

外 国 語

次の英文は *The New York Times* (2023年5月20日) に掲載された “Rice gets reimagined, from the Mississippi to the Mekong” (Somini Sengupta and Tran Le Thuy) の記事を一部改変したものです。この文章をよく読んで、医学科と歯学科の受験者は問題 , , , に答えなさい。保健衛生学科と口腔保健学科の受験者は問題 , , , , に答えなさい。解答は解答用紙の指定された欄に記入すること。

Rice is in trouble as the Earth heats up, threatening the food and livelihood of billions of people. Sometimes there's not enough rain when seedlings need water, or too much when the plants need to keep their heads above water. As the sea intrudes, salt *ruins* the crop. As nights warm, yields go down.

These *hazards* are forcing the world to find new ways to grow one of its most important crops. Rice farmers are shifting their planting calendars. Plant breeders are working on seeds to *withstand* high temperatures or salty soils. Hardy heirloom varieties are being resurrected.

And where water is running low, as it is in so many parts of the world, farmers are letting their fields dry out on purpose, a strategy that also reduces methane, a *potent* greenhouse gas that rises from paddy fields.

The climate crisis is particularly *distressing* for small farmers with little land, which is the case for hundreds of millions of farmers in Asia. “They have to *adapt*,” said Pham Tan Dao, the irrigation chief for Soc Trang, a coastal province in Vietnam, one of the biggest rice-producing countries in the world. “Otherwise they can't live.”

In China, a study found that extreme rainfall had reduced rice yields over the past 20 years. India limited rice exports out of concern for having enough to feed its own people. In Pakistan, heat and floods destroyed harvests, while in California,

a long drought led many farmers to fallow their fields.

Worldwide, rice production is *projected* to shrink this year, largely because of extreme weather.

Today, Vietnam is preparing to take nearly 250,000 acres of land in the Mekong Delta, its rice bowl, out of production. Climate change is partly to blame, but also dams upstream on the Mekong River that choke the flow of freshwater. Some years, when the rains are paltry, rice farmers don't even plant a third rice crop, as they had before, or they switch to shrimp, which is costly and can degrade the land further.

The challenges now are different from those 50 years ago. Then, the world needed to produce much more rice to stave off famine. High-yielding hybrid seeds, grown with chemical fertilizers, helped. In the Mekong Delta, farmers went on to produce as many as three harvests a year, feeding millions at home and abroad.

Today, that very system of intensive production has created new problems worldwide. It has depleted aquifers, driven up fertilizer use, reduced the diversity of rice breeds that are planted, and polluted the air with the smoke of burning rice stubble. On top of that, there's climate change: It³⁾ has upended the rhythm of sunshine and rain that rice depends on.

Perhaps most worrying, because rice is eaten every day by some of the world's poorest, elevated carbon dioxide concentrations in the atmosphere deplete nutrients from each grain.

Rice faces another climate problem. It accounts for an estimated 8 percent of all global methane emissions from human activity. That's a fraction of the emissions from coal, oil and gas, which together account for 35 percent of methane emissions. But fossil fuels can be replaced by other energy sources. Rice, not so much. Rice is the staple grain for an estimated three billion people. It⁴⁾ is biryani and pho, jollof and jambalaya — a source of tradition, and sustenance.

"We are in a fundamentally different moment," said Lewis H. Ziska, a professor of environmental health sciences at Columbia University. "It's a question of

producing more with less. How do you do that in a way that's sustainable? How do you do that in a climate that's changing?"

* * *

In 1975, facing famine after war, Vietnam *resolved* to grow more rice.

It succeeded spectacularly, eventually becoming the world's third-largest rice exporter after India and Thailand. The green patchwork of the Mekong Delta became its most prized rice region.

At the same time, though, the Mekong River was reshaped by human hands.

Starting in southeastern China, the river meanders through Myanmar, Laos, Thailand and Cambodia, interrupted by many dams. Today, by the time it reaches Vietnam, there is little freshwater left to flush out seawater seeping inland. Rising sea levels bring in more seawater. Irrigation canals turn salty. The problem is only going to get worse as temperatures rise.

"We now accept that fast-rising salty water is normal," said Mr. Pham, the irrigation chief. "We have to prepare to deal with it." Where saltwater used to intrude 30 kilometers or so (about 19 miles) during the dry season, he said, it can now reach 70 kilometers inland.

Climate change brings other risks. You can no longer count on the monsoon season to start in May, as before. And so in dry years, farmers now rush to sow rice 10 to 30 days earlier than usual, researchers have found. In coastal areas, many *rotate* between rice and shrimp, which like a bit of saltwater.

But this requires reining in greed, said Dang Thanh Sang, 60, a lifelong rice farmer in Soc Trang. Shrimp bring in high profits, but also high risks. Disease sets in easily. The land becomes barren. He has seen it happen to other farmers.

So, on his seven acres, Mr. Dang plants rice when there's freshwater in the canals, and shrimp when seawater seeps in. Rice cleans the water. Shrimp nourishes the soil. "It's not a lot of money like growing only shrimp," he said. "But it's safer."

Elsewhere, farmers will have to shift their calendars for rice and other staple

grains, researchers concluded in a recent paper. Scientists are already trying to help them.

* * *

The cabinet of wonders in Argelia Lorence's laboratory is filled with seeds of rice — 310 different kinds of rice.

Many are ancient, rarely grown now. But they hold genetic superpowers that Dr. Lorence, a plant biochemist at Arkansas State University, is trying to find, particularly those that enable rice plants to survive hot nights, one of the most *acute* hazards of climate change. She has found two such genes so far. They can be used to breed new hybrid varieties.

"I am convinced," she said, "that decades from now, farmers are going to need
⁽¹⁾very different kinds of seeds."

Dr. Lorence is among an army of rice breeders developing new varieties for a hotter planet. Multinational seed companies are heavily invested. RiceTec, from which most rice growers in the southeastern United States buy seeds, backs Dr. Lorence's research.

Critics say hybrid seeds and the chemical fertilizers they need make farmers heavily dependent on the companies' products, and because they promise high yields, effectively wipe out heirloom varieties that can be more resilient to climate hazards.

The new frontier of rice research involves Crispr, a gene-editing technology that U.S. scientists are using to create a seed that produces virtually no methane. (Genetically modified rice remains controversial, and only a handful of countries allow its cultivation.)

In Bangladesh, researchers have produced new varieties for the climate pressures that farmers are dealing with already. Some can grow when they're submerged in floodwaters for a few days.

Others can grow in soils that have turned salty. In the future, researchers say, the country will need new rice varieties that can grow with less fertilizer, which is

now heavily subsidized by the state. Or that must tolerate even higher salinity levels.

No matter what happens with the climate, said Khandakar M. Iftekharuddaula, chief scientific officer at the Bangladesh Rice Research Institute, Bangladesh will need to produce more. Rice is eaten at every meal. "Rice security is synonymous with food security," he said.

* * *

Rice is central to the story of the United States. It enriched the coastal states of the American South, all with the labor of enslaved Africans who brought with them generations of rice-growing knowledge.

Today, the country's dominant rice-growing area is spread across the hard clay soil near where the Mississippi River meets one of its tributaries, the Arkansas River. It looks nothing like the Mekong Delta. The fields here are laser-leveled flat as pancakes. Work is done by machine. Farms are vast, sometimes more than 20,000 acres.

What they share are the hazards of climate change. Nights are hotter. Rains are erratic. And there's the problem created by the very success of so much intensive rice farming: Groundwater is running dangerously low.

Enter Benjamin Runkle, an engineering professor from the University of Arkansas at Fayetteville. Instead of keeping rice fields flooded at all times, as growers have always done, Dr. Runkle suggested that Arkansas farmers let the fields dry out a bit, then let in the water again, then repeat. Oh, and would they let him measure the methane coming off their fields?

Mark Isbell, a second-generation rice farmer, signed up.

On the edge of Mr. Isbell's field, Dr. Runkle erected a tall white contraption that an egret might mistake for a cousin. The device measured the gases produced by bacteria stewing in the flooded fields. "It's like taking a breathalyzer test of the land," Dr. Runkle said.

His experiment, carried out over seven years, concluded that by not flooding

the fields continuously, farmers can reduce rice methane emissions by more than 60 percent.

Other farmers have taken to planting rice in rows, like corn, and leaving furrows in between for the water to flow. That, too, reduces water use and, according to research in China, where it's been common for some time, cuts methane emissions.

The most important finding, from Mr. Isbell's vantage point: It reduces his energy bills to pump water. "There are upsides to it beyond the climate benefits," he said.

By cutting his methane emissions, Mr. Isbell was also able to pick up some cash by selling "carbon credits," which is when polluting businesses pay someone else to make emissions cuts.

When neighbors asked him how that went, he told them he could buy them a drink and explain. "But it will have to be one drink," he said. He made very little money from it.

However, there will be more upsides soon. For farmers who can demonstrate emissions reductions, the Biden administration is offering federal funds for what it calls "climate smart" projects. Agriculture Secretary Tom Vilsack came to Mr. Isbell's farm last fall to promote the program. Mr. Isbell reckons the incentives will persuade other rice growers to adopt alternate wetting and drying.

"We kind of look over the hill and see what's coming for the future, and learn now," said his father, Chris Isbell.

問題

保健衛生学科と口腔保健学科のみ

1 The following words appear in bold italics in the text. On the answer sheet, circle the letter indicating the best definition for each word (based on how the word is used in the text).

ruins

- | | | |
|-------------|---------------|-------------|
| a) bleaches | b) covers | c) destroys |
| d) heats | e) stimulates | |

hazards

- | | | |
|-----------------|-----------|---------------|
| a) developments | b) events | c) intentions |
| d) reports | e) risks | |

withstand

- | | | |
|------------|---------------|----------|
| a) bear | b) experience | c) lower |
| d) prevent | e) require | |

potent

- | | | |
|-------------|-------------|-------------|
| a) common | b) new | c) powerful |
| d) seasonal | e) terrible | |

distressing

- | | | |
|--------------|-----------------|------------------|
| a) expensive | b) noteworthy | c) psychological |
| d) troubling | e) unacceptable | |

adapt

- | | | |
|-----------|--------------|----------|
| a) adjust | b) fight | c) leave |
| d) retire | e) speak out | |

projected

- | | | |
|-------------|---------------|----------|
| a) certain | b) predicted | c) ready |
| d) revealed | e) understood | |

resolved

- | | | |
|----------------|------------|-----------|
| a) anticipated | b) decided | c) failed |
| d) promoted | e) wanted | |

rotate

- | | | |
|------------|-----------|------------|
| a) balance | b) choose | c) prepare |
| d) switch | e) wonder | |

acute

- | | | |
|-------------|----------------|-----------|
| a) chronic | b) complicated | c) costly |
| d) expected | e) severe | |

leading exporters of rice, even surpassing Thailand and India.

- 12) It is implied that Mekong River dams have contributed to the growing problem of salty water in Vietnam.
- 13) According to Mr. Pham, Vietnam has lost 70 kilometers of land to saltwater.
- 14) The article suggests that farmers who raise shrimp can make a lot of money but can also lose a lot of money.
- 15) As a safety precaution, Dang Thanh Sang only uses shrimp as fertilizer for growing rice.
- 16) Argelia Lorence's research is focused on identifying genes that can help rice plants tolerate high temperatures.
- 17) RiceTec is a seed company that specializes in selling hardy heirloom varieties of rice seeds.
- 18) Genetic editing using Crispr technology has been widely accepted and implemented in rice cultivation.
- 19) Rice seeds that can grow despite flooding-related issues or saltier soils have been developed in Bangladesh.
- 20) The article suggests that rice farmers in Bangladesh rely heavily on fertilizers.
- 21) According to Khandakar M. Iftekharuddaula, more rice needs to be grown in Bangladesh no matter how the climate changes.
- 22) Unlike in Vietnam, rice fields in the southern United States are shaped like pancakes.
- 23) It is reasonable to conclude that if farmers follow Benjamin Runkle's advice, they will produce rice in a way that is better for the environment.
- 24) The article implies that participation in Dr. Runkle's experiment lowered Mr. Isbell's expenses.

医学科と歯学科のみ

4 Briefly (in 10 to 25 words) answer the following questions in your own words, using complete English sentences. Base your answers on the information presented in the article.

- 1) What are three problems that intensive rice production has created?
- 2) What do critics say are problems with hybrid seeds and the chemical fertilizers they require?
- 3) What are some ways described in the article for rice farmers to reduce methane emissions?

全学科

5 下線部(ア)と(イ)を日本語に訳しなさい。

全学科

6 現代の稲作における問題とその解決策について、この記事の著者が述べていることを、以下のキーワードすべてを用いて日本語で400字以内にまとめなさい。なお、キーワードは初出の際に四角く囲むこと。

例)

海	水
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※英数字は2文字で1マスとすること。

海水

遺伝子

メタンガス