HOW ROBOTICS
Is Changing the World

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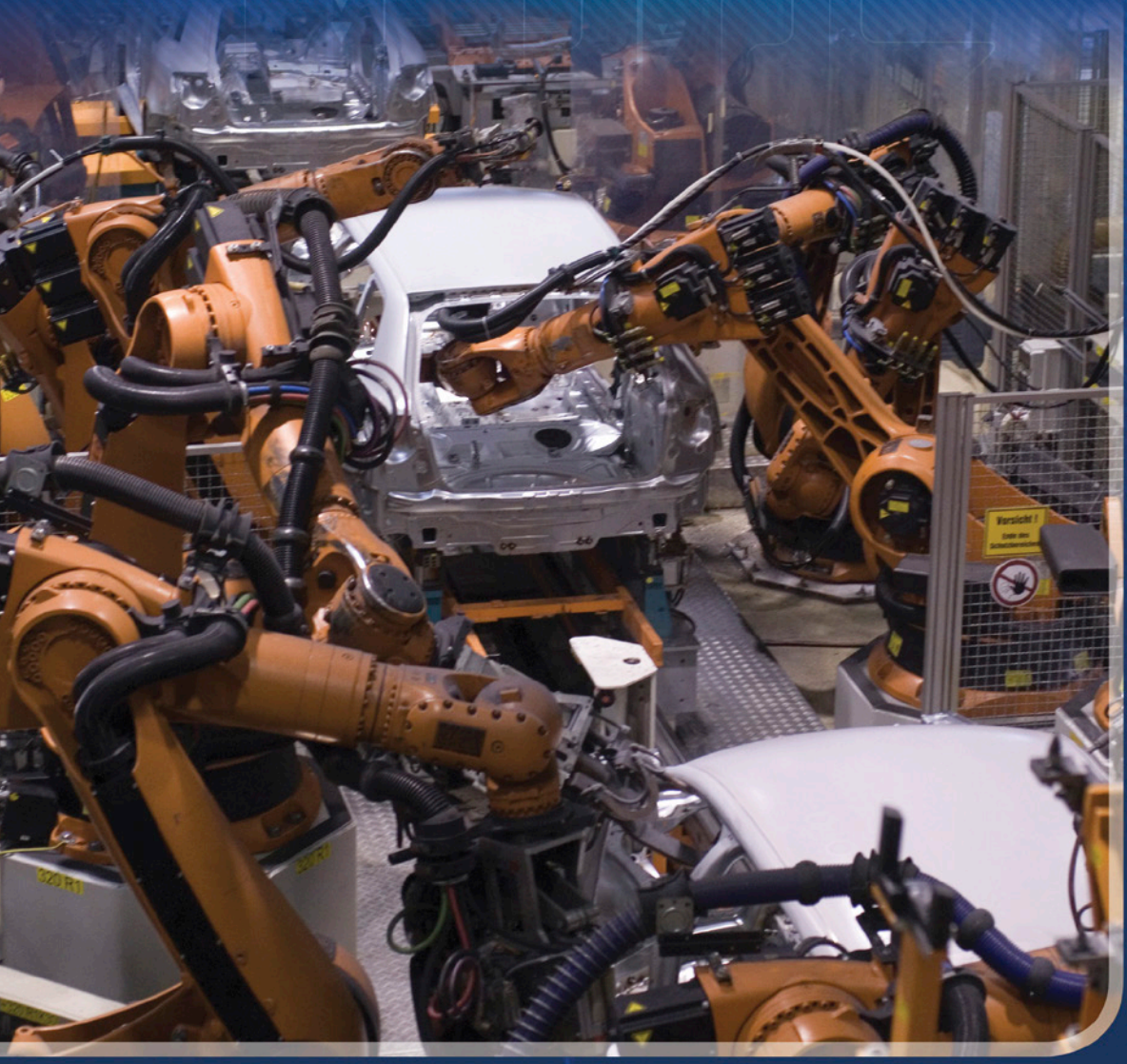


How Science
CHANGED THE WORLD

CONTENTS

IMPORTANT EVENTS IN THE HISTORY OF ROBOTICS

1948
William Grey Walter builds two robotic turtles, regarded as the first autonomous robots.

1954
George Devol files a patent for the first industrial robot.

1921
Karel Capek and his brother invent the word *robot* for a science fiction play.

1966
The Stanford Research Institute develops Shakey, the first mobile robot capable of planning out its own actions.

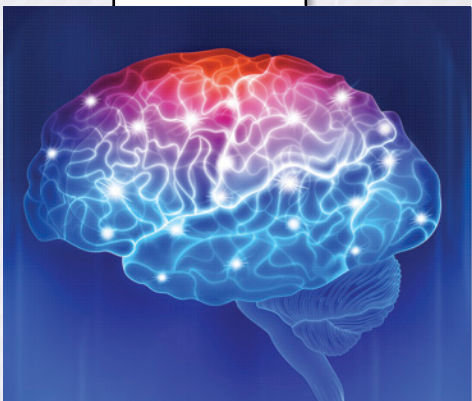
1925 / 1955 1965 1975 1985

1942
Isaac Asimov's short story "Runaround" introduces the Three Laws of Robotics.

1950
Alan Turing imagines the Turing test for machine intelligence.

1959
The Soviet space probe Luna 2 becomes the first robot to land on the moon.

1985
Surgeons use an industrial robotic arm to perform part of a brain surgery.



2016
Google's AlphaGo defeats human champion Lee Sedol in the strategy board game Go.

2015
South Korea's DRC-Hubo robot wins the DARPA Robotics Challenge for humanoid rescue robots.

1997
NASA lands the Pathfinder robotic spacecraft with the Sojourner rover on Mars.

2005
A car called Stanley wins the Defense Advanced Research Projects Agency (DARPA) Grand Challenge, a race for self-driving cars.

1999
The da Vinci Surgical System debuts, ushering in the age of robotic surgery.

2011
IBM's Watson defeats human *Jeopardy!* champions.

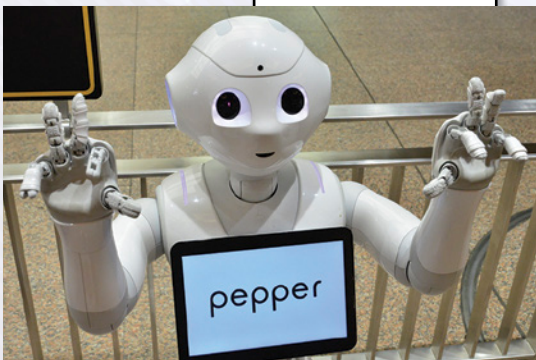
1995 2000 2005 2010 2015

1996
IBM's Deep Blue computer defeats world chess champion Gary Kasparov.

2002
The company iRobot releases the first Roomba vacuum cleaner.

2014
Aldebaran Robotics and SoftBank Robotics release Pepper, a social robot that responds to human emotions.

2000
Honda releases the first ASIMO, which becomes one of the world's most famous humanoid robots.



INTRODUCTION

Venturing Out into the Universe

Right now, 140 million miles (225 million km) away, a robot named Curiosity is driving over red-tinged rocks and rippling sand dunes. Curiosity is exploring the planet Mars. The robot navigates itself around obstacles as it takes photos, gathers samples of rocks and sand, and collects scientific data. It uses sunlight to charge its own batteries and occasionally takes selfies with a camera attached to the end of its arm. Curiosity is not the only robot to tour Mars. A rover named Sojourner landed in 1997 and was followed by Spirit and Opportunity during the 2000s. Opportunity is still running on the other side of the planet from Curiosity, which arrived in 2012.

Valiant Explorers

Robotic spacecraft have done much more than just explore Mars. They have also landed on Venus and have flown by every other planet in the solar system. The Soviet space probe Luna 2 landed on the moon and beamed back pictures in 1959, ten years before the first astronauts arrived. Robots have investigated comets, asteroids, and the outer edges of the solar system. Yet humans still have not set foot on a world other than Earth and its moon. In his book *Space Invaders*, Michael van Pelt writes, "It is a matter of fact that, until now, unmanned spacecraft have taught us far more

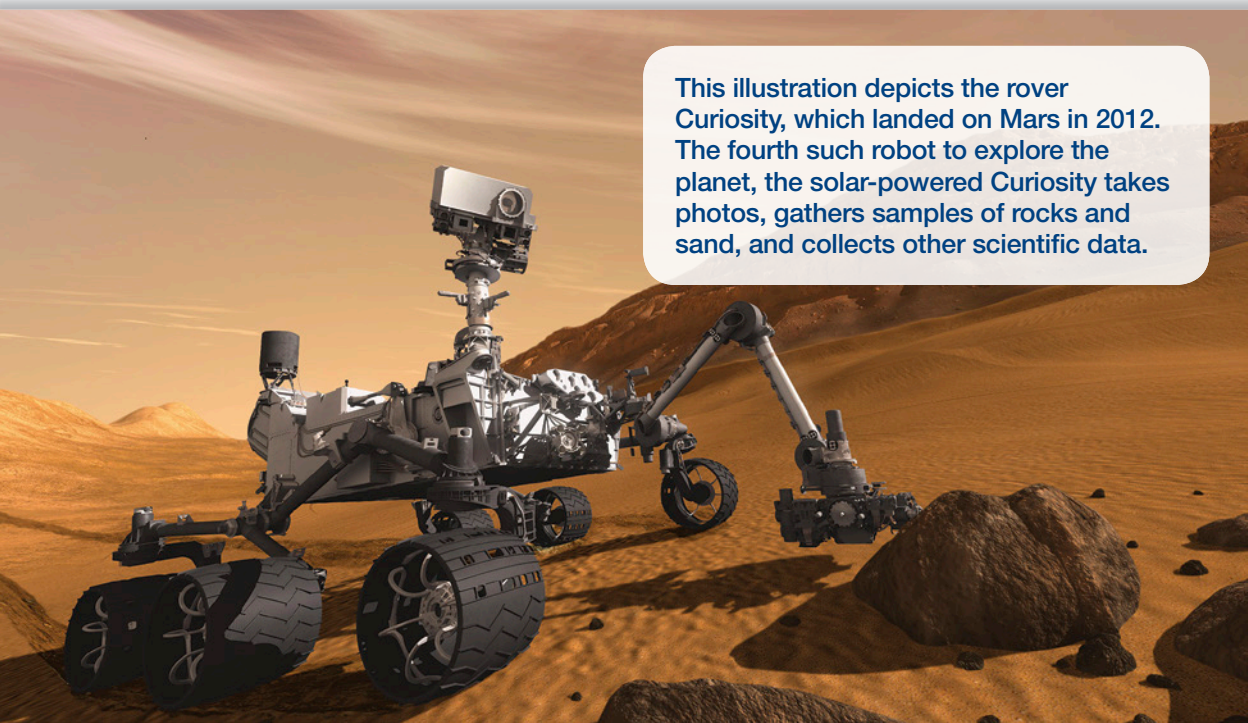
about the Universe than human missions."[1] A human mission to Mars is in the planning stages but will not happen any time soon.

However, robotics technology has made it possible to explore distant worlds without putting people at risk. "Extreme space environments are dangerous for humans. And, robots are ideal for dangerous tasks,"[2] says Taskin Padir, an engineer at Northeastern University. His team is working on building a humanoid robot that may one day be able to set up and repair equipment during a space mission.

Robots allow people to indirectly accomplish amazing things. Their impact on human culture goes far beyond exploration and discovery. Robots perform a huge range of tasks that are too dangerous, dirty, or dull for humans. In doing so, these machines make life safer, easier, and more interesting for people.

A Robot Revolution

Experts have predicted that a robot revolution will change our lives as much as the computer or Internet revolution did. Just as it is nearly impossible to imagine life today without computers or cell phones, in the near future we may be unable to imagine life without robots. As Microsoft cofounder Bill Gates has written, "As I look at



This illustration depicts the rover Curiosity, which landed on Mars in 2012. The fourth such robot to explore the planet, the solar-powered Curiosity takes photos, gathers samples of rocks and sand, and collects other scientific data.

A Robot Swarm

Most exploration robots are huge, heavy, and expensive. But bigger is not always better. In 1989 the famous roboticist Rodney Brooks wrote a paper titled *Fast, Cheap and Out of Control: A Robot Invasion of the Solar System*. His idea was that robot exploration might work better with hundreds or even millions of very tiny, simple robots rather than one large beast of a machine. Losing one or even many tiny robots would not mean the end of a mission. The rest of the robot swarm could continue to work and explore. Brooks and his team had already built a small insect-like robot named Genghis that pursued any moving infrared light. "When it was switched on, it came to life! It had a wasplike personality: mindless determination," Brooks explains.

Although robotic insect swarms have yet to be deployed on other planets, many researchers are still interested in the idea of robots that work together like ants or bees to perform complex tasks. In 2014 a team at SRI International (formerly the Stanford Research Institute) introduced its MicroFactory, which is inhabited by magnetic robots that are each only slightly larger than a grain of salt. Like an ant colony or beehive, these robots work together to build objects.

Rodney Brooks, *Flesh and Machines: How Robots Will Change Us*. New York: Pantheon, 2002, p. 46.

and forcing one hundred thousand people out of their homes. Toxic nuclear waste at the damaged plant made it too dangerous for humans to enter. PackBots were on the scene again, along with a larger iRobot product called Warrior. A Japanese robot called Quince also helped out. Humans operated multiple copies of each robot from afar, using cameras and other sensors to assess the situation and begin cleanup activities. Workers even taped a vacuum hose onto a Warrior in order to suck up radioactive dust.

Bombs Away

Both PackBot and Warrior robots were originally developed to make warfare safer for human troops on the ground. PackBot has been around since 1998. The current model is small, wide,

and flat. It folds up to the size of a very thick coffee-table book, allowing operators to carry it around like a backpack. On the ground, its treads and a set of two flipper-like feet allow it to climb over obstacles. It can also extend its one arm up and out to grab things. The robot can be equipped with sensors to smell specific chemicals, much like a trained bomb-sniffing dog. A human operator controls PackBot using a computer. If the robot goes too far out of range and loses contact with its operator, it knows to backtrack to a place where it can get a signal. It can also flip itself over if it falls on its back.

The US Army uses PackBot robots to check areas for bombs, chemical weapons, or enemies before sending in human troops. Colonel Bruce Jette used the robots in combat when he served in Afghanistan during the early 2000s. He points out that losing a robot is a whole lot easier than losing a soldier. Writing a letter to a deceased soldier's parents is a heartbreaking task. In contrast, he says, "I don't have any problem writing to iRobot, saying 'I'm sorry your robot died, can we get another?'"[33]

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>
> —US Army colonel Bruce Jette

The Warrior robot looks a lot like PackBot, only larger. It is almost six times heavier. Warrior can push cars around, pick up and move heavy rubble, and smash through windows. It is especially useful for checking out cars that may be armed with explosive devices. In 2011 iRobot came out with a third military robot called FirstLook. This one is tiny—it only weighs about 6 pounds (2.7 kg)—but has the same basic design as its cousins. The big difference is that FirstLook is meant to be tossed through windows and over walls. Then it can check out whether an area is safe. The hardy machine can survive drops up to 15 feet (4.6 m) onto concrete or under water.

What all military robots have in common is that they can go into potentially dangerous situations ahead of human beings. This

SOURCE NOTES

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2. Quoted in Tomasz Nowakowski, "NASA Counting on Humanoid Robots in Deep Space Exploration," Phys.org, January 26, 2016. https://phys.org.
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7. T.R. Kennedy Jr., "Electronic Computer Flashes Answers, May Speed Engineering," *New York Times*, February 15, 1946. www.nytimes.com.
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GLOSSARY

artificial intelligence: A machine's ability to perform tasks that usually require human intelligence.

autonomous: Able to act freely and independently.

cyborg: A being with both biological and mechanical body parts.

empathy: The ability to identify with and share another's feelings.

exoskeleton: In robotics, a suit that enhances the wearer's physical abilities.

gesticulate: The act of moving the arms or body to enhance spoken communication.

humanoid: A robot that looks like a person.

logistics: The managment of the details of an operation.

mundane: Boring or ordinary.

nanotechnology: The science of manipulating materials on an extremely small scale.

prosthetic: An artificial arm, hand, leg, or foot.

teleoperation: The act of controlling a robot from a distance.

telepresence: The use of robotics to be virtually present in a distant location.

unmanned aerial vehicles (UAVs): Aircraft that fly without pilots; also called drones.

FOR FURTHER RESEARCH

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INDEX