[**Chess**](https://www.britannica.com/topic/chess)

At Bletchley Park, Turing illustrated his ideas on machine intelligence by reference to [chess](https://www.britannica.com/topic/chess)—a useful source of challenging and clearly defined problems against which proposed methods for [problem solving](https://www.britannica.com/science/problem-solving) could be tested. In principle, a chess-playing computer could play by searching exhaustively through all the available moves, but in practice this is impossible because it would involve examining an astronomically large number of moves. [Heuristics](https://www.merriam-webster.com/dictionary/Heuristics) are necessary to guide a narrower, more discriminative search. Although Turing experimented with designing chess programs, he had to content himself with theory in the absence of a computer to run his chess program. The first true AI programs had to await the arrival of [stored-program electronic digital computers](https://www.britannica.com/technology/computer/ENIAC#ref216048).

In 1945 Turing predicted that computers would one day play very good chess, and just over 50 years later, in 1997, [Deep Blue](https://www.britannica.com/topic/Deep-Blue), a [chess computer](https://www.britannica.com/topic/chess/Chess-and-artificial-intelligence#ref80452) built by the [International Business Machines Corporation (IBM)](https://www.britannica.com/topic/International-Business-Machines-Corporation), beat the reigning world champion, [Garry Kasparov](https://www.britannica.com/biography/Garry-Kasparov), in a six-game match. While Turing’s prediction came true, his expectation that chess [programming](https://www.britannica.com/dictionary/programming) would contribute to the understanding of how human beings think did not. The huge improvement in computer chess since Turing’s day is attributable to advances in computer [engineering](https://www.britannica.com/technology/engineering) rather than advances in AI—Deep Blue’s 256 parallel processors enabled it to examine 200 million possible moves per second and to look ahead as many as 14 turns of play. Many agree with [Noam Chomsky](https://www.britannica.com/biography/Noam-Chomsky), a linguist at the [Massachusetts Institute of Technology (MIT)](https://www.britannica.com/topic/Massachusetts-Institute-of-Technology), who opined that a computer beating a grandmaster at chess is about as interesting as a bulldozer winning an [Olympic](https://www.britannica.com/sports/Olympic-Games) [weightlifting](https://www.britannica.com/sports/weightlifting) competition.

**The**[**Turing test**](https://www.britannica.com/technology/Turing-test)

In 1950 Turing sidestepped the traditional debate concerning the definition of intelligence, introducing a practical test for computer intelligence that is now known simply as the [Turing test](https://www.britannica.com/technology/Turing-test). The Turing test involves three participants: a computer, a human interrogator, and a human foil. The interrogator attempts to determine, by asking questions of the other two participants, which is the computer. All communication is via keyboard and display screen. The interrogator may ask questions as penetrating and wide-ranging as he or she likes, and the computer is permitted to do everything possible to force a wrong identification. (For instance, the computer might answer, “No,” in response to, “Are you a computer?” and might follow a request to multiply one large number by another with a long pause and an incorrect answer.) The foil must help the interrogator to make a correct identification. A number of different people play the roles of interrogator and foil, and, if a [sufficient](https://www.britannica.com/dictionary/sufficient) proportion of the interrogators are unable to distinguish the computer from the [human being](https://www.britannica.com/topic/human-being), then (according to proponents of Turing’s test) the computer is considered an intelligent, thinking entity.

In 1991 the American philanthropist Hugh Loebner started the annual Loebner Prize competition, promising a $100,000 payout to the first computer to pass the Turing test and awarding $2,000 each year to the best effort. However, no AI program has come close to passing an undiluted Turing test. In late 2022, the advent of [ChatGPT](https://www.britannica.com/technology/ChatGPT) reignited conversation about the likelihood that the components of the Turing test had been met.

**Early milestones in AI**

**The first AI programs**

The earliest successful AI program was written in 1951 by Christopher Strachey, later director of the [Programming](https://www.britannica.com/dictionary/Programming) Research Group at the [University of Oxford](https://www.britannica.com/topic/University-of-Oxford). Strachey’s [checkers](https://www.britannica.com/topic/checkers) (draughts) program ran on the [Ferranti Mark I](https://www.britannica.com/technology/computer/ENIAC#ref216048) computer at the [University of Manchester](https://www.britannica.com/topic/University-of-Manchester), England. By the summer of 1952 this program could play a complete game of checkers at a reasonable speed.

Information about the earliest successful demonstration of [machine learning](https://www.britannica.com/technology/machine-learning) was published in 1952. Shopper, written by Anthony Oettinger at the [University of Cambridge](https://www.britannica.com/topic/University-of-Cambridge), ran on the [EDSAC](https://www.britannica.com/technology/computer/ENIAC#ref216048) computer. Shopper’s simulated world was a mall of eight shops. When instructed to purchase an item, Shopper would search for it, visiting shops at random until the item was found. While searching, Shopper would memorize a few of the items stocked in each shop visited (just as a human shopper might). The next time Shopper was sent out for the same item, or for some other item that it had already located, it would go to the right shop straight away. This simple form of [learning](https://www.britannica.com/science/learning), as is pointed out in the introductory section [What is intelligence?](https://www.britannica.com/technology/artificial-intelligence#ref219078), is called rote learning.

The first AI program to run in the [United States](https://www.britannica.com/place/United-States) also was a checkers program, written in 1952 by Arthur Samuel for the [prototype](https://www.merriam-webster.com/dictionary/prototype) of the [IBM](https://www.britannica.com/topic/International-Business-Machines-Corporation) 701. Samuel took over the essentials of Strachey’s checkers program and over a period of years considerably extended it. In 1955 he added features that enabled the program to learn from experience. Samuel included mechanisms for both rote learning and generalization, enhancements that eventually led to his program’s winning one game against a former Connecticut [checkers](https://www.britannica.com/topic/checkers) champion in 1962.

**Evolutionary computing**

Samuel’s checkers program was also notable for being one of the first efforts at evolutionary computing. (His program “evolved” by pitting a modified copy against the current best version of his program, with the winner becoming the new standard.) Evolutionary computing typically involves the use of some automatic method of generating and evaluating successive “generations” of a program, until a highly proficient solution evolves.

A leading proponent of evolutionary computing, [John Holland](https://www.britannica.com/biography/John-Henry-Holland), also wrote test [software](https://www.britannica.com/technology/software) for the [prototype](https://www.merriam-webster.com/dictionary/prototype) of the IBM 701 computer. In particular, he helped design a [neural-network](https://www.britannica.com/technology/neural-network) “virtual” rat that could be trained to navigate through a maze. This work convinced Holland of the [efficacy](https://www.merriam-webster.com/dictionary/efficacy) of the bottom-up approach. While continuing to consult for [IBM](https://www.britannica.com/topic/International-Business-Machines-Corporation), Holland moved to the [University of Michigan](https://www.britannica.com/topic/University-of-Michigan) in 1952 to pursue a doctorate in [mathematics](https://www.britannica.com/science/mathematics). He soon switched, however, to a new interdisciplinary program in [computers](https://www.britannica.com/technology/computer) and information processing (later known as communications science) created by Arthur Burks, one of the builders of [ENIAC](https://www.britannica.com/technology/ENIAC) and its successor EDVAC. In his 1959 dissertation, for most likely the world’s first [computer science](https://www.britannica.com/science/computer-science) Ph.D., Holland proposed a new type of computer—a [multiprocessor](https://www.britannica.com/technology/multiprocessing) computer—that would assign each artificial [neuron](https://www.britannica.com/science/neuron) in a network to a separate processor. (In 1985 [Daniel Hillis](https://www.britannica.com/biography/Danny-Hillis) solved the [engineering](https://www.britannica.com/technology/engineering) difficulties to build the first such computer, the 65,536-processor Thinking Machines Corporation [supercomputer](https://www.britannica.com/technology/supercomputer#ref93020).)

Holland joined the faculty at Michigan after graduation and over the next four decades directed much of the research into methods of automating evolutionary computing, a process now known by the term [*genetic algorithms*](https://www.britannica.com/technology/genetic-algorithm). Systems [implemented](https://www.merriam-webster.com/dictionary/implemented) in Holland’s laboratory included a [chess](https://www.britannica.com/topic/chess) program, models of single-[cell](https://www.britannica.com/science/cell-biology) biological organisms, and a classifier system for controlling a simulated gas-pipeline network. Genetic [algorithms](https://www.merriam-webster.com/dictionary/algorithms) are no longer restricted to “academic” demonstrations, however; in one important practical application, a genetic [algorithm](https://www.merriam-webster.com/dictionary/algorithm) cooperates with a witness to a crime in order to generate a portrait of the criminal.

[**Logical**](https://www.britannica.com/topic/logic)**reasoning and problem solving**

The ability to reason logically is an important aspect of intelligence and has always been a major focus of AI research. An important landmark in this area was a theorem-proving program written in 1955–56 by [Allen Newell](https://www.britannica.com/biography/Allen-Newell) and J. Clifford Shaw of the [RAND Corporation](https://www.britannica.com/topic/RAND-Corporation) and [Herbert Simon](https://www.britannica.com/biography/Herbert-A-Simon) of the [Carnegie Mellon University](https://www.britannica.com/topic/Carnegie-Mellon-University). The [Logic Theorist](https://www.britannica.com/technology/Logic-Theorist), as the program became known, was designed to prove theorems from *Principia Mathematica* (1910–13), a three-volume work by the British philosopher-mathematicians [Alfred North Whitehead](https://www.britannica.com/biography/Alfred-North-Whitehead) and [Bertrand Russell](https://www.britannica.com/biography/Bertrand-Russell). In one instance, a proof devised by the program was more elegant than the proof given in the books.

Newell, Simon, and Shaw went on to write a more powerful program, the [General Problem Solver](https://www.britannica.com/science/General-Problem-Solver), or GPS. The first version of GPS ran in 1957, and work continued on the project for about a decade. GPS could solve an impressive variety of puzzles using a trial and error approach. However, one [criticism](https://www.merriam-webster.com/dictionary/criticism) of GPS, and similar programs that lack any [learning](https://www.britannica.com/science/learning) capability, is that the program’s intelligence is entirely secondhand, coming from whatever information the programmer explicitly includes.

**English dialogue**

Two of the best-known early AI programs, Eliza and [Parry](https://www.britannica.com/topic/Parry), gave an eerie semblance of intelligent conversation. (Details of both were first published in 1966.) Eliza, written by Joseph Weizenbaum of MIT’s AI Laboratory, simulated a human therapist. Parry, written by [Stanford University](https://www.britannica.com/topic/Stanford-University) psychiatrist Kenneth Colby, simulated a human [paranoiac](https://www.britannica.com/science/paranoia). Psychiatrists who were asked to decide whether they were communicating with Parry or a human paranoiac were often unable to tell. Nevertheless, neither Parry nor Eliza could reasonably be described as intelligent. Parry’s contributions to the conversation were canned—constructed in advance by the programmer and stored away in the [computer’s memory](https://www.britannica.com/technology/computer-memory). Eliza, too, relied on canned sentences and simple [programming](https://www.britannica.com/dictionary/programming) tricks.

**AI**[**programming languages**](https://www.britannica.com/technology/computer-programming-language)

In the course of their work on the Logic Theorist and GPS, Newell, Simon, and Shaw developed their [Information Processing Language](https://www.britannica.com/technology/Information-Processing-Language) (IPL), a computer language tailored for AI programming. At the heart of IPL was a highly flexible [data structure](https://www.britannica.com/technology/data-structure) that they called a list. A list is simply an ordered sequence of items of data. Some or all of the items in a list may themselves be lists. This scheme leads to richly branching structures.

In 1960 [John McCarthy](https://www.britannica.com/biography/John-McCarthy) combined elements of IPL with the [lambda calculus](https://www.britannica.com/topic/lambda-calculus) (a formal mathematical-logical system) to produce the programming language [LISP](https://www.britannica.com/technology/LISP-computer-language) (List Processor), which remains the principal language for AI work in the [United States](https://www.britannica.com/place/United-States). (The lambda calculus itself was invented in 1936 by the Princeton logician [Alonzo Church](https://www.britannica.com/biography/Alonzo-Church) while he was investigating the abstract *Entscheidungsproblem*, or “decision problem,” for [predicate](https://www.merriam-webster.com/dictionary/predicate) logic—the same problem that [Turing](https://www.britannica.com/biography/Alan-Turing) had been attacking when he invented the universal [Turing machine](https://www.britannica.com/technology/Turing-machine).)

The logic programming language [PROLOG](https://www.britannica.com/technology/PROLOG) (Programmation en Logique) was conceived by Alain Colmerauer at the University of Aix-Marseille, France, where the language was first implemented in 1973. PROLOG was further developed by the logician Robert Kowalski, a member of the AI group at the [University of Edinburgh](https://www.britannica.com/topic/University-of-Edinburgh). This language makes use of a powerful theorem-proving technique known as [resolution](https://www.britannica.com/technology/resolution-computer-logic), invented in 1963 at the U.S. [Atomic Energy Commission’s](https://www.britannica.com/topic/Atomic-Energy-Commission-United-States-organization) [Argonne National Laboratory](https://www.britannica.com/topic/Argonne-National-Laboratory) in Illinois by the British logician Alan Robinson. PROLOG can determine whether or not a given statement follows logically from other given statements. For example, given the statements “All logicians are rational” and “Robinson is a logician,” a PROLOG program responds in the [affirmative](https://www.merriam-webster.com/dictionary/affirmative) to the query “Robinson is rational?” PROLOG is widely used for AI work, especially in Europe and Japan.

Researchers at the Institute for New Generation Computer Technology in Tokyo have used PROLOG as the basis for sophisticated logic programming languages. Known as [fifth-generation languages](https://www.britannica.com/technology/fifth-generation-language), these are in use on nonnumerical parallel computers developed at the Institute.

Other recent work includes the development of languages for reasoning about time-dependent data such as “the account was paid yesterday.” These languages are based on [tense logic](https://www.britannica.com/topic/temporal-logic), which permits statements to be located in the flow of time. (Tense logic was invented in 1953 by the philosopher Arthur Prior at the University of Canterbury, Christchurch, New Zealand.)

**Microworld programs**

To cope with the bewildering complexity of the real world, scientists often ignore less relevant details; for instance, physicists often ignore [friction](https://www.britannica.com/science/friction) and [elasticity](https://www.britannica.com/science/elasticity-physics) in their models. In 1970 [Marvin Minsky](https://www.britannica.com/biography/Marvin-Lee-Minsky) and [Seymour Papert](https://www.britannica.com/biography/Seymour-Papert) of the MIT AI Laboratory proposed that likewise AI research should focus on developing programs capable of intelligent behaviour in simpler artificial [environments](https://www.merriam-webster.com/dictionary/environments) known as microworlds. Much research has focused on the so-called blocks world, which consists of coloured blocks of various shapes and sizes arrayed on a flat surface.

An early success of the microworld approach was [SHRDLU](https://www.britannica.com/technology/SHRDLU), written by Terry Winograd of MIT. (Details of the program were published in 1972.) SHRDLU controlled a robot arm that operated above a flat surface strewn with play blocks. Both the arm and the blocks were virtual. SHRDLU would respond to commands typed in natural English, such as “Will you please stack up both of the red blocks and either a green cube or a pyramid.” The program could also answer questions about its own actions.Although SHRDLU was initially hailed as a major breakthrough, Winograd soon announced that the program was, in fact, a dead end. The techniques pioneered in the program proved unsuitable for application in wider, more interesting worlds. Moreover, the appearance that SHRDLU gave of understanding the blocks microworld, and English statements concerning it, was in fact an [illusion](https://www.merriam-webster.com/dictionary/illusion). SHRDLU had no [idea](https://www.britannica.com/topic/idea) what a green block was.

Another product of the microworld approach was [Shakey](https://www.britannica.com/topic/Shakey), a mobile [robot](https://www.britannica.com/technology/robot-technology) developed at the Stanford Research Institute by Bertram Raphael, Nils Nilsson, and others during the period 1968–72. The robot occupied a specially built microworld consisting of walls, doorways, and a few simply shaped wooden blocks. Each wall had a carefully painted baseboard to enable the robot to “see” where the wall met the floor (a simplification of reality that is typical of the microworld approach). Shakey had about a dozen basic abilities, such as TURN, PUSH, and CLIMB-RAMP.

Critics pointed out the highly simplified nature of Shakey’s [environment](https://www.merriam-webster.com/dictionary/environment) and emphasized that, despite these simplifications, Shakey operated excruciatingly slowly; a series of actions that a human could plan out and execute in minutes took Shakey days.

The greatest success of the microworld approach is a type of program known as an [expert system](https://www.britannica.com/technology/expert-system), described in the next section.

[**Expert systems**](https://www.britannica.com/technology/expert-system)

Expert systems occupy a type of microworld—for example, a model of a ship’s hold and its cargo—that is self-contained and relatively uncomplicated. For such AI systems every effort is made to incorporate all the information about some narrow field that an expert (or group of experts) would know, so that a good expert system can often outperform any single human expert. There are many commercial expert systems, including programs for medical [diagnosis](https://www.merriam-webster.com/dictionary/diagnosis), [chemical analysis](https://www.britannica.com/science/chemical-analysis), credit authorization, financial management, corporate planning, financial document routing, [oil](https://www.britannica.com/science/oil-chemical-compound) and [mineral](https://www.britannica.com/science/mineral-chemical-compound) prospecting, [genetic engineering](https://www.britannica.com/science/genetic-engineering), [automobile](https://www.britannica.com/technology/automobile) design and manufacture, [camera](https://www.britannica.com/technology/camera) lens design, [computer](https://www.britannica.com/technology/computer) installation design, airline scheduling, cargo placement, and automatic help services for home computer owners.

**Knowledge and inference**

The basic components of an expert system are a [knowledge base](https://www.britannica.com/technology/knowledge-base), or KB, and an [inference](https://www.merriam-webster.com/dictionary/inference) engine. The information to be stored in the KB is obtained by interviewing people who are expert in the area in question. The interviewer, or knowledge engineer, organizes the information elicited from the experts into a collection of rules, typically of an “if-then” structure. Rules of this type are called production rules. The [inference engine](https://www.britannica.com/technology/inference-engine) enables the expert system to draw deductions from the rules in the KB. For example, if the KB contains the production rules “if *x*, then *y*” and “if *y*, then *z*,” the inference engine is able to deduce “if *x*, then *z*.” The expert system might then query its user, “Is *x* true in the situation that we are considering?” If the answer is [affirmative](https://www.merriam-webster.com/dictionary/affirmative), the system will proceed to infer *z*.

Some expert systems use [fuzzy logic](https://www.britannica.com/science/fuzzy-logic). In standard [logic](https://www.britannica.com/topic/logic) there are only two truth values, true and false. This absolute precision makes vague attributes or situations difficult to characterize. (When, precisely, does a thinning head of hair become a bald head?) Often the rules that human experts use contain vague expressions, and so it is useful for an expert system’s inference engine to employ fuzzy logic.

[**DENDRAL**](https://www.britannica.com/technology/DENDRAL)

In 1965 the AI researcher Edward Feigenbaum and the geneticist [Joshua Lederberg](https://www.britannica.com/biography/Joshua-Lederberg), both of [Stanford University](https://www.britannica.com/topic/Stanford-University), began work on [Heuristic](https://www.merriam-webster.com/dictionary/Heuristic) DENDRAL (later shortened to DENDRAL), a chemical-analysis expert system. The substance to be analyzed might, for example, be a complicated [compound](https://www.britannica.com/science/chemical-compound) of [carbon](https://www.britannica.com/science/carbon-chemical-element), [hydrogen](https://www.britannica.com/science/hydrogen), and [nitrogen](https://www.britannica.com/science/nitrogen). Starting from spectrographic data obtained from the substance, DENDRAL would hypothesize the substance’s [molecular](https://www.britannica.com/science/molecule) structure. DENDRAL’s performance rivaled that of [chemists](https://www.britannica.com/science/chemistry) expert at this task, and the program was used in industry and in [academia](https://www.merriam-webster.com/dictionary/academia).

[**MYCIN**](https://www.britannica.com/technology/MYCIN)

Work on MYCIN, an expert system for treating [blood](https://www.britannica.com/science/blood-biochemistry) infections, began at [Stanford University](https://www.britannica.com/topic/Stanford-University) in 1972. MYCIN would attempt to diagnose patients based on reported symptoms and medical test results. The program could request further information concerning the patient, as well as suggest additional laboratory tests, to arrive at a probable diagnosis, after which it would recommend a course of treatment. If requested, MYCIN would explain the reasoning that led to its diagnosis and recommendation. Using about 500 production rules, MYCIN operated at roughly the same level of competence as human specialists in blood infections and rather better than general practitioners.

Nevertheless, expert systems have no common sense or understanding of the limits of their expertise. For instance, if MYCIN were told that a patient who had received a gunshot wound was bleeding to death, the program would attempt to diagnose a [bacterial](https://www.britannica.com/science/bacteria) cause for the patient’s symptoms. Expert systems can also act on absurd clerical errors, such as prescribing an obviously incorrect dosage of a drug for a patient whose weight and age data were accidentally transposed.

**The**[**CYC project**](https://www.britannica.com/topic/CYC)

CYC is a large experiment in [symbolic AI](https://www.britannica.com/technology/top-down-approach). The project began in 1984 under the [auspices](https://www.merriam-webster.com/dictionary/auspices) of the Microelectronics and Computer Technology Corporation, a [consortium](https://www.merriam-webster.com/dictionary/consortium) of computer, [semiconductor](https://www.britannica.com/science/semiconductor), and [electronics](https://www.britannica.com/technology/electronics) manufacturers. In 1995 Douglas Lenat, the CYC project director, spun off the project as Cycorp, Inc., based in Austin, Texas. The most ambitious goal of Cycorp was to build a KB containing a significant percentage of the commonsense knowledge of a [human being](https://www.britannica.com/topic/human-being). Millions of commonsense assertions, or rules, were coded into CYC. The expectation was that this “critical mass” would allow the system itself to extract further rules directly from ordinary prose and eventually serve as the foundation for future generations of expert systems.

With only a fraction of its commonsense KB compiled, CYC could draw [inferences](https://www.merriam-webster.com/dictionary/inferences) that would defeat simpler systems. For example, CYC could infer, “Garcia is wet,” from the statement, “Garcia is finishing a marathon run,” by employing its rules that running a [marathon](https://www.britannica.com/sports/marathon-race) entails high exertion, that people sweat at high levels of exertion, and that when something sweats it is wet. Among the outstanding remaining problems are issues in searching and problem solving—for example, how to search the KB automatically for information that is relevant to a given problem. AI researchers call the problem of updating, searching, and otherwise manipulating a large structure of symbols in realistic amounts of time the frame problem. Some critics of symbolic AI believe that the frame problem is largely unsolvable and so maintain that the symbolic approach will never yield genuinely intelligent systems. It is possible that CYC, for example, will [succumb](https://www.merriam-webster.com/dictionary/succumb) to the frame problem long before the system achieves human levels of knowledge.

Слова:

1. exhaustively – исчерпывающие
2. narrower – узкий/ограниченный
3. absence  - отсутстывие
4. reigning  - царствующий
5. expectation – ожидание
6. opined  - полагать
7. human foil – посредник
8. interrogator – допрашивающий
9. checkers - шашки(игра)
10. took over  - перенял
11. landmark  - ориентир
12. eerie  - зловещий
13. semblance  - подобие
14. therapist – терапевт
15. tailored – адаптированный
16. further  - дальнейший
17. cope – справиться
18. bewildering – ошеломляющей
19. strewn  - усыпанный
20. breakthrough – прорыв
21. baseboard  - плинтус
22. pointed out  - указать
23. emphasized  - подчеркнул
24. excruciatingly – мучительно
25. elicited – выявленный
26. affirmatie – утвердительный
27. fuzzy logic – нечеткая логика
28. thinning – прореженный
29. roughly – грубо
30. auspices – эгида/покровительство
31. spun off – развернул
32. exertion – усилие