

# RIPPLE ENGLISH

## ACTIVE LEARNING PROGRAM

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Workbook for:  
“Genome Editing: The In-Vitro Creation”

問題は解きっぱなしにしないで！

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また、数日置いてから再度解き直すのも効果的です。答えを記憶してしまっているかもしれませんが、**回答の根拠をなぞりながら繰り返し解くことで有効な復習になります！**



## Genome Editing: The In-Vitro Creation

1. In the Bible, the book of Genesis states that God created plants, animals, and humans. Traditionally, the ability to design and produce creatures has been considered to be divine power. Besides the Bible, there are multiple versions of mythological fictions around the world about the origin of creatures. Today, however, Homo sapiens are acquiring this divine ability. It has been 3.8 billion years since the first organisms appeared on earth, and all of life has evolved following the principle of natural selection. But for the first time in the history of biology, we are going to add a new rule to the game of life. With the exponential progress of gene editing technologies in recent years, including CRISPR/Cas9, humanity is becoming able to modify the blueprint of life. This technology has the potential to eliminate genetic ailments, increase agricultural production, and even upgrade human capabilities. What kind of future will be brought by genome editing?
  2. Geneticists had been longing for decades for a technology to precisely target and edit specific genomic sequences. In 2012, a paper on the defense system of microbes called “CRISPR/Cas9” was published in *Science* magazine. It immediately sparked the imagination of biologists around the world. Some bacterial species have evolved a system to cut off the genomes of invading viruses to kill them. The system recognizes the offender viruses by their DNA sequence. The cuts are not delivered at random places, but at specific targeted sites in the virus’s DNA.
  3. Researchers found that this defense system consists of two critical components; “seeker” and “cutter.” The seeker is an RNA encoded in the bacterial genome that looks for the DNA sequence that matches itself in the viruses’ genome. The cutter is a protein named Cas9. Once the seeker recognizes the virus as an enemy, Cas9 is deployed to cut off the DNA at the spot specified by the seeker. To put it simply, the seeker finds the target spot and brings the cutter to the spot, and the cutter snips the targeted DNA.
- (1) According to paragraph 1, which of the following is true?
    - A. Until recently, only divine entities have had the ability to design and create organisms.
    - B. Gene editing technologies are potentially capable of curing hereditary diseases.
    - C. All of life was designed by the Creator based on the principle of natural selection 3.8 billion years ago.
    - D. Ancient people have created a fiction about the origin of life, hoping to modify the blueprint of creatures.
  - (2) According to paragraph 2, CRISPR/Cas9 is
    - A. a system for randomly cutting DNA.
    - B. a defense system of microbes to fight invaders.
    - C. a technology for precisely targeting and editing specific cells.
    - D. a method to kill off bacterial species.
  - (3) According to paragraph 3, which of the following is NOT true?
    - A. Cas9 cuts off the DNA at the place instructed by the seeker.
    - B. The seeker is an RNA that corresponds with the DNA of its potential enemy.
    - C. Cas9 is carrying a piece of information that matches its target.
    - D. The function of CRISPR/Cas9 can be divided into two parts.

4. Researchers discovered that we can edit genes with pinpoint accuracy by introducing two manipulations in this mechanism. First, we can change the target DNA sequence by replacing the seeker. Second, we can interfere in the recovery process of DNA. When DNA is cut open, it tries to recover the lost part, usually from the other copy of the gene in the cell. But if a cell is flooded with foreign DNA, then the gene accidentally copies the information from this external DNA, rather than from its backup. This works more easily, precisely, and efficiently than any other gene-editing methods ever existed.
5. With the **appearance** of CRISPR technologies, we can edit genes precisely and efficiently with a lower cost. In principle, a single letter of human DNA can be mutated to another letter, leaving the 3.2 billion other bases of the genome largely untouched. The cost and efficiency are also important as research funds and time are obviously limited.
6. Since this new genome editing technology was unveiled in 2012, its various potential applications have been suggested. One notable application is crop improvement. For instance, crops like high-yield rice, non-toxic potatoes, and less perishable tomatoes have already been created using CRISPR/Cas9. Given the climate change and food shortages caused by overpopulation, genome editing for crop enhancement is going to be essential. Also, genome editing can solve the problem of food allergies. Most allergens are specific proteins. We can reduce allergens in food by removing genes associated with the production of allergenic proteins. There are already ongoing studies on genome editing in livestock animals, such as chickens that lay eggs with less allergen.
7. Another application of genome editing is, of course, in medicine. Genetic disorders like hemophilia and muscular dystrophy are caused by mutations in specific genes. Hemophilia, for instance, is a condition where liver cells can't produce blood clotting factors properly and thus bleeding can't easily stop. By employing CRISPR technology, we can cut off the malfunctioning genes in liver cells and insert the correct DNA sequence. There are various technical challenges that need to be solved, including off-target effects, in which the tool falsely targets wrong sites and delivers unintended modifications. **We are not there yet**, but before long, we will gain the ability to purge thousands of diseases from our lives.

- (4) According to paragraph 4, which pair of manipulations do we need to introduce to edit genes?
  - A. Swapping the seeker and pouring external DNA into the cell.
  - B. Deactivating the seeker and removing the snipped DNA sequence from the cell.
  - C. Swapping the seeker and removing the snipped DNA sequence from the cell.
  - D. Deactivating the seeker and pouring external DNA into the cell.
- (5) The word “appearance” in the passage is closest in meaning to
  - A. aspect
  - B. impression
  - C. illusion
  - D. advent
- (6) According to the paragraph 6, which of the following is NOT true?
  - A. Genome editing can be used for crop improvement.
  - B. Genome editing can reduce allergens in food.
  - C. Chickens have been edited to lay eggs with less allergen.
  - D. Potatoes have been edited to be unlikely to rot.
- (7) Which of the following text best expresses the essential information in the highlighted sentence?

**We are not there yet,**

- A. We have the ability to cure thousands of diseases.
- B. We have already solved all technical challenges.
- C. We are not currently capable, but we are making progress.
- D. We will never be able to eliminate diseases.

8. While genome editing offers numerous potential benefits, it presents particularly significant ethical challenges. One of the biggest concerns is that this technology could be used not only to cure disease but also to enhance human capabilities. There is no clear line that separates healing from enhancing. In most cases, medicine is first developed and approved to save people from falling below what is considered to be the standard. However, the same tools can then be used to surpass the standard. For example, plastic surgery was first developed during the First World War to treat soldiers whose faces got injured in battles. When the war was over, surgeons realized that the same treatments could also turn healthy individuals more beautiful. Today, plastic or cosmetic surgeons earn millions by upgrading the wealthy, and we take it for granted.
9. Genome editing might follow the same path. It will begin with parents who hope to eliminate fatal genetic ailments from their babies. But once it becomes possible to edit human DNA to replace deadly genes, we might start using the same mechanism to fix less fatal genes, such as ones responsible for autism and obesity. Who would like their child to suffer from any of these? Furthermore, if you are about to provide your child such treatments, wouldn't you want to give them a little more push by enhancing their memory, athletic ability, or immune system? Even if you are personally against such upgradings, what if the neighbors are doing it for their children? Would you dare to have your child lag behind them? Any upgradings are initially justified as healing. But once it is approved, it may end up being unstoppable by moral discussions.

- (8) In paragraph 8, what does the history of plastic surgery imply?
- A. It is difficult to distinguish necessary healings and enhancements.
  - B. Medical innovations can be immensely profitable.
  - C. Plastic and cosmetic surgery should be prohibited.
  - D. Wars often encourage innovations.
- (9) Why does paragraph 9 mention the possibility of enhancing memory, athletic ability, or immune systems in children?
- A. To persuade readers of the potential benefit of genome editing.
  - B. To illustrate how genome editing may expand beyond its initial purpose.
  - C. To warn readers not to use the technology for upgrading humans.
  - D. To highlight the potential applications of genome editing.

10. The caste system in Hinduism has divided people into four groups based on the family they were born into. They believe that individuals in higher caste groups were intrinsically superior, but this was pure fiction. There is no biological difference between Brahmins and Shudras, Kshatriyas and Vaishyas. Brahmins insisted that they were naturally smarter than everyone else, but even after thorough examination of their DNA, we can never find any sequence unique to Brahmins. Historically, social and economic disparities have not arisen from genetic differences. Rather, they have been the result of cultural and environmental factors which have been justified and amplified by fictions.
11. However, with the advancement of genome editing, the nature of inequality may fundamentally change. Once it becomes possible to upgrade Homo sapiens through genome editing, we will see real gaps in physical and cognitive abilities between an enhanced upper class and the rest of society. These upgraded superhumans will enjoy **unprecedented** health, abilities, and creativity, which will further accelerate inequalities.
12. After hearing all of these, your reaction might be to hope that somebody will hit the brakes to stop it. But we may not be able to halt its progress. In November 2018, a Chinese scientist had claimed to have created the world's first genome-edited babies. He used the CRISPR/Cas9 technology to modify the DNA of twin girls, making them resistant to HIV infection. Many scientists and organizations criticized the experiment for its potential impacts and violation of ethical guidelines. However, different nations have different moral codes. If some countries use genome editing to produce geniuses that far outperform other citizens whose country forbids genetic engineering, can we still keep hitting the brakes?
- (10) According to paragraph 10, the difference between caste groups come from
- A. their genetic features.
  - B. their innate abilities.
  - C. invented stories.
  - D. divine judgements.
- (11) The word “unprecedented” in the passage is closest in meaning to
- A. excessive
  - B. unparalleled
  - C. impressive
  - D. robust
- (12) According to paragraph 12, what is NOT mentioned as concerns with genome editing technologies?
- A. A competitive spiral that will accelerate the practical use of the technology.
  - B. The difference in ethical norms between nations.
  - C. Letting patients suffer from diseases that could have been cured with the technology.
  - D. The potential consequences of the technology.

Answers

- (1) B
- (2) B
- (3) C
- (4) A
- (5) D
- (6) D
- (7) C
- (8) A
- (9) B
- (10) C
- (11) B
- (12) C

(1) 一段落の内容と合致するのは？

A. Until recently, only divine entities have had the ability to design and create organisms. (最近まで、神聖な存在のみが生物を設計し創造する能力を持っていた)

**B. Gene editing technologies are potentially capable of curing hereditary diseases. (遺伝子編集技術は遺伝疾患を治癒する可能性を秘めている)**

C. All of life was designed by the Creator based on the principle of natural selection 3.8 billion years ago. (あらゆる生命は38億年前に自然淘汰の摂理に基づいて創造主によって設計された)

D. Ancient people have created a fiction about the origin of life, hoping to modify the blueprint of creatures. (古代の人々は生き物の設計図を編集することを望んで生命の起源に関するフィクションを作った)

本文中の”genetic ailments”を”hereditary diseases”と言い換えている。

(2) 2段落によると、CRISPR/Cas9とは

A. a system for randomly cutting DNA. (DNAを無作為に切るシステム)

**B. a defense system of microbes to fight invaders. (微生物が侵入者と戦うための防御システム)**

C. a technology for precisely targeting and editing specific cells. (特定の細胞を正確に狙い撃ちして編集する技術)

D. a method to kill off bacterial species. (微生物種を死滅させる方法)

(3) 3段落の内容と合致しないのは？

A. Cas9 cuts off the DNA at the place instructed by the seeker. (Cas9はシーカーから指示された場所でDNAを切断する)

B. The seeker is an RNA that corresponds with the DNA of its potential enemy. (シーカーは、潜在的な敵のDNAに対応するRNAだ)

**C. Cas9 is carrying a piece of information that matches its target. (Cas9は、そのターゲットに一致する情報を保持している)**

D. The function of CRISPR/Cas9 can be divided into two parts. (CRISPR/Cas9の機能は2つの部分に分けることができる)

Cの、ターゲットに一致する情報を保持しているのはCas9 (cutter) ではなくRNA (seeker) である。

(4) 4段落によると、遺伝子を編集するために必要な操作の組み合わせはどれか？

**A. Swapping the seeker and pouring external DNA into the cell. (シーカーを交換し、外部 DNA をセルに注入する)**

B. Deactivating the seeker and removing the snipped DNA sequence from the cell. (シーカーを非活性化し、切り取られた DNA 配列を細胞から除去する)

C. Swapping the seeker and removing the snipped DNA sequence from the cell. (シーカーを交換し、切り取られた DNA 配列を細胞から除去する)

D. Deactivating the seeker and pouring external DNA into the cell. (シーカーを非活性化し、外部 DNA を細胞に注入する)

”change the target DNA sequence by replacing the seeker”を”swapping the seeker”と、”if a cell is flooded with foreign DNA...”を”pouring external DNA into the cell”と言い換えているAが正解。

(5) 文中の “appearance” と意味が最も近いのは

A. aspect (様相)

B. impression (印象)

C. illusion (幻想)

**D. advent (登場)**

どれもappearanceの意味になり得るが、「ゲノム編集技術の登場によって」という文脈中での意味と近いのはD。

(6) 6段落の内容に合致しないのは？

A. Genome editing can be used for crop improvement. (ゲノム編集は作物の改良に利用できる)

B. Genome editing can reduce allergens in food. (ゲノム編集により、食品中のアレルゲンを減らすことができる)

C. Chickens have been edited to lay eggs with less allergen. (鶏は、アレルゲンの少ない卵を産むように編集されている)

**D. Potatoes have been edited to be unlikely to rot. (ジャガイモは腐りにくいように編集されている)**  
腐りにくいように編集されるのはトマトなのでDが誤り。

(7) ハイライトされた箇所のエッセンスを最もよく表しているのは？

***We are not there yet,***

A. We have the ability to cure thousands of diseases. (数千の疾病を治癒できる可能性がある)

B. We have already solved all technical challenges. (技術上のあらゆる課題はすでに解決された)

**C. We are not currently capable, but we are making progress. (今はまだ可能ではないが、進展している)**

D. We will never be able to eliminate diseases. (疾病を根絶することは決してできないだろう)

(8) 8段落で整形外科の歴史が示唆しているのは？

**A. It is difficult to distinguish necessary healings and enhancements. (必要な治癒と能力の強化を区別するのは困難だ)**

B. Medical innovations can be immensely profitable. (医療イノベーションは莫大な利益をもたらす可能性がある)

C. Plastic and cosmetic surgery should be prohibited. (形成外科および美容整形は禁止されるべきである)

D. Wars often encourage innovations. (戦争はしばしばイノベーションを促進する)

(9) 9段落で子供の記憶力、運動能力、免疫システムを強化する可能性について言及している理由は？

A. To persuade readers of the potential benefit of genome editing. (ゲノム編集の潜在的な利点を読者に説得するため)

**B. To illustrate how genome editing may expand beyond its initial purpose.** (ゲノム編集が当初の目的を超えてどのように拡大する可能性があるかを説明するため)

C. To warn readers not to use the technology for upgrading humans. (人間をアップグレードするためにテクノロジーを使用しないよう読者に警告するため)

D. To highlight the potential applications of genome editing. (ゲノム編集の潜在的な応用可能性について強調するため)

命に関わる疾患の治療に始まり、致命的でない疾患の治療、さらには健康な個体のアップデートまでどのように展開する可能性があるのかを説明する流れの中で例示されているのでBが正解。

(10) 10段落によると、カーストグループ間の違いは何によって起因するか？

A. their genetic features. (遺伝的特徴)

B. their innate abilities. (生まれながらの能力)

**C. invented stories.** (でっちあげられたストーリー)

D. solemn judgements. (神による決め事)

(11) 文中の“unprecedented”と意味が最も近いのは

A. excessive (過度な)

**B. unparalleled** (並ぶものがない、前代未聞の)

C. impressive (印象的な)

D. robust (頑強な、壮健な)

unprecedented (未曾有の、前例のない) という意味なのでBがもっとも近い。

(12) 12段落によれば、ゲノム編集技術に関する懸念として言及されていないものは？

A. A competitive spiral that will accelerate the practical use of the technology. (技術の実用化を加速する競争のスパイラル)

B. The difference in ethical norms between nations. (国家間の倫理規範の違い)

**C. Letting patients suffer from diseases that could have been cured with the technology.** (その技術によって治せたかもしれない病気で患者を苦しめること)

D. The potential consequences of the technology. (技術のもたらす潜在的な帰結)