

# What's the Beef? Cultivated Meat.

Cultivated meat is a billion-dollar industry in a growing scientific ecosystem receiving unprecedented governmental support. The invention was a futuristic dream of academic scientists only a few years ago. Today, cultivated meat has the potential to end global hunger through sustainable methods by replacing conventional meat production.

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References

## Introduction

Meat is a source of nutrition for billions around the world. While concentrated with complete proteins—a necessary macronutrient for tissue growth and recovery—meat is also rich in essential nutrients, such as iron, zinc, and B vitamins (Streit et. al, 2023). Although meat is highly nutritious and beneficial in combatting world hunger, the production of meat has numerous negative environmental impacts, including greenhouse gas emissions, agricultural land exploitation, and extreme freshwater use (Tuomisto & Teixeira de Mattos, 2011). This situation makes feeding the world's hunger for meat sustainably one of the world's most pressing challenges. Cultivated meat (CM) is real animal meat produced by cultivating animal cells directly (Swartz and Bomkamp, 2023). CM is the cumulation of decades of research in cell culture, stem cell biology, fermentation, and other biochemical processes. As a novel technology, CM is proposed to solve the problems associated with conventional meat.

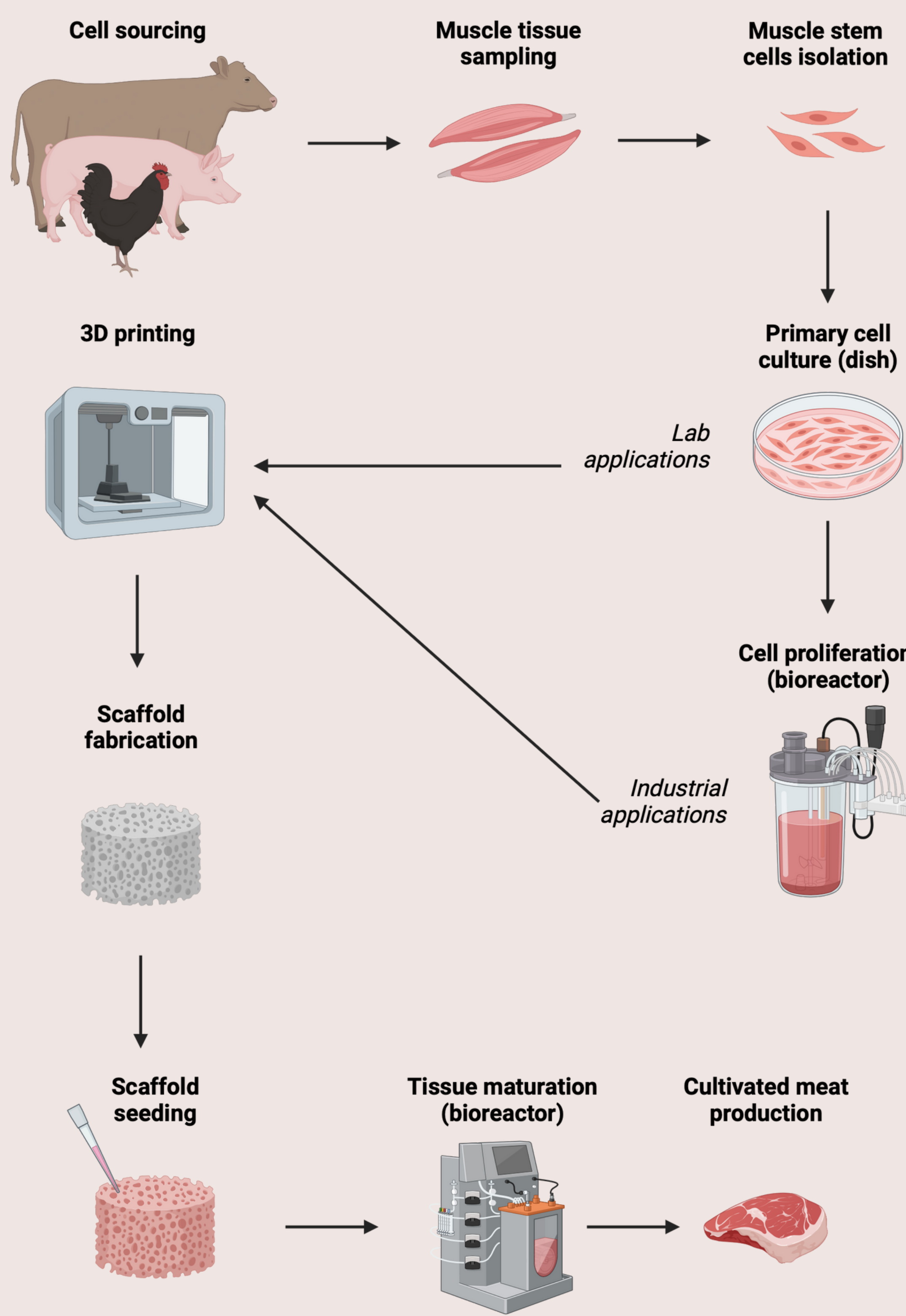


Figure 1: Diagram of the cultivated meat production process (Created with BioRender.com)

## Details, Data, and Analysis

- Humans consume ~ 350 Mt of meat annually; demand for meat expected to reach 460 M by 2050 (Adams, 2022)
- Global meat industry market value expected to rise over \$1.3 T by 2027 from \$897.5 B in 2021 ("Meat," 2023)
- Meat production releases greenhouse gases including carbon dioxide, methane, and nitrous oxide
- CM can reduce harmful impacts of meat production by requiring less land, animal slaughter, and arduous labor
- Concerns arise as cumulative energy demand for CM > conventional meat processes
  - Driven by energy sources within the facility (fossil fuels or renewables) and chemical production of medium ingredients (biopharmaceutical or food-grade) (Love, 2023)
  - Energy from heating and cooling varies due to reactor design, cell densities, oxygen uptake rates (OUR), and glucose consumption (Li et al., 2020)
  - Lack of data for heating and cooling efficiency on commercial scales
- Online survey of 673 participants found 2/3 would try CM, and 1/3 would eat it regularly (Wilks and Phillips, 2017)
- Governmental bodies are most concerned about the safety and risk of food fraud
- For every 500,000 mt of cultivated protein, 5,000 to 5,500 factory jobs are demanded (Brennan et al., 2021)
- Possible job losses in conventional meat production as technical skills vary
- CM companies can shift to new geographies closer to urban centers and employ specialized labor for R&D

Figure 2: Predicted global sales of different forms of meat worldwide in billion U.S. dollars from 2025 to 2040. Adapted from Vultaggio, 2023)

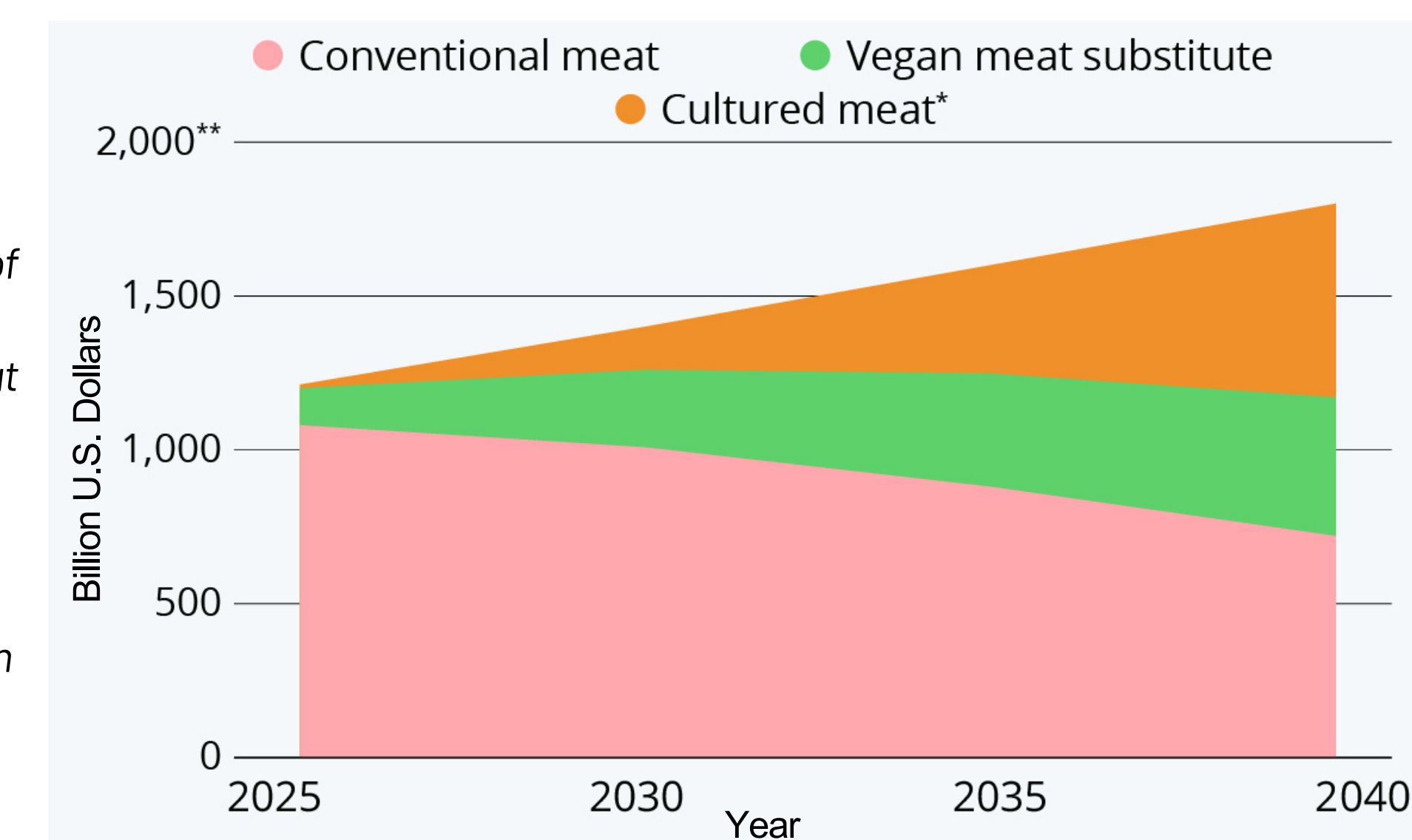
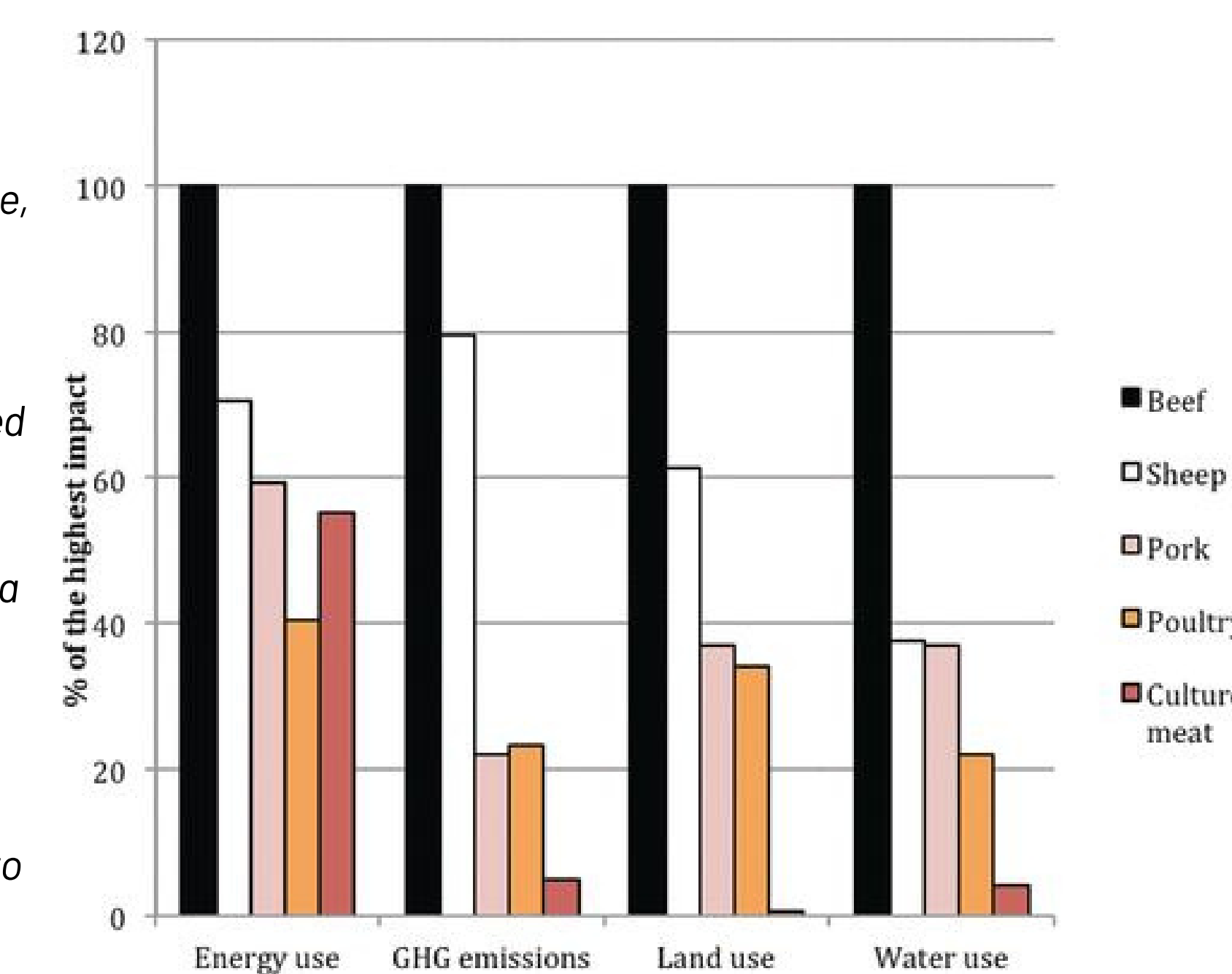


Figure 3: Comparing primary energy input, GHG emissions, land use, and water use of cultured meat production with conventionally produced European beef, sheep, pork, and poultry per 1000 kg edible meat as a percent of the impacts of the product with the highest impact in each impact category (Adapted from Tuomisto et al., 2011)



Category	No. of words	Percentage	Example words
Artificial	73	15.2	Fake, unnatural, artificial
Science	54	11.3	Scientific, laboratory, chemicals
Positive	50	10.4	Good, awesome, super
Natural	40	8.3	Natural, no hormones, unprocessed
Unusual	35	7.3	Weird, strange, different
Food	27	5.6	Beef, calories, steak
Healthy	26	5.4	Fat-free, healthy, good for health
Clean	25	5.2	Sterilized, washed, soap
Disgust	24	5.0	Disgusting, yuck, gross
Other	18	3.8	Options, jars, grown
Taste	16	3.3	Tasty, bland, delicious
Food technology	14	2.9	GMOs, cultured meat, laboratory meat
Interesting	12	2.5	Interesting, intriguing
Animals	10	2.1	Chicken, fish, pig
Ethical	10	2.1	Ethical, cruelty-free, humane
Fear	10	2.1	Unsafe, danger, creepy
Negative	9	1.9	Abomination, dystopia, never
Safety	7	1.5	Safe, safety, passes regulation
Uncertainty	7	1.5	Confusing, why, unobtainable
Environment	5	1.0	Sustainable, biofriendly, green
Special diet	5	1.0	Vegetarian, Halal, Kosher
Cost	3	0.6	Expensive, pricey, cost
Total	480	100	

Figure 4: Word associations given by participants after learning about CM (Adapted from Bryant and Dillard, 2019)

## Discussion and Conclusion

- CM production has a smaller carbon footprint and occupies less land space
- Data demonstrates that cell culture capacity and energy consumption pose major challenges
- Scaling the industry requires access to large and consistent quantities of sugar and media components
- Further investment, ingenuity, and commitment are necessary to move cultivated meat from the laboratory onto billions of people's plates

## Learning from the case study

### Learning objectives:

1. Describe advantages/disadvantages of CM
2. Outline next steps for the industry
3. Research and compare costs associated with CM and conventional meat

### Pre-class activity:

- Reading research
- Completing assignment

### In-class activity:

- UPSIDE Foods proposes expansion to stakeholders

### Engaging activities:

- Visiting a CM production facility
- Guest lecture from Upside Foods and Just Meat
- Trying CM

Stakeholders	
Biotechnology industry, food and agriculture industry, investors	<ul style="list-style-type: none"> <li>• Develop AI and machine-learning tools for manufacturers</li> <li>• Market is expected to attract agricultural and food companies to collaborate and differentiate</li> </ul>
Environmental and animal welfare advocates	<ul style="list-style-type: none"> <li>• CM resolves concerns associated with meat production for those who find switching to vegetarian or vegan diets difficult</li> </ul>
Consumers, restaurants, and food retailers	<ul style="list-style-type: none"> <li>• Most people would try CM, and depending on the taste characteristics, affordability, and accessibility of the laboratory alternative, some will add it to their diet</li> </ul>