Milk Without a Cow: The Science of Precision Fermentation

Name Date Class

Reading

1 Imagine a glass of milk that never came from a cow. Using a process called **precision fermentation**, researchers can now grow the exact proteins found in dairy milk inside steel tanks, with no animal involved at all. Genetically engineered yeast or bacteria are grown in **bioreactors**, fed a sugar-based **feedstock**, and over several days convert it into a target protein. The idea sounds futuristic, but the technology is not new. It has been used in food production since the 1990s to make an enzyme that curdles milk for cheese. What has changed is the ambition: companies are no longer producing one small ingredient. They are trying to replace a share of the dairy industry itself.

2 Precision fermentation differs from the oat, soy, and almond milks already on supermarket shelves. Those are plant-based substitutes, recognizable as milk but chemically distinct from it. Proteins made this way are described as **bioidentical** to their animal-derived counterparts, meaning they are, at the molecular level, the same substance a cow would have produced. Most commercial efforts have focused on beta-lactoglobulin, the main whey protein in cow's milk, which the American company Perfect Day already produces at industrial scale. Similar ventures have appeared elsewhere: Remilk's fermented-protein milk reached cafes and shops in Israel in late 2025, while Eden Brew in Australia is still waiting on regulatory approval for its own version of this **novel** protein.

3 A study published in February 2026 in Frontiers in Sustainable Food Systems, by researchers at Imperial College London, focuses on land rather than the greenhouse gas emissions most earlier assessments examined. The team calculated milk's **land footprint**, the area needed to produce one metric ton, for both conventional and fermented milk in the United Kingdom. Because fermentation itself needs no farmland, only the crops behind it do, the researchers **allocated** a share of cropland to each nutritional component, protein, fat, and carbohydrate, based on the crop realistically supplying it: sugar beet for the carbohydrate and feedstock, oilseed rape for the fat. Fermented milk's land footprint came out 94 to 96 percent lower than that of milk from a cow.

4 Applied nationally, that gap becomes substantial. The researchers modeled three scenarios drawn from the UK Climate Change Committee's own targets: replacing 20, 50, or all of the country's cow's milk with the fermented version by 2050. Even the smallest scenario was projected to free roughly 859,000 hectares once used for grazing and feed crops, and full replacement was projected to free about 4.29 million hectares, an area **comparable** to mainland Denmark. Some of that land, the authors note, could go toward the country's own climate commitments, including **afforestation** and the restoration of drained **peatland**, both of which need exactly the kind of land dairy farming currently occupies. Under the more ambitious of the two official scenarios, released land could cover nearly 80 percent of what the government's 2050 land use targets call for.

5 The analysis is explicitly UK-specific, and its authors caution that the numbers cannot simply be applied elsewhere. Even so, the global picture gives the finding weight. The United Kingdom produces only about 1.6 percent of the world's milk, while demand elsewhere is rising fast: per-person milk consumption has climbed by more than a thousand percent in India and by well over two thousand percent in China since 1961. If similar land savings held in faster-growing markets, precision fermentation could help **mitigate** some of the pressure that expanding dairy production puts on land worldwide, though a country-by-country analysis would be needed to know by how much.

6 Several caveats temper the headline figure. The study measured land alone, not water use, emissions, or the nutritional gap between fermented and cow's milk, including a large difference in saturated fat: roughly 8 percent of total fat in the study's assumed rapeseed oil, against 64 percent in whole cow's milk. The footprint excludes the bioreactors themselves, and it assumes the leftover microbial biomass is simply discarded, since its genetically modified nature complicates any **valorization** as animal feed. The estimate, in that sense, sits closer to a floor than a ceiling. A separate American analysis of one commercial fermented milk found a far smaller footprint, a **discrepancy** the authors attribute mainly to differences between US and UK dairy farming, compounded by a general **scarcity** of independent data on fermentation at commercial scale.

7 Whether any of this land is actually released depends on questions the study does not model: consumer acceptance, regulatory approval, and the **viability** of scaling fermentation tanks to a size that could realistically stand in for a national herd of nearly two million dairy cows. The researchers call for further work on all three. Until then, the 4.29 million hectares remains what it has always been: a calculation of what could be freed, not a plan for freeing it.

Vocabulary Matching

Match each word from the reading with its meaning. Write the letter on the line.

1	**precision fermentation**	_____	**A**	vessels used to grow microorganisms under controlled conditions
2	**bioreactors**	_____	**B**	a difference between figures expected to match
3	**feedstock**	_____	**C**	a shortage of something needed
4	**bioidentical**	_____	**D**	boggy land made of decayed plant matter
5	**novel**	_____	**E**	the planting of new forest on open land
6	**land footprint**	_____	**F**	the ability to work successfully in practice
7	**allocated**	_____	**G**	new and not existing before
8	**afforestation**	_____	**H**	raw material fed into an industrial process
9	**peatland**	_____	**I**	assigned for a particular purpose
10	**comparable**	_____	**J**	to make a problem less severe
11	**mitigate**	_____	**K**	finding a useful purpose for a leftover byproduct
12	**valorization**	_____	**L**	chemically identical to the natural version
13	**discrepancy**	_____	**M**	the area of land a product requires to be made
14	**scarcity**	_____	**N**	a process using engineered microbes to brew a specific protein
15	**viability**	_____	**O**	similar enough to be usefully compared

Fill in the Blank

Choose a word from the box to complete each sentence. Use each word once. The words are already in the correct form.

afforestation	**allocated**	**bioidentical**	**bioreactors**	**comparable**	**discrepancy**	**feedstock**	**land footprint**
mitigate	**novel**	**peatland**	**scarcity**	**valorization**	**viability**		

1 The engineered microbes were grown inside industrial _____ .

2 Sugar beet supplied the _____ that the microbes converted into protein.

3 The lab-grown protein is _____ to the protein found in cow's milk.

4 Regulators had to classify this _____ protein before it could be sold.

5 Researchers compared the _____ of fermented milk with that of cow's milk.

6 The researchers _____ a share of cropland to each nutrient in the milk.

7 Freed farmland could be used for _____ , planting trees where none grew before.

8 Restoring drained _____ can help a country meet its climate targets.

9 The freed land was _____ in size to a small European country.

10 Fermented protein could help _____ some of the land pressure from rising demand.

11 There was a large _____ between the UK and US land footprint estimates.

12 A _____ of independent data forced the researchers to rely on industry estimates.

13 Finding a use for the leftover biomass would require successful _____ of the waste.

14 Scaling up fermentation tanks will test the _____ of replacing dairy herds nationally.

Comprehension Questions

Answer in your notebook or discuss with a partner. Questions 10 to 12 are IELTS-style.

1 According to the reading, what happens inside a bioreactor during precision fermentation?

2 How does precision-fermented protein differ from plant-based milk substitutes such as oat or soy milk?

3 What method did the researchers use to calculate milk's land footprint, and which two crops supply its fat and carbohydrate?

4 By how much was fermented milk's land footprint found to be lower than cow's milk, and what could the freed UK land be used for?

5 Why does the reading say the study's findings cannot simply be applied outside the United Kingdom?

6 What does the reading say about milk consumption trends in India and China, and why does this matter for the study's conclusions?

7 List three things the study's land footprint calculation does not include.

8 Explain in your own words why the reading calls the estimate "closer to a floor than a ceiling."

9 The reading moves from mechanism, to a UK study, to global implications, to limitations. Why might the writer have chosen this order?

IELTS-Style Questions

10 **True, False, or Not Given:** *"The Imperial College London study proves that precision fermentation produces less greenhouse gas than dairy farming."* Explain your answer using evidence from the reading.

11 **Yes, No, or Not Given:** *"The writer believes precision-fermented milk will replace cow's milk everywhere within the next few years."* Explain your answer using evidence from the reading.

12 **Author's purpose:** Why does the writer end with the sentence "a calculation of what could be freed, not a plan for freeing it"? Is its purpose to dismiss the study's findings, to keep the finding in proportion, or something else?

True or False

Circle T (true) or F (false) according to the reading. Write a correction for each false statement on the dotted line.

1 **T / F** The reading says fermentation technology has been used in food production since the 1990s.

2 **T / F** The reading says companies are trying to produce only one small specialized ingredient.

3 **T / F** Fermented protein is described as bioidentical to the protein in cow's milk.

4 **T / F** The reading says Perfect Day is based in Australia.

5 **T / F** The study focused on land rather than on greenhouse gas emissions.

6 **T / F** The reading says the researchers assumed maize would supply the fat in fermented milk.

7 **T / F** Full replacement of UK cow's milk was projected to free about 4.29 million hectares.

8 **T / F** The reading says the freed land could not be used for any of the UK's climate targets.

9 **T / F** Per-person milk consumption has fallen in India and China since 1961.

10 **T / F** The researchers say further work on consumer acceptance and regulation is still needed.

Discussion Questions

Talk with a partner or in a small group. The questions move from personal to more abstract.

1 Would you try milk made without a cow if it tasted and behaved exactly like dairy milk? Why or why not?

2 Does it matter to you whether a food is "natural," even if a lab-made version is chemically identical? Explain your view.

3 The reading says fermented protein is bioidentical to the protein in cow's milk. Does knowing something is chemically identical change how you feel about eating it?

4 In your country, how would traditional dairy farmers likely react to fermented milk entering the market? What might they gain or lose?

5 The study looked only at land use. Why might a government or a company choose to highlight one environmental measure, such as land, over others, such as emissions or water?

6 If precision-fermented milk became cheaper than dairy milk, should governments still support traditional dairy farmers? Why or why not?

7 The reading names companies in the United States, Israel, and Australia. Why might a global technology like this develop first in a small number of countries?

8 Rising milk consumption in China and India is mentioned in the reading. What social or economic changes usually cause a country's dairy consumption to rise?

9 Would you eat cheese, yogurt, or ice cream made from a fermented protein even if you would not drink the milk itself? Does the product matter more than the process?

10 The reading says the researchers do not know what will happen to the leftover microbial biomass. Should companies be required to solve a byproduct problem before scaling up a new food technology?

11 Freeing farmland for forests or restored peatland sounds appealing on paper. What practical obstacles might slow this down in real life?

12 If a technology could genuinely free up millions of hectares of farmland, who should decide what that land is used for: government, private landowners, or someone else?

13 The reading ends by saying the study describes what "could" happen, not a plan. How do you usually react when you read impressive projections in the news?

14 Do you think most people would accept an entirely new way of producing a familiar food like milk within your lifetime? What would it take to convince them?

Language Focus: Comparative Language for Scale and Proportion

Comparative language expresses how big a change or difference is, using percentages, multiples, and approximate comparisons, instead of just stating a fact without any sense of scale.

In the reading:

- "Fermented milk's land footprint came out **94 to 96 percent lower** than that of milk from a cow."
- "…full replacement was projected to free about 4.29 million hectares, an area **comparable to** mainland Denmark."
- "…released land could cover **nearly 80 percent** of what the government's 2050 land use targets call for."

Practice: Rewrite this sentence using comparative language for scale: *"The new factory uses much less water than the old one."* Invent a specific percentage or multiple.

Activities and speed challenge
englishbridges.com/lessons/milk-without-a-cow

Notes