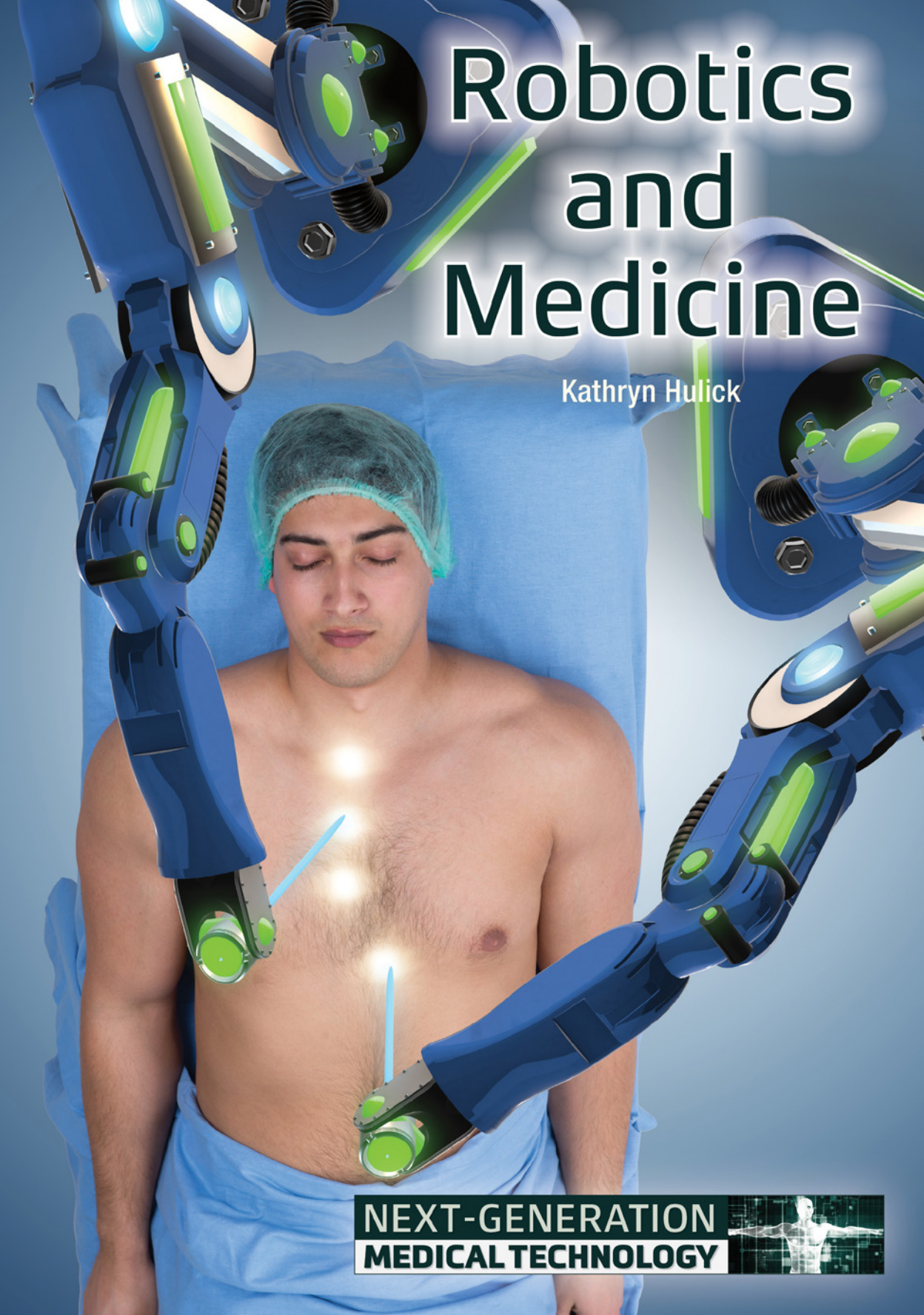
Robotics and Medicine

Kathryn Hulick



NEXT-GENERATION
MEDICAL TECHNOLOGY

CONTENTS

IMPORTANT EVENTS IN THE HISTORY OF ROBOTICS

1954
George Devol files a patent for the first industrial robot, which is eventually named Unimate.

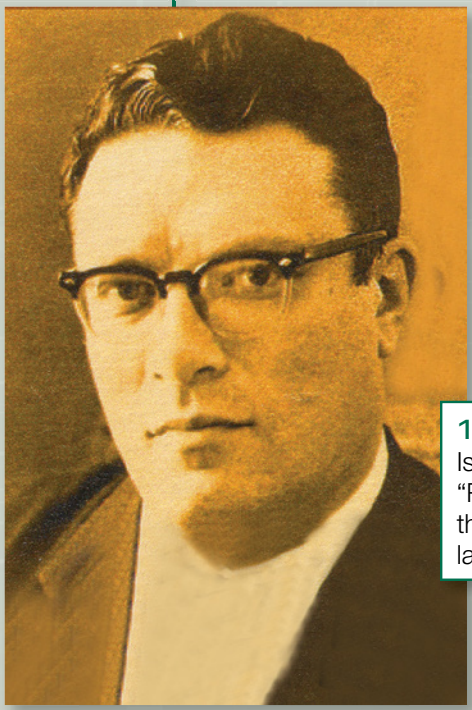
1921
Karel Čapek coins the word *robot* for a science fiction play.

1950
Alan Turing imagines the Turing test for machine intelligence.

1960
Unimate goes to work on the General Motors automobile assembly line.

1977
R2-D2 and C-3PO first appear in the *Star Wars* trilogy.

1945 1955 1965 1975 1985



1968
HAL appears in the movie *2001: A Space Odyssey*.

1983
In the first use of robotics in the operating room, Arthrobot is used to hold and move patients' legs during surgery.

1942
Isaac Asimov's short story "Runaround" introduces the now-famous three laws of robotics.

1985
Surgeons use the PUMA 200 industrial robotic arm to perform part of a brain surgery.

Transforming Health Care

A robot lifts its head and gazes into an elderly patient's face. Lights rim the robot's eyes, changing color from blue to green as the machine gathers data. After a moment the robot knows that the patient's heart rate and breathing rate are normal. The patient asks the robot a few questions, nods at the replies, and then heads into the kitchen to make dinner. A few moments later the person falls with a thump. The robot cannot see or hear the impact, but it knows immediately that something is wrong. Its sensor that detects movement warns that the person is no longer moving. Another sensor knows that the stove is still on. So the robot calls for help. Soon a human nurse arrives, turns off the burner, and helps the patient get up.

This robot is called the IBM MERA, for Multi-Purpose Eldercare Robot Assistant. MERA is not ready to assist elderly people at home yet, but IBM is testing the robot at a lab at Rice University in Texas. The robot combines several cutting-edge technologies: a humanoid robot body called Pepper that can navigate the house, state-of-the-art sensors that monitor the environment and detect changes, and IBM's artificial intelligence (AI) software called Watson that can recognize and respond to human speech. This software is best known for defeating human champions on the quiz show *Jeopardy!* in 2011. But since that landmark victory, IBM has been applying Watson to new tasks, including health care.

The Doctor Shortage

Robots such as MERA are poised to transform the health care industry at a critical time. Several countries around the world are

facing a similar dilemma. In the United States and Japan, the population of elderly people is growing faster than the working population. The Japanese Ministry of Health, Labor, and Welfare predicts that by 2025, the country will face a shortage of 1 million nurses and care workers. By that same year the United States will likely face a shortage of 500,000 nurses, according to *MD Magazine*. "Assistive, intelligent robots for older people could relieve pressures in hospitals and care homes as well as improving care delivery at home and promoting independent living for the elderly," says Irena Papadopoulos, founder of the European Transcultural Nursing Association.[1] Doctors are in short supply as well. Over the next decade the United States will likely need up to ninety thousand more doctors than are available, according to the Association of American Medical Colleges.

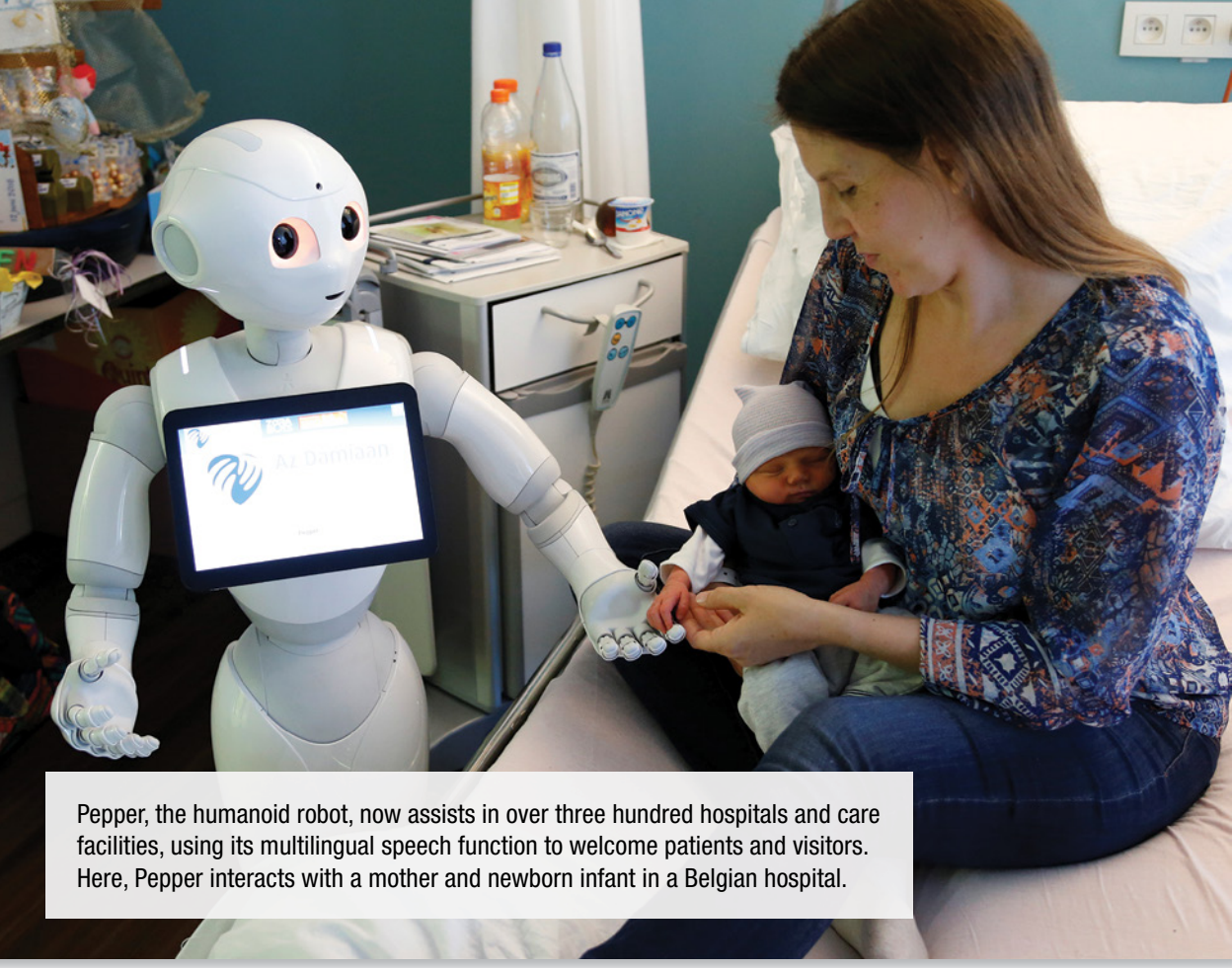
humanoid

resembling a human being

Japan, especially, is focusing on robotics as the answer to this problematic situation. The country is one of the world leaders in electronics and computing, and many innovations and breakthroughs in medical robotics have come from Japan. However, despite the progress being made on medical robots, these machines are not going to step in and take over every aspect of a nurse's or doctor's job, at least not any time soon. Rather, they are performing tasks that are boring, time consuming, or dangerous, or that require great accuracy and precision. They perform this work continuously without getting tired, becoming frustrated, or needing a vacation. The time and money that robots save frees up people to do more of the work that needs a human touch, such as talking a cancer patient through his or her options for treatment. "It is not a question of replacing human support but enhancing and complementing existing care," says Papadopoulos.[2]

Robots Among Us

Robots have already begun taking over low-skilled labor at hospitals and other medical facilities. Courier robots carry meals, medication, and fresh sheets to patient rooms, and cart trash and dirty



Pepper, the humanoid robot, now assists in over three hundred hospitals and care facilities, using its multilingual speech function to welcome patients and visitors. Here, Pepper interacts with a mother and newborn infant in a Belgian hospital.

laundry away. Cleaning robots disinfect floors and other surfaces. Pharmacy robots count and dispense medication. Robotic wheelchairs, exoskeletons, and bionic arms and legs help patients with limited mobility to get around and perform daily tasks. Some robots are doing jobs that are difficult and time consuming for even the smartest human, such as testing thousands of compounds during medical research or sorting through huge amounts of data to help doctors make a diagnosis.

Other robots are working directly with patients. Telepresence robots allow a doctor to interact with a patient from afar through a video conferencing screen and instrument attachments. Surgical robots are enhancing the accuracy and safety of surgery, augmenting a surgeon's vision with powerful cameras and replacing his or her hands with a suite of minuscule, precise instruments. Some of these robots are getting smart enough to perform repetitive aspects of surgery, such as suturing, on their own. Mean-

while, social robots such as MERA have learned to communicate with people in order to answer questions, provide basic physical or educational therapy, or entertain patients. “In the 21st century robots will increasingly be living among us,” says Peter Dominey of CNRS, the French National Center for Scientific Research. “These robots must be able to take our perspective and co-operate with us and, if our plans change, they must be able to adjust their behavior accordingly. Most important of all, they must be safe.”[3]

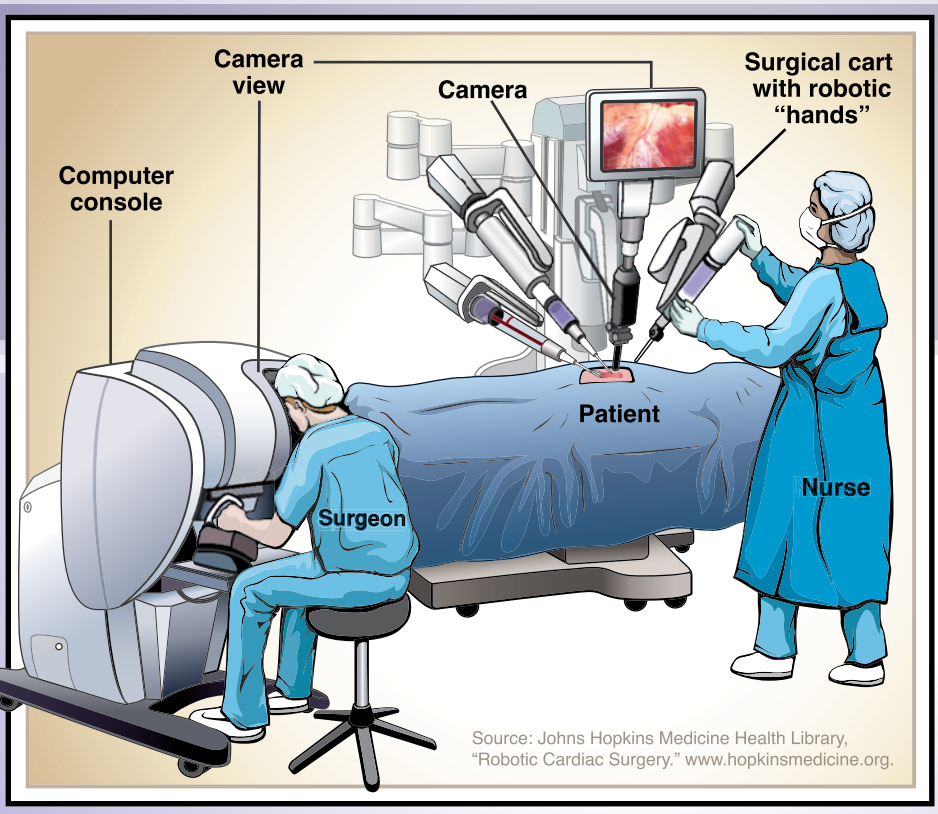
telepresence

the use of technology to remotely control a robot or mechanical system

There is still a long way to go before a robot could take over the job of a human caretaker in the home, but robotics technology is improving every day. One day it may not be so strange for elderly people to remain in their homes much longer, thanks to the supervision and attention of a robot nurse like MERA. In the home and at school, robots might be able to diagnose and recommend treatment for minor health issues, while also offering an instant link to a human specialist through telepresence. In surgery, robots will get softer, smaller, and more flexible. They will enter the body without requiring an incision and perform operations with less and less human guidance. Some robots may shrink to minuscule dimensions, floating through the bloodstream to monitor health, make repairs, or destroy diseased cells. Robots will help us live longer, healthier lives.

Robotic Cardiac Surgery

Cardiac surgery with the da Vinci and similar robotic systems is less invasive than traditional surgery. It allows a surgeon to make smaller and more precise cuts, which means less chance of complications. Robotic surgery has been used for heart-related procedures such as coronary artery bypass, heart defect repair, and tumor removal. In this type of operation, the surgeon manipulates the robotic hands from a console while looking at a camera view of the heart.



its sensors. "CARLO goes much further than the well-known da Vinci operations robot, which actually only does what the surgeons tell it," says Philippe C. Cattin of the University of Basel in Switzerland, who helped develop the robot.[10]

One of the first medical robots, ROBODOC, assisted with hip replacement surgery in 1992. Since then robots have remained an important part of hip and knee replacement surgeries. NAVIO, MAKO, and TSolution One are all state-of-the-art robots designed

avoid these infections, hospitals devote a lot of time and effort to keeping surfaces, floors, and equipment squeaky clean. But robots promise to make hospital-cleaning tasks quicker, easier, and more thorough.

Many people are already familiar with cleaning robots and may even have one at home. Roomba, a robotic vacuum cleaner, and Scooba, a robotic mop, are two examples of consumer products that people can purchase to help clean their homes. But a hospital needs a more heavy-duty cleaning machine. Intellibot robots scrub, vacuum, or sweep floors in hospitals and other large buildings. They do this automatically, so cleaning staff do not have to spend all day pushing heavy mopping machines around. At Kapi'olani Medical Center for Women & Children in Hawaii, a pair of Intellibot machines were decorated to resemble a train and a school bus. "Beyond freeing up the cleaning crew so they can focus on keeping the environment as safe and clean as possible, the robots are putting a smile on the faces of their patients," says Thomas Boscher of Intellibot Robotics.[20]

Mopping robots clean a floor with soap and water in much the same way that a human would. But when it comes to disinfecting tables, door handles, toilet seats, medical equipment, and other surfaces in hospital rooms, robots have an advantage.

First Robotic Hospital

At Humber River Hospital in Toronto, Canada, pharmacy robots mix drugs and courier robots scurry around, transporting supplies. Robotic beds can automatically position patients. But these machines aren't the only robotic aspect of the hospital. The entire building is connected digitally. Hospital workers and patients wear tracking devices, making it possible to always know where a particular person is. Using bedside touchscreen interfaces, patients can video chat with their doctors, access their electronic health records, order food, or read e-books. In a way the hospital is like one huge robot. "Humber is the first hospital in North America to have all of its systems electronic and integrated together," says CEO Dr. Reuben Devlin.

Quoted in MEDITECH, "Humber River Hospital Opens North America's First Fully Digital Hospital," October 27, 2015. https://ehr.meditech.com.

They can use ultraviolet (UV) light. This high-energy light destroys DNA, which is an essential part of the cells of all living things. UV light zaps dangerous bacteria that are gathered on surfaces or even floating in the air. Since UV light harms humans, too, a person can't safely use this method to clean a room. But robots that clean with UV light abound, including Xenex, Tru-D, and UV-Disinfection Robot.

ultraviolet

light with a very short wavelength that is damaging to living cells

In most hospitals these robots do not replace human workers, but instead add an extra layer of protection against dangerous germs. Human workers follow the usual routine of removing linens and trash from a room, then wiping down surfaces using chemical cleaning spray and a cloth. The robot comes in afterward to sanitize any areas the human may have missed. The robots are especially important in the areas of a hospital where patients are at the highest risk of acquiring an infection, including burn units, intensive care units, and operating rooms. "The robot gives us one more tool in the arsenal," says Debbie Sandberg of Sutter Health Medical Center in California, which uses a Xenex robot that the staff named Xhaiden. "People want to know they're in a clean environment. This gives everyone more confidence from a patient-safety perspective."[21] Several hospitals have reported that health care–associated infection rates dropped significantly after they added UV-disinfecting robots to their cleaning routines.

Dispensing Drugs

In addition to combating health care–associated infections, robots could help eliminate medication errors. If a patient takes the wrong medicine, an incorrect dose, or a problematic combination of drugs, his or her health may suffer. This is called an adverse drug event, and it usually happens due to human error in dispensing or delivering prescription medications. A pharmacist is the person tasked with preparing doses of medication for patients. A 2012 study in the *American Journal of Health-System Pharmacy* found that a human pharmacist makes an average of five errors in every

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FOR FURTHER RESEARCH

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