次の英文を読み，下の設問に答えなさい。

Imagine a microscopic machine that could swim through a person's blood vessels on its way to delivering medicine to a cancerous tumor. Or one that unclogs an artery to prevent a heart attack, or even performs delicate vision-saving surgery from inside the eye. These feats aren't possible yet. But researchers are designing miniature robots, called *microswimmers*, that may soon do all of these things. And more.

Imagine a robot and Star Wars' beloved R2-D2 may come to mind, or his pal C-3PO. The robots scientists want to deploy in the human body are much, much smaller. They're typically less than 1 millimeter (0.04 inch) in size. At their largest, they might be the size of a few grains of table salt. But they can be much smaller — so small that they can be seen only with a microscope.

The human body is made up mostly (a) wet stuff.　Blood, spinal fluid and other liquids make up about 60 to 65 percent of the volume of the human body. So to move through this environment (b) ease, robots must swim. But finding the right materials and designs to send robots swimming through even the tiniest blood vessels has proven tough. But not impossible. Indeed, scientists have been inching toward this vision throughout the past decade.

The payoff should be worth the wait, says David Cappilleri. He's a microroboticist at Purdue University in West Lafayette, Ind. "Microrobots can go places that larger robots can't." [A]What's more, he argues, "they can handle tools with finer precision."

Humans don't have much experience moving things around micro-environments of the body, explains Bradley Nelson. He's a roboticist at the Swiss Federal Institute of Technology in Zurich. But some other organisms do this well. So Nelson and other robot designers are looking (c) them for [10]inspiration.

Before scientists could create robots to swim inside the body, they first had to solve the problem of scale. The physics of swimming changes as an object gets smaller and smaller, Nelson observes. That's because on a microscopic scale, liquids become much more *viscous*. (Viscosity is the thickness of a liquid.)

"If you were to shrink down to the size of a [microrobot] and jump into a pool of water," says Nelson, "the water wouldn't feel like water anymore. It would feel like thick honey."

That's why he and other scientists have copied some of nature's tiniest swimmers: single-celled lifeforms that infect people. These master swimmers can navigate swiftly through our bodies.

For design tips, Nelson focused on a type of microbe known as a *protozoan*. He picked the species *Trypanosoma brucei* (Try-PAN-oh-SO-mah BRU-see-eye). In people, this parasite causes African sleeping sickness. Affected people often can't sleep at night but are overcome with drowsiness by day.

T. brucei swims through the bloodstream by swishing a whiplike tail. This tail is called a *flagellum* (Fla-JEL-um).

As it moves, *T. brucei* also changes its shape. This helps it get from one part of the body to another. The protozoan can go from short and stumpy to slender and needle-like. That lets it penetrate blood vessel walls and invade the spinal cord.

Nelson liked the idea of building a microrobot with this talent for shape-shifting. Such a robot could do jobs in different parts of the body, depending on its shape. These tasks might include unclogging arteries or delivering medicines, Nelson explains. Or maybe the robot could make microscopic repairs in the blood vessels of the eye.

He used a gel-like material to build a soft microrobot. By altering the gel's temperature, he can make his robot short and stumpy or long and needle-like.

Nelson described this new design last year in the journal *Nature Communications*.

Nelson's soft-bodied microswimmer isn't the only nano-medic that researchers are building. Some at Drexel University in Philadelphia, Penn., created a different type to bring cancer-killing medicine to tumors.

B<u>One challenge to designing robots that will go inside the body is powering them</u>. These robots are too small to carry an engine or battery pack, notes Min Jun Kim, who led the Drexel team.

Kim is a mechanical engineer. (He now works at Southern Methodist University in Dallas, Texas.) Mechanical engineers use rules of motion, energy and force to design and build machinery. Kim's team used magnets to solve the power problem. Unlike Nelson's soft microswimmer, Kim's design is made entirely of metal.

He looked to bacteria for inspiration. And he found it in *Borrelia burgdorferi* (Bor-REL-ee-ah Burg-DOR-fur-eye). This spiral-shaped germ causes an illness known as Lyme disease. People fall ill after being bitten by an infected tick. The bacterium uses a corkscrew-like motion to swim and bore through tissue.

Kim mimicked its corkscrew shape by joining together strands of magnetic beads. Those beads are so small they can barely be seen without a microscope.

He used magnets to propel his microrobot through artificial blood vessels in a *petri dish*. By increasing or decreasing the strength of the magnets, Kim can make the robot swim faster or slower. Changing the direction of the magnetic field lets him steer the robot left or right. He can join several chains together to make strands as long as 20 to 30 beads. Or he can break them apart into strands as short as three beads.

Kim says the surfaces of these beads could be coated with medicines. To treat cancer, a microswimmer that's a longer chain could bore into a thick tumor. Once inside, it could break apart into smaller chains to spread its cancer-killing medicine around, he says.

Kim's team shared its findings last year in the journal *Scientific Reports*.

Some microrobots can already swim in petri dishes. But there would likely be big hurdles before they could be released in people, notes Zhang Li.

He studies nanotechnology — the design and harnessing of extremely small devices — at the Chinese University of Hong Kong. Scientists need to know, for instance, how safe the itty-bitty devices are. They also need to know how to remove those [11]tiny swimmers once their work is done, Li notes.

For now, researchers plan to test their microscopic devices in animals such as mice. Those tests can also help scientists make sure that the materials in their robots aren't [12]*toxic*.

Scientists also can use animals to practice inserting, tracking and removing microswimmers before they put them in people. CWorking with robots in a real body — whether a human or a mouse — is a lot different from doing it in a petri dish under a microscope, Li explains. In a petri dish, there's no skin, blood or other tissues to block the view.

Despite these challenges, scientists find this "an exciting time" Li observes. "There's so much left to learn."

Lindsey Konkel, Science News for Students, July 6, 2017. Used with permission.

Notes:

microscopic 顕微鏡でしか見えない,
spinal fluid せき髄液,
whiplike むち状の,
spinal cord せき髄,
bacterium バクテリア(bacteria の単数形),
petri dish ペトリ皿
unclog(s) ～から障害を取り除く,
drowsiness(うとうとする)眠さ,
stumpy ずんぐりした,
tick ダニ,
corkscrew らせん状の,
itty-bitty ちっぽけな

〔1〕英文中の下線部 A, B, C を日本語にしなさい。

〔2〕英文中の空所（a),(b),(c)に適切な前置詞を補いなさい。

〔3〕1～10 の質問に対して英文の内容から判断し，最も適切なものを一つ選び，その番号をマークしなさい。

1. What is the best title for this passage?

(1) Therapeutic robots may soon swim within the body
(2) Star Wars' robots fit the image of science
(3) Robots can't be adopted to help us with our health
(4) Scientists have figured out a way to deliver robots to our bloodstream

2. A microscopic machine today can

(1) swim through a human's bloodstream.
(2) deliver medicine to a cancerous tumor.
(3) unclog arteries.
(4) None of the above.

3. Finding out how to send tiny robots through a human's blood vessels has

(1) been and will be impossible.
(2) been difficult thus far.
(3) proven to be easy.

(4) been delayed for years.

4. Nelson of the Zurich Institute used __________ as his model for minirobots.
(1) a professional swimmer
(2) an affected person
(3) a microbe
(4) a navigator

5. Nelson chose *T. brucei* as his model because it can
(1) change its shape.
(2) move through the bloodstream.
(3) enter blood vessels and the spinal cord.
(4) All of the above.

6. Nelson's robots
(I) remain short and stumpy.
(2) have gel applied to their surface.
(3) can shift shape when the temperature of the gel is changed.
(4) are hard but can be made to be soft.

7. Kim's robots
(1) swim just like Nelson's.
(2) are made of the same material as Nelson's.
(3) differ from Nelson's in the way they move.
(4) were produced in a petri dish.

8. Kim's microrobots imitate __________ to swim and bore though material.
(1) a corkscrew
(2) magnetic beads
(3) artificial blood vessels
(4) a microscope

9. Li's concerns about the microrobots are related to
(1) safety.
(2) removal of the devices.
(3) working with them outside of a petri dish.

(4) All of the above.

10. The word “inspiration” is closest in meaning to
(1) motivation.
(2) discouragement.
(3) depression.
(4) invitation.

11. The word “tiny” means
(1) small.
(2) adequate.
(3) fragile.
(4) hard.

12. The word “toxic” means
(1) difficult.
(2) healthy.
(3) harmful.
(4) beneficial.