**Artificial intelligence**

**artificial intelligence (AI)**, the ability of a digital [computer](https://www.britannica.com/technology/computer) or computer-controlled [robot](https://www.britannica.com/technology/robot-technology) to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the [intellectual](https://www.merriam-webster.com/dictionary/intellectual) processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience. Since the development of the [digital computer](https://www.britannica.com/technology/digital-computer) in the 1940s, it has been demonstrated that computers can be programmed to carry out very complex tasks—as, for example, discovering proofs for mathematical theorems or playing [chess](https://www.britannica.com/topic/chess)—with great proficiency. Still, despite continuing advances in computer processing speed and memory capacity, there are as yet no programs that can match human flexibility over wider domains or in tasks requiring much everyday knowledge. On the other hand, some programs have attained the performance levels of human experts and professionals in performing certain specific tasks, so that artificial intelligence in this limited sense is found in applications as [diverse](https://www.merriam-webster.com/dictionary/diverse) as medical [diagnosis](https://www.merriam-webster.com/dictionary/diagnosis), computer [search engines](https://www.britannica.com/technology/search-engine), and voice or handwriting recognition.

**What is intelligence?**

All but the simplest [human behaviour](https://www.britannica.com/topic/human-behavior) is ascribed to intelligence, while even the most complicated [insect](https://www.britannica.com/animal/insect) behaviour is never taken as an indication of intelligence. What is the difference? Consider the behaviour of the digger [wasp](https://www.britannica.com/animal/wasp), *Sphex ichneumoneus*. When the female wasp returns to her burrow with food, she first deposits it on the [threshold](https://www.merriam-webster.com/dictionary/threshold), checks for intruders inside her burrow, and only then, if the coast is clear, carries her food inside. The real nature of the wasp’s [instinctual behaviour](https://www.britannica.com/animal/insect/Role-of-hormones#ref41274) is revealed if the food is moved a few inches away from the entrance to her burrow while she is inside: on emerging, she will repeat the whole procedure as often as the food is displaced. Intelligence—conspicuously absent in the case of *Sphex*—must include the ability to adapt to new circumstances.

[Psychologists](https://www.britannica.com/science/psychology) generally do not characterize [human intelligence](https://www.britannica.com/science/human-intelligence-psychology) by just one trait but by the combination of many diverse abilities. Research in AI has focused chiefly on the following components of intelligence: learning, reasoning, [problem solving](https://www.britannica.com/science/problem-solving), [perception](https://www.britannica.com/topic/perception), and using language.

[**Learning**](https://www.britannica.com/technology/machine-learning)

There are a number of different forms of learning as applied to artificial intelligence. The simplest is learning by trial and error. For example, a simple [computer](https://www.britannica.com/technology/computer) program for solving mate-in-one [chess](https://www.britannica.com/topic/chess) problems might try moves at random until mate is found. The program might then store the solution with the position so that the next time the computer encountered the same position it would recall the solution. This simple memorizing of individual items and procedures—known as rote learning—is relatively easy to [implement](https://www.merriam-webster.com/dictionary/implement) on a computer. More challenging is the problem of [implementing](https://www.merriam-webster.com/dictionary/implementing) what is called [generalization](https://www.britannica.com/topic/generalization). Generalization involves applying past experience to [analogous](https://www.merriam-webster.com/dictionary/analogous) new situations. For example, a program that learns the past tense of regular English verbs by rote will not be able to produce the past tense of a word such as *jump* unless it previously had been presented with *jumped*, whereas a program that is able to generalize can learn the “add *ed*” rule and so form the past tense of *jump* based on experience with similar verbs.

**Reasoning**

To reason is to draw [inferences](https://www.merriam-webster.com/dictionary/inferences) appropriate to the situation. Inferences are classified as either [deductive](https://www.britannica.com/topic/deduction-reason) or [inductive](https://www.britannica.com/topic/induction-reason). An example of the former is, “Fred must be in either the museum or the café. He is not in the café; therefore he is in the museum,” and of the latter, “Previous accidents of this sort were caused by instrument failure; therefore this accident was caused by instrument failure.” The most significant difference between these forms of reasoning is that in the deductive case the truth of the [premises](https://www.merriam-webster.com/dictionary/premises) guarantees the truth of the conclusion, whereas in the inductive case the truth of the [premise](https://www.merriam-webster.com/dictionary/premise) lends support to the conclusion without giving absolute [assurance](https://www.merriam-webster.com/dictionary/assurance). Inductive reasoning is common in [science](https://www.britannica.com/science/science), where data are collected and tentative models are developed to describe and predict future behaviour—until the appearance of anomalous data forces the model to be revised. Deductive reasoning is common in [mathematics](https://www.britannica.com/science/mathematics) and [logic](https://www.britannica.com/topic/logic), where elaborate structures of irrefutable theorems are built up from a small set of basic axioms and rules.

There has been considerable success in programming computers to draw inferences, especially deductive inferences. However, true reasoning involves more than just drawing inferences; it involves drawing inferences *relevant* to the solution of the particular task or situation. This is one of the hardest problems confronting AI.

[**Problem solving**](https://www.britannica.com/science/problem-solving)

Problem solving, particularly in artificial intelligence, may be characterized as a systematic search through a range of possible actions in order to reach some predefined goal or solution. Problem-solving methods divide into special purpose and general purpose. A special-purpose method is tailor-made for a particular problem and often exploits very specific features of the situation in which the problem is embedded. In contrast, a general-purpose method is applicable to a wide variety of problems. One general-purpose technique used in AI is means-end analysis—a step-by-step, or [incremental](https://www.merriam-webster.com/dictionary/incremental), reduction of the difference between the current state and the final goal. The program selects actions from a list of means—in the case of a simple [robot](https://www.britannica.com/technology/robot-technology) this might consist of PICKUP, PUTDOWN, MOVEFORWARD, MOVEBACK, MOVELEFT, and MOVERIGHT—until the goal is reached.

Many [diverse](https://www.merriam-webster.com/dictionary/diverse) problems have been solved by artificial intelligence programs. Some examples are finding the winning move (or sequence of moves) in a board game, devising mathematical proofs, and manipulating “virtual objects” in a computer-generated world.

**Perception**

In [perception](https://www.britannica.com/topic/perception) the [environment](https://www.merriam-webster.com/dictionary/environment) is scanned by means of various sensory organs, real or artificial, and the scene is decomposed into separate objects in various spatial relationships. Analysis is complicated by the fact that an object may appear different depending on the angle from which it is viewed, the direction and intensity of illumination in the scene, and how much the object contrasts with the surrounding field.

At present, artificial perception is sufficiently well advanced to enable optical sensors to identify individuals, [autonomous](https://www.merriam-webster.com/dictionary/autonomous) vehicles to drive at moderate speeds on the open road, and robots to roam through buildings collecting empty soda cans. One of the earliest systems to [integrate](https://www.merriam-webster.com/dictionary/integrate) perception and action was FREDDY, a stationary robot with a moving television eye and a pincer hand, constructed at the [University of Edinburgh](https://www.britannica.com/topic/University-of-Edinburgh), Scotland, during the period 1966–73 under the direction of Donald Michie. FREDDY was able to recognize a variety of objects and could be instructed to assemble simple [artifacts](https://www.merriam-webster.com/dictionary/artifacts), such as a toy car, from a random heap of components.

[**Language**](https://www.britannica.com/topic/language)

A [language](https://www.britannica.com/topic/language) is a system of signs having meaning by convention. In this sense, language need not be confined to the spoken word. Traffic signs, for example, form a minilanguage, it being a matter of convention that ⚠ means “hazard ahead” in some countries. It is distinctive of languages that linguistic units possess meaning by convention, and linguistic meaning is very different from what is called natural meaning, exemplified in statements such as “Those clouds mean rain” and “The fall in pressure means the valve is malfunctioning.”

An important characteristic of full-fledged human languages—in contrast to birdcalls and traffic signs—is their productivity. A productive language can formulate an unlimited variety of sentences.

It is relatively easy to write [computer programs](https://www.britannica.com/technology/computer-program) that seem able, in severely restricted [contexts](https://www.merriam-webster.com/dictionary/contexts), to respond fluently in a human language to questions and statements. Although none of these programs actually understands language, they may, in principle, reach the point where their command of a language is indistinguishable from that of a normal human. What, then, is involved in genuine understanding, if even a computer that uses language like a native human speaker is not acknowledged to understand? There is no universally agreed upon answer to this difficult question. According to one theory, whether or not one understands depends not only on one’s behaviour but also on one’s history: in order to be said to understand, one must have learned the language and have been trained to take one’s place in the linguistic [community](https://www.merriam-webster.com/dictionary/community) by means of interaction with other language users.

**Methods and goals in AI**

**Symbolic vs. connectionist approaches**

AI research follows two distinct, and to some extent competing, methods, the symbolic (or “top-down”) approach, and the connectionist (or “bottom-up”) approach. The [top-down approach](https://www.britannica.com/technology/top-down-approach) seeks to replicate intelligence by analyzing [cognition](https://www.britannica.com/topic/cognition-thought-process) independent of the biological structure of the [brain](https://www.britannica.com/science/brain), in terms of the processing of symbols—whence the *symbolic* label. The [bottom-up approach](https://www.britannica.com/technology/bottom-up-approach), on the other hand, involves creating artificial [neural networks](https://www.britannica.com/technology/neural-network) in imitation of the brain’s structure—whence the *connectionist* label.

To illustrate the difference between these approaches, consider the task of building a system, equipped with an [optical scanner](https://www.britannica.com/technology/optical-scanner), that recognizes the letters of the alphabet. A bottom-up approach typically involves training an artificial neural network by presenting letters to it one by one, gradually improving performance by “tuning” the network. (Tuning adjusts the responsiveness of different neural pathways to different stimuli.) In contrast, a top-down approach typically involves writing a [computer program](https://www.britannica.com/technology/computer-program) that compares each letter with geometric descriptions. Simply put, neural activities are the basis of the bottom-up approach, while symbolic descriptions are the basis of the top-down approach.

In *The Fundamentals of Learning* (1932), [Edward Thorndike](https://www.britannica.com/biography/Edward-L-Thorndike), a psychologist at [Columbia University](https://www.britannica.com/topic/Columbia-University), [New York City](https://www.britannica.com/place/New-York-City), first suggested that human [learning](https://www.britannica.com/science/learning) consists of some unknown property of connections between [neurons](https://www.britannica.com/science/neuron) in the brain. In *The Organization of Behavior* (1949), Donald Hebb, a psychologist at [McGill University](https://www.britannica.com/topic/McGill-University), Montreal, Canada, suggested that learning specifically involves strengthening certain patterns of neural activity by increasing the probability (weight) of induced [neuron](https://www.britannica.com/science/neuron) firing between the associated connections. The notion of weighted connections is described in a later section, [Connectionism](https://www.britannica.com/technology/artificial-intelligence/Connectionism#ref219103).

In 1957 two vigorous advocates of symbolic AI—Allen Newell, a researcher at the [RAND Corporation](https://www.britannica.com/topic/RAND-Corporation), [Santa Monica](https://www.britannica.com/place/Santa-Monica), California, and [Herbert Simon](https://www.britannica.com/biography/Herbert-A-Simon), a [psychologist](https://www.britannica.com/science/psychology) and [computer scientist](https://www.britannica.com/science/computer-science) at [Carnegie Mellon University](https://www.britannica.com/topic/Carnegie-Mellon-University), Pittsburgh, Pennsylvania—summed up the top-down approach in what they called the physical symbol system hypothesis. This [hypothesis](https://www.merriam-webster.com/dictionary/hypothesis) states that processing structures of symbols is sufficient, in principle, to produce artificial intelligence in a [digital computer](https://www.britannica.com/technology/digital-computer) and that, moreover, [human intelligence](https://www.britannica.com/science/human-intelligence-psychology) is the result of the same type of symbolic manipulations.

During the 1950s and ’60s the top-down and bottom-up approaches were pursued simultaneously, and both achieved noteworthy, if limited, results. During the 1970s, however, bottom-up AI was neglected, and it was not until the 1980s that this approach again became prominent. Nowadays both approaches are followed, and both are acknowledged as facing difficulties. Symbolic techniques work in simplified realms but typically break down when confronted with the real world; meanwhile, bottom-up researchers have been unable to replicate the nervous systems of even the simplest living things. *Caenorhabditis elegans*, a much-studied worm, has approximately 300 neurons whose pattern of interconnections is perfectly known. Yet connectionist models have failed to mimic even this worm. Evidently, the neurons of connectionist theory are gross oversimplifications of the real thing.

**Strong AI, applied AI, and cognitive simulation**

Employing the methods outlined above, AI research attempts to reach one of three goals: strong AI, applied AI, or [cognitive](https://www.merriam-webster.com/dictionary/cognitive) simulation. [Strong AI](https://www.britannica.com/technology/strong-artificial-intelligence) aims to build machines that think. (The term *strong AI* was introduced for this category of research in 1980 by the philosopher [John Searle](https://www.britannica.com/biography/John-Searle) of the [University of California](https://www.britannica.com/topic/University-of-California) at Berkeley.) The ultimate ambition of strong AI is to produce a [machine](https://www.britannica.com/technology/machine) whose overall [intellectual](https://www.merriam-webster.com/dictionary/intellectual) ability is indistinguishable from that of a [human being](https://www.britannica.com/topic/human-being). As is described in the section [Early milestones in AI](https://www.britannica.com/technology/artificial-intelligence/The-Turing-test#ref219091), this goal generated great interest in the 1950s and ’60s, but such optimism has given way to an appreciation of the extreme difficulties involved. To date, progress has been meagre. Some critics doubt whether research will produce even a system with the overall intellectual ability of an [ant](https://www.britannica.com/animal/ant) in the foreseeable future. Indeed, some researchers working in AI’s other two branches view strong AI as not worth pursuing.

Applied AI, also known as advanced [information processing](https://www.britannica.com/technology/information-processing), aims to produce commercially viable “smart” systems—for example, “expert” medical [diagnosis](https://www.merriam-webster.com/dictionary/diagnosis) systems and stock-trading systems. Applied AI has enjoyed considerable success, as described in the section [Expert systems](https://www.britannica.com/technology/artificial-intelligence/Expert-systems#ref219098).

In cognitive simulation, computers are used to test theories about how the human [mind](https://www.britannica.com/topic/mind) works—for example, theories about how people recognize faces or recall memories. Cognitive simulation is already a powerful [tool](https://www.britannica.com/technology/tool) in both neuroscience and [cognitive psychology](https://www.britannica.com/science/cognitive-psychology).

[**Alan Turing**](https://www.britannica.com/biography/Alan-Turing)**and the beginning of AI**

**Theoretical work**

[Alan Turing](https://cdn.britannica.com/81/191581-050-8C0A8CD3/Alan-Turing.jpg)

The earliest substantial work in the field of artificial intelligence was done in the mid-20th century by the British logician and computer pioneer [Alan Mathison Turing](https://www.britannica.com/biography/Alan-Turing). In 1935 Turing described an abstract computing [machine](https://www.britannica.com/technology/machine) consisting of a limitless memory and a scanner that moves back and forth through the [memory](https://www.britannica.com/technology/computer-memory), symbol by symbol, reading what it finds and writing further symbols. The actions of the scanner are dictated by a program of instructions that also is stored in the memory in the form of symbols. This is Turing’s [stored-program](https://www.britannica.com/technology/stored-program-concept) concept, and [implicit](https://www.merriam-webster.com/dictionary/implicit) in it is the possibility of the machine operating on, and so modifying or improving, its own program. Turing’s [conception](https://www.merriam-webster.com/dictionary/conception) is now known simply as the universal [Turing machine](https://www.britannica.com/technology/Turing-machine). All modern computers are in essence universal Turing machines.

During [World War II](https://www.britannica.com/event/World-War-II), Turing was a leading cryptanalyst at the Government Code and Cypher School in [Bletchley Park](https://www.britannica.com/place/Bletchley-Park), Buckinghamshire, England. Turing could not turn to the project of building a stored-program electronic computing machine until the cessation of hostilities in Europe in 1945. Nevertheless, during the war he gave considerable thought to the issue of machine intelligence. One of Turing’s colleagues at Bletchley Park, Donald Michie (who later founded the Department of Machine Intelligence and Perception at the University of Edinburgh), later recalled that Turing often discussed how computers could learn from experience as well as solve new problems through the use of guiding principles—a process now known as heuristic problem solving.

Turing gave quite possibly the earliest public lecture (London, 1947) to mention computer intelligence, saying, “What we want is a machine that can learn from experience,” and that the “possibility of letting the machine alter its own instructions provides the mechanism for this.” In 1948 he introduced many of the central [concepts](https://www.britannica.com/dictionary/concepts) of AI in a report entitled “Intelligent Machinery.” However, Turing did not publish this paper, and many of his ideas were later reinvented by others. For instance, one of Turing’s original ideas was to train a network of artificial [neurons](https://www.britannica.com/science/neuron) to perform specific tasks, an approach described in the section [Connectionism](https://www.britannica.com/technology/artificial-intelligence/Connectionism#ref219103).

Слова:

1. endowed  - одаренный
2. carry out – выполнять
3. flexibility  - гибкость
4. wasp  - оса
5. [threshold](https://www.merriam-webster.com/dictionary/threshold) – порог
6. intruders  - нарушитель
7. mate-in-one – мат в один ход
8. encountered  - сталкиваться
9. rote  - механическое запоминание
10. inference – вывод
11. To reason – рассуждать
12. Premise – предпосылка
13. tentative – предварительный
14. irrefutable  - неопровержимый
15. tailor-made – сделанный на заказ
16. sufficiently  - достаточно
17. pincer  - клещи
18. heap  - куча
19. distinctive  - отличительный/особенный
20. possess  - обладатель
21. malfunctioning – неисправный
22. full-fledged – полноценный
23. distinct – отчетливый
24. simultaneously – одновременно
25. neglected заброшен
26. approximately  - приблизительно
27. substantial  -существенный