# AI in Natural Sciences: A Primer

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**Abstract** Artificial intelligence (AI) is a field of computer science that enables machines to perform tasks normally requiring human intelligence. AI is a comprehensive technology involving psychology, cognitive science, thinking science, information science, system science, and biological science. The original goal of artificial intelligence (AI) was to build autonomous systems capable of matching human-level intelligence in specific areas of application. Modern AI systems vastly surpass humanly achievable performance across a variety of applications. AI is being used more and more by natural scientists such as physics, chemists, and biologists to perform various tasks. This paper is a primer on the uses of AI in natural sciences.

**Keywords** artificial intelligence, artificial intelligence in natural sciences

## Introduction

Nature is an unparalleled scientist. Traditionally, we learn about nature through observation (or experiment) and simulation. Due to the massive amount of information produced by many of today's physics and astronomy experiments, help is being sought for artificial intelligence which can detect patterns that humans could never have spotted. AI technology is increasingly being used to open up new horizons for s researchers worldwide. AI has become a critical tool for modeling and prediction across diverse areas such as natural sciences, materials, photon science, environmental sciences, manufacturing sciences, biomedicine, genomics, and cosmology. Today, AI is already everywhere and it drives many aspects of our lives. Imagine what computers (the "artificial intelligences") can do: driving a driverless cars, beating world champions at board games like chess, and predicting purchases. That is just a small sample of AI's potential applications in science [1].

We are in a global arms race for making cool things happen with AI technology.

Governments all over the world have launched research initiatives for AI. The United States has expressed its commitment to developing artificial intelligence (AI) by unequivocally declaring 2019 as the Year of AI. The White House established the American AI Initiative, whose goals are to fuel economic growth, enhance national security, and improve quality of life [2].

As shown in Figure 1, AI is a science and technology based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering [3].

AI is being employed aid tasks as diverse as driving cars, scoring job candidates, determining credit scores, and rendering medical diagnoses.
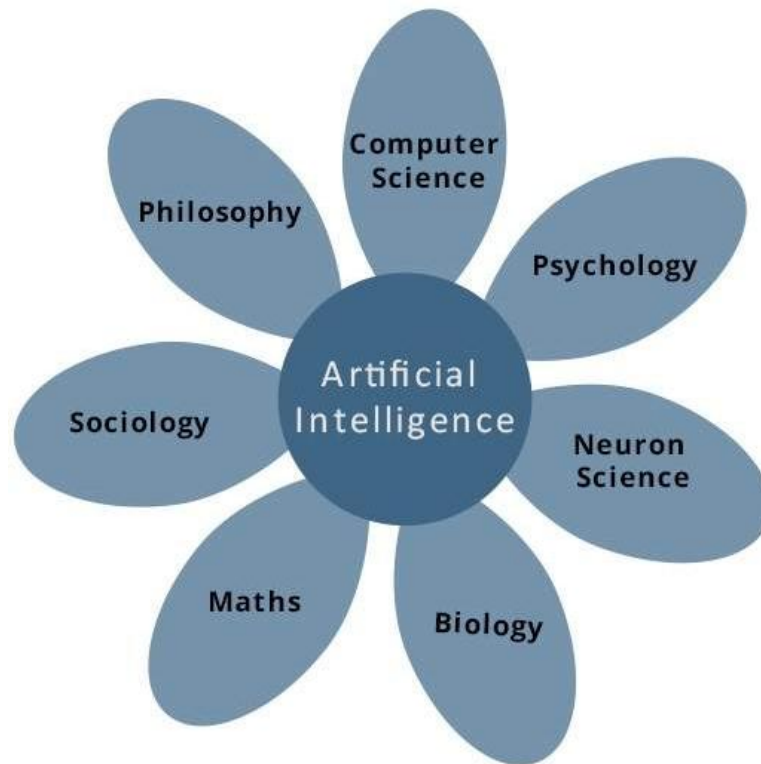
*Figure 1: Artificial intelligence comprises of fields such as computer science, neuron science, psychology, mathematics, engineering, etc. [3]*

**Overview on Artificial Intelligence**

The term "artificial intelligence" (AI) was first used at a Dartmouth College conference in 1956. AI is now one of the most important global issues of the 21st century. AI is the branch of computer science that deals with designing intelligent computer systems that mimic human intelligence, e.g. visual perception, speech recognition, decision-making, and language translation. The ability of machines to process natural language, to learn, to plan makes it possible for new tasks to be performed by intelligent systems. The main purpose of AI is to mimic the cognitive function of human beings and perform activities that would typically be performed by a human being. Without being taught by humans, machines use their own experience to solve a problem.

AI is stand-alone independent electronic entity that functions much like human expert. Today, AI is integrated into our daily lives in several forms, such as personal assistants, automated mass transportation, aviation, computer gaming, facial recognition at passport control, voice recognition on virtual assistants, driverless cars, companion robots, etc. AI is not a single technology but a range of computational models and algorithms.

Some forms of AI that are most commonly used in different applications include the following [4,5]:

- *Expert systems:* They solve problems with an inference engine that draws from a knowledge base equipped with information about a specialized domain, mainly in the form of if-then rules. Expert systems are the earliest, most extensive, the most active and most fruitful area.
- *Fuzzy logic:* This makes it possible to create rules for how machines respond to inputs that account for a continuum of possible conditions, rather than straightforward binary.
- *Neural networks:* These are specific types of machine learning systems that consist of artificial synapses designed to imitate the structure and function of brains. They are similar to the human brain. They are made up of artificial neurons, take in multiple inputs, and produce a single output. The network observes and learns as the synapses transmit data to one another, processing information as it passes through multiple layers.
- *Machine learning:* This includes a broad range of algorithms and statistical models that make it possible for systems to find patterns, draw inferences, and learn to perform tasks without specific

instructions. Machine learning is a process that involves the application of AI to automatically perform a specific task without explicitly programming it. ML techniques may result in data insights that increase production efficiency. Today, artificial intelligence is narrow and mainly based on machine learning.

- *Deep learning***:** This is a form of machine learning based on artificial neural networks. Deep learning architectures are able to process hierarchies of increasingly abstract features, making them especially useful for purposes like speech and image recognition and natural language processing. Deep learning networks can deal with complex non-linear problems.

- *Natural Language Processors*: For AI to be useful to us humans, it needs to be able to communicate with us in our language. Computer programs can translate or interpret language as it is spoken by normal people.

- *Robots*: These are computer-based programmable machines that have physical manipulators and sensors. Sensors can monitor temperature, humidity, pressure, time, record data, and make critical decisions in some cases. Robots have moved from science fiction to your local hospital. In jobs with repetitive and monotonous functions they might even completely replace humans. Robotics and autonomous systems are regarded as the fourth industrial revolution. Robot police with facial recognition technology have started to patrol the streets in China.

These AI tools are illustrated in Figure 2 [6]. Each AI tool has its own advantages. Using a combination of these models, rather than a single model, is recommended. AI systems are designed to make decisions using real-time data. They have the ability to learn and adapt as they make decisions.
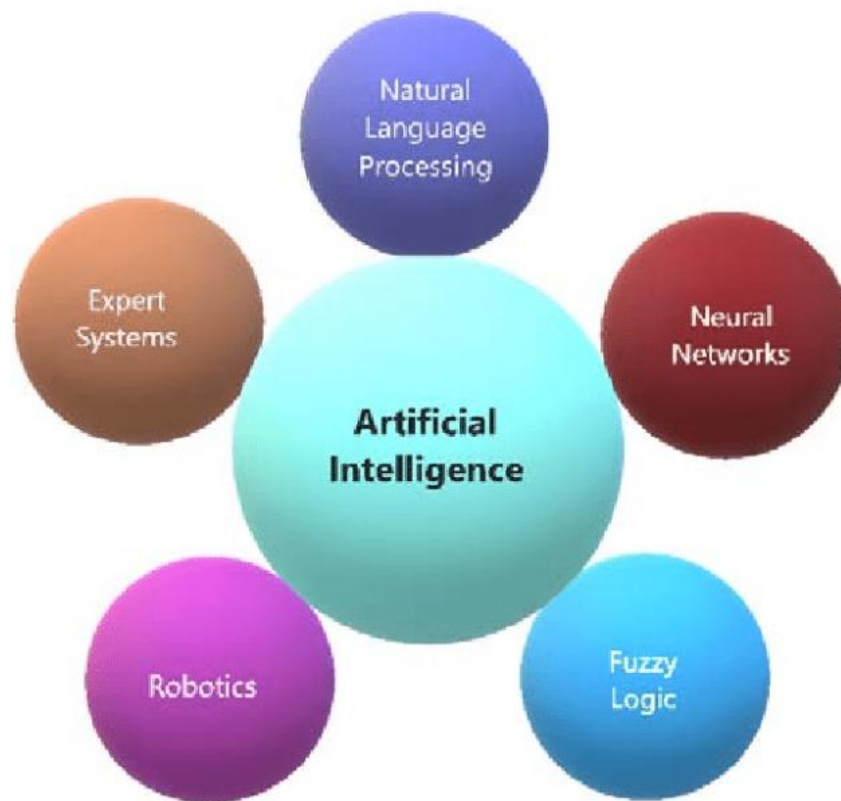


*Figure 2: AI tools [6]*

**Applications of AI in Natural Sciences**

Natural sciences are the frontrunner beneficiaries of artificial intelligence. Science researchers see a world of applications for AI. Today, many of the innovations in AI are driven by machine language techniques. We now highlight some of the uses of AI in physics, biology, and chemistry.

- *Physics:* Physics can lend to the world of AI and AI can enhance the world of physics. AI can be used to do physics better, while physics can be used to build better AI. Physics and machine learning have a basic similarity in that both fields are concerned with making observations and then building models to predict future observations. Most applications of AI in physics loosely fall into three main categories: Data analysis, modeling, and model analysis. Data analysis is the most widely known application of machine learning. This is used in image analysis. Machine learning aids the modeling of physical systems by speeding up calculations. For model analysis, machine learning is applied to understand better the properties of already known theories which cannot be extracted by other mathematical methods [7]. Physicists populate AI research lab at every industry. Quantum systems, statistical mechanics, astrophysics, and particle physics are on the forefront of machine learning.

- *Biology:* Biology is one of the most promising beneficiaries of AI. Artificial intelligence is changing the field of synthetic biology and how we engineer biology. The more data these algorithms collect, the more accurate their predictions become. Many subdisciplines of biology, including imaging, are reaping the rewards of those predictions. As with any computational-biology technique, the results that arise from algorithms are only as good as the data that go in [8]. Machine learning algorithms enable the use of an individual's comprehensive biological information to predict or diagnose diseases. AI has been applied in computational biology and molecular biology.

- *Chemistry:* AI is commonly being used by chemists to perform several tasks. Applications in chemistry include problems where it is necessary to encode chemical expertise, and where chemistry is simply an additional domain to which standard artificial intelligence techniques can be applied. As illustrated in Figure 3, AI has made significant progress towards the acceleration of drug discovery R&D to reduce its huge costs and the time to market for new drugs [9]. Artificial intelligence has emerged as a valuable tool for designing new molecules and it is less biased than human creativity. The prediction of molecular properties can also be done using machine learning algorithms, which have been used to predict properties such as bioactivity, toxicity, solubility, melting points, and atomization energies. Machine learning-based tools are now capable of helping scientists design new molecules and synthesize them [10].
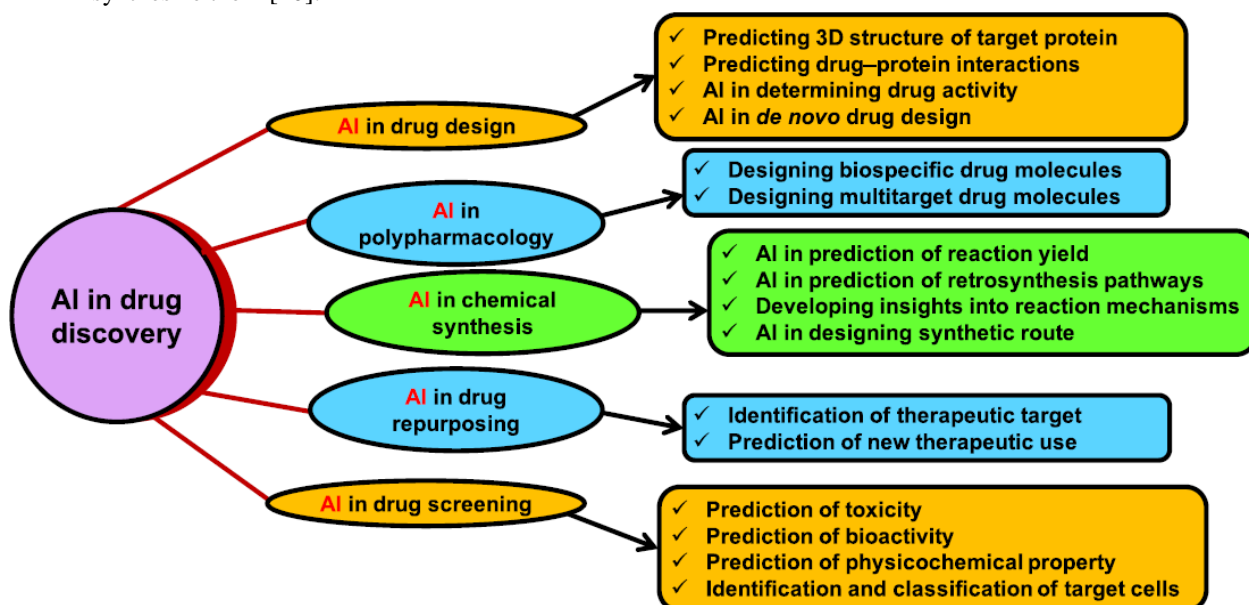


*Figure 3: Role of artificial intelligence (AI) in drug discovery [9]*

**Benefits and Challenges**

Artificial intelligence has several advantages over the natural intelligence because it is more permanent, consistent, less expensive, has the ease of duplication and dissemination, and can perform certain tasks much faster and better than the human. AI technologies have matured to the point in offering real practical benefits in

many areas of applications [11]. It is realized as a revolutionary technology potentially changing our society, industry, culture, and even our philosophy.  AI technology is used to solve societal challenges and boost scientific discovery across fields.  It brings together industry, universities, and investors leading to an array of innovative applications. States and localities also are taking action on AI. AI is leading to faster time-to-solution and providing more precise results.

However, AI must address some critical challenges in order for AI to be more widely trusted, accepted, and seamlessly integrated within the fabric of society. Artificial intelligence does not today bear much of a relationship to natural intelligence. In the US, there are no uniform standards in terms of data access, data sharing, or data protection. In view of privacy, to what extent should AI systems be allowed to access one's personal data from surveillance cameras, phone lines, or emails, in the name of performance customization? [12]. If an autonomous car goes out of control, should it be programmed to kill its own passengers or the pedestrians who are crossing the street?  Computers (the "artificial intelligences") must be better able to perceive and act in the real world,

## Conclusion

Artificial intelligence has become an important, indispensable technology that supports daily social life and economic activities. In view of the rapid development of AI technologies in recent times, there is consensus that AI will have a significant impact on society worldwide. Artificial intelligence is expected to dominate natural sciences in the near future.  The AI community should use natural sciences as a benchmark domain on a regular basis. More information about AI in natural sciences can be found in the book in [13] and related journal: *Artificial Intelligence.*

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