

 **findout!**

Robots



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Penguin
Random
House

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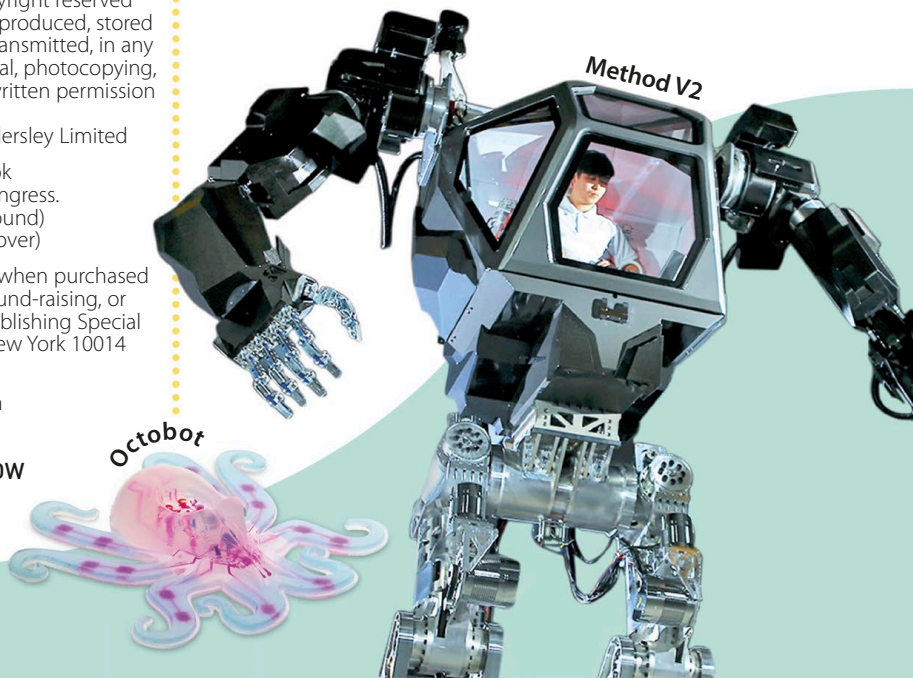
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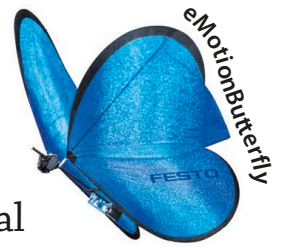
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SEE ALL THERE IS TO KNOW

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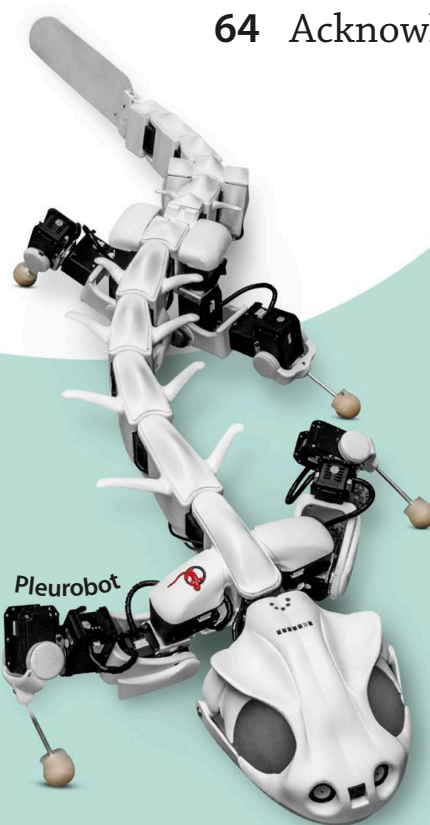


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SwagBot



Pleurobot



Marty



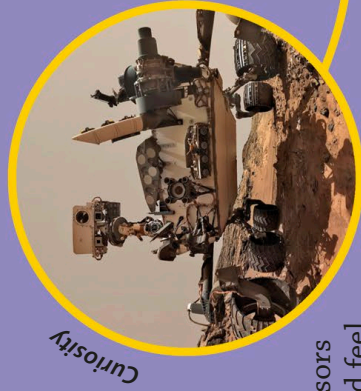
Dot



Wakamaru

What is a robot?

Robots are machines that can do many amazing things. They build cars, explore space, and fix our bodies. Like humans, a robot needs to see, hear, or feel with its senses, and move its body. Robots, just like us, also need energy to work and intelligence to make decisions.



Sensing

Robots use sensors to see, hear, and feel. The Mars rover *Curiosity* has cameras for eyes to see where it is going. Some robots have senses that we don't have, such as being able to see heat.

HRP-3 Promet MK-II



Energy

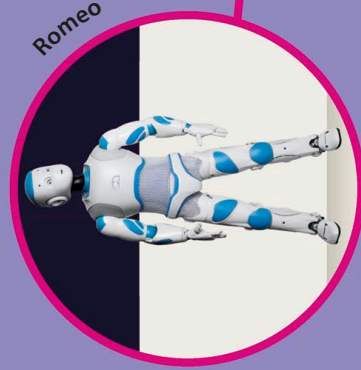
Moving, sensing, and thinking all need energy. Robots usually run on electricity. They get this electricity either from being plugged into a power supply or from batteries, like Promet MK-II's battery backpack.



4 REASONS FOR ROBOTS

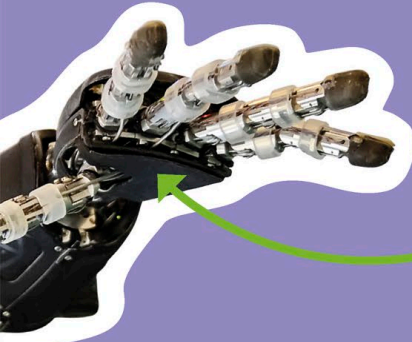
There are some jobs that robots are much better at than people. The four main reasons we use robots to do something are because a job is:

- 1 Dangerous** Places or tasks that would harm people.
- 2 Dull** Long and repetitive tasks that are boring.
- 3 Dirty** In unpleasant places like sewers and mines.
- 4 Delicate** Too difficult to do with our hands.



Movement

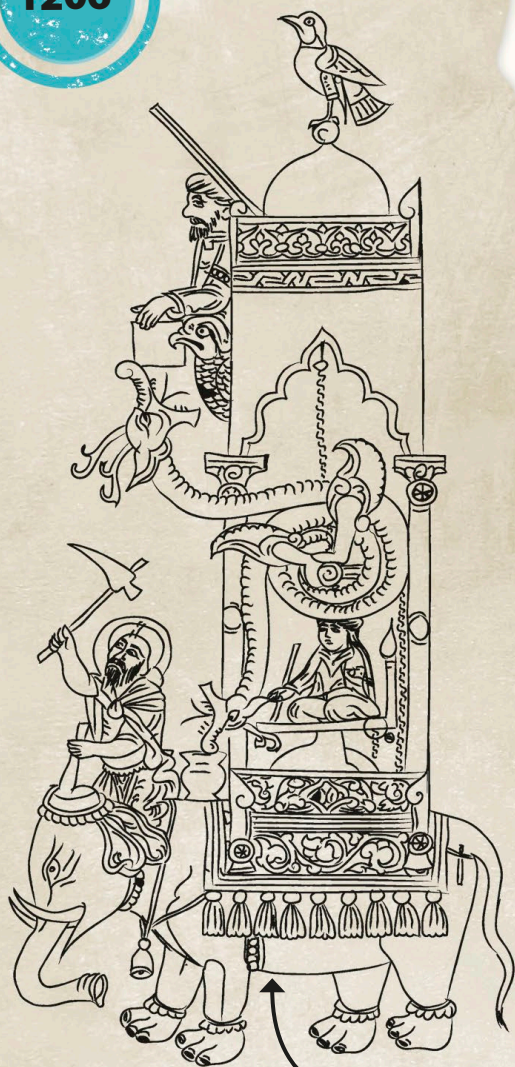
Inside a robot are motors to move the parts of its body. Most robots move around on wheels. Others, such as Romeo, have legs.



Intelligence

Robots need intelligence to decide what to do. Most robots use computers as their “brains.” Modern robots, such as iCub, can learn from their surroundings.

1206



The water that drove the clock was hidden inside the elephant's body.

The elephant clock

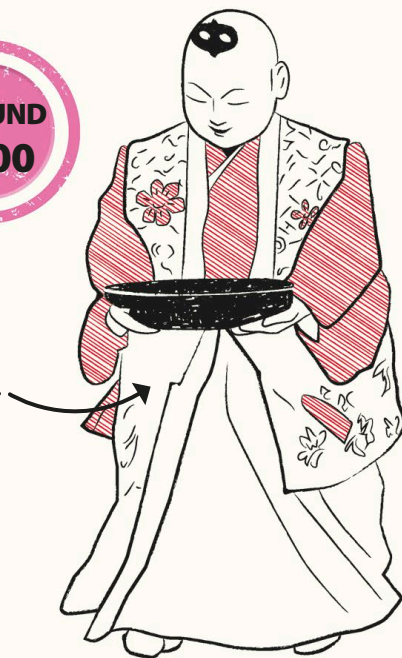
This automaton was designed by al-Jazari, an Arab inventor. The clock was driven by water, which caused the man to strike a cymbal and the bird to whistle every half an hour.

Early robots

Inventors have designed robots since ancient times. Before modern robots there were automata—moving machines driven by clockwork, air, or water. In the 20th century, robots began to run on electricity and use computers to think for themselves.

AROUND
1800

Springs and levers moved the puppet's arms and legs.



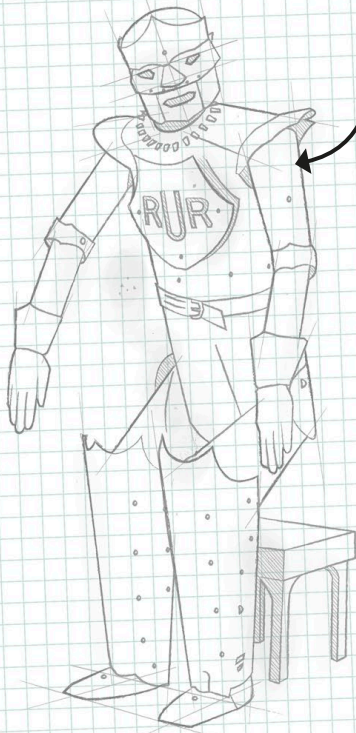
Karakuri puppets

These mechanical dolls from Japan could act out stories for the theater or even serve tea to guests! Karakuri is a Japanese word meaning “trick” or “mechanisms.”

1928

Eric

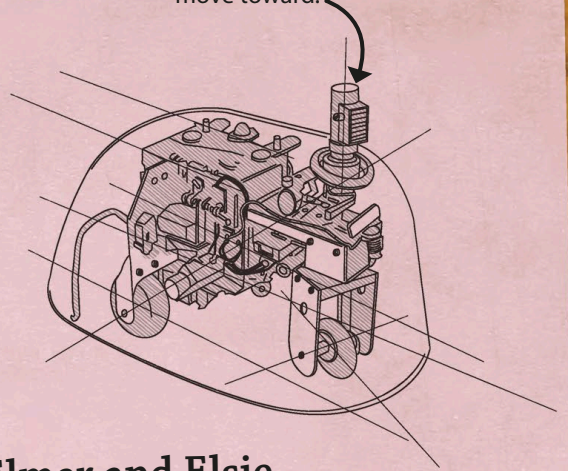
Eric was a human-shaped automaton that was 7 ft (2 m) tall. Inside its body were miles of wires connected to motors. These made it stand and sit down, turn to the left and right, and wave its arms while talking.



Eric's armor made it look like a knight.

1948

A sensor detected light, which the robot could then move toward.



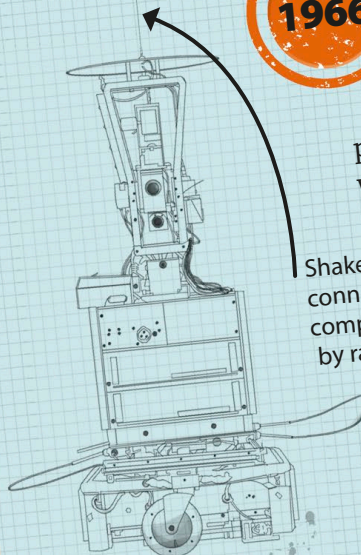
Elmer and Elsie

These tortoiselike machines were the first robots to make their own decisions. Scientist William Grey Walter designed them to react to their surroundings like real animals.

Shakey

1966

Shakey was the first robot able to think for itself. From looking around a room with a camera, it could plan how to move around without bumping into things.



Shakey was connected to its computer "brain" by radio.

! WOW!

Eric the robot used electricity to make **blue sparks** fire from its teeth.

Famous robot engineers

There has been huge progress in robotics over the last 50 years. Robots have changed from large, clunky machines into sleek, lifelike devices. Thousands of scientists and engineers have helped develop the fantastic robots we have today. Here are a few of the most famous.

! WOW!

Over **500 years** ago, the famous artist **Leonardo da Vinci** designed a **humanoid knight!**

HIROSHI ISHIGURO

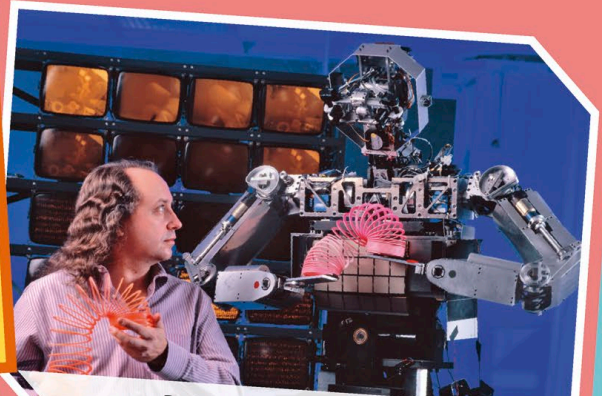
Hiroshi Ishiguro is a Japanese engineer who builds robots that look like real people. He calls these robots "Geminoids™." His laboratory has built a Geminoid™ of himself and of several other people.



Hiroshi Ishiguro and his Geminoid™
Geminoid™ HI-4: Osaka University

RODNEY BROOKS

Australian engineer Rodney Brooks is famous both as a scientist and a businessman. He built a famous humanoid robot called Cog that learns like a human. He also started the companies that make the robot vacuum cleaner Roomba and the worker robot Baxter.



Rodney Brooks with Cog

CYNTHIA BREAZEAL

Cynthia Breazeal is an American engineer who makes social robots that people can talk to and play with. Her robots often have faces that show feelings, such as happiness, sadness, or fear.



Leonardo is a fluffy social robot.

SEBASTIAN THRUN

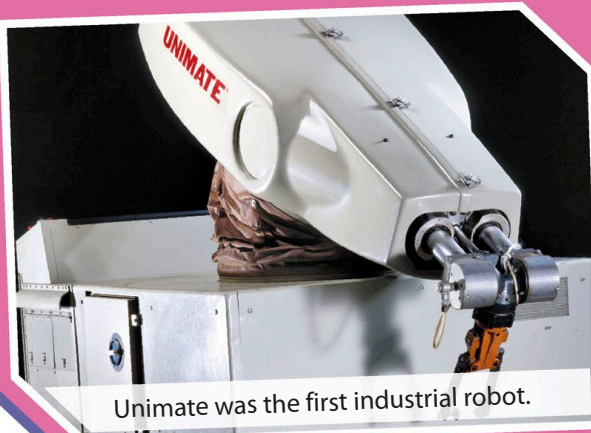
German Sebastian Thrun and a team of engineers built a self-driving car called Stanley. In 2005, Stanley won a tricky, self-driving car race called the DARPA Grand Challenge, which includes racing around mountains.



Stanley is a robot car that drives itself.

JOSEPH F. ENGELBERGER

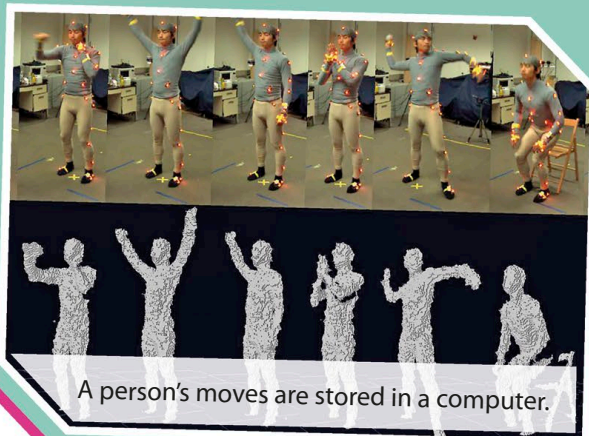
American Joseph F. Engelberger and his colleague George Devol made the first industrial robot. These robots work in factories and do jobs such as building cars. Their robot was called Unimate and looked like a large metal arm.



Unimate was the first industrial robot.

RUZENA BAJCSY

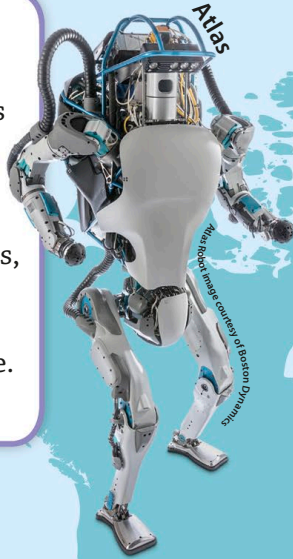
Ruzena Bajcsy is an American engineer who invents ways for robots to sense the world like humans. She worked on robot hands that feel and eyes that look around. Her laboratory can also scan your body to store your movements inside a computer.



A person's moves are stored in a computer.

North America

Atlas is made in the US and is one of the world's best robots at walking and balancing. It is designed to travel over difficult ground. If it trips, it can keep itself from falling over. One day it could help rescue people.



! WOW!

By **2025** Japan expects to have **1 million** industrial robots.

Robots around the world

Amazing robots are being built all around the world. From agricultural robots that patrol Australia's huge farms to nursing robots that help care for Japan's aging population, new types of robot can help in many different ways. The designs for these robots can be shared around the globe.

Wheelie moves when you move your face



South America

Wheelie is a robot wheelchair developed in Brazil by HOOBOX Robotics. This chair is for people who cannot walk or move their hands. You can tell Wheelie where to go by speaking or making different faces.

Europe

YuMi is a two-armed robot created for working in factories. It can work with humans without accidentally harming them and can even make paper airplanes.



YuMi helping to make wall sockets

Asia

ROBEAR is a Japanese nursing robot that looks like a friendly bear. It weighs 309 lb (140 kg) and has padded arms. It can gently lift a sick patient into a bed or wheelchair.



ROBEAR helps a woman into a wheelchair



Africa

These giant robot police officers direct traffic in Kinshasa, Democratic Republic of the Congo. Standing 8 ft (2.5 m) tall, they also tell people when to cross the road.

SwagBot patrolling a field



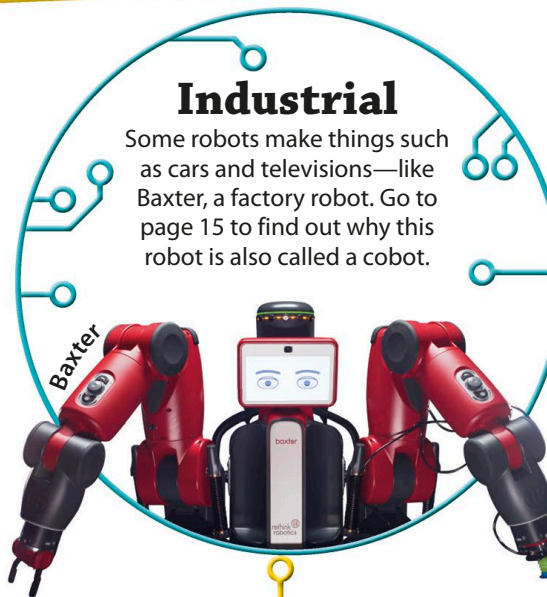
Australasia

SwagBot is a robot cowboy from Australia that helps farmers. The robot is designed to drive around huge areas of land, watching cows and helping to herd them around.

Answer our quiz to find out which robot you need!

Types of robot

Do you need help with something? This quiz will help you find out which robot you need. Robots are grouped together by the jobs that they do. Their most common work is in homes and factories. However, they can do much more—even exploring space!



Industrial

Some robots make things such as cars and televisions—like Baxter, a factory robot. Go to page 15 to find out why this robot is also called a cobot.

START HERE

Do you want this robot to work in your home?

NO

YES

Do you need help with chores?

NO

YES

Domestic

Domestic robots help around the house—like Clocky, a robot alarm clock. Go to page 17 to find out how it gets you out of bed.

Clocky



Do you need to make lots of the same thing?

YES

NO

Do you feel sick?

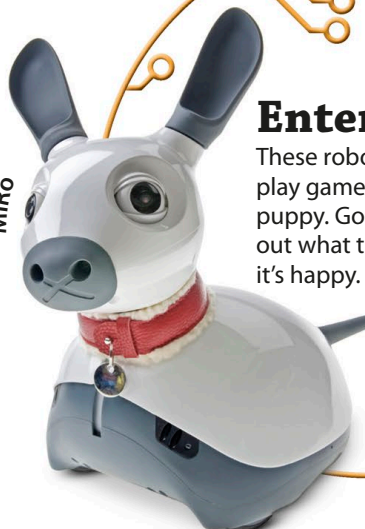
YES

NO

Entertainment

These robots are for fun and can play games—like MiRo, a robot puppy. Go to page 23 to find out what this robot does when it's happy.

MiRo





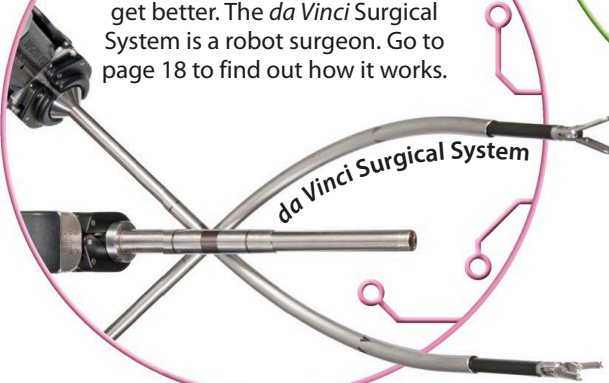
Security

Robots such as Spider Mite, a robot guard, protect people and places. Go to page 21 to find out how it looks for danger.



Medical

These robots help sick people get better. The *da Vinci* Surgical System is a robot surgeon. Go to page 18 to find out how it works.



Coming soon!

New robots are being invented all the time. They are starting to help with farming, building, and many more jobs. Can you think of a job for the humanoid robot Valkyrie?



Do you need help protecting something?

YES

NO

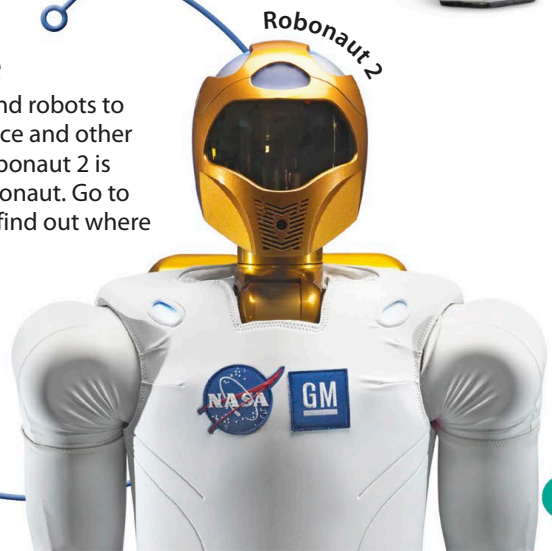
Do you want to explore space?

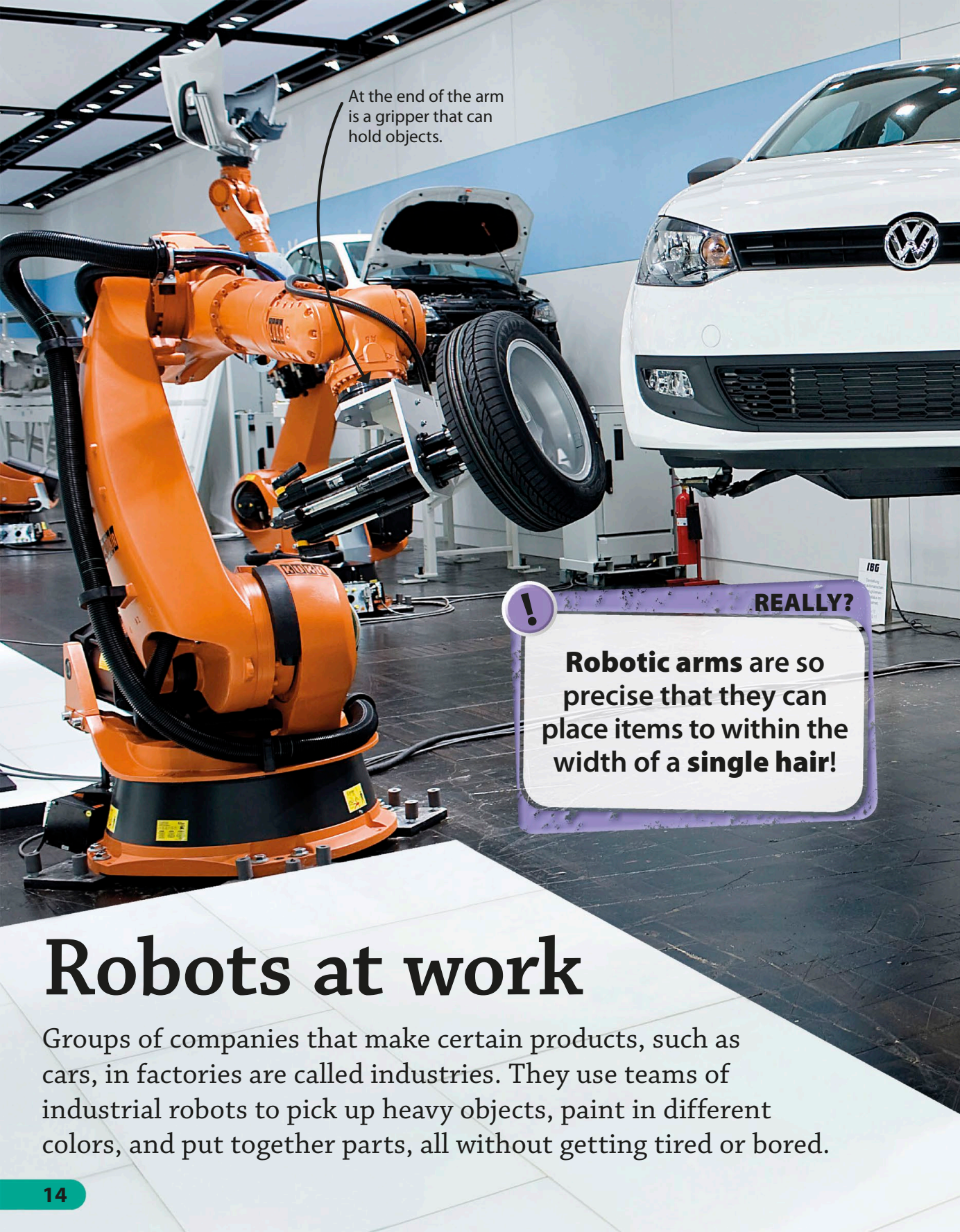
NO

YES

Space

Humans send robots to explore space and other planets. Robonaut 2 is a robot astronaut. Go to page 25 to find out where it works.





At the end of the arm is a gripper that can hold objects.



REALLY?

Robotic arms are so precise that they can place items to within the width of a **single hair!**

Robots at work

Groups of companies that make certain products, such as cars, in factories are called industries. They use teams of industrial robots to pick up heavy objects, paint in different colors, and put together parts, all without getting tired or bored.



Robotic arms The most common type of industrial robot is shaped like an arm. The KR 1000 Titan is a huge arm that can lift up to 2,870 lb (1,300 kg). That's the weight of an adult rhinoceros!

Inside the arm are powerful electric motors.

Cobots

There are now new types of industrial robot helpers, called cobots. They can work safely alongside people in factories. Baxter is a cobot that can be trained by a coworker. A person just has to move Baxter's arms to show it how to do something.



A Baxter robot packs boxes in a factory.

Robots at home

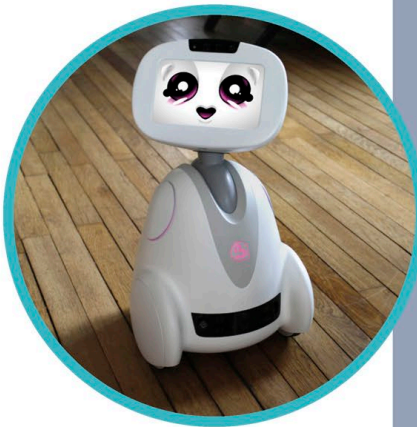
Mini-drones can be used to carry small items around. The Parrot Mambo can carry objects weighing up to 0.14 oz (4 g).



Imagine having a robot that could clean up your bedroom, put out the trash, and cook your food! These chores around the home are jobs for home or “domestic” robots. Domestic robots of the future will be able to do more and more of the boring jobs that people do now.

Buddy

This cute family robot can learn to recognize people and play games. It even knows hide-and-seek!



! WOW!

Over **15 million** Roombas have been sold—enough for almost everyone in **London and New York City.**



Roomba

Millions of homes use this robot vacuum cleaner to keep floors dirt-free. It uses sensors to avoid objects in its way.

Clocky

Clocky is a robot alarm clock. It runs away from you so you have to get out of bed to turn it off!



The FoldiMate folds clean clothes.



Robotic Kitchen

Scientists are working on a two-armed “robo chef.” One day it could chop, mix, and cook to make meals from a library of recipes.

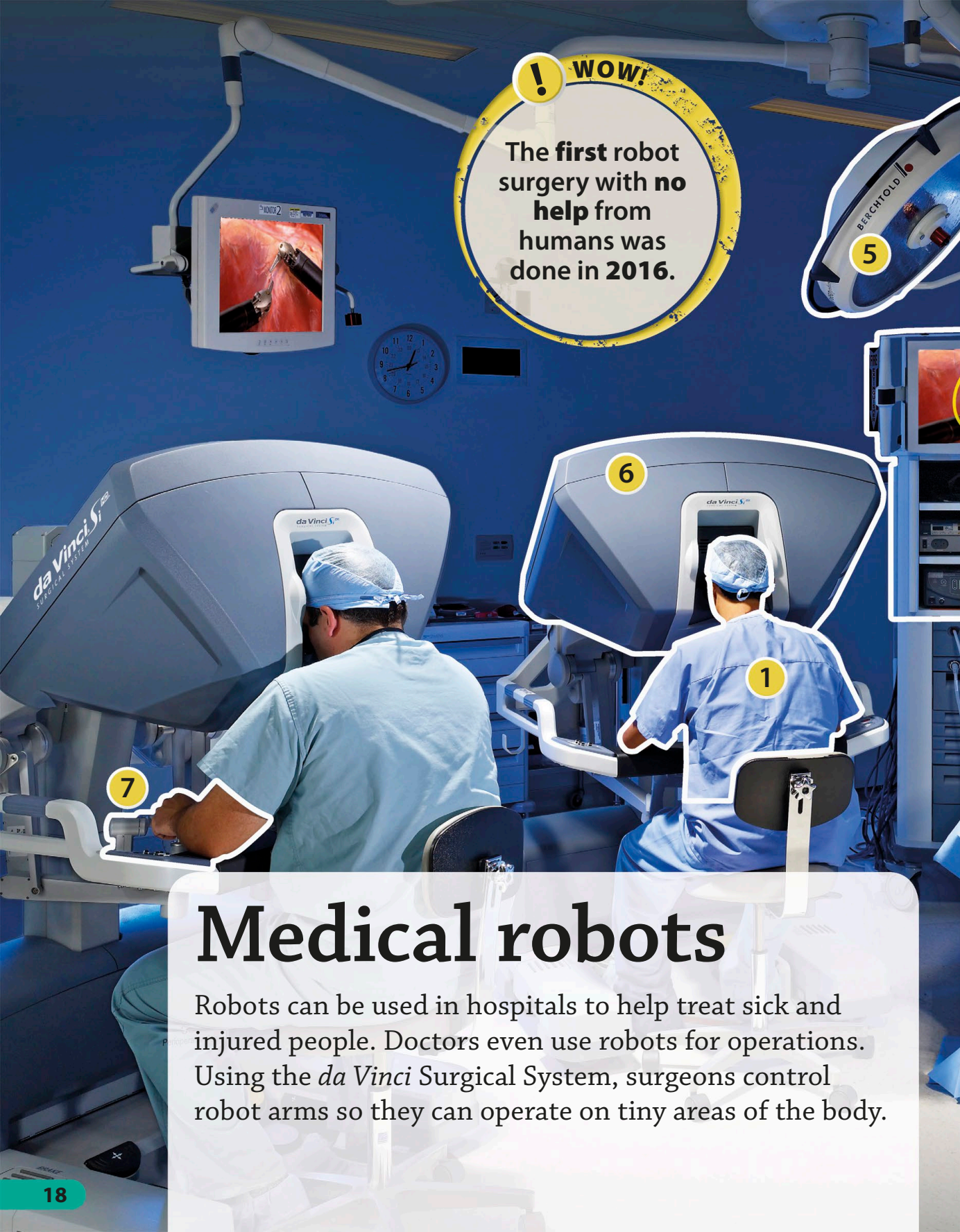
Braava 380t is a robotic mop that cleans the floor.



L30 Elite

This wheeled robot moves up and down your yard to neatly trim the grass. It goes back to its base if it starts raining.





! WOW!

The first robot surgery with **no help** from humans was done in **2016**.

7

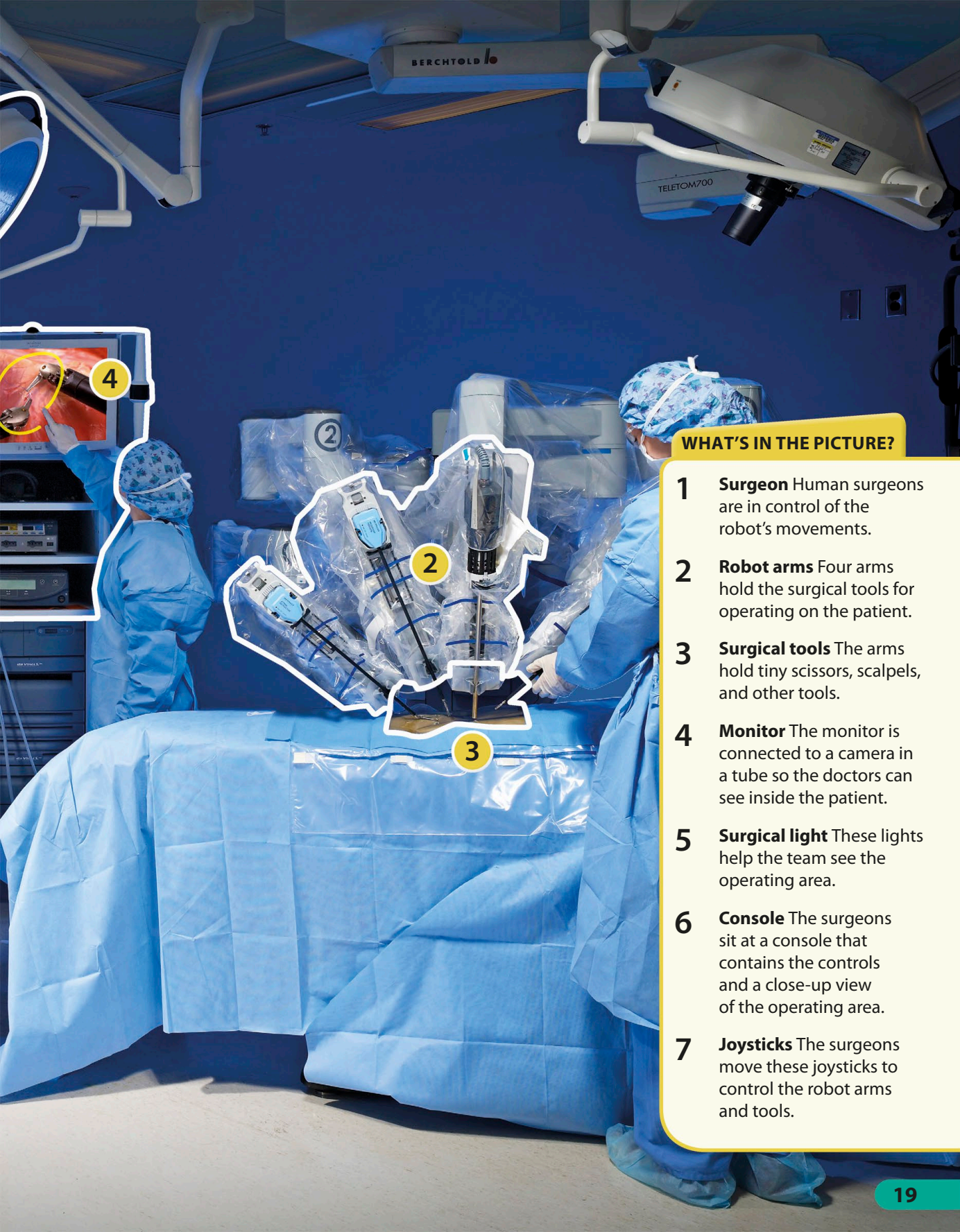
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1

5

Medical robots

Robots can be used in hospitals to help treat sick and injured people. Doctors even use robots for operations. Using the *da Vinci* Surgical System, surgeons control robot arms so they can operate on tiny areas of the body.



WHAT'S IN THE PICTURE?

- 1 Surgeon** Human surgeons are in control of the robot's movements.
- 2 Robot arms** Four arms hold the surgical tools for operating on the patient.
- 3 Surgical tools** The arms hold tiny scissors, scalpels, and other tools.
- 4 Monitor** The monitor is connected to a camera in a tube so the doctors can see inside the patient.
- 5 Surgical light** These lights help the team see the operating area.
- 6 Console** The surgeons sit at a console that contains the controls and a close-up view of the operating area.
- 7 Joysticks** The surgeons move these joysticks to control the robot arms and tools.

Security robots

Robots make great security guards. They can wait silently for a long time and when they see something unusual, they call the police or sound an alarm. Some security robots have arms that can be used to pick up suspicious items. They can also be remote-controlled, so people can stay at a safe distance.

GUARDROBO D1

This robot guards against intruders, fires, and leaks. It even carries a fire extinguisher to put out fires.



TALON

Talon is a robot used in the army to find bombs and land mines, and make them safe. Its arm and gripper can be controlled by a remote to pick up objects.

BigDog

BigDog is a four-legged robot that can carry supplies and food—like a packhorse. It can walk on stony ground, muddy trails, and even on ice!





The camera is safe inside a frame.

SPIDER MITE

Spider Mite is like a tough, remote-controlled car. This robot can climb steep slopes and it has a camera so you can see what is happening around it. It can even see in the dark. It can be used to patrol buildings.

Big tires help Spider Mite drive over rough ground.

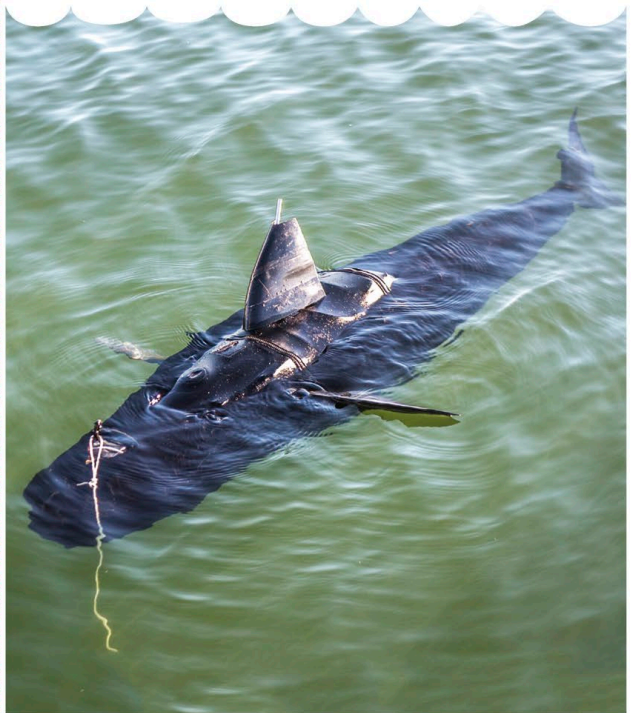
Knightscope K3

Knightscope K3 patrols around shopping malls on the look-out for thieves. Its mission is to stop crime. Upon seeing anything suspicious, it alerts the police. Knightscope can also sound a loud alarm to alert people to danger.



GhostSwimmer

GhostSwimmer is designed to look like a tuna or shark. It even swims like a real fish by wagging its tail. It can dive down to 300 ft (91 m) to see what is below the surface of the water!





Fingers

Fingers is the band's guitar player. It has 78 fingers and can play quicker than the fastest human!

Bones

Bones is the bass guitar player. It has two hands and eight fingers. Instead of legs, Bones uses tank tracks to move around the stage.

Fun with robots

Some robots are made to entertain us. There are many different types of entertainment robot: the smallest are robot toys and pets; the largest are robot dinosaurs in theme parks; and the loudest are robot rock bands—like Compressorhead!



Robotic pets

Robot pets are shaped like animals and are designed to play with humans. These clever robots respond to what you say and can perform tricks. You don't have to clean up after them either!

AIBO

This robot pet looks and acts like a small dog. It can learn its name and even play soccer!



AIBO fetches plastic bones.

Stickboy

Stickboy is a robot drummer with four arms and two legs. It has spikes for hair and moves its head in time to the music.

Compressorhead

Compressorhead is a rock band of robots. Made in Germany, there are three main members: a guitarist, a bassist, and a drummer. They may be machines, but they play real instruments!



MiRo wags its tail when it's happy.

MiRo

This cute robot looks as though it is part-rabbit and part-puppy. Like an animal, it reacts to sounds and movement.

Robots in space

Space is a dangerous place for people. There is harmful radiation, no air to breathe, and it takes a very long time to get anywhere! Scientists have built many robots to help us explore it. Some robot crafts circle alien planets, but others have landed to take a close-up look.

Cassini

This spacecraft was sent to explore the planet Saturn, its moons, and rings. It took nearly seven years to get there.

Voyager I

This robot has traveled for around 40 years and is now outside the Solar System. It is the first robot to reach interstellar space.

Space snaps

Space exploration robots have cameras to take photographs. As well as lots of scientific information, these robots send photos back to Earth. These show amazing sights never seen before by people.



Curiosity photographed this hill on Mars. The color has been changed so the scene appears how it would look on Earth.

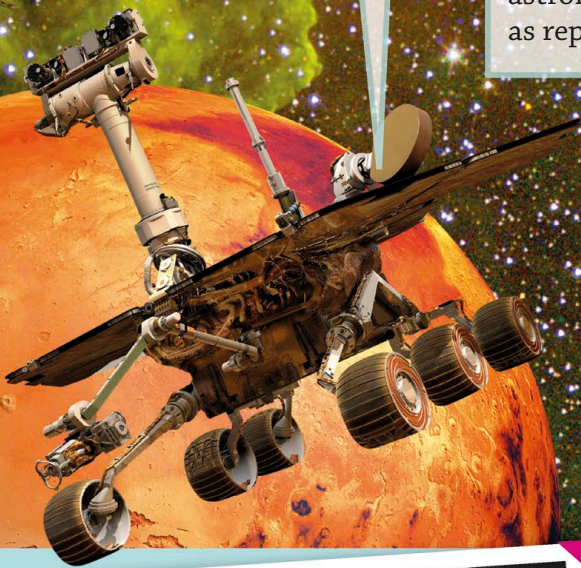


International Space Station (ISS)



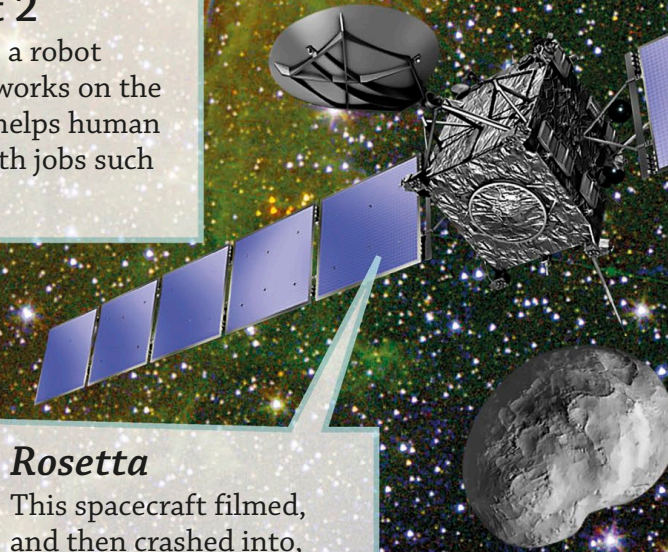
Mars rovers

Three of these wheeled robots are on the surface of Mars—*Opportunity*, *Spirit*, and *Curiosity*. Two continue to study the planet's surface.



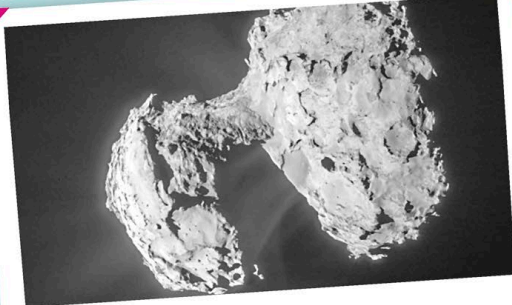
Robonaut 2

Robonaut 2 is a robot astronaut. It works on the ISS, where it helps human astronauts with jobs such as repairs.

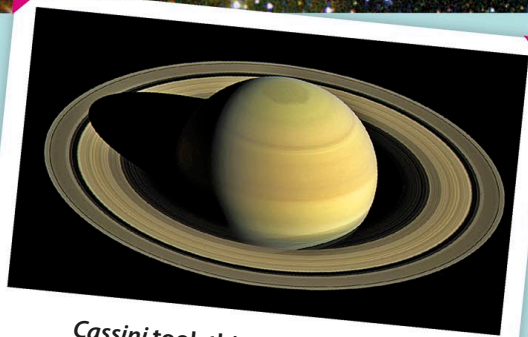


Rosetta

This spacecraft filmed, and then crashed into, a comet—a ball of rock and ice far out in space.



Rosetta photographed the comet 67P/Churyumov-Gerasimenko in 2015.



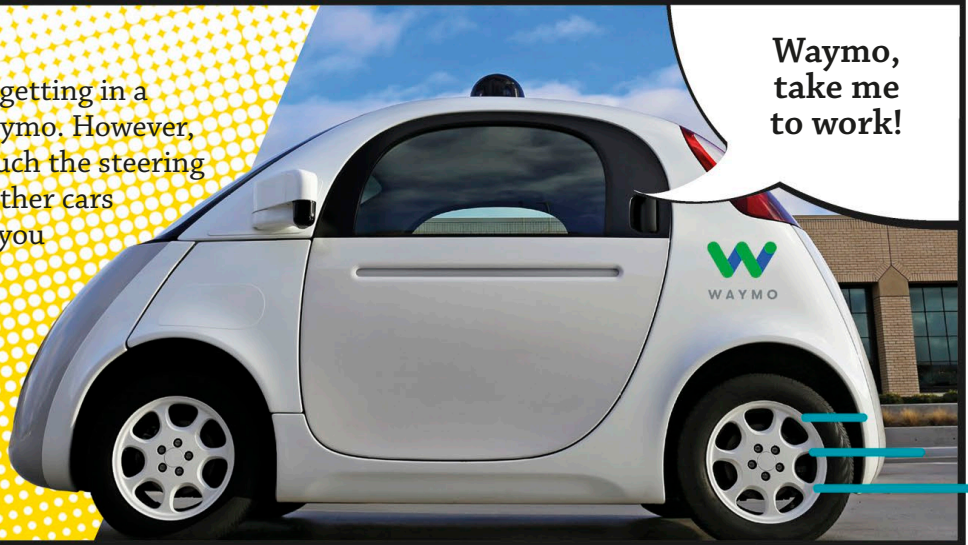
Cassini took this photo of Saturn and its rings in 2016.

A day with robots

There are more and more robots around us in the world. They can help at home, at work, drive us around, carry our shopping, make deliveries, and be our friends. Let us imagine a day in the future with your robot helpers.

Waymo

You start the day by getting in a robot car such as Waymo. However, you don't need to touch the steering wheel. It can sense other cars and people, to drive you safely to work.



Waymo,
take me
to work!

Aiko Chihira

When you arrive at your office, you are greeted by a robot receptionist. Aiko can speak, and knows sign language.



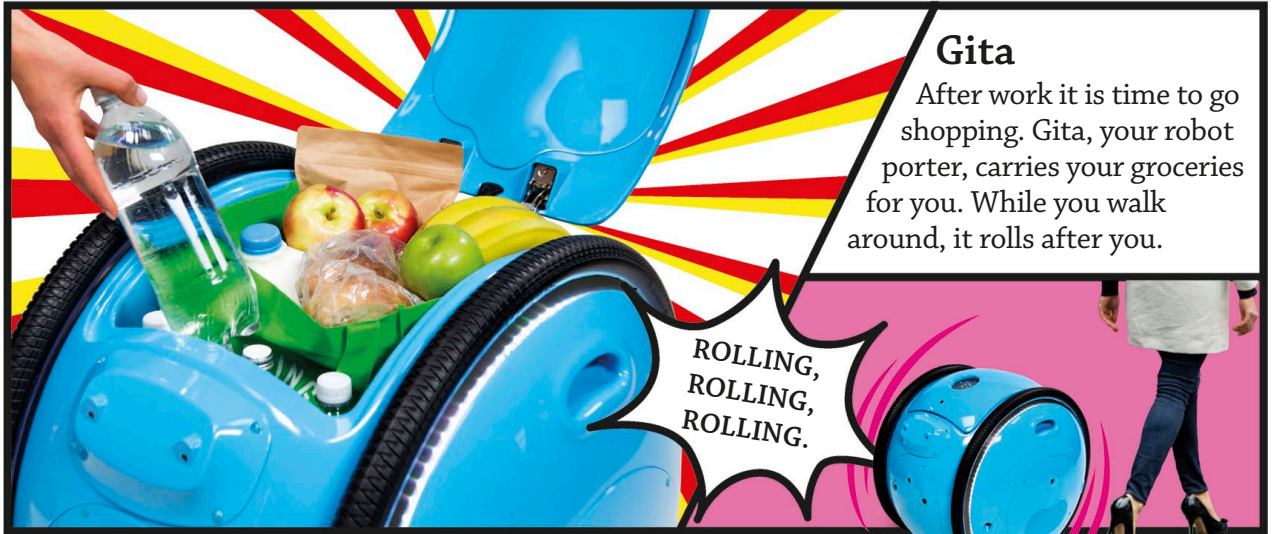
Hello! Have a
nice day.

That's a
great idea!

BeamPro telepresence robot

You have a meeting, but it's at another office. No problem, your telepresence robot is there. You can use it to look around, and it has a screen attached so you can see and talk through it.





Gita

After work it is time to go shopping. Gita, your robot porter, carries your groceries for you. While you walk around, it rolls after you.

ROLLING,
ROLLING,
ROLLING.



Delivery robot
You get home and realize you've forgotten to buy something! That's OK. A delivery robot will pick up your shopping, then drive it to your house to drop it off.

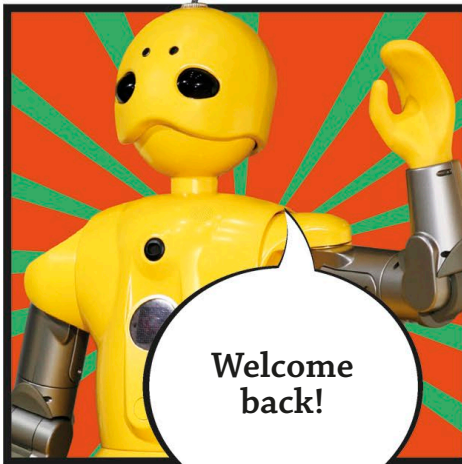
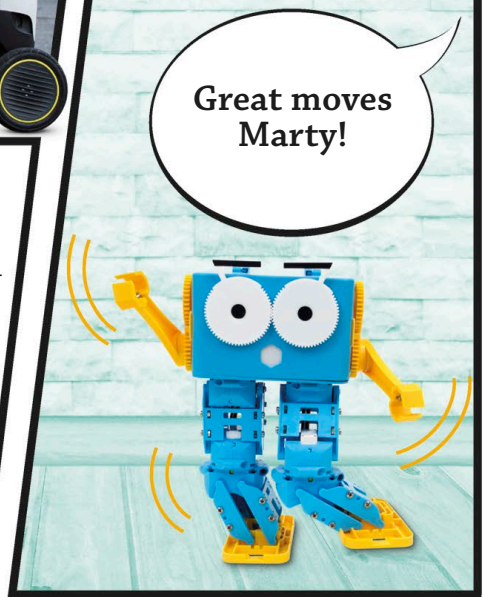


Just in time.

Marty

You would like to learn more about robots, so you make one yourself! Marty is a walking robot that you build from a kit. It can be programmed to carry out simple tasks, such as dancing.

Great moves
Marty!



Welcome
back!

Wakamaru

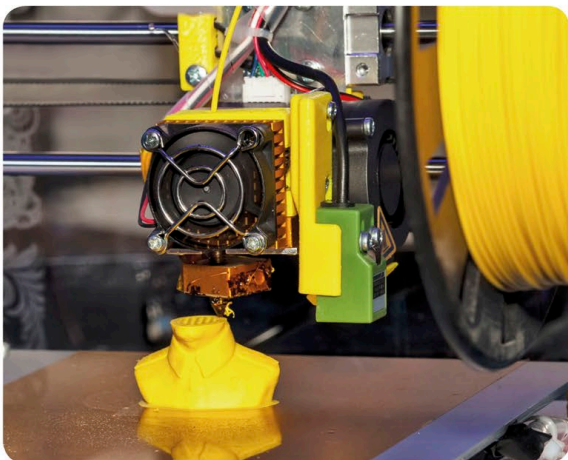
When you walk through the door, you are greeted by your friendly home robot, Wakamaru. It offers to read out your emails while you sit down and relax.

Building a robot

Complex robots can have millions of different parts. Most are built in factories. Some industrial robots are even built using finished copies of themselves! A technology called “3D printing” is helping people build their own robots at home. The printer makes the robot parts, which you can then assemble.

3D printing

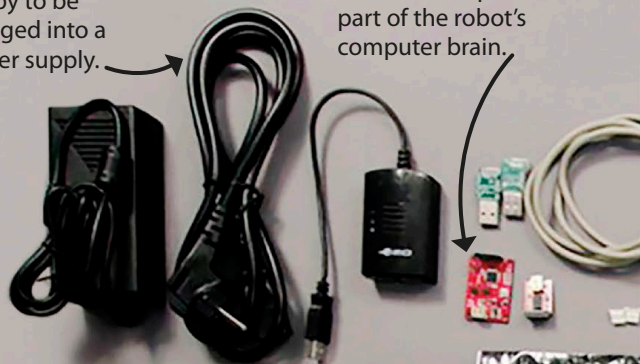
Regular printing puts images on flat objects such as sheets of paper—just like in a book. 3D printers make three dimensional (3D) solid objects, which have height, length, and width. To do this, most printers squeeze plastic out of a tube, in the same way you would put frosting on a cake!



A 3D printer making a plastic model

These wires allow Poppy to be plugged into a power supply.

This microchip is part of the robot's computer brain.



These bags contain the screws and wires used to connect the robot's electronics and body parts.



Plenty of parts

In order to build a robot, you need body parts that will give the robot shape, motors to make it move, microchips so it can think, and lots of wires and screws to connect it all together! Here are the pieces for a Poppy robot.

The robot's body parts are made using a 3D printer.

A plastic head will contain the computer brain.

! WOW!

Poppy can be built in around 7 hours.

Poppy complete

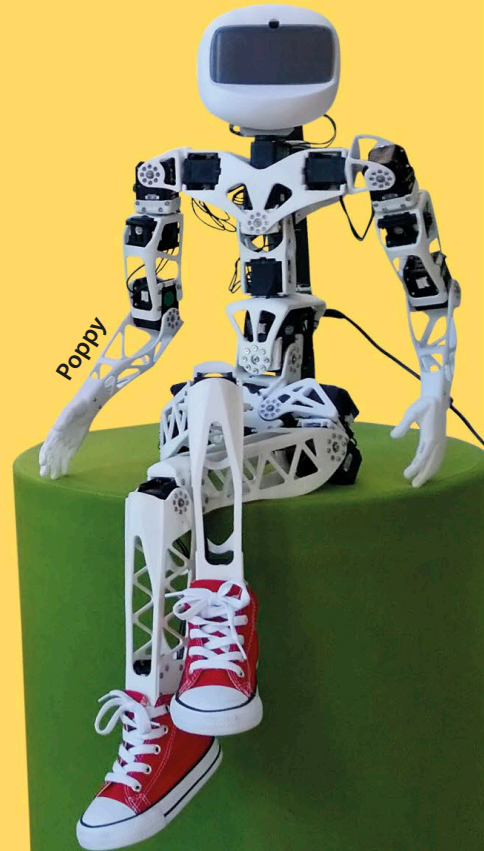
Poppy is a humanoid robot that stands 33 in (83 cm) tall. Its body parts are made on a 3D printer. These parts are joined to 25 motors to make Poppy move. The finished Poppy can walk and dance!

This model has hands that are fixed, so the robot can't pick up small objects.

Lots of different body parts allow the robot to bend at its joints, just like a human skeleton!

These are the motors that allow the robot to move. They are also called actuators.

Feet make sure that Poppy can stand up without falling over.



Coding a robot

Robots use computer code to tell them what to do. Code is made up of lines of instructions that can be written in different “languages.” Robots read these instructions in order—like when you read how to build a model. Follow the code on this page to see how the robot works.

The robot is built to look like a penguin.

A computer inside the robot receives instructions from a phone or tablet.

! WOW!

The code that runs Google is **two billion lines long!**



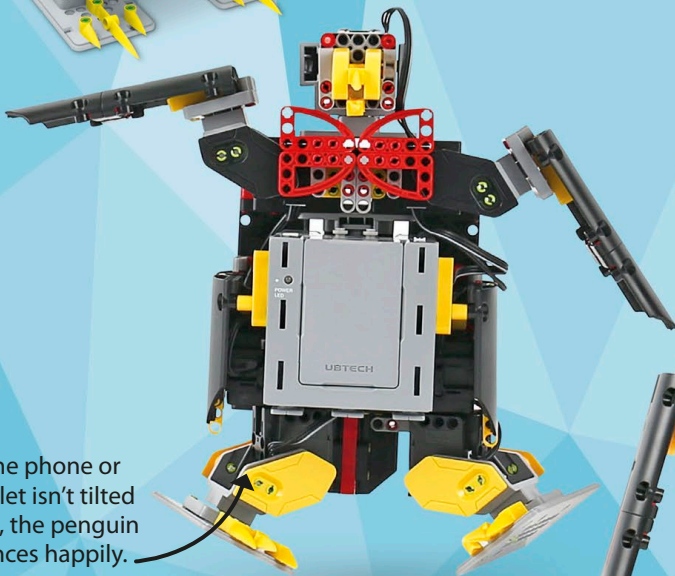
Coding with blocks

This programming language uses colored blocks to tell the robot what to do. If the robot reads code words such as “if” or “else,” it knows to check for something to happen—such as you tilting your phone to the left. This makes it “do” an action, such as dancing or walking.

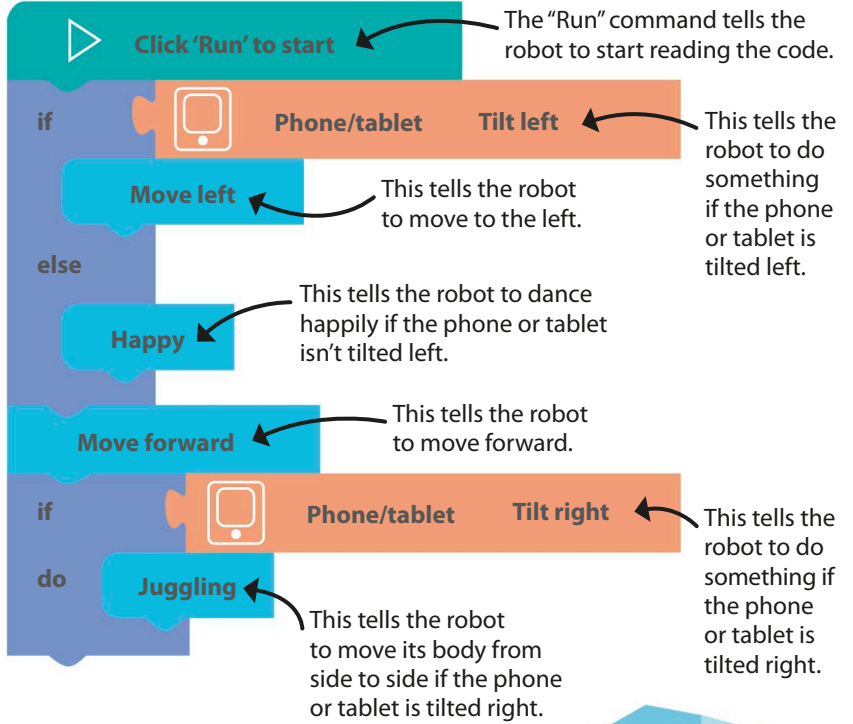
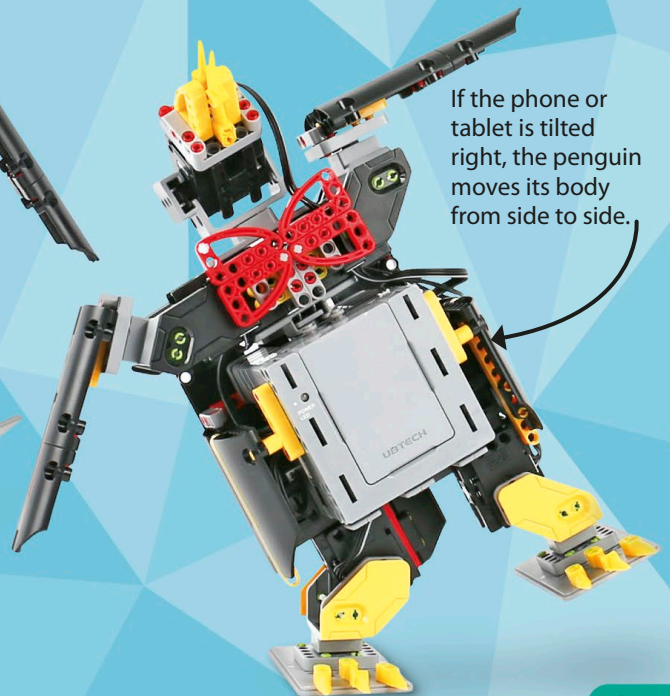
If the phone or tablet is tilted left, the penguin moves left.



If the phone or tablet isn't tilted left, the penguin dances happily.



If the phone or tablet is tilted right, the penguin moves its body from side to side.



Swarm robots

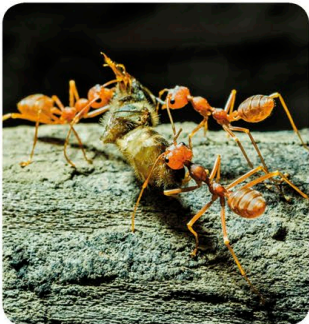
Robot swarms are made from large groups of simple robots teaming up. The whole swarm works together to function as one bigger, more intelligent robot. Robot swarms can do things that would be difficult for other robots to do, such as changing shape.

Swarm intelligence

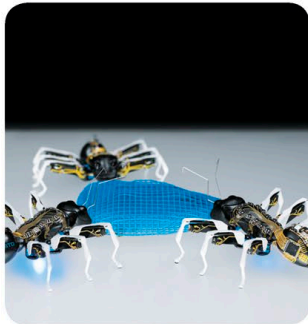
Swarm robots must send messages to each other to know what to do. To make a “K” shape, these robots communicate with those closest to them to find out if they are in the right place.

Copying nature

Animals like ants form swarms to do things they could not do alone, for example, moving big objects. Robots such as BionicANTs that imitate the behavior of animals are called “biomimetic” robots because they copy, or mimic, nature.

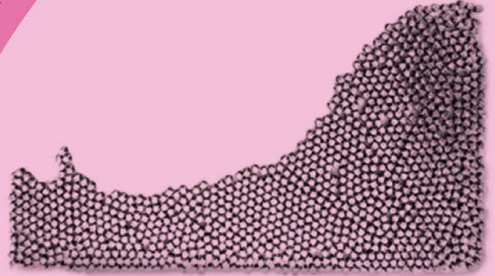


Ants working together

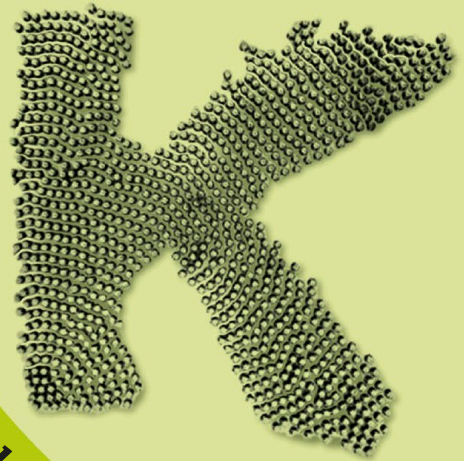


BionicANTs working together

Step 1: Random group
The robots start clustered together in a random shape.



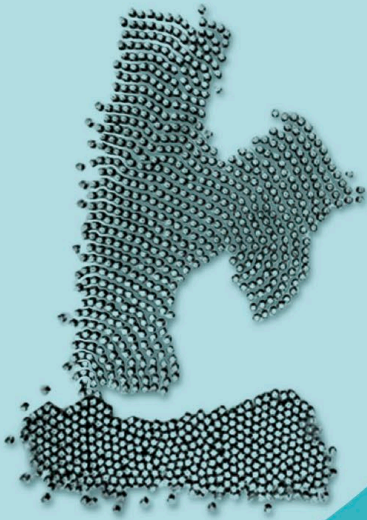
Step 4: Making a “K”
It takes $11^{3/4}$ hours to form a “K” shape.



Step 2: Beginning to move
Four "seed" robots tell the group where to start.



Step 3: Taking shape
The robots move around the edge until they find a free space.



Kilobots

The "K" swarm is made of over 1,000 individuals, called kilobots. Each one is coin-sized, with three thin legs, and moves by vibrating. Kilobots use infrared light to send messages to each other.





Drones

Flying robots are called drones. Some look like miniature airplanes and others like helicopters with lots of blades. The largest drones are as big as jet aircraft, but the smallest are tiny fliers about 1 in (3 cm) across. Most carry cameras to show people their view from the air.



How drones work

Drones can be remote-controlled or fly themselves. Both types use spinning blades to keep them up in the air. The best drones are smart enough to fly straight even when it's windy.

Flying high

This drone, also called a quadcopter, has four helicopter blades. Each blade spins like a fan. These push air down to lift the robot up.



Eye in the sky This photograph was taken by a drone flying above the boat. Drones can take amazing photos that would be almost impossible to capture otherwise—like this one of a humpback whale!

Remote control

Controls on a remote let the user tell the robot where to move. A tablet screen shows the view from the robot's camera so you can get the perfect shot.



Robot explorers

There are places on Earth that are difficult for people to visit. The bottom of the ocean, the icy polar regions, and inside volcanoes are just some of these. Scientists have created robots to help us see these exciting places.

Solar panels generate electricity for energy.



GROVER

Explorers built this robot to work in the coldest temperatures on Earth. It is designed to drive over frozen ice sheets in the Arctic.

Crabster CR200

Would you like to meet a crab that is 4 ft (1.3 m) tall? Crabster walks along the seafloor, where the tide is too strong for divers.

Each leg has multiple joints that bend.



OceanOne

This underwater robot has a human-shaped body, but propellers instead of legs. Scientists used it to find treasure on a shipwreck 328 ft (100 m) deep!



OceanOne's hands let its controller feel what the robot is touching.

Nomad

This four-wheeled robot is the size of a small car. Nomad can explore dry places such as deserts, which are similar to the surface of planets like Mars.

Special tyres help Nomad roll across sand.



VolcanoBot 1

Scientists built this small two-wheeled robot to explore vents in volcanoes where lava has escaped. It is only 1 ft (30 cm) long.

VolcanoBot 1 can fit into small cracks.



Pyramid Rover

Inside the Great Pyramid of Giza, in Egypt, is a tunnel that is too narrow for a person. Scientists built Pyramid Rover to explore the tunnel. At the end of the tunnel, it drilled a hole through a stone door and discovered a secret room with a second door. No one knows what, if anything, lies beyond the next door!

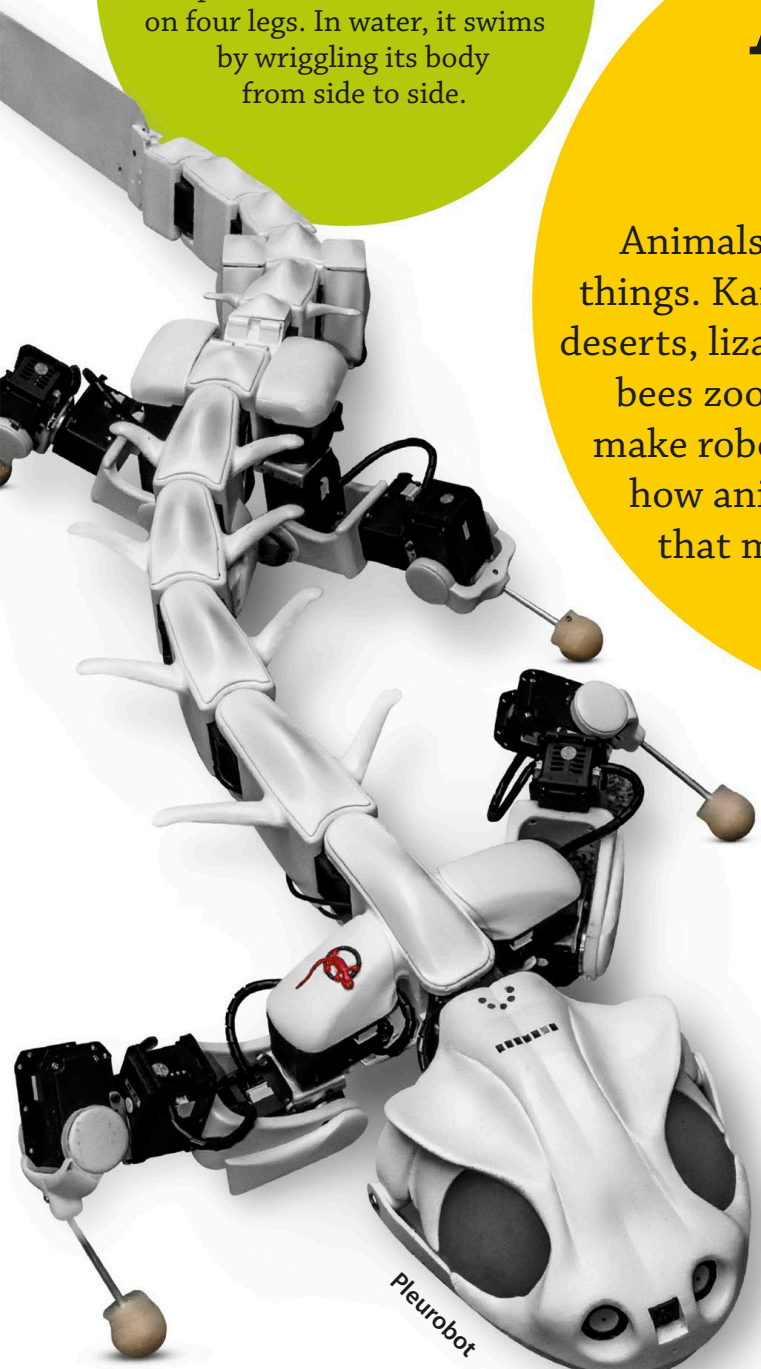


Pleurobot

Scientists designed this robot to look and move like a salamander—a slimy, lizardlike amphibian. On land, it walks on four legs. In water, it swims by wriggling its body from side to side.

Animal robots

Animals are able to do extraordinary things. Kangaroos bound for miles across deserts, lizards grip onto vertical walls, and bees zoom through the air. Scientists make robots that copy animals, to learn how animals do these things and so that machines can do them, too.

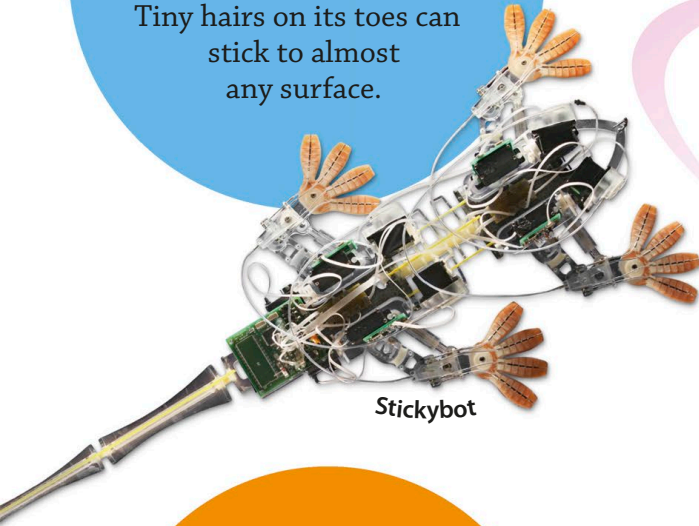


Robotic Fish

Just like an actual fish, these swimming robots have lifelike skin covered in scales. When people see them in a tank, they can mistake them for real fish because they swim so well.

Stickybot

Stickybot is a robot lizard that can climb walls. Its feet have a special sticky skin, like that of a gecko lizard. Tiny hairs on its toes can stick to almost any surface.



Stickybot

eMotionButterflies

These flying robots look like giant, flapping butterflies. Their wings are 20 in (50 cm) across, making them about 10 times the size of a garden butterfly.



eMotionButterfly

BionicKangaroo

BionicKangaroo is shaped like a small kangaroo. It can hop the length of its body without falling over—about 3 ft (1 m).

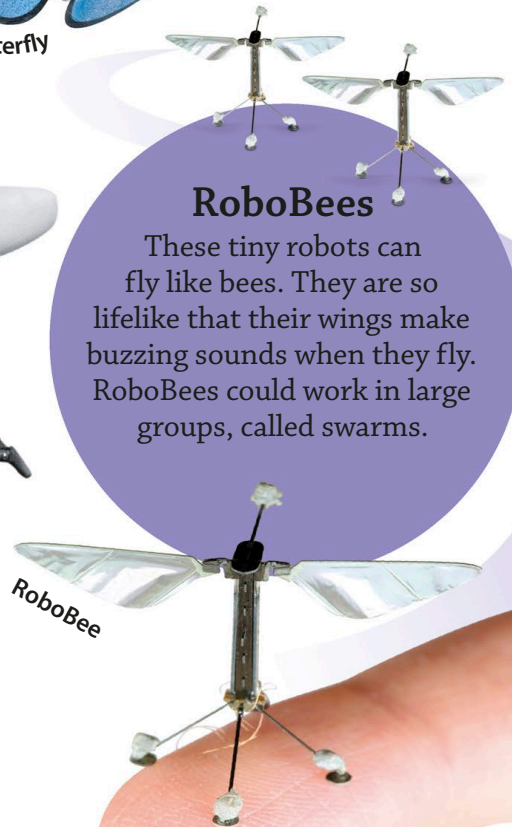


BionicKangaroo

FESTO

RoboBees

These tiny robots can fly like bees. They are so lifelike that their wings make buzzing sounds when they fly. RoboBees could work in large groups, called swarms.



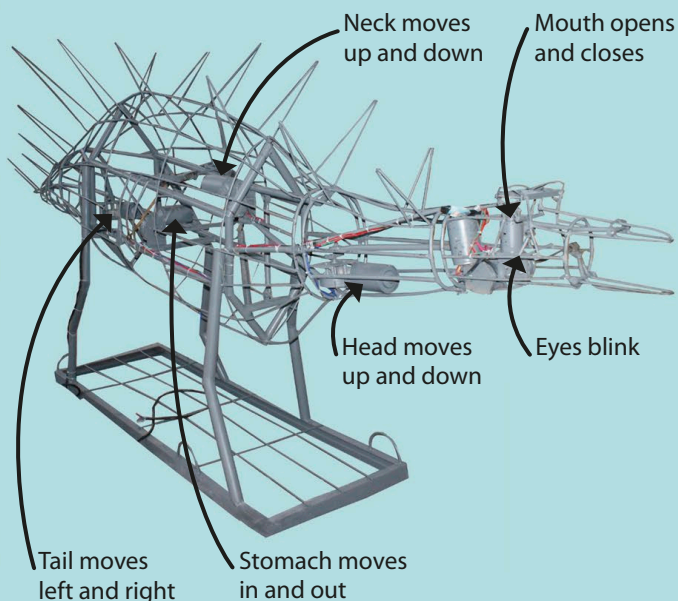
RoboBee

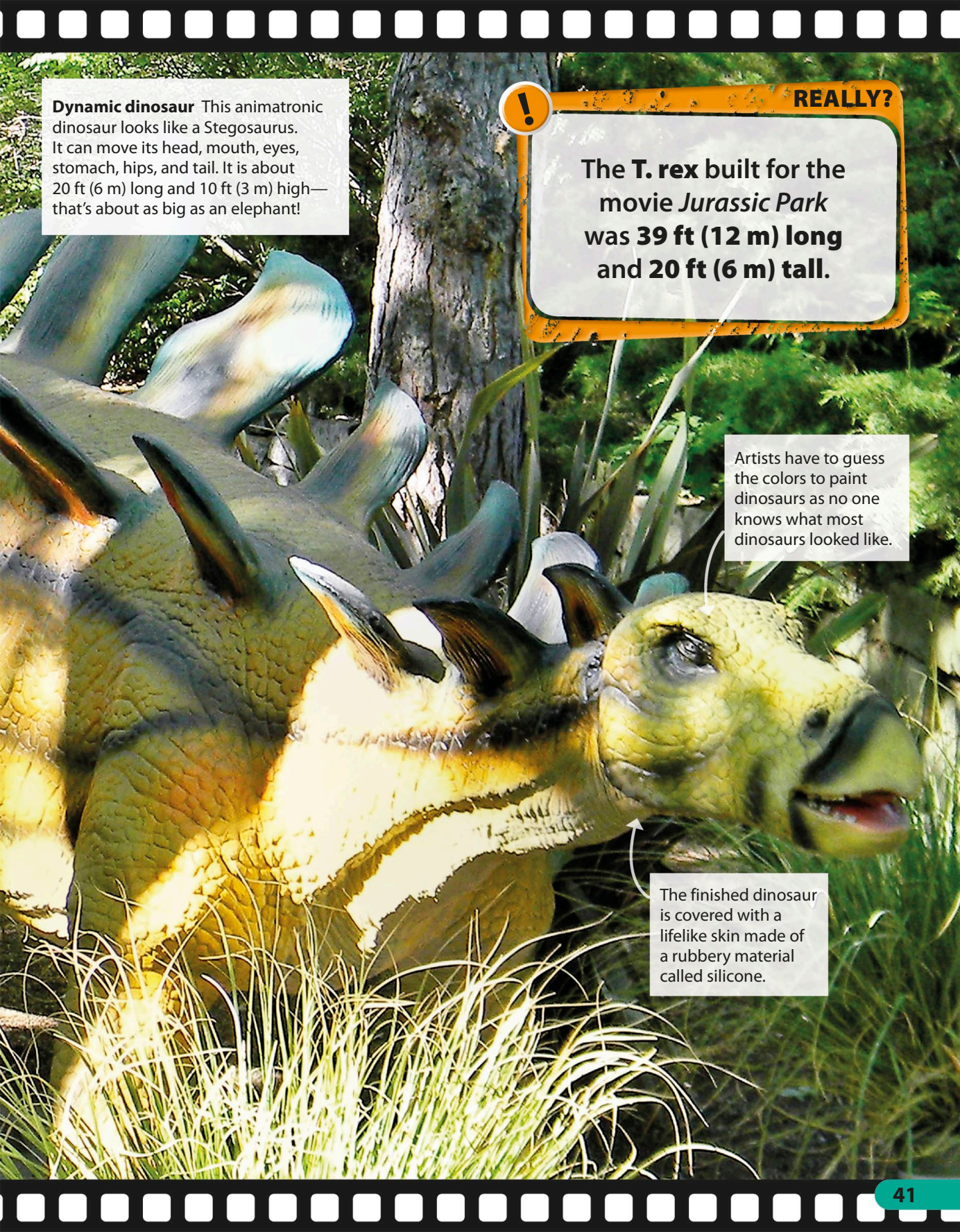
Animatronics

Animatronic models are robots made to look like living animals or people. They are mechanical puppets that are moved by motors rather than strings. Animatronics are often used in movies to bring creatures like dinosaurs to life. You can also see them in many theme parks and museums.

What's inside?

Inside this animatronic dinosaur is a metal skeleton connected to motors. The motors move the different parts to make the dinosaur seem as though it is alive. As the skeleton moves, the eyes look around and the stomach moves in and out, so the dinosaur looks as if it is breathing.





Dynamic dinosaur This animatronic dinosaur looks like a Stegosaurus. It can move its head, mouth, eyes, stomach, hips, and tail. It is about 20 ft (6 m) long and 10 ft (3 m) high—that's about as big as an elephant!



REALLY?

The **T. rex** built for the movie *Jurassic Park* was **39 ft (12 m) long** and **20 ft (6 m) tall**.

Artists have to guess the colors to paint dinosaurs as no one knows what most dinosaurs looked like.

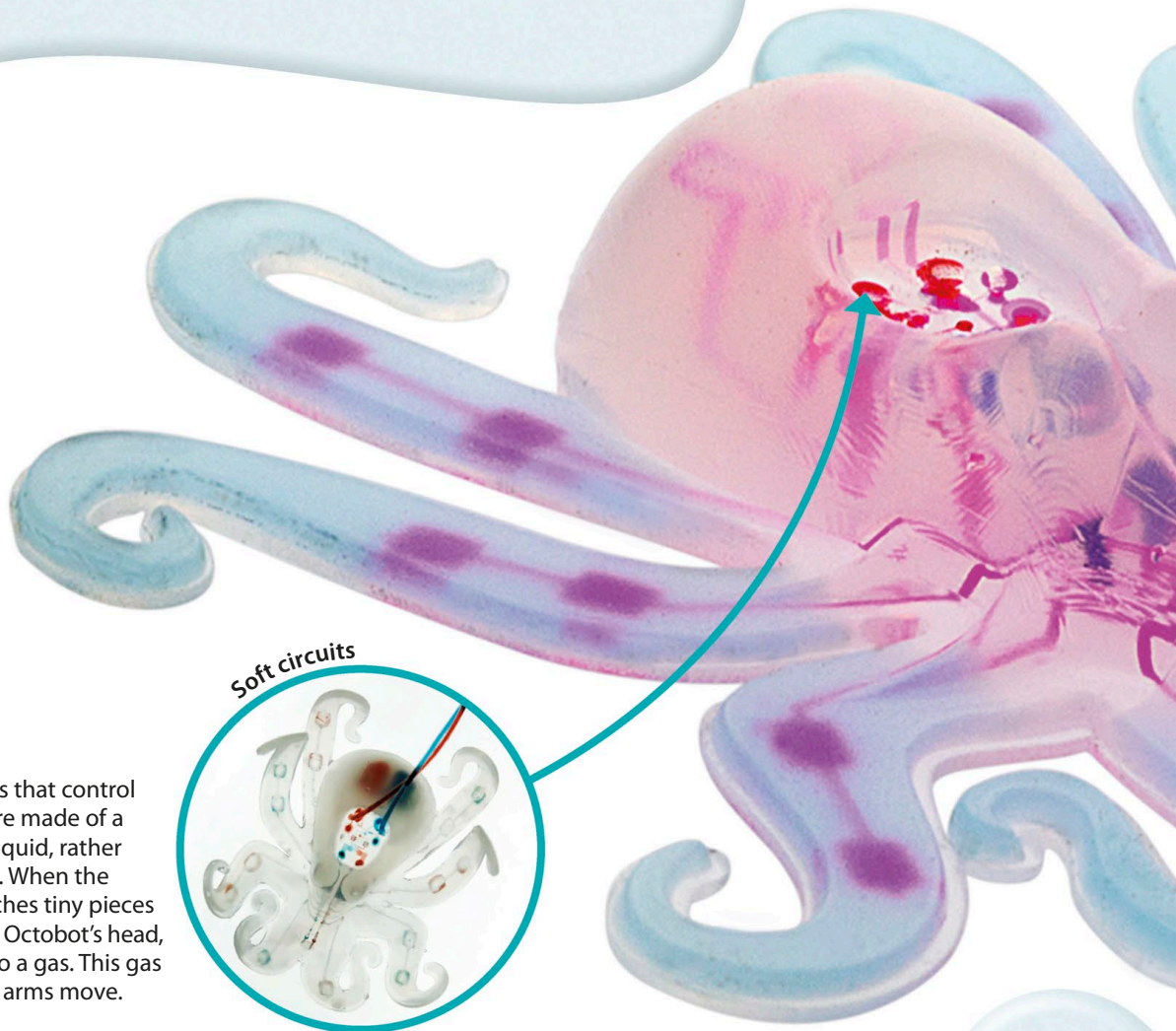
The finished dinosaur is covered with a lifelike skin made of a rubbery material called silicone.

Soft robotics

Scientists can now build robots out of soft, squishy materials. These soft robots are safer and less easily broken than hard robots. Soft robots are like soft-bodied animals, such as octopuses. They could be designed to squeeze through gaps and pick up delicate objects.

Octobot

Octobot is based on an octopus with eight bendy tentacles. It is made from rubbery materials and doesn't have any hard parts. It is even controlled by chemical reactions, not electricity!



The circuits that control Octobot are made of a chemical liquid, rather than wires. When the liquid touches tiny pieces of metal in Octobot's head, it turns into a gas. This gas makes the arms move.

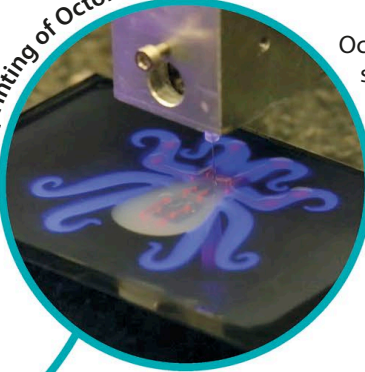
Soft gripper

A chameleon's long tongue can grab insects instantly thanks to the tongue's flexible tip that wraps around its prey. FlexShapeGripper is a soft robot gripper that works in the same way. Its soft tip molds around objects to hold them securely. It can even pick up more than one object at a time!



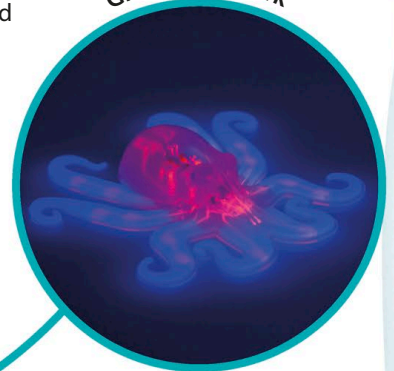
The FlexShapeGripper picking up an object

3D printing of Octobot's circuits



Octobot is made of soft parts, including a silicone body, a liquid circuit to control its movements, and stretchy actuators, which are the parts that make the arms move.

Glow in the dark



Glowing inks inside Octobot mean you can clearly see the circuits that control the robot using special lights.

Arms moving



Each of Octobot's arms has square actuators that allow it to move. When gas enters these actuators, they inflate, moving the arm—like blowing air into a balloon.

Human

Our five main senses are sight, hearing, touch, taste, and smell. We also have other senses, such as balance and temperature. Our brains use these senses to understand the world.

Sight

Light bounces off objects and into our eyes through a small hole called a pupil. Our eyes use the light to create an image in our brain.

Hearing

Inside our ears are tiny drums, which move whenever sound hits them. This movement is how we hear sound.

Smell

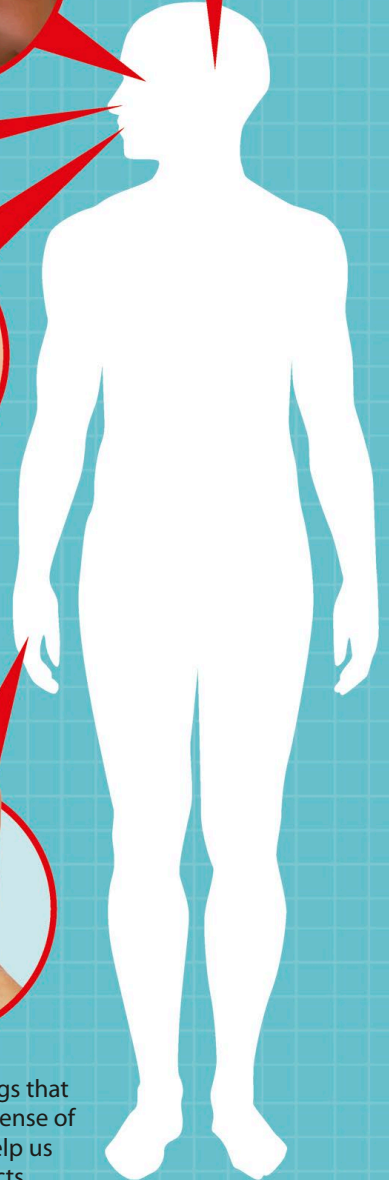
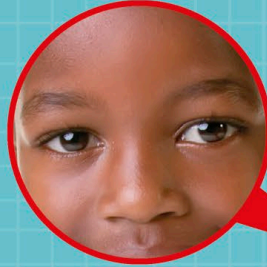
Inside our noses are millions of tiny sensors. These sensors recognize little particles in the air as smells.

Taste

Our tongues are covered in lots of tiny sensors called taste buds. They detect tastes such as salty and sweet.

Touch

Our skin can feel things that press against it. This sense of touch is needed to help us feel and pick up objects.



Senses

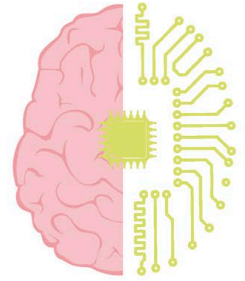
All robots need senses to tell them what is happening around them. Humans have sense organs such as eyes, whereas robots have electrical sensors such as cameras. Many robot senses are like those of humans, but they also have some superhuman powers that we do not have.

Robot

Robots also need senses so they don't bump into things and can find objects. However, robots have different senses added to them depending on the job they are designed to do.

Brainpower

Both humans and robots need to make sense of the information their sensors give them. Human sensations are sent to our brains, which then tell our bodies what to do. Robots are similar, but instead of brains, robots have computers.



PR2



Nearness

Nearness is the robot sense of distance. Robots can use infrared light or lasers to scan a room in order to map the shape of everything.



RoboGasInspector

Smell

Some robots are equipped with sensors that detect smells. These robots can be used to detect gas leaks.

Kuri



Hearing

Robots use microphones for ears. They turn sounds into electricity. A computer can then work out what the sounds mean.

Chest microphone

NEXTAGE



Sight

Robots have cameras instead of eyes. Sometimes, robots have the cameras in their chest or even in their hands so they can see what they are picking up.

Tactile Hand



Touch

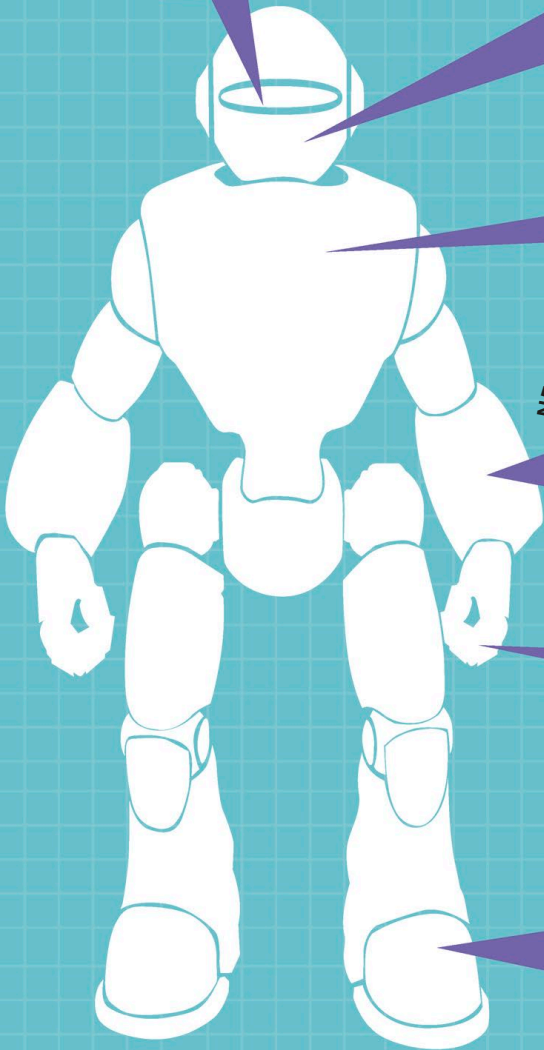
Some robots have sensitive skin that feels touch. This sense can help them hold delicate objects.

Mip



Balance

Robots need a sense of balance to move. Otherwise, they would fall over. Tilt sensors tell them which way up they are.



Humanoids

A humanoid robot has a body shaped like a person. Most humanoids have a head, chest, and two arms. Some also have legs and can walk. Others roll around on wheels. Robots that have a face and look more like people are called androids.

Pepper

When you talk to Pepper, it can tell how you feel. If you are sad, it can try to cheer you up by playing a song!



NAO

Nao is a little humanoid, about the size of a baby. It is an interactive robot—great at dancing and playing soccer.



Romeo

This robot is designed to help elderly or sick people. It can do simple tasks such as opening doors and getting things.



Why make an android?

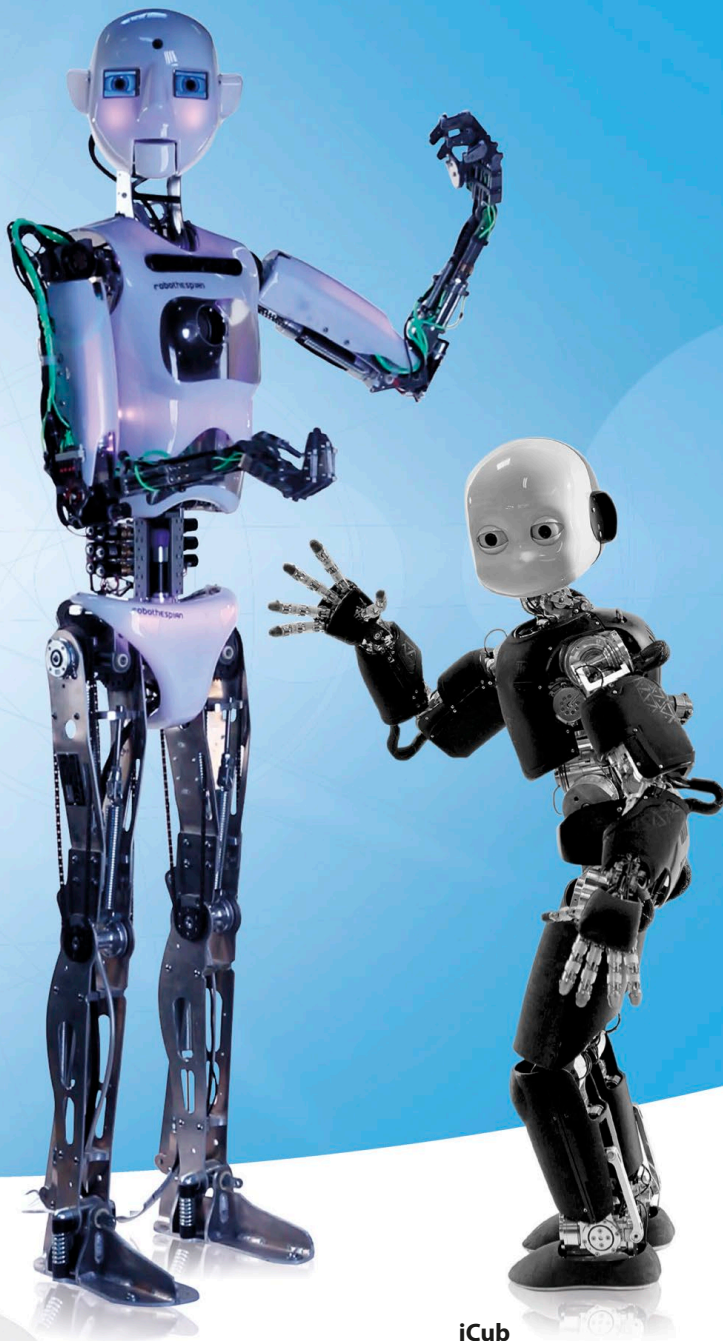
One day, scientists hope that androids will do any job that a person can do. By making androids look like people, they hope coworkers may feel more comfortable working with robots.



This HRP-4C android is also called Miim.

Alpha1 Pro

This little humanoid can dance, perform yoga exercises, and even do kung-fu!



RoboThespian

You can listen and watch this robot actor tell stories and jokes. It uses its hands to gesture as it speaks.

iCub

The iCub is about the height of a four-year-old child. Like a child, it needs to learn how to use its body by interacting with its environment.



What is artificial intelligence?

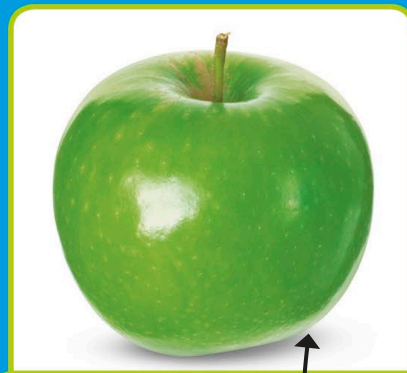
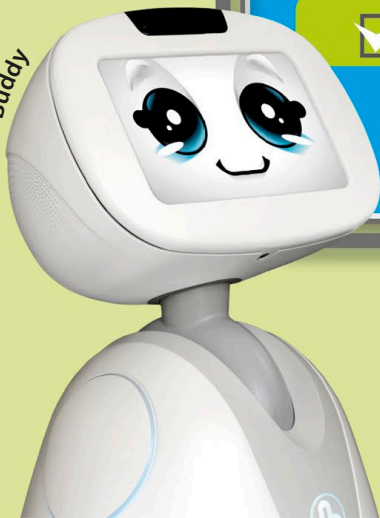
Artificial intelligence is a term used when machines or robots think, learn, and plan for themselves. It is commonly called “AI” for short. Computers use AI to beat people at games like chess. Self-driving cars use AI to plan how to drive along busy roads. The Internet can also work using AI, to give you the right answers in search engines.

The robot is also shown lots of pictures of oranges. It could be shown hundreds or even thousands of photographs.

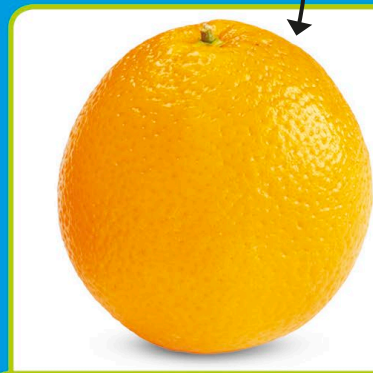
Teaching robots

Some intelligent robots can be taught what to do. Like people, they learn from trying a task. As they repeat the task, such as when learning to tell the difference between two types of object, they get better.

Buddy



APPLE



ORANGE

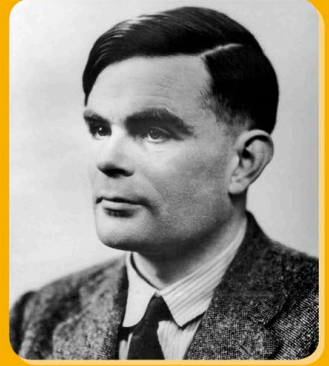
The robot is shown lots of pictures of apples that it needs to remember. It is told that these are apples.

! WOW!

A computer program **passed the Turing test in 2013**. However, it only fooled some judges.

The Turing test

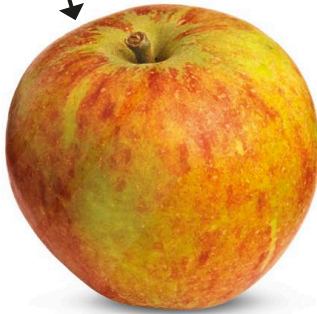
How do you know if a machine is as intelligent as a person? In 1950, computer scientist Alan Turing invented a clever test. A judge talks with a machine that they cannot see using text messages. If the machine can trick the judge into thinking it is a real person, it passes the test!



Alan Turing

The robot is shown a picture it has never seen before. Is it an apple or an orange?

The robot compares the new picture with its memory of the pictures it has seen before to guess what the right answer is.



APPLE

Pepper

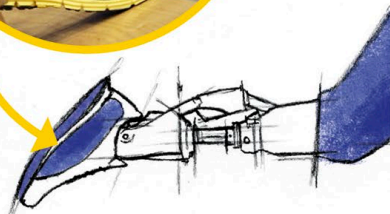
Kuri

Superhumans

Robot technologies can help us become superhuman! Scientists have made machines that are like parts of the body. Some of these, called prosthetics, replace body parts that have been lost through injury, such as a hand or leg. Others can make us faster or stronger.

This powerful device replaces a human foot. It has a special ankle that is similar to a human ankle, helping you to walk, run, and jump.

PowerFoot BiOM



Walking Assist



This robotic device superpowers your leg muscles. You wear it on your hips and thighs to walk and run faster. It is especially useful for people with weakened legs.

Argus II glasses



These special glasses can help people with damaged sight. A camera connects to a chip inside your eye and sends small electrical signals to the brain so you can see.





LUKE arm

This device replaces a human arm. It has a hand that can pick up delicate objects, such as light bulbs, and is controlled by tiny muscle movements.

HAL-5 exoskeleton

An exoskeleton is a skeleton on the outside of the body. You wear it to make you stronger, so you can lift heavy objects.

Robot friends

Social robots are designed to interact with humans. They try to understand how we feel and act, and what we say, and then respond. They can be used for everything from caring to friendship, and often have friendly faces that make us want to like them!



PARO responds when you stroke it. It is charged through a wire that connects to its mouth.

Caring

PARO is a robot that looks like a baby seal. It is designed to calm patients who feel scared. It has a friendly face and cuddly body that reacts to being held. It is meant to give comfort, like a pet cat or dog.



Kuri the helper robot answers a question by beeping.

Teaching

Kuri is a friendly, wheeled robot that helps around the home. It can follow you around and answer questions with beeps. It can even wake you up with an alarm in the morning or tell you a bedtime story at night.

3

LAWS OF ROBOTICS

The Three Laws of Robotics are rules for how robots should act around people. They were invented by author Isaac Asimov for his *Robot* series of books. The laws were invented in 1942, but are still used today. They say that a robot should:

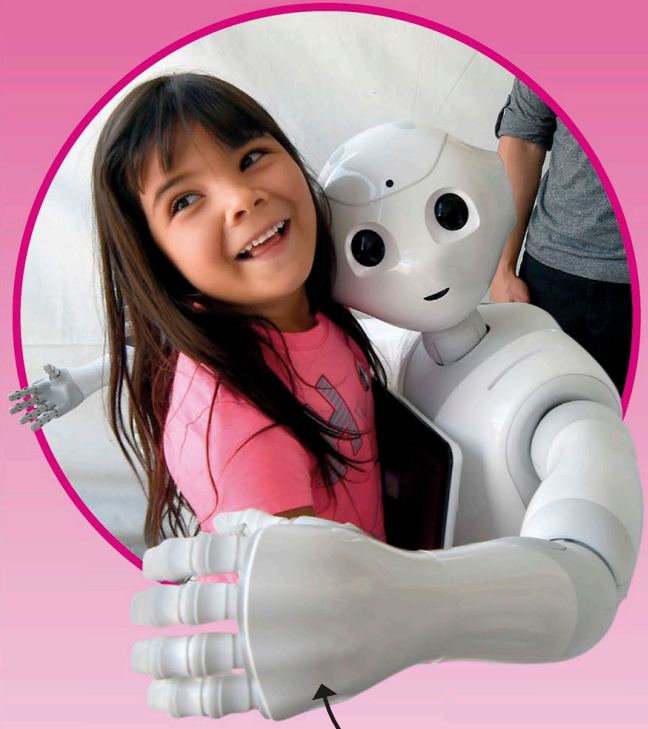
- 1 Not harm humans, or let them be hurt by not helping them.
- 2 Obey orders from humans unless the orders break the first law.
- 3 Protect itself from harm unless its actions would break the first and second laws.



You can raise your hand in class using NAO even if you're at home!

Learning

NAO is a small humanoid that can be used as a telepresence robot. If you can't travel to school, it can be there for you. Using a camera and a speaker, you can talk and communicate with your class through it.



Pepper can give you a hug.

Friendship

Pepper is a companion robot who can recognize your emotions. It uses your face and voice to figure out how you are, and changes its behavior according to how you feel.

! WOW!

The Interaction Lab works with more than 20 different robots.



Maja with the robots Maki, and Spritebot in its green “Kiwi” skin.

Interview with...

We put some questions to Dr. Maja Matarić, a professor at the University of Southern California. She runs the Interaction Lab, which develops socially assistive robots that help people.



Q: We know it is something to do with robots, but what do you actually do?

A: My students and I create robots that help people as friends and companions. For example, we created a robot that helps children in hospitals cope with fear and anxiety, and a robot that recognizes bullying gestures and calls them out to help children stop being bullied or being bullies.

Q: What made you decide to become a robot engineer?

A: When I was in high school, my uncle told me computers were the future, and he was right. I wanted to make computers interact in the real, physical world—our world—and that led me to robotics.

Q: What is a usual work day for you?

A: There is no usual day! I meet with students and other scientists to invent new robots. I advise companies, show children why robotics is exciting, go to conferences, give talks, and read and write research papers. Most of all, I work with people.



Spritebot in its red "Chili" skin

Q: What are your office and lab like?

A: My office is full of books and small toy robots for inspiration. My lab is full of students of all ages, many kinds of robots—such as Spritebot and Maki—and tools for experiments. We use all sorts of things, including people trackers, LEGO, a baby highchair, and a table-sized touch tablet.

Q: What are the best and worst parts of your job?

A: The best part is swapping ideas with students and working with them on interesting challenges. The worst part is too many emails.

Q: Do you have a favorite robot?

A: WALL-E from the film is a perfect robot. It is appealing, caring, friendly, fun, but imperfect. It has the best of human qualities without the worst.

Q: How do you think robots will help us in the future?

A: Early robots were created for dirty, dull, and dangerous jobs. Now they are created for everything. I believe that robot companions are some of the most important types of robots. Everyone should have a friend that is always there for them.

Future of robotics

In the future, there will be lots of robots. They'll help us at home, at work, in hospitals, and even inside our bodies. They will also become easier to communicate with. Robots may become so lifelike that we won't even think of them as robots any more!



Personal robots

Robots in the future may help us more in everyday life and act as personal assistants. You will also be able to program them to do what you want. In the future, everyone may have their own robot helper!



Dash and Dot are robots that anyone can program.

SAM100 the bricklaying robot

Dash can be programmed to play tunes on a xylophone.

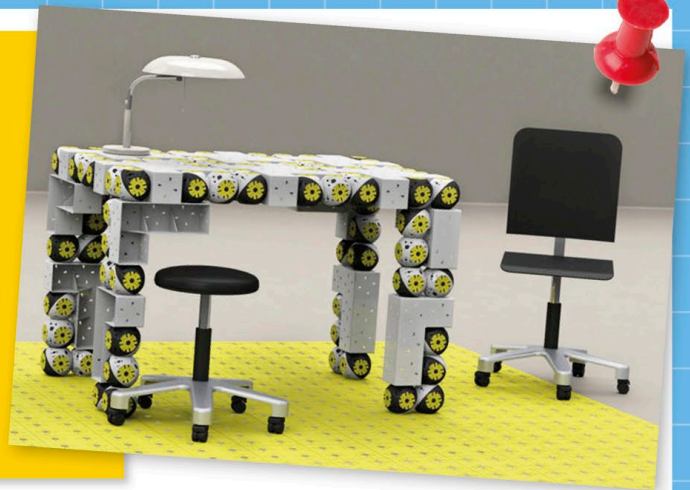
Robot builders

Future houses could be built entirely by robots. The robot bricklayer SAM100 can work six times faster than a human, placing 3,000 bricks a day. Other houses may be 3D printed using giant robotic arms.



Self-assembling furniture

Imagine your tables and chairs could change shape and move. Scientists are working on self-assembling robots that join up to make furniture. A table could change into a chair and walk across the room!

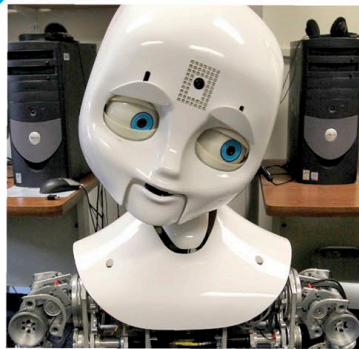


Roombots are small robots that can twist and join up to make furniture.

Guardian LF1 catches lionfish that have been introduced into the Atlantic Ocean.

Robots with feelings

Most robots today look and behave like any other machine. Future robots could feel happy or sad just like people. This would help them understand what people want and even become our friends!

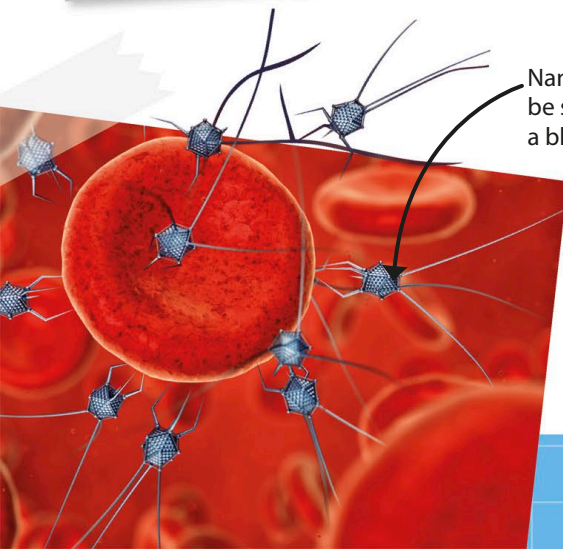


Nexi can appear to show feelings, but it doesn't have emotions.



Green robots

New robots could help look after the environment. From recycling garbage to protecting rare animals, and even eating pollution in the sea, they could work to protect the planet.



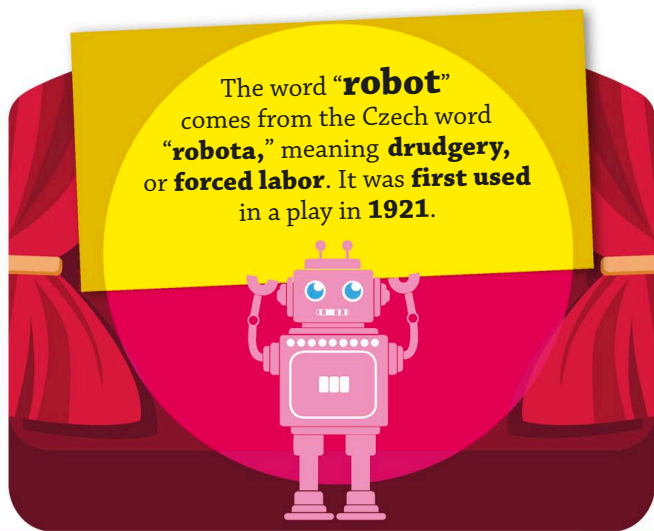
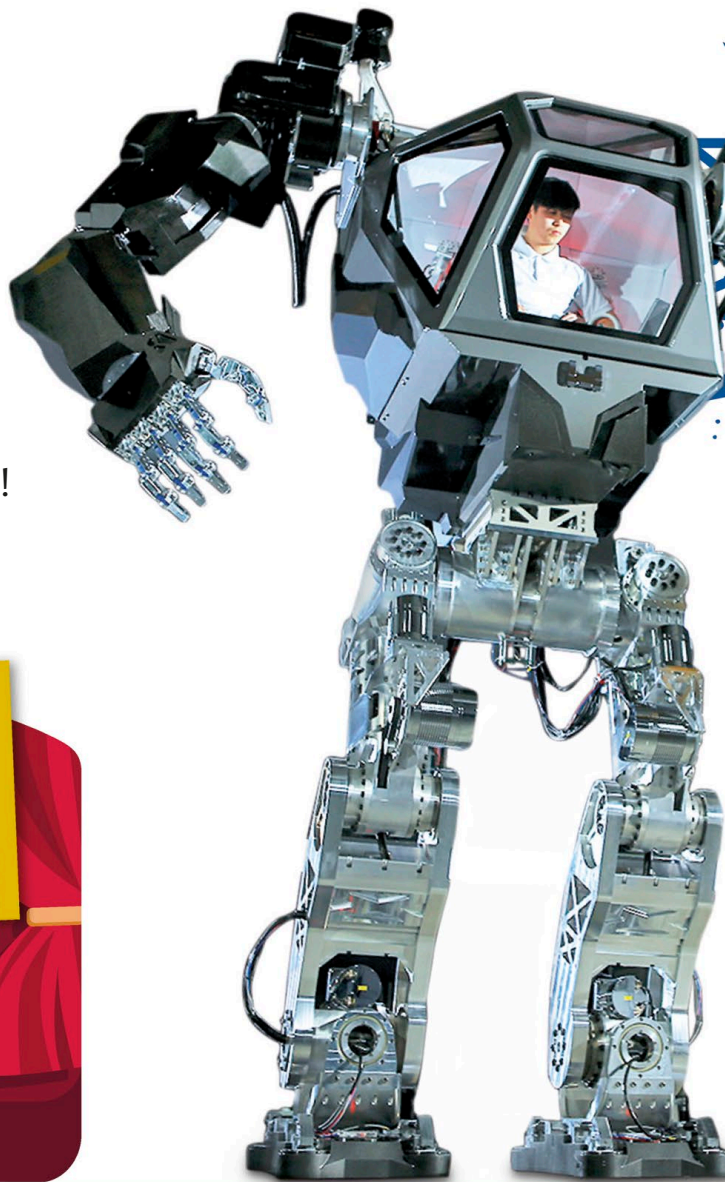
Nanorobots can be smaller than a blood cell.

Nanorobots

Scientists are trying to make robots that are too small to see. These "nanobots" could be used inside the body. Doctors could use them to hunt down germs or deliver medicines.

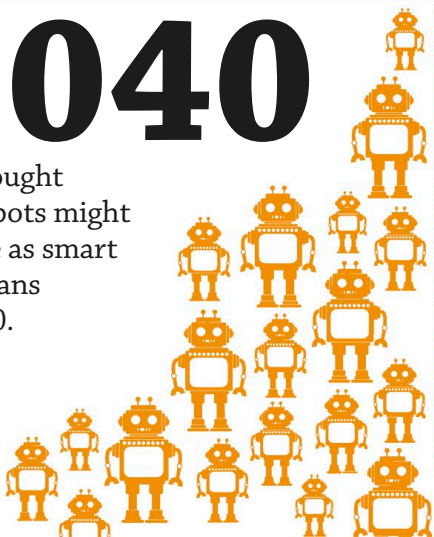
Robot facts and figures

Robots are amazing machines. Here are some weird and wonderful facts about robots that you can impress your friends with!



2040

It is thought that robots might become as smart as humans by 2040.



1,200

1,200 gallons (4,542 liters) per minute is the amount of water the firefighting robot Thermite 3.0 can spray to put out a fire.





Method V2 is a **robotic suit** with two legs controlled by a **HUMAN PILOT**.



TOPIO is a robot that **plays table tennis**.

A **NANOBOT** can be **less than one-thousandth** of a **millimeter**. That's even **smaller** than a **period**.

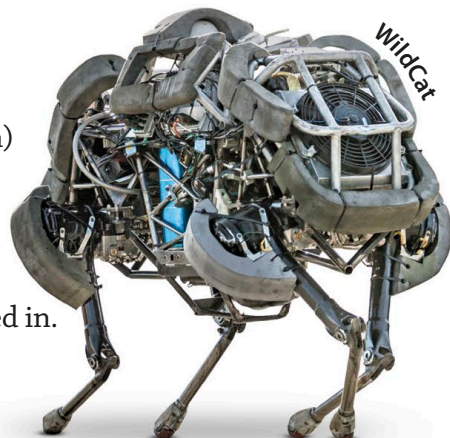
Hello!



Scientists have created a robot called **CRAM** that looks like a **GIANT COCKROACH**. It can squeeze through **small gaps** and could be used to find people trapped at a disaster site.

20

20 mph (32 kph) is WildCat's top speed, making it the fastest robot on legs—that isn't plugged in.



WildCat robot image courtesy of Boston Dynamics

3,500

About 3,500 people from more than 40 countries take part in the annual soccer tournament **RoboCup**.





Glossary

Here are the meanings of some words that are useful for you to know when learning about robots.

3D printing Way to make a solid object using a printer. Most 3D printers squeeze liquid plastic out of a thin tube one layer at a time

actuator Part of a machine that makes it move, such as a motor

agricultural robot Robot that works on a farm

amphibian Cold-blooded animal that starts life in the water

android Robot that has a human face

animatronics Machines that look like real humans or animals. They are often used in movies and theme parks

artificial intelligence When a machine can think for itself. Artificial intelligence can be shortened to “AI”

automaton Machine that repeats the same movements. Automata are often driven by water, air, or clockwork

autonomous Device that works on its own without human help

biomimetic Objects made by copying animals or plants

clockwork Machine that works using cogs and gears. It must be wound up to work

cobot Robot that works safely with human coworkers

code Written commands used in a computer program

computers Machines that can perform different tasks by following programs

console Device containing controls for a machine

domestic robot Robot made to work in the home

drone Flying machine with no pilot

electricity Type of energy that can be used to power machines

environment Area that someone lives in, or that a machine works in

factory Building where lots of the same objects are made

haptic When we feel objects through our sense of touch and body movement

humanoid Robot with a body shaped like a human. Humanoids usually have a head and arms, and often legs

industrial robot Robot that works in a factory

industry Business of making things in factories, such as cars

International Space Station Large space station and laboratory that orbits the Earth. It can be shortened to “ISS”

interstellar space Area of space between stars

joystick Small lever used to control a machine

machine Something that is powered by energy and is used to carry out a task

mechanical To do with machines, especially those with moving parts

microchip Tiny device that stores code in memory or runs programs

monitor Screen used for interacting with a computer

motor Device that changes electricity into movement. Motors are used to make robots move

nanotechnology Science that studies and makes tiny devices too small to see with the human eye

nursing robot Robot that helps to take care of sick or injured people

power supply Source of energy that is used to make a machine work

probe Unmanned spacecraft designed to study objects in space and send information back to Earth

program Set of instructions a computer or robot follows to complete a task

programming Creating instructions for a robot to follow, written in a language that computers understand

programming language Set of words and rules used to give computers instructions

propeller Spinning blades used to push a machine or boat through water or air

prosthetic Artificial body part to replace one that is missing, such as a leg or hand

quadcopter Flying drone with four spinning helicopter blades

robot Moving machine that is programmed by a computer to do different tasks. They can sense their environment and respond

robotic Something that is, or is like, a robot

satellite Any object that travels around a planet, but often a manufactured machine that collects scientific information

sensor Part of an animal or machine that picks up information from its surroundings, such as eyes or a camera

sign language Way of talking using your hands. Different shapes are used for different letters and words

social robot Robot you can interact with. They can often talk and play

soft robot Robot made using soft, bendy materials rather than hard, rigid ones

surgery Operation on a patient to treat an injury or disease

swarm Collection of many animals or robots

technology Using scientific knowledge to create machinery and devices, such as robots

telepresence robot Robot with a screen that you can see and speak through. Usually used when you are in a different place from the robot



Buddy is a social robot.



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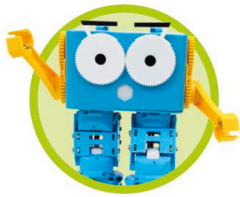
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