics assist in identifying symptoms, forecasting disease outbreaks, and sending early alerts to stop the spread of infectious diseases. Drug Discovery and Vaccine Development expedites research procedures by predicting molecular structures and analyzing large datasets, which results in more rapid and effective drug discovery and vaccine development. With the growth of virtual healthcare, Al improves telemedicine by assisting with diagnosis, suggesting therapies, and keeping an eye on patients from a distance.
2. Workforce Automation and Remote Work :- Intelligent Automation is changing the nature of work by handling repetitive and data-intensive tasks, improving productivity, and enabling a shift in workforce focus toward creative and strategic roles. Remote Collaboration Tools: Al-powered platforms now facilitate seamless communication, project management, and collaboration in distributed work environments, which became vital during COVID-19. Employee Health and Safety Monitoring is used to insure workplace safety, monitoring compliance with health protocols, and analyzing workforce health trends.
3. Education and E-Learning :- Personalized Learning: Al helps close knowledge gaps and learning preferences that emerged in remote learning environments by customizing instructional materials to meet the needs of each individual learner. Al has emerged as a key player in the development of interactive virtual classrooms and the use of proctoring and integrity-checking software to facilitate online tests. Al provides adaptive training programs to help workers deskill and upskill in response to the pandemic's effects on the labor market.
4. Supply Chain and Logistics :- Demand Forecasting and inventories Management: As global supply chains experienced previously unheard-of shocks, Al's assistance to businesses in precisely forecasting demand and managing inventories became crucial. Warehouse Automation and Robotics collaborate to improve warehouse safety and efficiency while lowering human intervention and promoting social separation. Last-mile delivery solutions Al uses drones and driverless cars to solve the problem of safely and effectively delivering goods to customers.
5. Mental Health and Wellbeing :- Al in Apps for Mental Health: Counseling, mood monitoring, and mindfulness exercises are all provided by Al-powered mental health apps, which increase access to mental health care, particularly in the wake of COVID-19. Emotional Al and Behavior Analysis examine user behavior to spot indications of stress, anxiety, or depression so that prompt action and tailored health advice can be provided.
6. Government and Public Policy :- Crisis Response and Public Health Management: Al assists governments in monitoring the spread of diseases, organizing efficient responses, and managing public health emergencies. Citizen services and smart cities optimize resources to manage future emergencies while improving public services and urban management effectiveness. Data-Driven Decision Making makes it possible to analyze data in real time, which helps decision-makers create timely, well-informed policies in times of crisis.
7. Environment and Sustainability :- Climate Monitoring and Disaster Response: Al-powered sensors and analytics aid in the prediction of natural disasters, the monitoring of environmental changes, and the provision of aid. Food security and smart agriculture: Al maximizes agricultural resource usage to boost food production while reducing environmental effects, which is essential given that food security is still a major concern worldwide even after the epidemic.
8. Cybersecurity and Data Privacy :- Improved Security Procedures: Security issues are brought up by the rise in digital contacts. Al finds and eliminates dangers, safeguarding private information in the financial, medical, and other industries. Privacy-Preserving innovations that prioritize privacy make sure that international data laws are followed while striking a balance between personal freedom and innovation.

AI in COVID-19 Vaccine Development :-

Al helped with several phases of the research and development process, which significantly accelerated the creation of the COVID-19 vaccine. This is how it was successfully applied:

1. Analyzing the Virus Structure :- By analyzing massive amounts of genomic and structural data, Al systems were able to quickly evaluate the structure of SARS-CoV-2, giving researchers a better understanding of how the virus works and infects cells. For instance, Al was used by DeepMind's AlphaFold to predict protein structures, which helped researchers comprehend how viruses interact with their proteins and find possible vaccine targets.
2. Identifying Vaccine Candidates :- Millions of possible chemicals were screened using Al-driven platforms to determine which ones would work best as vaccination candidates. By mimicking how these substances may interact with the virus, this greatly shortened the time needed to get to promising possibilities. Al models, such as Google's DeepVariant and IBM's Watson, for example, examined and pinpointed particular chemical structures that would be crucial to the effectiveness of a vaccination.

3. Predicting Immune Response :- Understanding immunological responses to COVID-19 and identifying the elements that will elicit a robust immune response were made easier with the aid of Al models. Al was able to help researchers create more effective vaccines by examining data from COVID-19 patients and earlier vaccinations.
4. Optimizing Clinical Trials :- By finding appropriate volunteers and forecasting results, Al was utilized to plan and streamline clinical studies, which shortened trial durations. Additionally, this increased trial efficiency, particularly when choosing places with higher virus dissemination or enrolling varied populations. Al assisted researchers with early adverse effect detection, dosage adjustments, and more accurate efficacy monitoring by evaluating patient data in real time.
5. Enhancing Production and Distribution :- Al had a key role in expanding distribution and production. In order to manage cold-chain requirements for mRNA vaccines, machine learning techniques were very helpful in forecasting demand and optimizing supply networks. Al-driven systems made sure vaccines reached communities effectively by forecasting areas of high demand, controlling distribution routes, and reducing waste.
6. Monitoring Adverse Effects :- Al models continuously tracked real-time data on vaccination safety after the rollout by examining side symptoms that recipients reported all throughout the world. Health organizations were able to promptly detect and address any safety issues because to this data analysis.
7. Modeling Virus Variants :- Al technologies were crucial for monitoring virus changes and determining how variations would impact the effectiveness of vaccines. As the virus changed, researchers were able to modify vaccinations to keep them effective because to this predictive ability.

AI In Pharmaceutical field :-

With its contributions to clinical trials, drug development, customized treatment, and discovery, artificial intelligence is rapidly changing the pharmaceutical sector. AI is being used in this field in the following ways:

1. Drug Discovery and Development :- Target Identification: AI algorithms analyze biological data to find new targets for drug development, predicting proteins or genes linked to diseases. Compound Screening AI models can screen millions of compounds quickly, predicting which are likely to bind to a target, cutting down research time and cost. Molecular design Generative AI techniques design new molecules with desired properties, helping scientists discover more effective drug candidates faster.
2. Clinical Trials Optimization :- Patient Recruitment: AI helps identify suitable trial participants by analyzing medical records and other health data, leading to better trial outcomes and reduced dropout rates. Predictive Analytics: AI models can predict trial outcomes, potential adverse effects, and efficacy, helping in trial design and decision-making. Real-Time Monitoring: Machine learning algorithms monitor patient data in real-time, detecting issues that might require intervention.
3. Precision Medicine and Personalized Treatment :- Genomic Analysis AI analyzes genetic data to tailor treatments to individual patients, aiming to increase the effectiveness and reduce adverse effects. Disease prediction Predictive models help in early diagnosis by analyzing patient history, lifestyle, and genetic data, enabling timely intervention. Drug Response Prediction: AI can predict how patients with different genetic profiles will respond to a treatment, aiding in personalized medicine approaches.
4. Drug Repurposing :- AI assists in identifying existing drugs that could be repurposed for new indications, accelerating development by bypassing early safety trials. Analyzing big data from published studies, clinical trials, and patient outcomes enables AI to make predictions about drug efficacy in treating other conditions.
5. Supply Chain and Manufacturing :- Process Optimization: AI models optimize manufacturing processes, ensuring consistent quality and efficiency in drug production. Inventory Management: Machine learning algorithms improve supply chain efficiency, forecasting demand to minimize shortages and waste. Quality Control: AI-based image analysis can monitor the quality of drug formulations, ensuring compliance with regulatory standards.
6. Safety and Pharmacovigilance :- Adverse Event Detection Using AI, analyzes large datasets, such as social media and electronic health records, to detect potential adverse drug reactions early. Risk Prediction: Machine learning models predict the likelihood of adverse effects, helping regulatory bodies and pharmaceutical companies make informed decisions. Regulatory Compliance: Natural language processing (NLP) helps companies keep up with changing regulations by analyzing regulatory documents and guidelines efficiently.
7. AI-Driven Insights in Drug Marketing and Post-Launch Monitoring :- Market Analysis AI analyzes market trends, physician prescribing behavior, and patient demographics to guide marketing strategies. Post-Launch Surveillance AI monitors real-world evidence from patient feedback, prescription data, and health outcomes to continuously assess drug efficacy and safety.

Importance of artificial intelligence in pharma filed :-

In the pharmaceutical sector, artificial intelligence (AI) is becoming more and more significant as it spurs innovation and improves the speed, accuracy, and efficiency of the drug development process. AI is essential in this industry for the following reasons:

1. Accelerating Drug Discovery and Development:- Reduced Time and Cost: Traditional drug discovery is a time-consuming, costly process. AI algorithms can screen large datasets, predict drug-target interactions, and identify promising compounds faster than traditional methods. Enhanced Molecular Design AI helps design new molecules with desired properties, streamlining the drug creation process and potentially leading to drugs that are more effective and have fewer side effects.

2. Improving Success Rates of Clinical Trials :- Precision in Patient Selection: AI can analyze medical records and genetic information to recruit the right participants, increasing the chances of a trial's success and reducing dropout rates. Adaptive Trial Design Predictive models allow researchers to adjust trials based on real-time data, making trials safer and more effective. Cost Efficiency: By predicting adverse effects and potential outcomes, AI can help companies avoid costly failures in late-stage trials.

3. Enabling Precision Medicine :- Personalized Treatment Plans: AI algorithms can analyze genetic, environmental, and lifestyle data to predict how patients might respond to specific drugs, enabling tailored treatments. Higher Efficacy and Lower Risks, Precision medicine supported by AI can improve drug efficacy for individual patients and reduce adverse reactions, leading to better patient outcomes and higher patient satisfaction.

4. Enhancing Drug Repurposing Efforts :-Faster Identification of New Uses for Existing Drugs, AI can find connections between diseases and existing drugs, potentially accelerating the treatment options for rare or emerging diseases by repurposing approved drugs. Reduced Development Risk: Because safety profiles are already established for repurposed drugs, this approach is often less risky and costly than developing new drugs from scratch.

5. Optimizing Manufacturing and Supply Chain :- Process Efficiency: AI improves manufacturing efficiency by optimizing processes, monitoring quality, and minimizing waste, leading to more consistent drug quality. Supply Chain Resilience: AI models help predict demand, improve inventory management, and insure timely distribution of drugs, especially important during emergencies or global health crises.

6. Improving Pharmacovigilance and Safety Monitoring :- Early Detection of Adverse Effects: AI can monitor electronic health records, social media, and other data sources to detect adverse effects early, enabling quick interventions to insure patient safety. Real-Time Risk Assessment: Machine learning models predict potential risks based on ongoing patient data, helping pharmaceutical companies meet safety standards and regulatory requirements.

7. Enhancing Market and Post-Launch Surveillance :- Market Insights AI can analyze physician prescribing behavior, patient demographics, and competitive landscapes, providing insights that guide strategic decision-making and product launches. Continuous Monitoring of Drug Efficacy: AI-powered post-launch surveillance collects real-world data to continuously assess a drug's efficacy and safety, allowing companies to make adjustments as needed.

8. Supporting Regulatory Compliance and Documentation :- Efficient Processing of Regulatory Documents: NLP and other AI techniques streamline the analysis and management of regulatory documents, helping companies insure compliance with changing regulations. Automated Reporting AI-powered tools can assist in generating reports for regulatory submissions, reducing administrative burden and freeing up resources for innovation.

Optimizing drug management, streamlining operations, and improving patient care are all possible with the integration of artificial intelligence (AI) into pharmacies. Here are several important domains in which AI can be applied, along with doable implementation steps:-

1. Medication Management and Optimization - AI in Drug Discovery and Development AI can speed up drug discovery by analyzing large datasets to identify potential drug compounds and predict their effectiveness. Personalized medicine AI can analyze genetic, environmental, and lifestyle data to personalize medications and doses based on individual patient characteristics. Medication Adherence Monitoring: AI-driven apps and tools can track and remind patients to take their medications, improving adherence. Implementation: Partner with AI platforms specialized in healthcare analytics. Utilize AI-based clinical decision support tools to tailor treatments. Educate pharmacists on interpreting AI recommendations for personalized medicine.

2. Operations Efficiency in Pharmacies - Inventory Management AI algorithms can analyze sales patterns to predict demand and optimize inventory. Automating Refill Requests AI can predict refill needs and send reminders, minimizing stock outs and enhancing service. Workflow Optimization AI can streamline workflows by managing repetitive tasks, such as prescription processing and drug dispensing. Implementation: Use AI-powered inventory management software. Set up an automated prescription refill system that integrates with the patient records. Train staff on how AI can support daily tasks and optimize their time.

3. Clinical Decision Support - Drug Interaction Detection AI can rapidly analyze drug combinations to detect potentially harmful interactions. Predictive Analytics for Patient Outcomes: AI can analyze patient data to predict health outcomes and recommend interventions.

Implementation: Integrate AI-based decision support systems with pharmacy information systems. Train pharmacists to interpret AI-based recommendations to insure accurate drug dispensing.

4. Patient Engagement and Education - Chatbots for Patient Queries AI chatbots can answer common questions, provide medication guidance, and offer support for patients. AI-Powered Mobile Apps: AI-enabled mobile apps can guide patients on medication management, potential side effects, and lifestyle recommendations. Implementation: Incorporate chatbot tools into pharmacy websites or mobile apps. Develop or adopt AI-powered patient-facing apps that integrate educational resources on medication.
5. Pharmacovigilance and Drug Safety - Adverse Event Detection AI can analyze real-time data to identify adverse drug reactions, allowing pharmacies to respond proactively. Sentiment Analysis on Social Media AI can monitor social media and other platforms for patient feedback, identifying potential safety concerns with certain drugs. Implementation Collaborate with pharmacovigilance software providers to integrate real-time adverse event monitoring. Train pharmacy staff to recognize and report patterns in adverse event data flagged by AI.
6. Regulatory Compliance and Data Security Data Analysis for Compliance: AI can monitor and analyze pharmacy operations to insure compliance with regulations. Secure Data Handling: AI tools can improve the security of sensitive patient data, ensuring HIPAA compliance. Implementation: Implement AI tools designed to audit and insure compliance with healthcare regulations. Educate staff on the importance of data security and how AI supports these efforts.
7. Steps to Begin Integration - Assess Needs Identify specific areas where AI can address pain points or improve processes. Choose Scalable Solutions: Select AI tools and platforms that can grow with your pharmacy's needs. Train and Educate Staff: insure those pharmacists and staff understand how to use AI tools effectively. Monitor and Evaluate Regularly evaluate AI tools to insure they are meeting objectives and improving pharmacy operations. Challenges and Considerations, Ethics and Privacy, Handle patient data responsibly and insure compliance with privacy laws. Cost of Implementation: Initial costs can be high, so consider starting with small, high-impact AI projects.

Continuous Learning AI is evolving, so keep up-to-date with advances and retrain staff as needed. Integrating AI into pharmacy requires a thoughtful approach to align technology with patient care and operational goals. Starting with incremental implementations, along with a focus on training and continuous evaluation, can make the transition smoother and more impactful.

COMPANIES	**AI APPLICATIONS**
PFIZER	Designing drugs, Find individuals with uncommon illnesses, research treatment designs, find possible drug candidates for up to three target proteins, and use artificial intelligence to comprehend patients' clinical histories.
NOVARTIS	Determine early indicators of patient responses to treatments for inflammatory disorders, such as multiple sclerosis (MS) and psoriasis, and decode cancer pathology images using artificial intelligence (AI), macular degeneration medicines, cell and gene therapy, and drug creation.
JOHNSON & JOHNSON	tracking the true needs and health of the skin, and using speech samples to forecast dementia and neurodegenerative illnesses.
SANOFI	Determine and confirm medication target combinations for metabolic diseases such as diabetes.
GLAXOSMITHKLINE (GSK)	Biomedical medicines, which are implantable devices that can modify electrical signals that pass along nerves in the body, including irregular or altered impulses that occur in many illnesses; applying artificial intelligence to synthetic chemistry; and in vivo active lead molecule, which targets a novel pathway for the treatment of chronic obstructive pulmonary disease (COPD).

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