壹、閱讀（70%）

(1) Ancient DNA (35 points)

More than 1,600 ancient genomes have helped to trace the roots of a host of genetic __i__ found in modern Europeans. The genomes suggest that many __ii__ — including a heightened risk for multiple sclerosis — were carried to Europe by people who migrated to the continent in three distinct waves starting around 45,000 years ago. Evidence suggested that some of the regional variation in certain traits was caused by differences in migrants' dispersal patterns. That contradicts the idea that genetic differences arose mainly as people __iii__ to conditions in specific locations in Europe. A recently published study provides unprecedented detail on how ancient ancestry can influence disease risk to this day.

Europe was settled by __iv__ modern humans in three main waves: hunter-gatherers reached Europe from Asia around 45,000 years ago; farmers arrived from the Middle East 11,000 years ago; and pastoralists — animal herders — came from the steppes of western Asia and eastern Europe 5,000 years ago. Historians and __v__ had assumed that these groups mixed with one another throughout the continent, and that populations in particular places __vi__ distinct traits in response to their local environments. But when geneticists began investigating the ancient-human genomes, they found that that wasn't the full story. The researchers collected and sequenced DNA from 317 ancient skeletons found in Europe, most of which were between 3,000 and 11,000 years old. They then combined these sequences with existing genomic data from more than 1,300 other ancient Eurasians. By comparing the remains' genetic markers, ages and burial locations, the scientists were able to draw a European __vii__ tree and migration map that revealed how genomic characteristics in a specific location changed as populations moved over time. It showed, for instance, that the steppe pastoralists mainly went to the more northern parts of Europe, whereas the Middle Eastern farmers went to the south and west. The dispersal patterns mean that many modern Europeans carry some genetic ancestry from all three population waves, but the relative amount of each varies depending on the location.

Next, the researchers compared the ancient genomes with those of 410,000 modern individuals. The data provided clear evidence that many traits __viii__ back directly to one of the three migration waves. For instance, modern northern Europeans are taller and lighter skinned than their southern counterparts because they have more ancestry from the steppe pastoralists. And those with the most hunter-gatherer ancestry, commonly found in northeastern Europe, have __ix__ that put them at higher risk of diabetes and Alzheimer's disease. One of the traits that seems to have had a strong evolutionary advantage is one associated with a predisposition to multiple sclerosis. This trait arrived in Europe with the west-Asian pastoralists and became even more common in northern Europe over the subsequent millennia. Today, multiple sclerosis is a devastating disease caused by an __x__ immune system attacking the nervous system. But that superpowered immune system, or genetic variants associated with it, could have helped ancient people to survive plagues and common pathogens.

1. Please fill each blank (i-x) in the above article (Ancient DNA) with the most appropriate word listed below (*a* to *o*) (2 points for each blank; 20 points in total)

a. ancestry	*b.* archaeologists	*c.* evolutionary	*d.* variants	*e.* adapted
f. evolved	*g.* skeletons	*h.* traits	*i.* overactive	*j.* family
k. sequenced	*l.* characteristics	*m.* trace	*n.* migration	*o.* anatomically

2. According to the article, which of the following countries' citizens are most likely at high risk of developing diabetes? (2 points)
   (A) Spain (B) Italy (C) Greece (D) Sweden (E) Germany

3. About how many years ago did the most ancient modern human reach Europe? (2 points)
   (A) 100,000 (B) 45,000 (C) 11,000 (D) 5,000 (E) 2,000

4. Which system is damaged in patients suffering from multiple sclerosis? (2 points)
   (A) immune (B) circulatory (C) nervous (D) muscular (E) digestive

見背面

5. Which of the following statements is true regarding the research strategies scientists used in the study? (2 points)
   (A) Most ancient human DNAs sequenced for this study are no more than 11,000 years old.
   (B) More than 1,500 ancient human DNAs were collected and sequenced by scientists for this study.
   (C) Only ancient human genomes were analyzed in this study.
   (D) Ancient human DNAs were extracted from the hair of the samples.
   (E) The scientists only compared the human genome data sequenced for this study.

6. Which of the following statements is not true about modern Europeans? (2 points)
   (A) Three main waves of ancient humans moved from Asia to Europe.
   (B) The earliest ancient modern humans who arrived in Europe were hunters.
   (C) Farmers who grew plants settled in Europe earlier than those who bred and cared for animals.
   (D) Northern Europeans are taller than Southern Europeans due to their different ancestors.
   (E) The trait associated to multiple sclerosis did not bring any benefits to ancient humans settled to northern Europe.

7. Based on the article, please discuss how the distribution pattern of multiple sclerosis has developed in Europeans. (5 points)

(2) Monkey cloning (35 points)

For the first time, a rhesus monkey (*Macaca mulatta*) cloned in the laboratory has lived into adulthood — surviving for almost three years so far. This work, published in 2024, marked the first successful cloning of the species. It was __i__ using a slightly different approach to the conventional cloning technique used to clone Dolly the sheep and other mammals, including long-tailed macaques (*Macaca fascicularis*), which were the first __ii__ to be cloned. By replacing the placenta of the cloned embryo with a placenta from embryos produced by *in vitro* fertilization, scientists could reduce developmental defects that often hinder the survival of cloned embryos. The new technique could unlock possibilities for using cloned primates in drug testing and behavioral research by producing many __iii__ uniform monkeys.

The standard cloning technique known as somatic cell nuclear transfer (SCNT) — where the nucleus of a body cell is transferred into an egg cell whose nucleus has been removed — typically results in extremely low birth and survival rates for cloned embryos. Success in primates has been particularly limited. When researchers cloned long-tailed macaques in 2018, they created 109 cloned embryos and __iv__ nearly three-quarters of them into 21 __v__ monkeys, which resulted in six pregnancies. Just two of the monkeys survived birth. In 2022, researchers cloned a rhesus monkey using SCNT, but the animal survived for less than 12 hours.

Researchers compared 484 SCNT rhesus embryos with 499 embryos produced by __vi__ *in vitro* fertilization to investigate what goes wrong in the cloning process. The two types of embryos showed similar development before they were implanted into surrogates. However, the number of cloned embryos that were successfully implanted was around half that of IVF embryos (35 vs. 74), and fewer cloned embryos survived to term. The researchers ran a series of DNA analyses of SCNT embryos. They found significant differences in __vii__ modification during development — structural changes that impact gene activity without altering the DNA sequence. This included reduced DNA methylation, a process that affects gene expression. The researchers also found that genes that are normally expressed differently between maternal and paternal genomes lost their distinct __viii__ in cloned embryos, especially in cells within the placenta. Furthermore, the placentas developed for SCNT embryos appeared thicker than normal and contained defects.

To address this, the researchers developed a __ix__ that involved replacing the SCNT trophoblast — the outer layer of cells in a developing embryo, which later forms the major part of the placenta — with trophoblasts from IVF embryos. Using this approach, the researchers created 113 cloned rhesus monkey embryos and implanted 11 into seven surrogates, resulting in two

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pregnancies. One of the pregnant surrogates gave birth to a healthy male rhesus monkey, which has survived for over two years. The researchers showed that incorporating the trophoblast __x__ into SCNT clones reduced defects in the placenta and DNA methylation. The efficiency of the process, however, is still low. These experiments are extremely difficult to succeed.

8. Please fill each blank (i-x) in the above article (Monkey cloning) with the most appropriate word listed below (*a* to *o*) (2 points for each blank; 20 points in total)

a. nucleus	*b.* primates	*c.* conventional	*d.* trophoblast	*e.* technique
f. patterns	*g.* implanted	*h.* expression	*i.* embryos	*j.* genetically
k. achieved	*l.* epigenetic	*m.* placenta	*n.* surrogate	*o.* replacement

9. What kind of animal is the first cloned vertebrate? (2 points)
(A) a rhesus monkey (B) a sheep (C) a long-tailed macaque (D) a dog (E) a goat

10. When was the first cloned monkey born, which survived into adulthood? (2 points)
(A) 1996 (B) 2000 (C) 2021 (D) 2022 (E) 2024

11. During the "somatic cell nuclear transfer (SCNT)" process, what is transferred into an enucleated egg? (2 points)
(A) a haploid sperm nucleus (B) a haploid egg nucleus (C) a diploid trophoblast nucleus
(D) a diploid zygote nucleus (E) a diploid somatic nucleus

12. Which of the following structures is the placenta derived from? (two correct choices) (2 points)
(A) trophoblast (B) inner cell mass (C) york sac (D) amnion (E) endometrium

13. What potential defects lead to a lower survival rate of cloned embryos than *in vitro* fertilization embryos? (three correct choices) (2 points)
(A) DNA sequence change in SCNT embryos (B) altered DNA methylation pattern in SCNT embryos
(C) development defect in early SCNT embryos (D) thicker trophoblast in SCNT embryos
(E) loss of asymmetric expression from paternal and maternal genomes in SCNT embryos

14. According to the article, what special process was adopted by the researchers leading to the success of cloning the first healthy monkey that survived to adulthood? (5 points)

貳、翻譯（10%）

15. Translate the following article into Chinese. (10 points)

Rice paddies (稻田) play a dual role, protecting global food security and being a crucial source of methane (CH_4) emissions. Flooded rice paddy fields emit CH_4 to around 12% of global anthropogenic (人為的) CH_4 emissions. Why does rice paddy emit such tremendous CH_4 emissions? A simple answer is a group of microorganisms called "methanogens." In the anaerobic conditions of flooded rice paddies, methanogens thrive around rice roots, producing CH_4 by utilizing root exudates (滲出物) as a food source, including organic acids and carbon compounds transported through rice stem channels. A higher-yield rice cultivar (品種) generally secretes higher amounts of root exudates, resulting in higher CH_4 emissions in the field. It resembles chasing two rabbits that run in different directions in the yard.

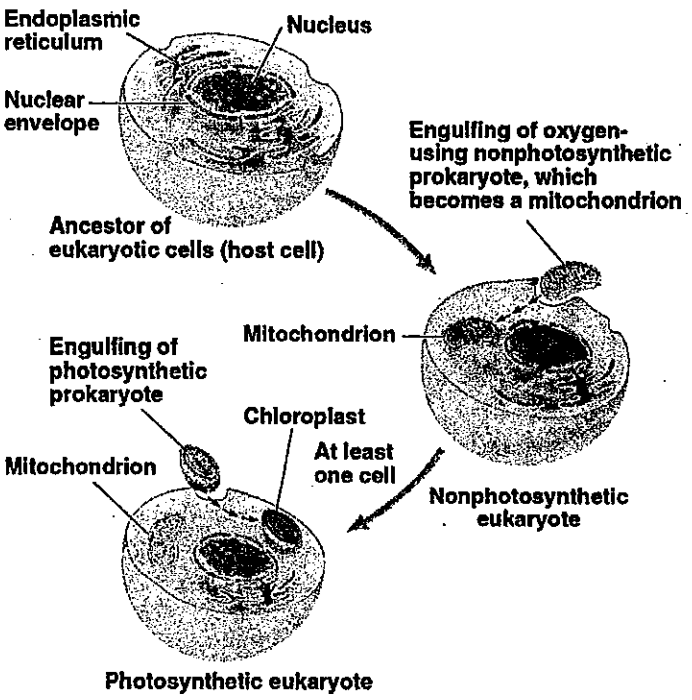
To overcome such a fundamental problem, scientists focused on allocating (分配) photosynthesis production from carbon fixation. They hypothesized that a rice trait could allocate the sink and source tissues such as photosynthates into rice grain and secretion of root exudates. They developed 'Milany360' by introgressing (基因滲入) the loss of function *GS3* allele in natural

見背面

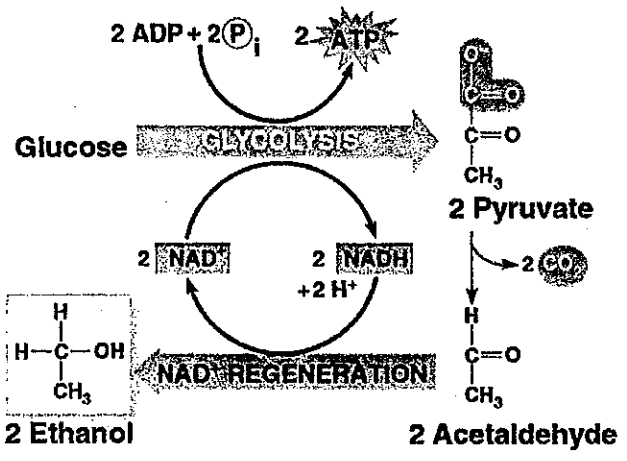
variation using a conventional breeding program. The *GS3* gene exerts its influence on organ size through its Organ Size Regulation (OSR) domain, acting as a negative regulator. Through natural genetic variation, a loss of function in the *GS3* allele showed a notable 16% reduction in CH_4 emissions, coupled with a 6% increase in crop yield. This outcome of *gs3* mutants highlights the potential for a dual benefit, akin to catching "two rabbits at once."

參、英文科學短文（20%）

16. Based on the figure, please write a short essay explaining the endosymbiont theory of the origins of mitochondria and chloroplasts in eukaryotic cells. Your writing should include all the terms and labels provided. (10%)



17. Based on the figure, please write a short essay explaining the alcohol fermentation process. Your writing should include all the terms and labels provided. (10%)



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