Cellular Agriculture Italy

Carne coltivata: stato dell'arte e potenziali pericoli

Nike Schiavo

Presidente di Agricoltura Cellulare Italia APS

Biotecnologa presso Bruno Cell

Collaboratrice dell'Universitá di Trento

3 settembre 2024 - VET MARE 2024 (Policastro)

Programma

Presentazioni

Premessa:
l’uomo mangia

Scienza e
tecnologia

Sostenibilità
ambientale

Investimenti

Pericoli

www.cellag.it

Agricoltura Cellulare Italia

Home | Agricoltura Cellulare | Chi siamo | Risorse | Attività | Eventi

Agricoltura Cellulare Italia è un'associazione **senza fini di lucro**, nata per accelerare il progresso nel settore dell'agricoltura cellulare, promuovendo dialogo ed interazione fra soggetti interessati a livello italiano e internazionale.

Agricoltura Cellulare Italia

Divulgazione

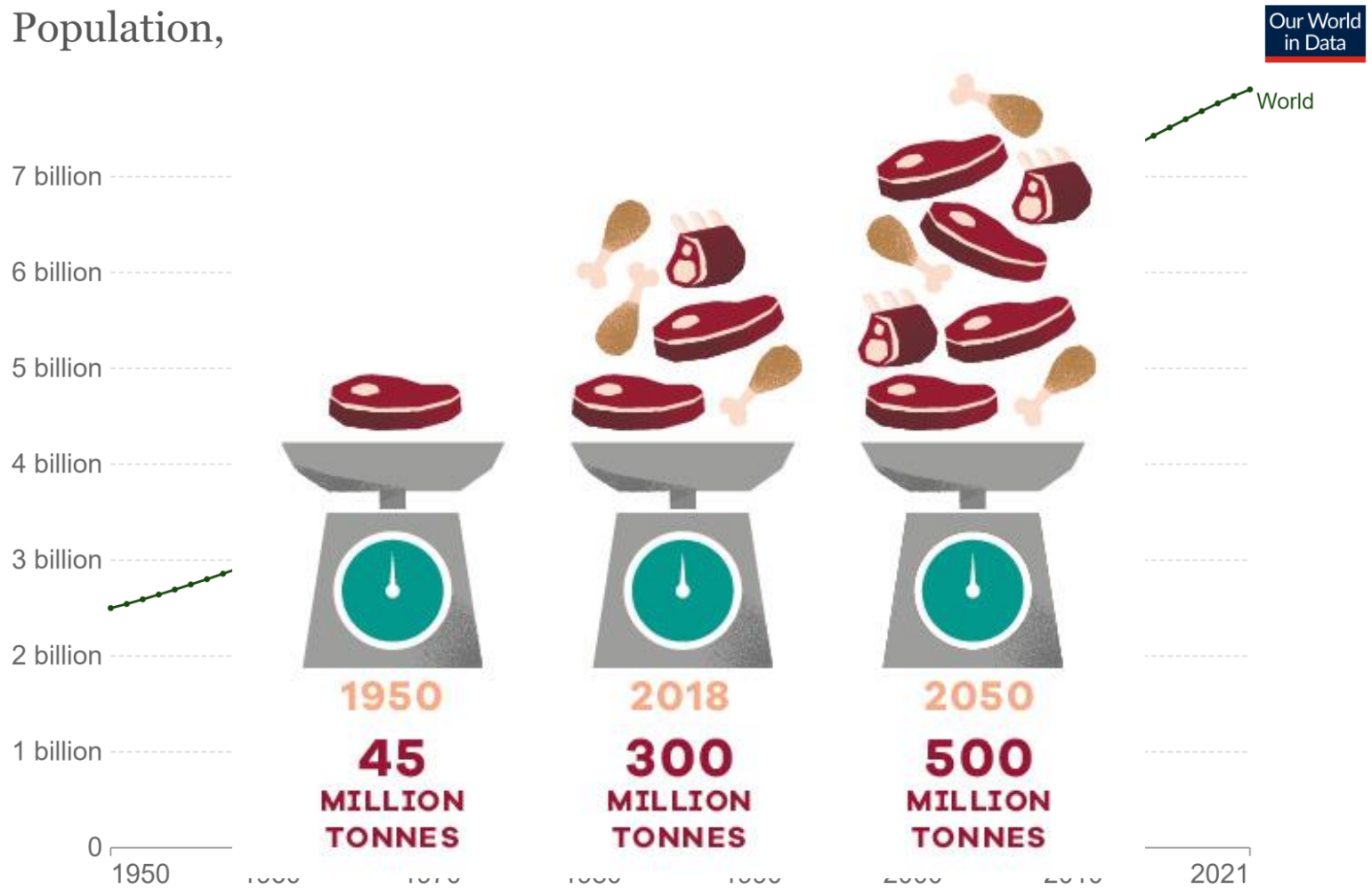
Community building

Sostegno ricerca

Educazione

L’uomo mangia

L’uomo mangia



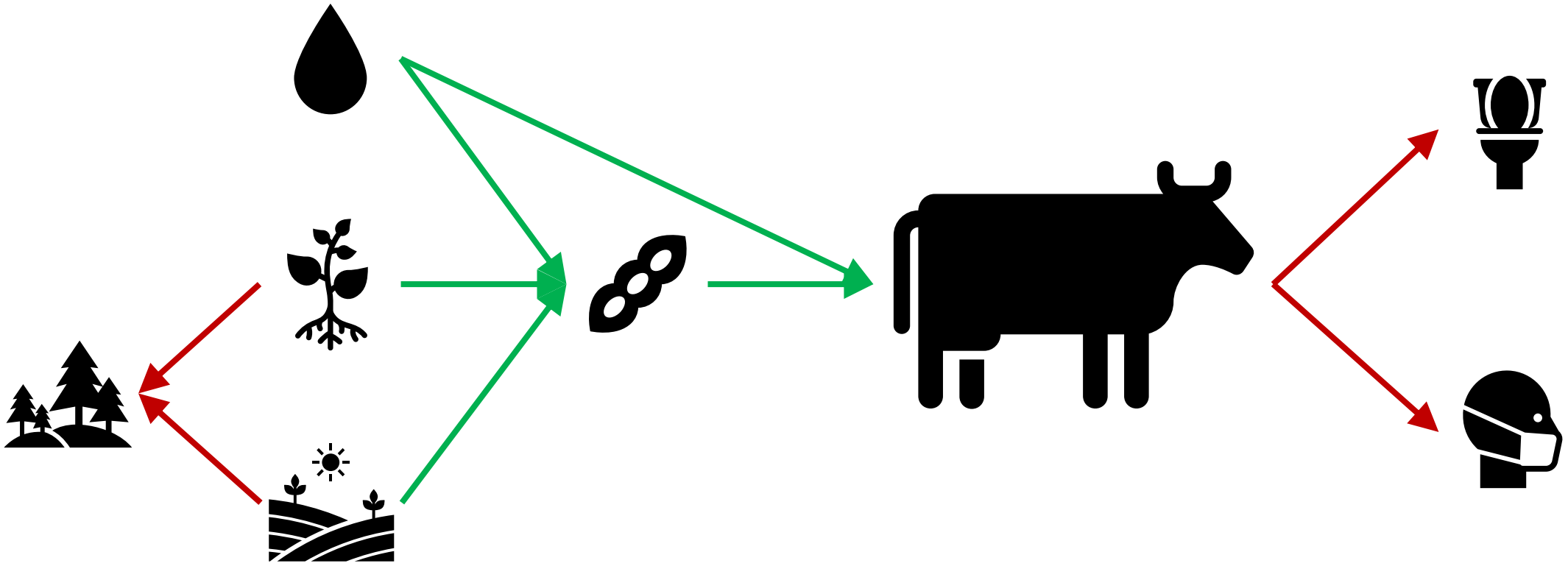
Source: United Nations, World Population Prospects (2022)

Dati FAO

Immagine da Slowfood

Il cibo occupa spazio

L’animale mangia



Come nutrire 10 mld di persone?

10 miliardi di persone nel 2050

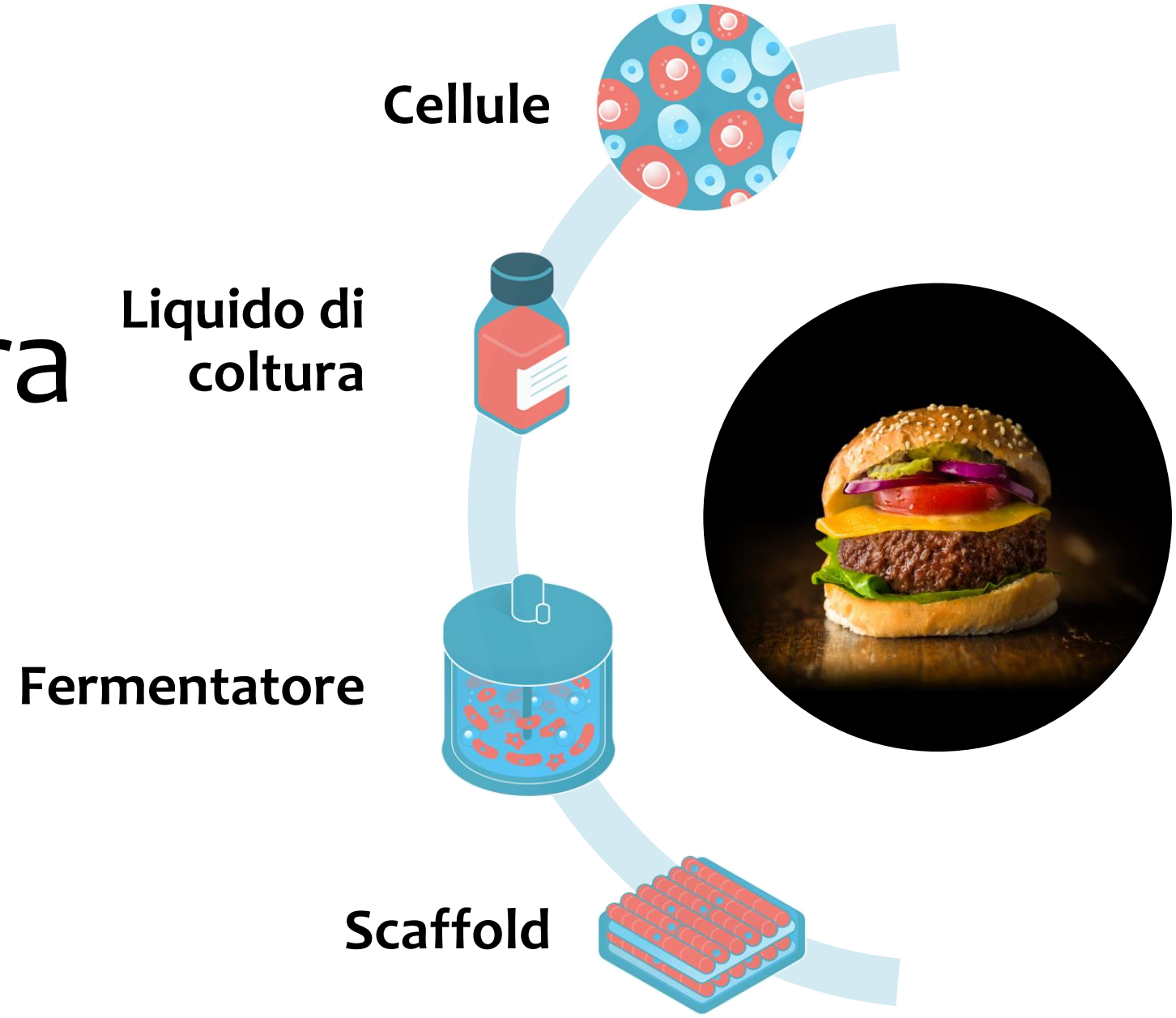
Sostenibilità

- Gas serra
- Consumo d’acqua
- Consumo terreno
- Particolato
- Eutrofizzazione

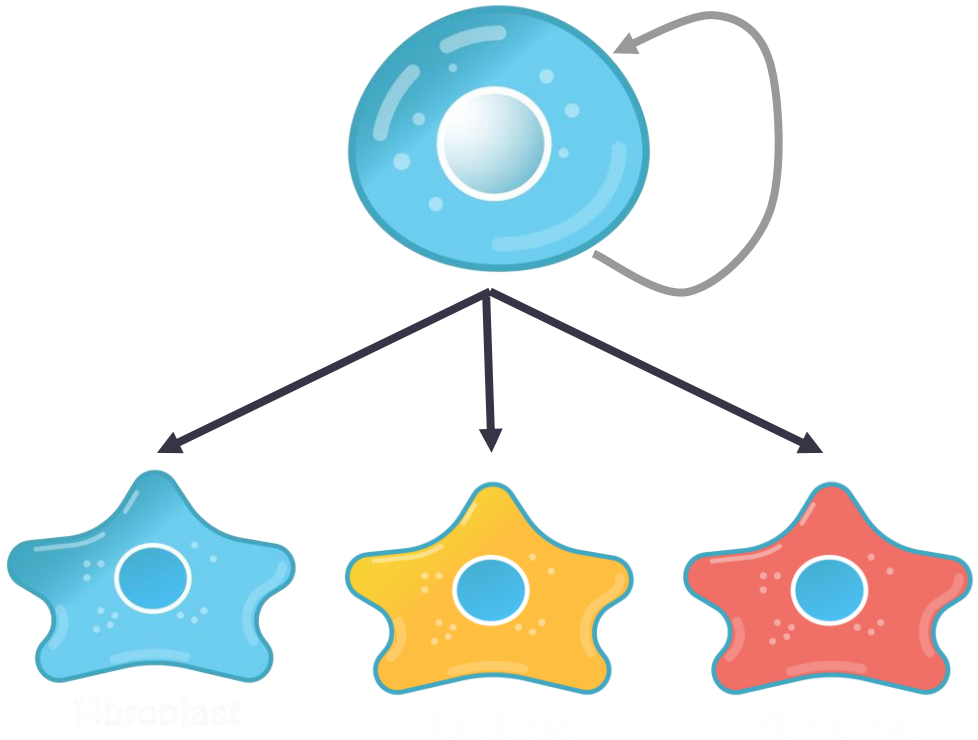
Benessere animale

Scienza e tecnologia

L’agricoltura cellulare produce cibo



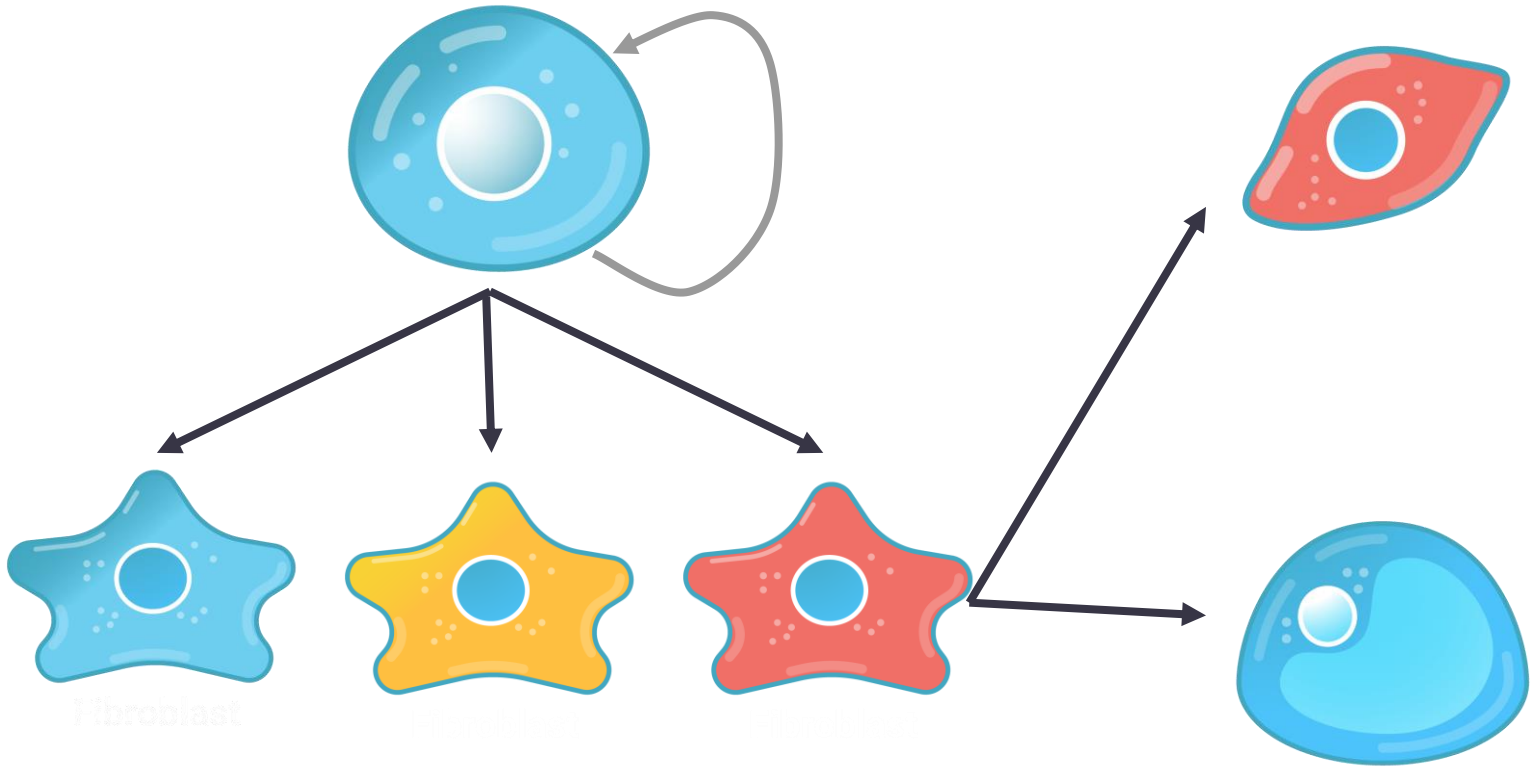
Gli animali nascono da cellule staminali



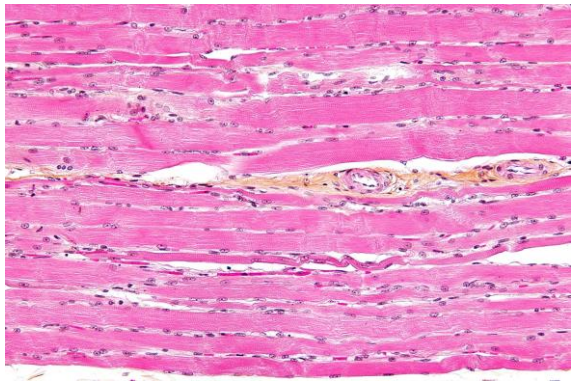
Auto-rinnovamento	✅ ✅
Differenziamento	✅ ✅

Auto-rinnovamento	✅ ✅ ✅
Differenziamento	✅ ✅ ✅

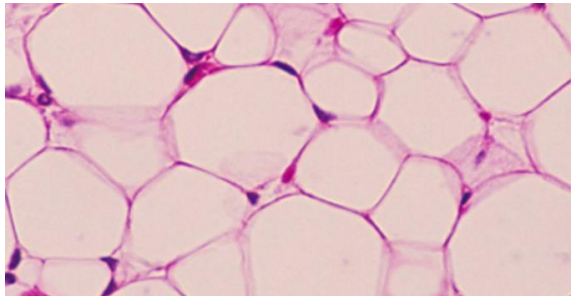
Gli animali nascono da cellule staminali



Muscolo

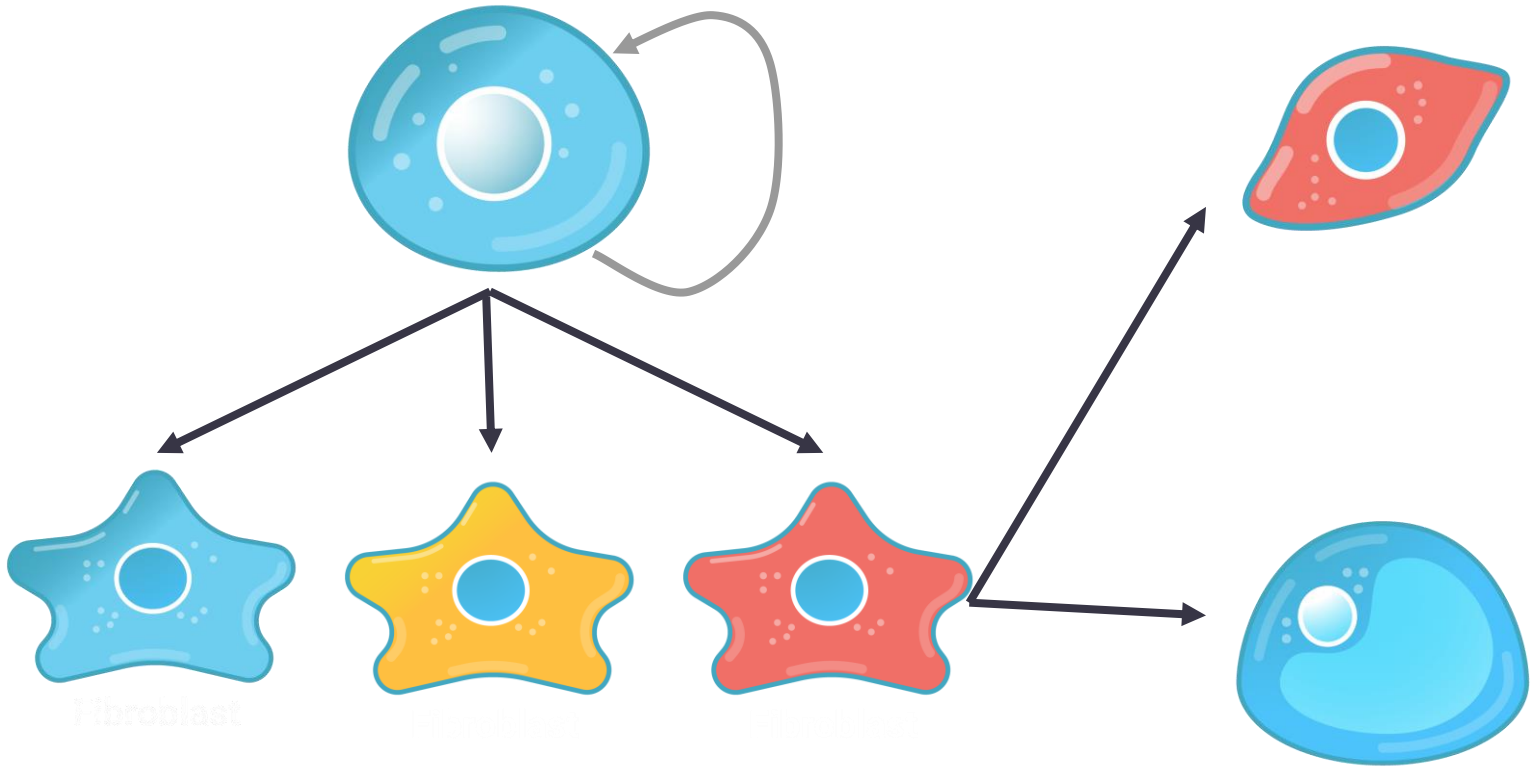


Grasso

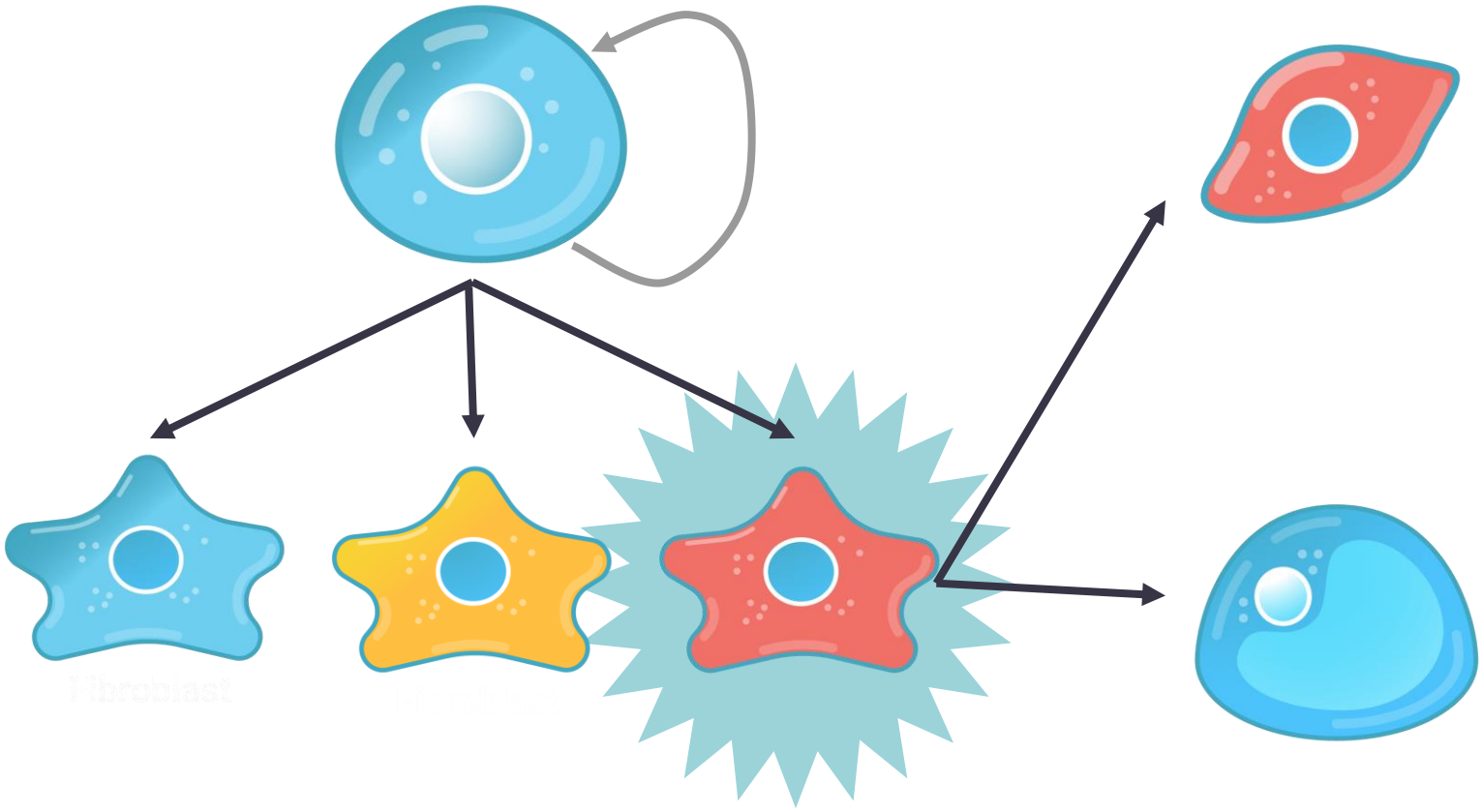


Auto-rinnovamento	✗✗✗
Differenziamento	✗✗✗

La carne coltivata sfrutta gli stessi processi

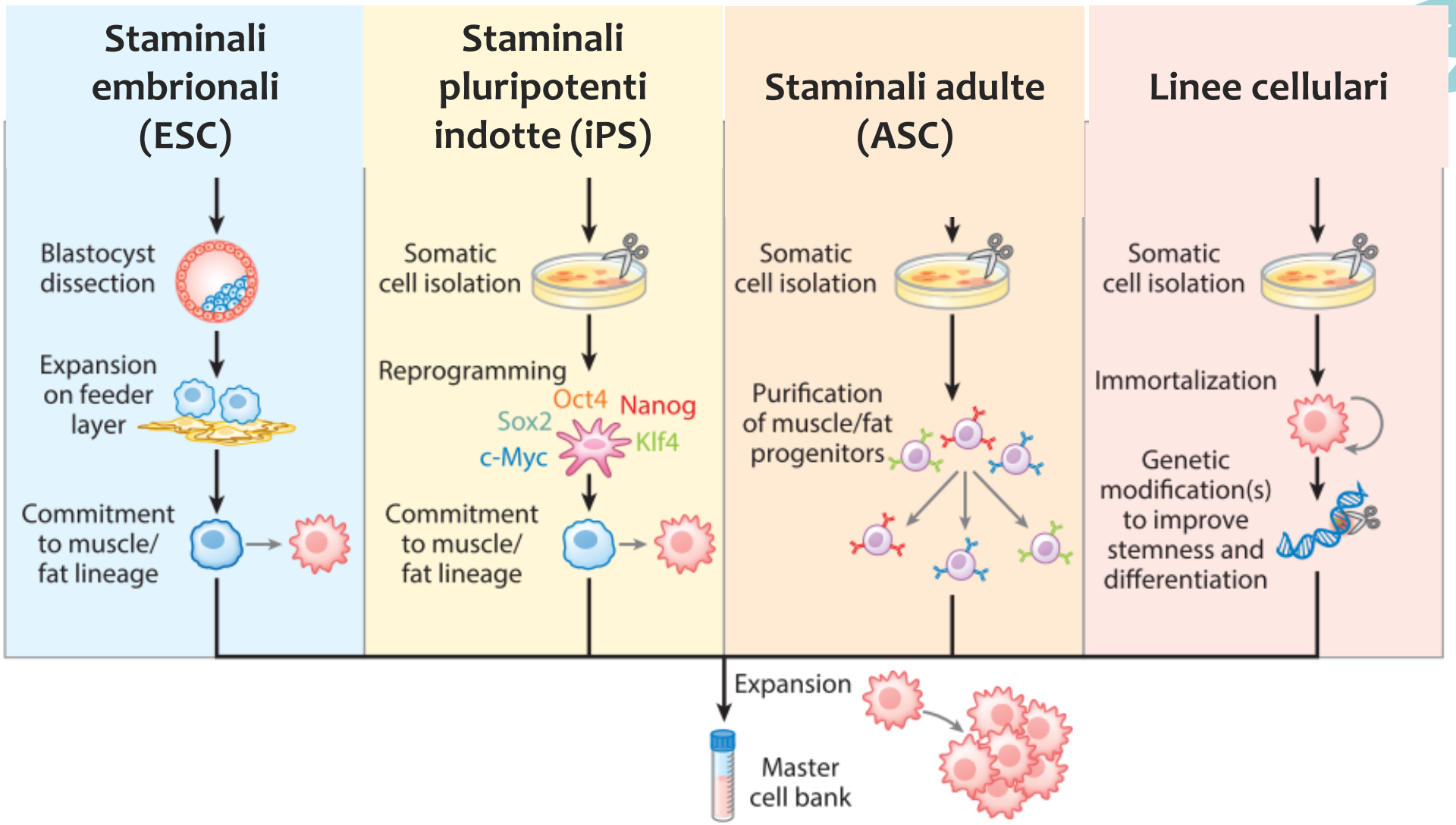


La carne coltivata sfrutta gli stessi processi



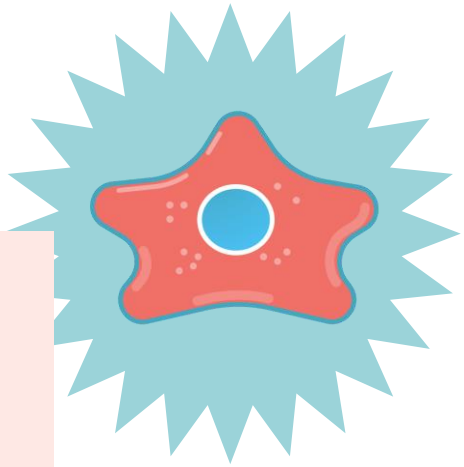
Crescita e maturazione

Si possono usare diversi tipi di cellule



Martins et al. (2024)

Si possono usare diversi tipi di cellule



Staminali embrionali (ESC)	Staminali pluripotenti indotte (iPS)	Staminali adulte (ASC)	Linee cellulari
Longeve	Longeve	Facili da ottenere	Longeve
Difficili da crescere e differenziare	Difficili da ottenere e differenziare	Non longeve	Difficili e costose da ottenere
Aleph Farms	MEATABLE	Mosa Meat	UPSIDE Foods	GOOD
			Fibroblasti indifferenziati

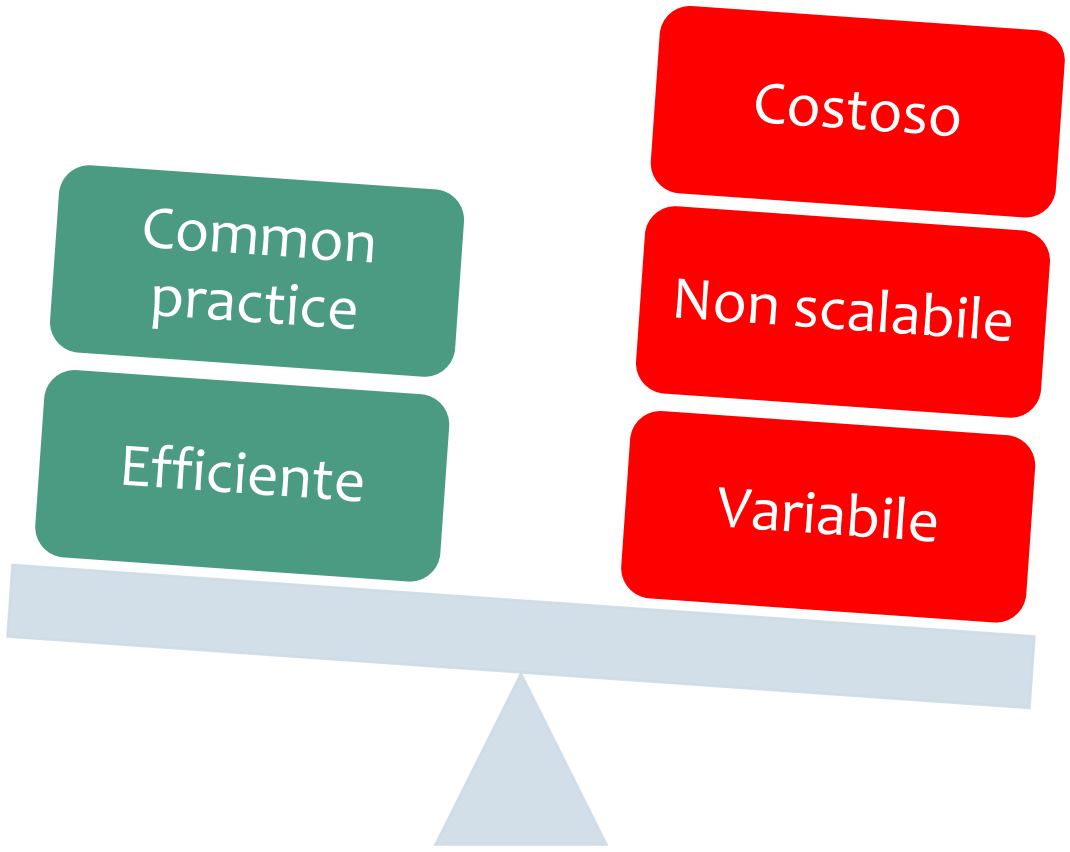
Martins et al. (2024)

Il liquido di coltura contiene nutrienti

Nutriente	*Esempio*	*Fonte*
Carboidrati	Glucosio	Cereali o altre piantagioni 🌽 o scarti di altre industrie alimentari 🗑️ + processi fermentativi 🦠
Proteine	Amminoacidi	Processi fermentativi 🦠
Grassi	Acidi grassi	Processi chimici o fermentativi ⚗️ 🦠
Micronutrienti	Sali minerali	Processi chimici ⚗️
	Vitamine	Processi chimici o fermentativi ⚗️ 🦠
Altro	Fattori di crescita	Processi fermentativi 🦠

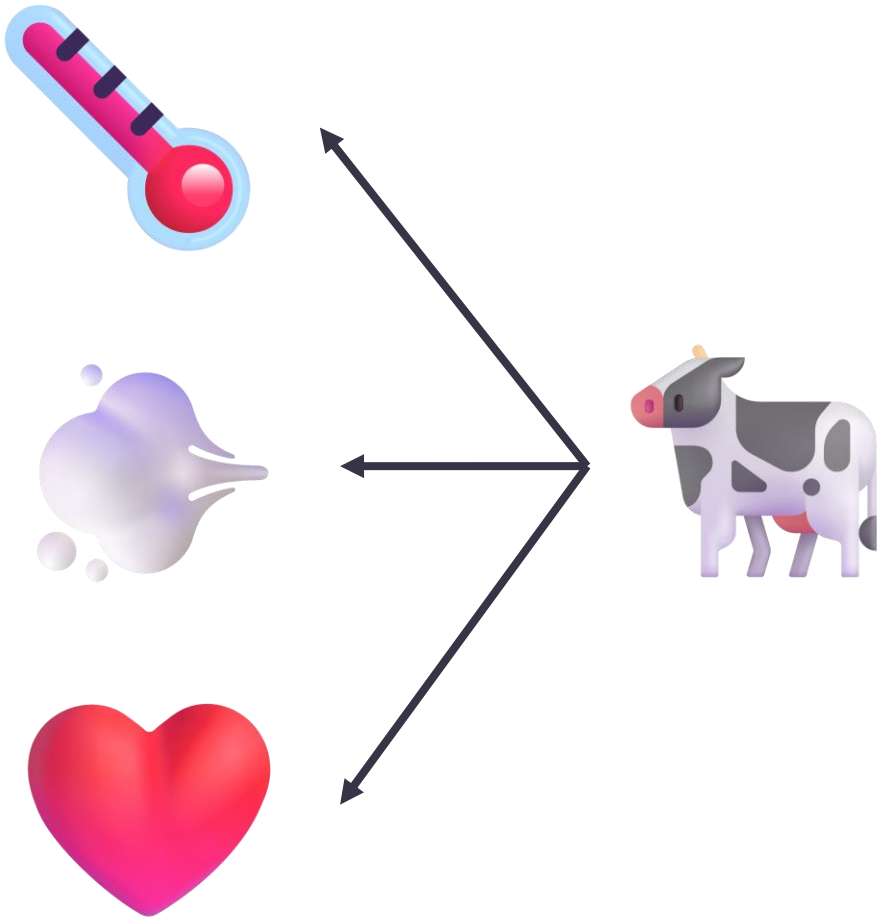
Si usa il siero fetale bovino?

Pro	Contro
Common practice	Costoso
Efficiente	Non scalabile
	Variabile

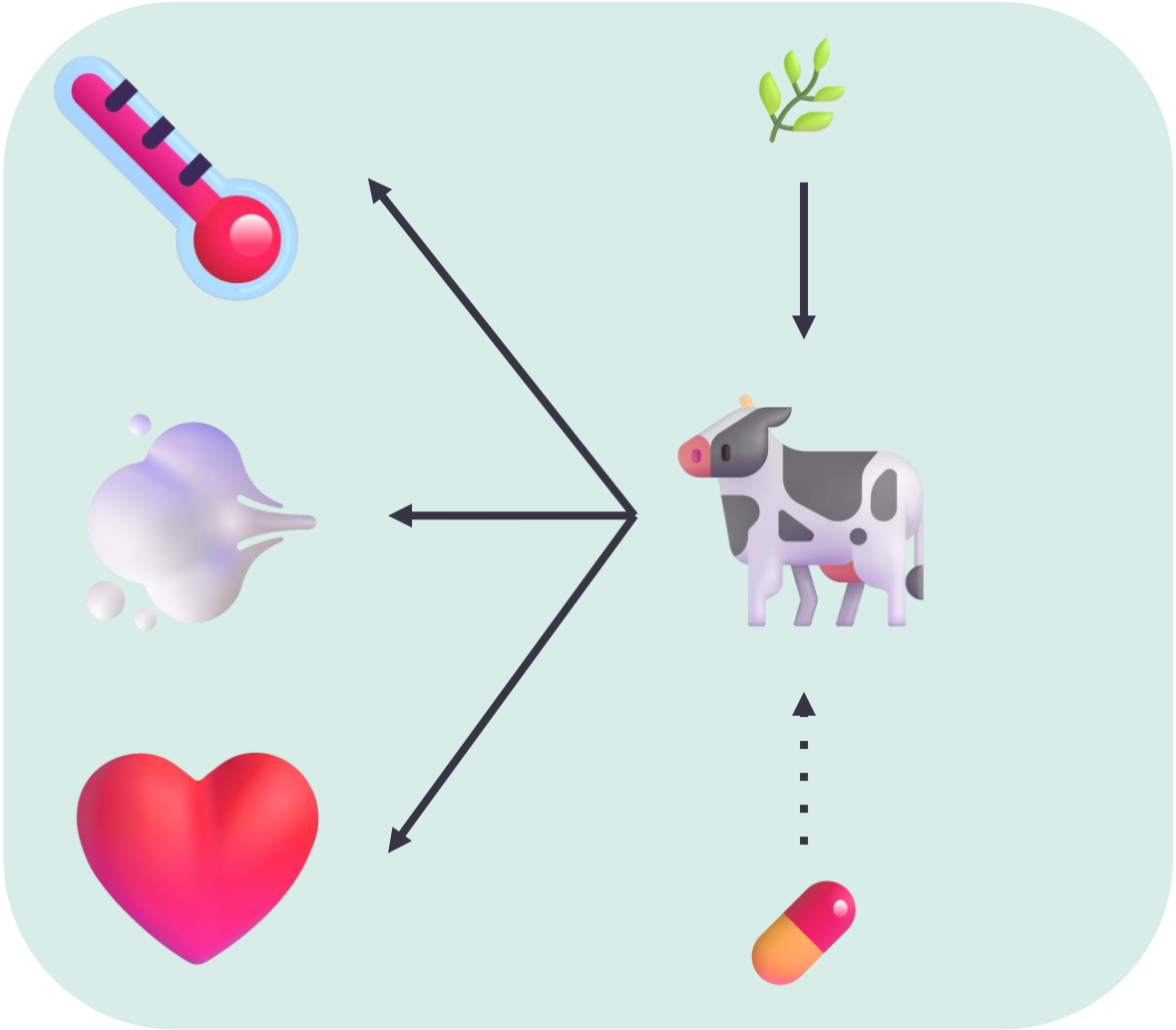


Cellular Agriculture Europe

Il corpo crea condizioni ideali per crescere cellule



Il corpo crea condizioni ideali per crescere cellule

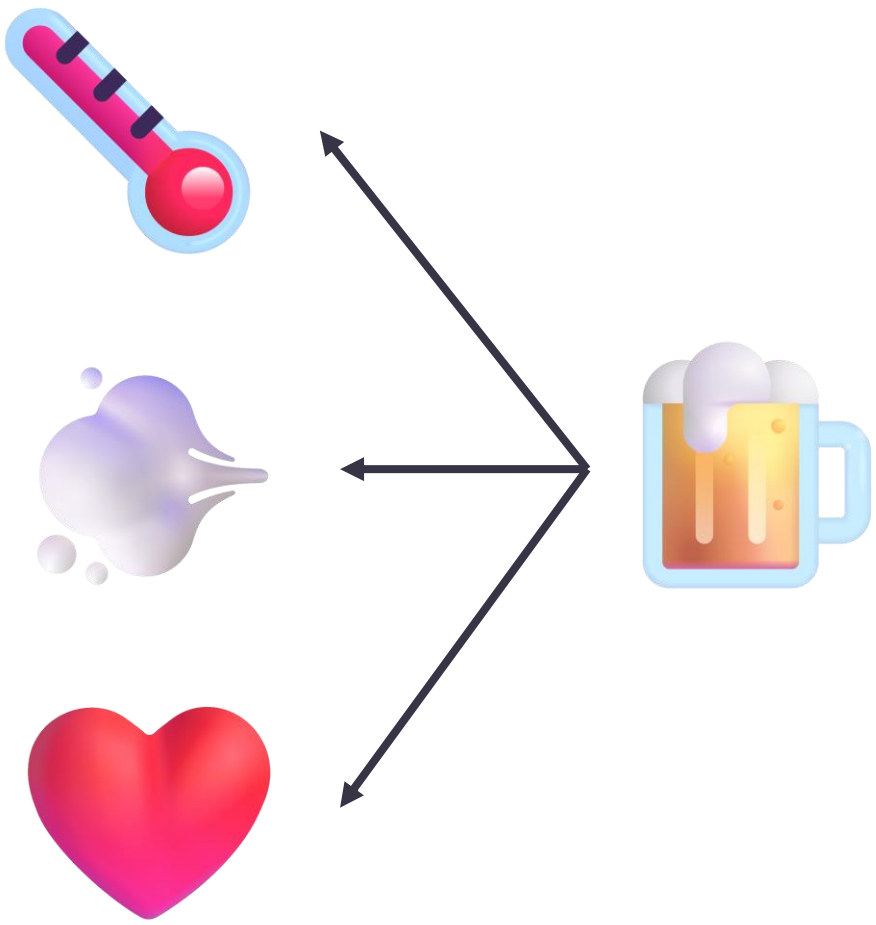


8 - 18 mesi

⬇️

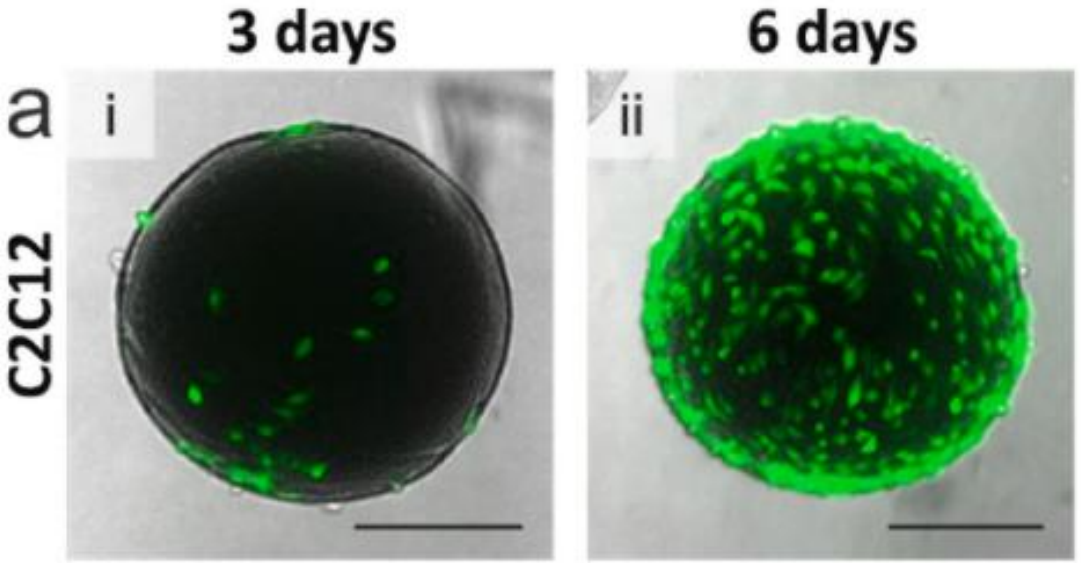
~350 - 600 kg

Il bioreattore svolge alcune funzioni del corpo



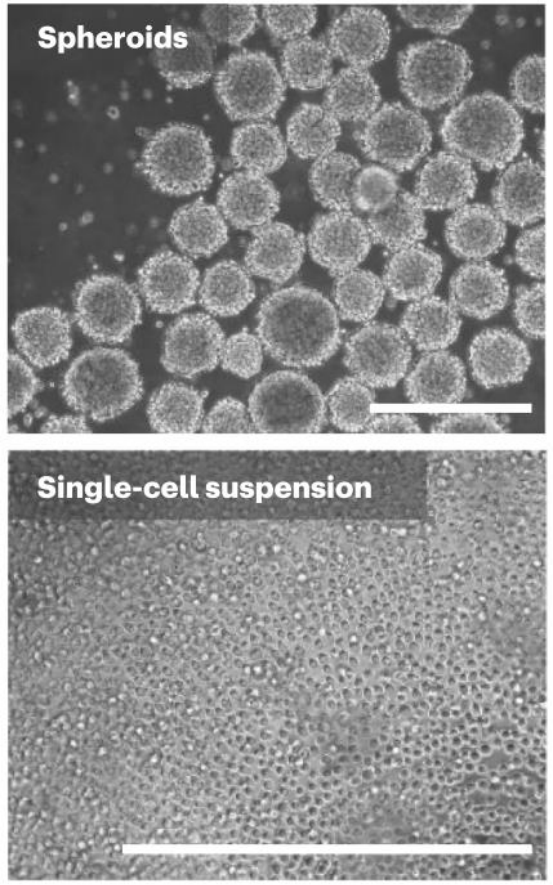
Le cellule nuotano?

Crescita su microcarriers



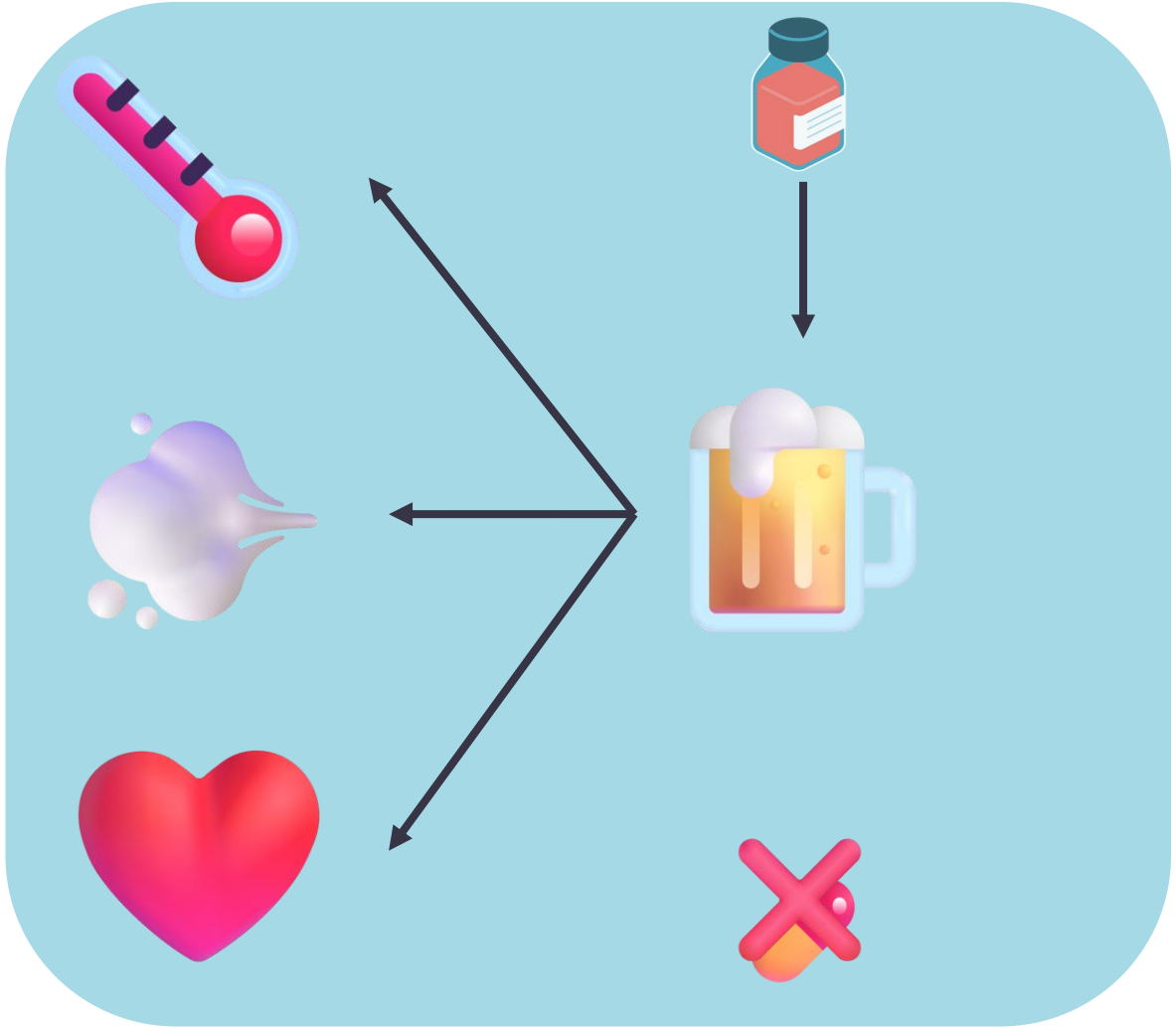
Zenov et al. (2022)

Crescita in sospensione



Pasitka et al. (2022)

Il bioreattore svolge alcune funzioni del corpo



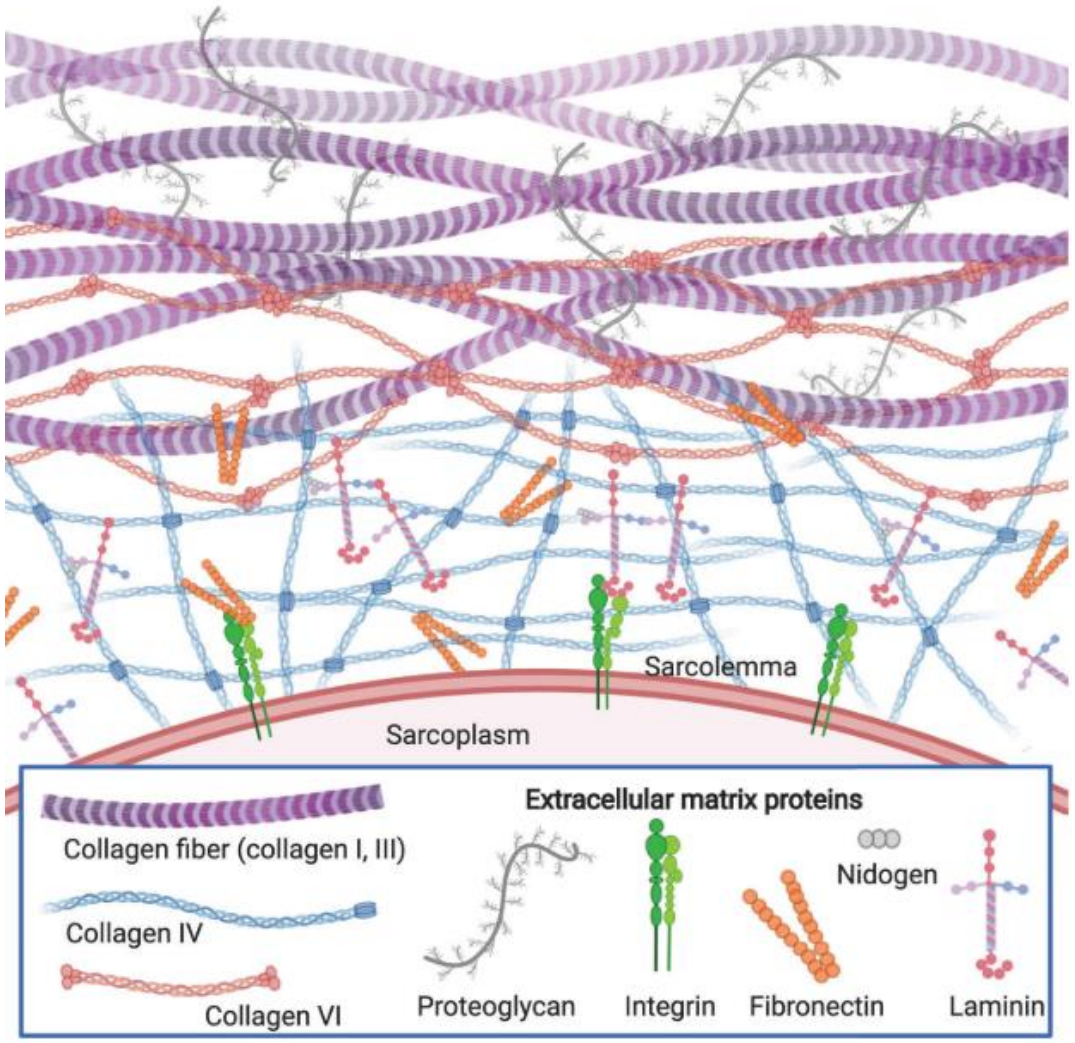
2-8 settimane

⬇️

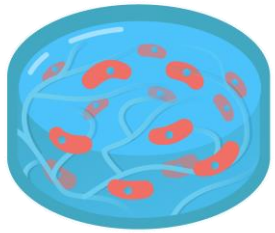
~3000 - 5000 kg

La matrice extracellulare dà struttura alle cellule

- Proteine (collagene) → gel
- Microambiente stabile
- Funzioni:
    - Adesione
    - Migrazione
    - Proliferazione
    - Differenziazione
    - Organizzazione tessuto

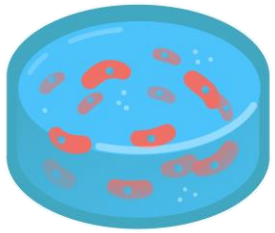


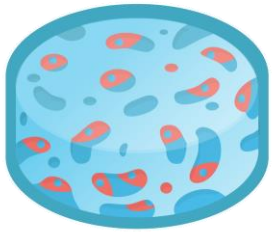
Lo scaffold conferisce struttura alle cellule



Fibroso

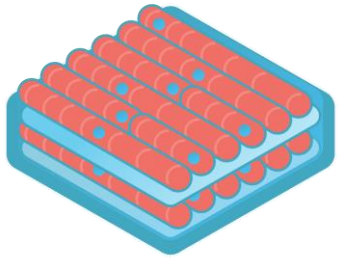
Gelatinosi





Porosi

Piani



🌱 Vegetali

🍄 Funghi

🍮 Gelatina

🟢 Alghe

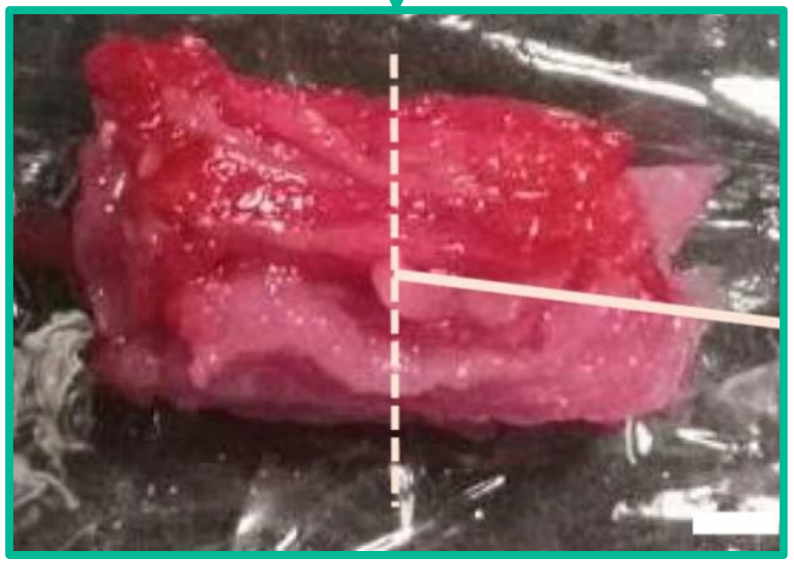
Dohmen et al. (2022)

Scaffold di ultima generazione

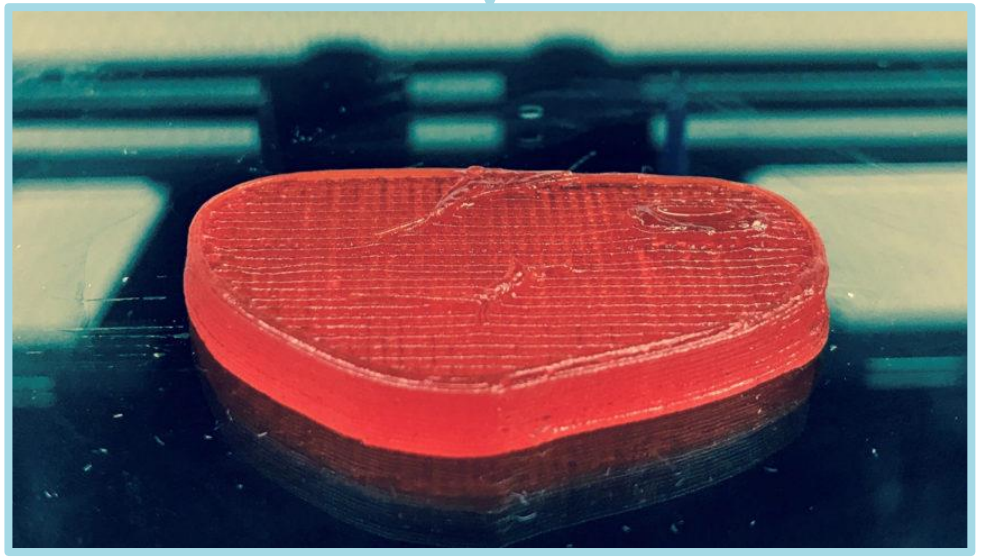
Bio-stampanti 3D

Cellule

Supporto

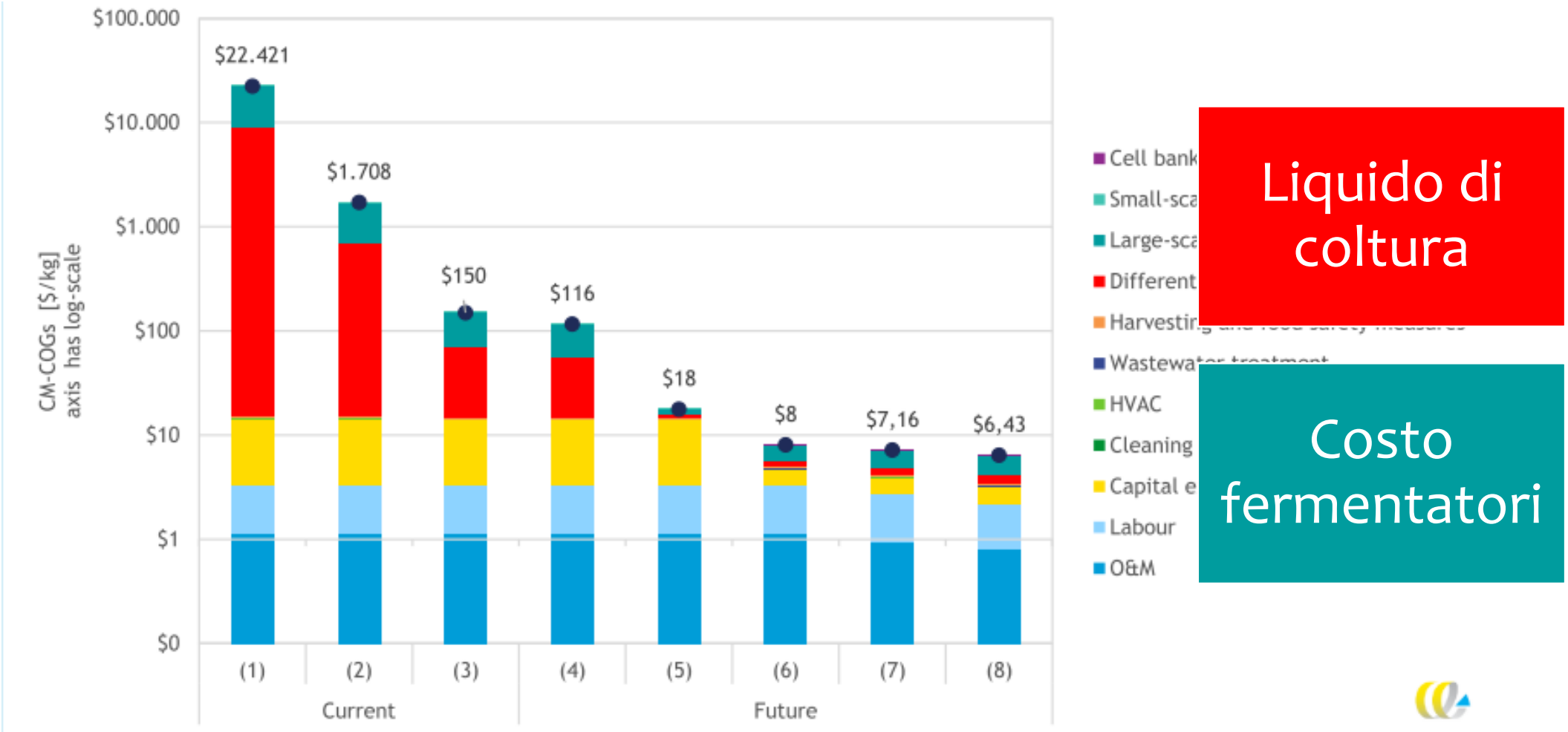


Kang et al. (2021)



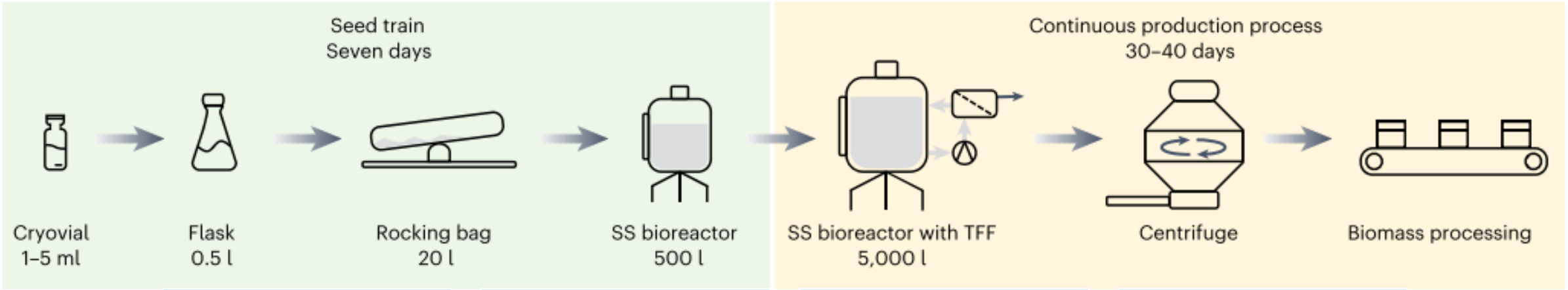
Novameat

Per ottenere prezzi competitivi si devono abbassare i costi



Vergeer, Pelle, Odegard (2021)

Processo produttivo di Believer Meat



10 bioreattori da 5000 L

1 mln ton/anno di cellule

Liquido costo 0,63 USD/L

13,3 EUR/kg cellule

Linea cellulare immortale

No differenziamento

No scaffold

Pasitka et al. (2024)

La carne coltivata sarà carne

Proprietá organolettiche

- Grassi
- Scaffold

Profilo nutrizionale

- Da ottimizzare
- Possibilitá di introdurre omega-3

Mark Post (Paesi Bassi)

Wildtype (USA)

Aleph Farms (Israele)

Il profilo nutrizionale deve essere migliorato

Table 11: UPSIDE Foods cultivated chicken and conventional chicken

(g/100g, normalized to 20 w/w% solids)

	USDA skinless light chicken	USDA all chicken	Serum-containing CPM			Serum-free CPM		
			Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
AMINO ACIDS								
Alanine	1.0	0.8	0.8	0.8	0.8	0.7	0.6	0.7
Arginine	1.1	0.9	1.2	1.2	1.2	0.9	0.7	0.9
Aspartic Acid, Asparagine	1.6	1.3	1.6	1.5	1.6	1.2	1.0	1.1
Cysteine	0.2	0.1	0.3	0.3	0.3	0.2	0.2	0.2
Glutamic Acid, Glutamine	2.6	2.1	2.2	2.0	2.0	1.7	1.4	1.6
Glycine	0.8	0.7	0.9	0.9	1.0	0.8	0.6	0.7
Histidine	0.6	0.4	0.5	0.4	0.5	0.4	0.4	0.5
Isoleucine	0.9	0.7	0.8	0.8	0.7	0.6	0.5	0.5
Leucine	1.4	1.1	1.2	1.2	1.2	1.0	0.9	1.0
Lysine	1.5	1.2	1.0	1.1	1.0	0.9	0.8	0.9
Methionine	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2
Phenylalanine	0.7	0.5	0.7	0.7	0.7	0.6	0.5	0.6
Proline	0.7	0.6	0.9	0.9	0.9	0.7	0.6	0.6
Serine	0.6	0.5	0.8	0.8	0.8	0.6	0.5	0.6
Threonine	0.8	0.6	1.0	1.0	1.0	0.6	0.5	0.6
Tryptophan	0.2	0.2	0.3	0.3	0.2	0.2	0.1	0.2
Tyrosine	0.6	0.5	0.7	0.7	0.7	0.5	0.4	0.5
Valine	0.9	0.7	1.0	0.9	0.9	0.7	0.6	0.7

- < proteine
- < grassi
- Profilo aminoacidico
- Minerali
- Vitamine

2022 State of the Industry Report | Cultivated meat and seafood

Ma la carne coltivata è sicura?

THE STRAITS TIMES | SATURDAY, APRIL 8, 2023

UN report says lab-grown meat is safe, cites Singapore as case study

Singapore is the only country in the world where consumers can buy cell-cultured chicken, but how safe are such laboratory-grown meat compared to ...?

The United Nations (UN) agencies have put out a report to address this issue, its efforts to bring more of such foods to the dining table and assure consumers that they are safe to eat.

Traces of antibiotics in the meat product, pathogens in the animal cells that can spread to humans and possible genetic changes in cells as they multiply were identified as some of the potential hazards of cell-based meats in the report.

Put together by the Food and Agriculture Organization (FAO) and the World Health Organisation (WHO), the report cited Singapore, which approved cell-cultured chicken for sale in 2020, as a case study in the regulation of such meats.

The report concluded that many of the hazards identified in cell-based foods already exist in conventionally produced foods and livestock agriculture, and hence the meats are safe for consumption.

The use of antibiotics to prevent the cells from being contaminated by bacteria was also identified as an issue as residual antibiotics in the meat products could be a health hazard and contribute to antimicrobial resistance.

The report recommended that limited amounts of antibiotics should be used. Washing can help remove or reduce the concentration of contaminants in the final product.

Mutations from changes to the genes as the cells multiply could build up and create novel toxins.

However, the mutations alone will not pose any significant problems to consumers, said Professor William Chen, director of Nanyang Technological University's Food Science and Technology programme.

"DNA from meat, with or without mutations, will be degraded in our digestive system, and thus they have a low possibility of integrating into our genes and leading to any potential health risks," said Prof Chen. He is the vice-chair of the panel of international experts who gathered in Singa-

with couscous and fried chicken salad. Each dish costs $18.50.

Other cell-cultured meats, such as beef and fish, are still being developed, while some firms abroad are seeking approval from the Singapore Food Agency (SFA) to sell their slaughter-free thin-cut steaks and minced pork items here.

Currently, there are more than 100 cell-based food start-ups around the world.

Cell-based meat is made by taking cells from a cow, chicken or fish through a biopsy and then growing the cells in a nutrient broth and media. The tissues are harvested, prepared and packaged into meat products.

Such meats generated from cells may combine different cell types like muscle and fat cells to replicate the structure and texture of meat. Extrusion techniques and 3D printing, as well as

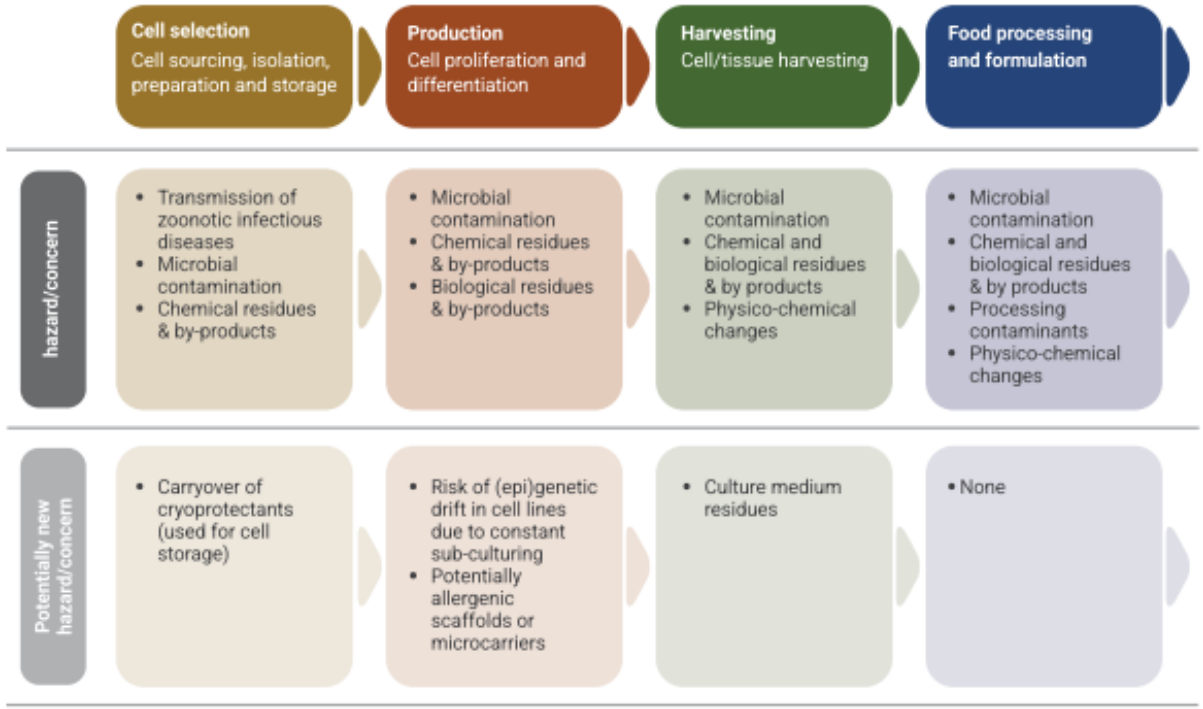
The document also noted that cell-based meats are an "alleged sustainable alternative" to conventional livestock, and more work is needed to prove that such meats are indeed greener.

The report concluded that hazard identification is only the first step of the formal risk assessment process for cell-based food, and more scientific data, insights and the sharing of information are needed to further the safety and trust in these future foods.

Prof Chen, who is also a consultant to FAO on alternative and novel foods, said: "The report would help cell-based meat companies align themselves with the global standard and harmonise their processes. This in turn would enhance food safety and boost consumer confidence."

ruhaib@sph.com.sg

Figure 5. Examples of potential food safety hazards and concerns at different phases of cell-based food production



Source: Authors' own elaboration.

Based on the literature review, the majority of the potential food safety hazards in the cell-based food production process, such as microbiological contamination and residue issues, are not new. For such common food safety hazards, there are many risk-mitigating tools available, such as good hygiene, manufacturing, cell-culture, and hazard analysis and critical control points practices (HACCP), as well as the general principles and methodologies for the end-product whole food safety assessment (FAO, 2009). Thus, it is important to learn from various past experiences and consider an effective application of the risk analysis paradigm (Ong *et al.*, 2021). In adopting several established safety assessment methodologies and detection methods from a range of disciplinary fields, such as pharmaceuticals and food biotechnologies including both conventional and modern technologies, various hazards can be systematically identified, and relevant safety assessments can be appropriately conducted. It is important that these methodologies are also validated for the new matrices that are presented by the cell-based food products.

… la maggior parte dei potenziali pericoli per la sicurezza alimentare nel processo di produzione di cibi a base cellulare […] non sono nuovi. Per tali comuni rischi legati alla sicurezza alimentare, esistono giá molti strumenti atti a mitigarli.

4.2.1. Potential hazards during cell-sourcing

Table 5. Hazards identified by the Technical Panel for the cell sourcing stage

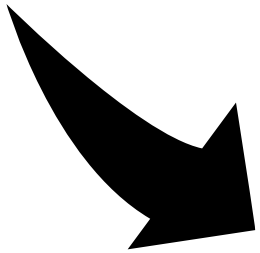
	Production step(s)[a]	Hazard agent	Problem description / consequence to	Hazard type(s)[b]	Potential mitigation control	Potential testing control	Similar presence of the hazard in other	Causal chain examples
1.	Cell sourcing (biopsy step)	Veterinary dr (including antimicrobial	which include allergenicity to antimicrobials				aquaculture	The drug is present in the sampled tissue and the cells brought into culture > the cell culture is not disrupted > the drug is not degraded or washed away, and the drug goes undetected throughout the cell sourcing, production and harvesting, and food processing stages > the drug survives food preparation > the drug reaches the final product at a concentration that exceeds a minimum residue level or tolerable

53 potenziali rischi per la salute del consumatore, che sono già riscontrati in altri tipi di produzione alimentare

4.4. Concerns not included in the scope of hazard identification

During the process of identifying the hazards and discussing the respective sequence of events that would need to occur to result in harm to consumers in each case, the Technical Panel noted that there are additional issues that people may encounter in popular press and social media alleging certain concerns in connection with the cell-based food production process and its potential products. Given the attention they have received, these concerns have been considered by the Technical Panel, even if it was not possible to describe a sequence of events consistent with the current understanding of relevant science that could result in harm to consumers.

One purported concern involves the potential survival of cells after consumption. In the process of cell-based food production, living cells are used as source material and propagated to large numbers to eventually form a product. The possibility was considered that living cells with the capability of extended or immortalized replication could enter the body and survive, leading to harm through some type of tumour formation.



The probability of even one of these events is extremely low, and their occurrence is not consistent with current scientific understanding. Isolated animal cells, unlike single bacteria or yeast cells, do not have adaptations that protect them from the external environment or allow them to survive without the support of the organism; this consideration is a significant factor in the technical challenges of building bioreactors. More over, based on the current understanding of the relevant science, the capability for extended or sustained cell replication in the environment of the bioreactor does not confer any increased capacity for cell survival outside the controlled environment of the bioreactor. Neither does it convey capabilities that would be useful for establishing residence in tissues, such as immune evasion or tissue invasion. Furthermore, current scientific knowledge does not support the plausibility of human cancer contagion via introduction of cells even from other humans.


Sostenibilità ambientale

The International Journal of Life Cycle Assessment (2023) 28:234–254
https://doi.org/10.1007/s11367-022-02128-8

LCA FOR ENERGY SYSTEMS AND FOOD PRODUCTS

Ex-ante life cycle assessment of commercial-scale cultivated meat production in 2030

Pelle Sinke[1] · Elliot Swartz[2] · Hermes Sanctorum[3] · Coen van der Giesen[1] · Ingrid Odegard[1]

- 15 aziende del settore
- Previsione dati

ARTICLE
pubs.acs.org/est

Anticipatory Life Cycle Analysis of In Vitro Biomass Cultivation for Cultured Meat Production in the United States

Carolyn S. Mattick,*[,†] Amy E. Landis,[‡] Braden R. Allenby,[§] and Nicholas J. Genovese[∥]

Article
pubs.acs.org/est

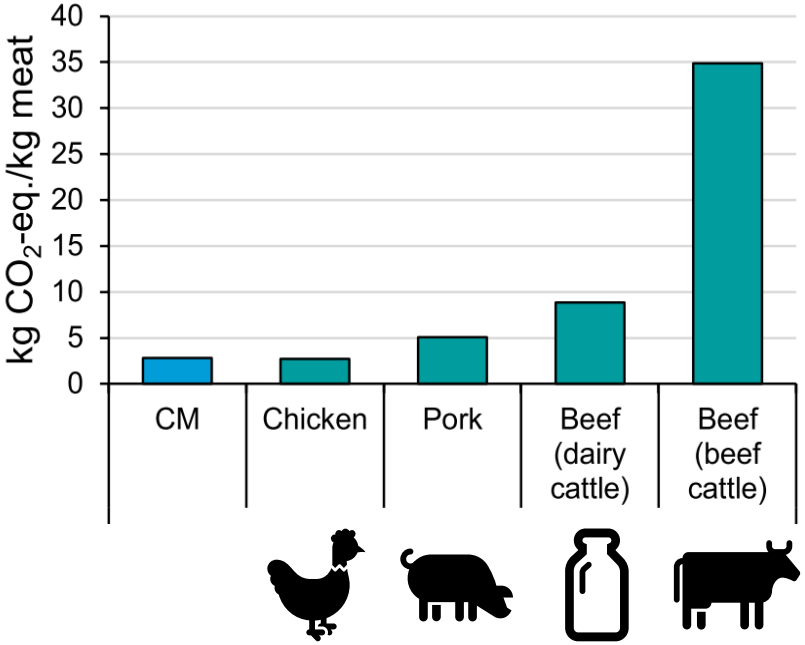
Int J Life Cycle Assess (2015) 20:1254–1267
DOI 10.1007/s11367-015-0931-6

LCA FOR ENERGY SYSTEMS AND FOOD PRODUCTS

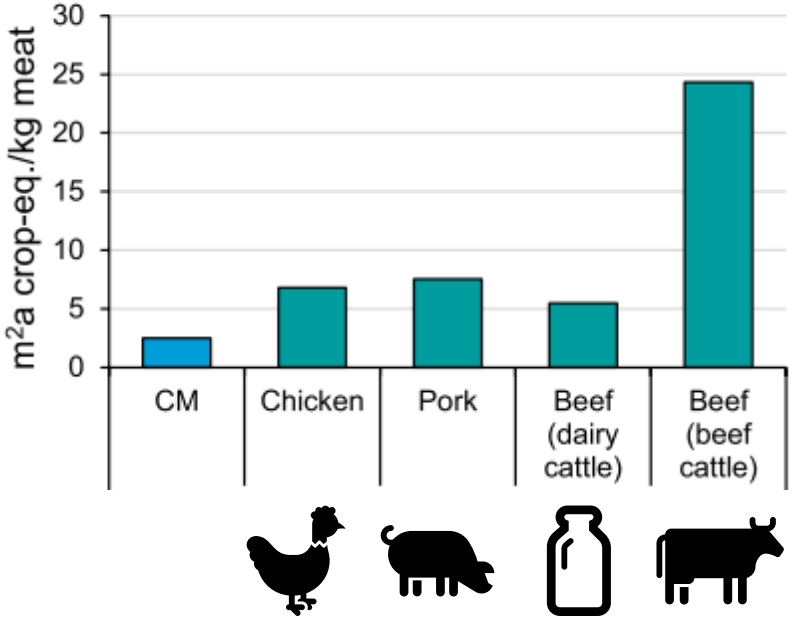
Meat alternatives: life cycle assessment of most known meat substitutes

Sergiy Smetana[1,2] · Alexander Mathys[1] · Achim Knoch[1] · Volker Heinz[1]

Produzione di gas serra



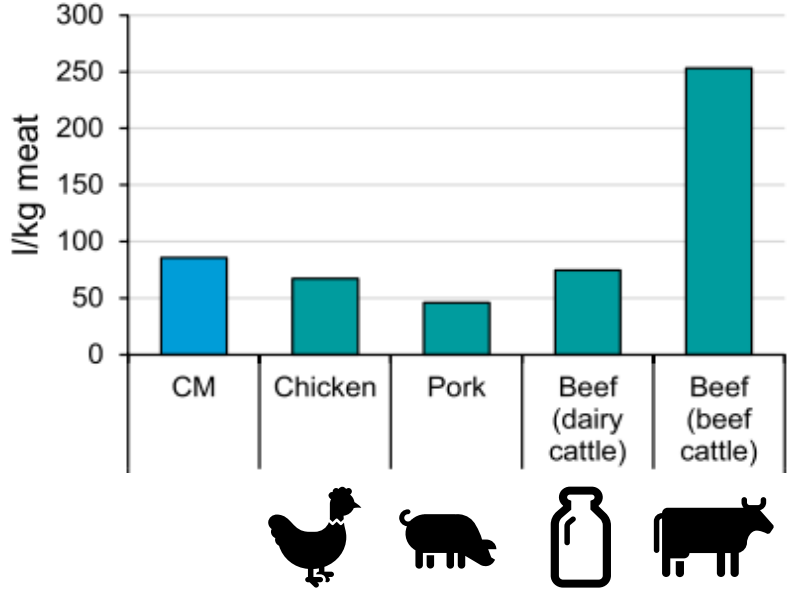
Consumo terreno



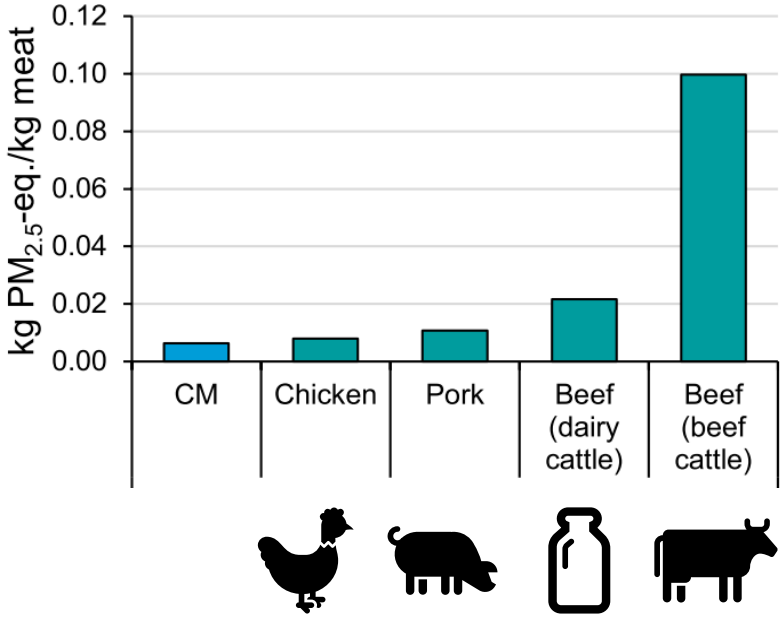
La carne coltivata potrebbe:

- produrre meno **gas serra** di suino e bovino (**-92%**)
- utilizzare meno **terreno** di pollo, suino e bovino (**-90%**)
- consumare **acqua** come pollo e suino, ma meno di bovino (**-64%**)
- produrre meno **particolato** di pollo, suino e bovino (**-99%**)

Consumo acqua



Produzione particolato



Sinke et al. (2023)

La carne coltivata potrebbe essere più efficiente dell'allevamento intensivo

The International Journal of Life Cycle Assessment

Table 3 Feed conversion ratio (FCR) of the ambitious benchmarks, dm in:fresh meat out

Resource type	Description	Cultivated meat	Chicken[a]	Pork[a]	Beef (dairy cattle)[a]	Beef (beef cattle)[a]
Biotic	Primary feed	0.8	1.5	3.1	3.7	4.6
	By-product feed	0.2	1.3	1.5	2.1	1.1
	Grass				7.5	31.6
Mineral	Salts and other	0.2				
Total biotic + mineral (incl. grass)		1.3	2.8	4.6	13.4	37.3
Total biotic + mineral (excl. grass)		1.3	2.8	4.6	5.8	5.7
Total biotic (excl. grass)		1.0	2.8	4.6	5.8	5.7

[a]Intensive, Western European production

1.0 2.8 4.6 5.8 5.7

Investimenti

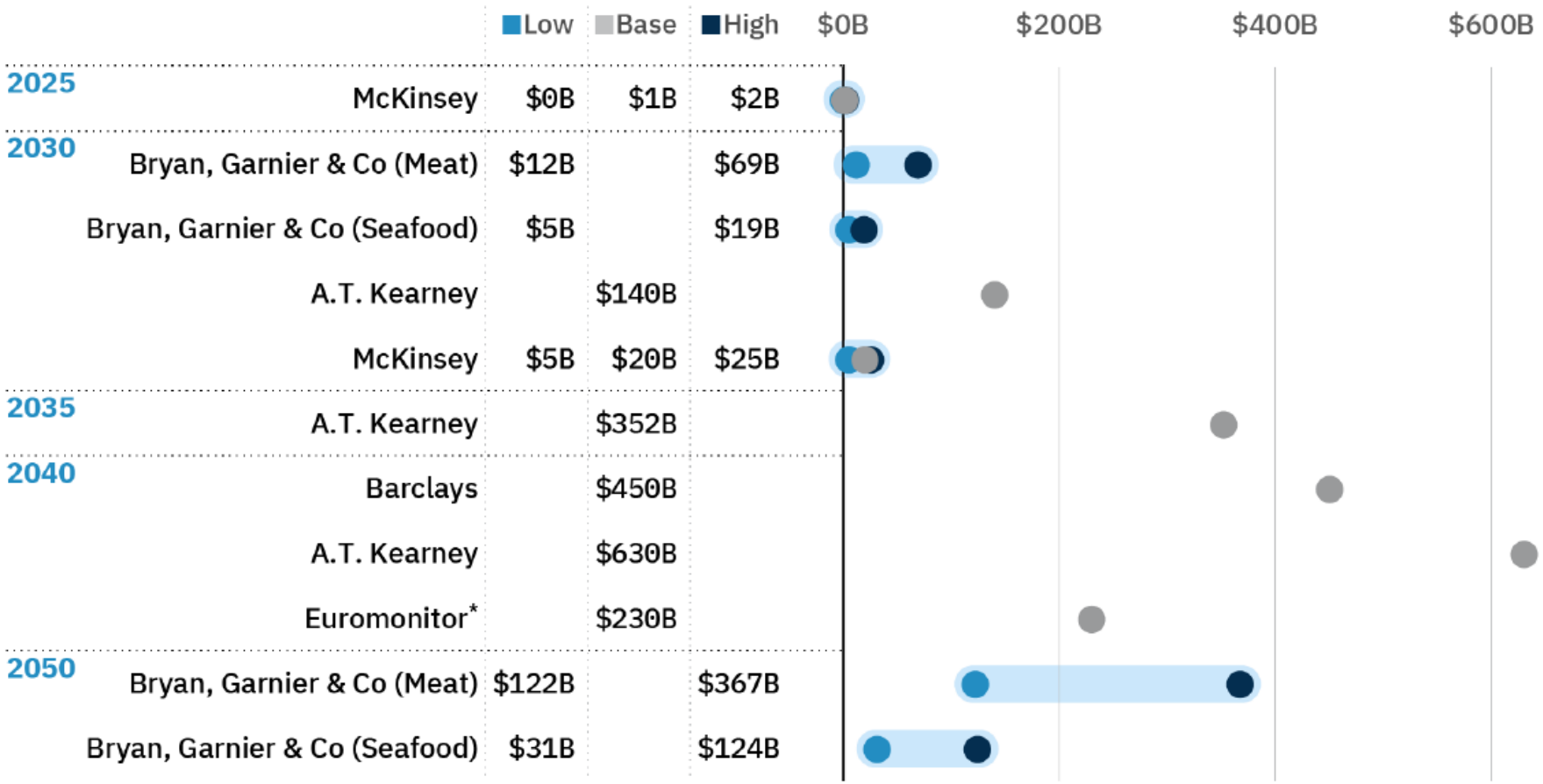
Alcune multinazionali stanno investendo in carne coltivata, sostenendo le diverse start-up (aziende di piccole dimensioni) del settore…
ma non solo!

L'Unione Europea finanzia la ricerca

FEASTS

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Stime di mercato inattendibili

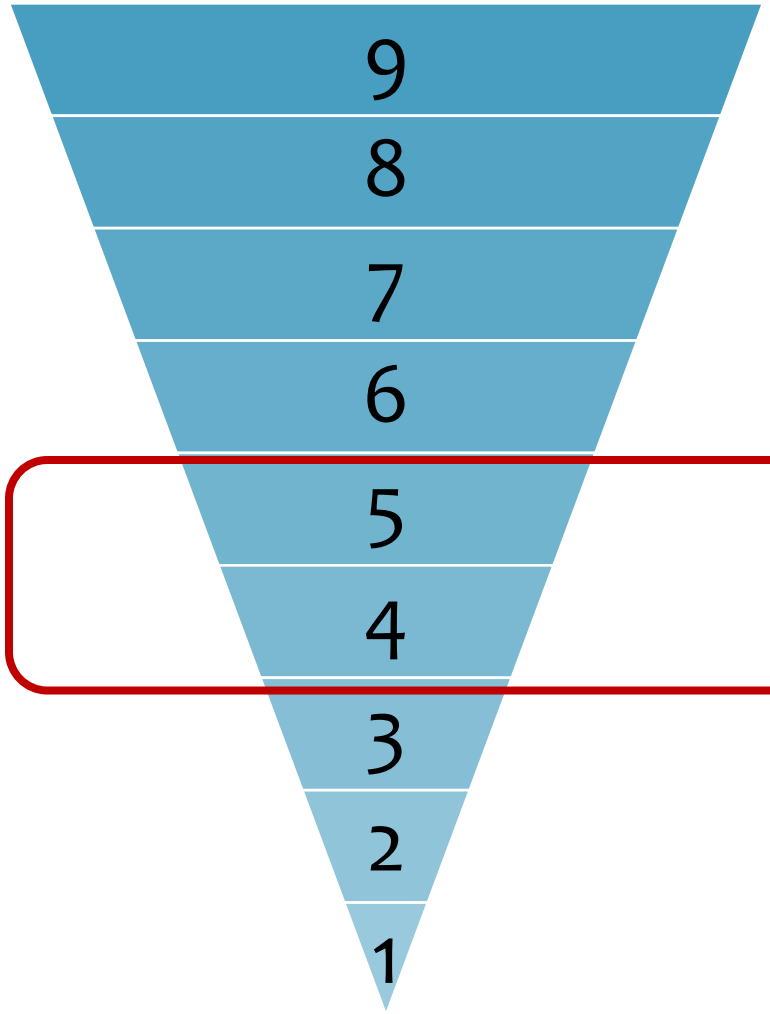



Quali sono i pericoli?

Quali sono i pericoli della carne coltivata?

Monopolio	Sostenibilità	Rivoluzione alimentare	Scontro con allevatori
• Investimenti pubblici	• Necesssità di studi indipendenti	• Proteine *complementari* • Mercato in espansione	• MacMillan et al. (2024) • Possibilità di collaborazioni

La tecnologia non è pronta



9 Sistema dimostrato in un ambiente operativo

8 Sistema completo e qualificato

7 Dimostrazione del prototipo in un ambiente operativo

6 Dimostrazione della tecnologia in un settore rilevante

5 Validazione della tecnologia in un settore rilevante

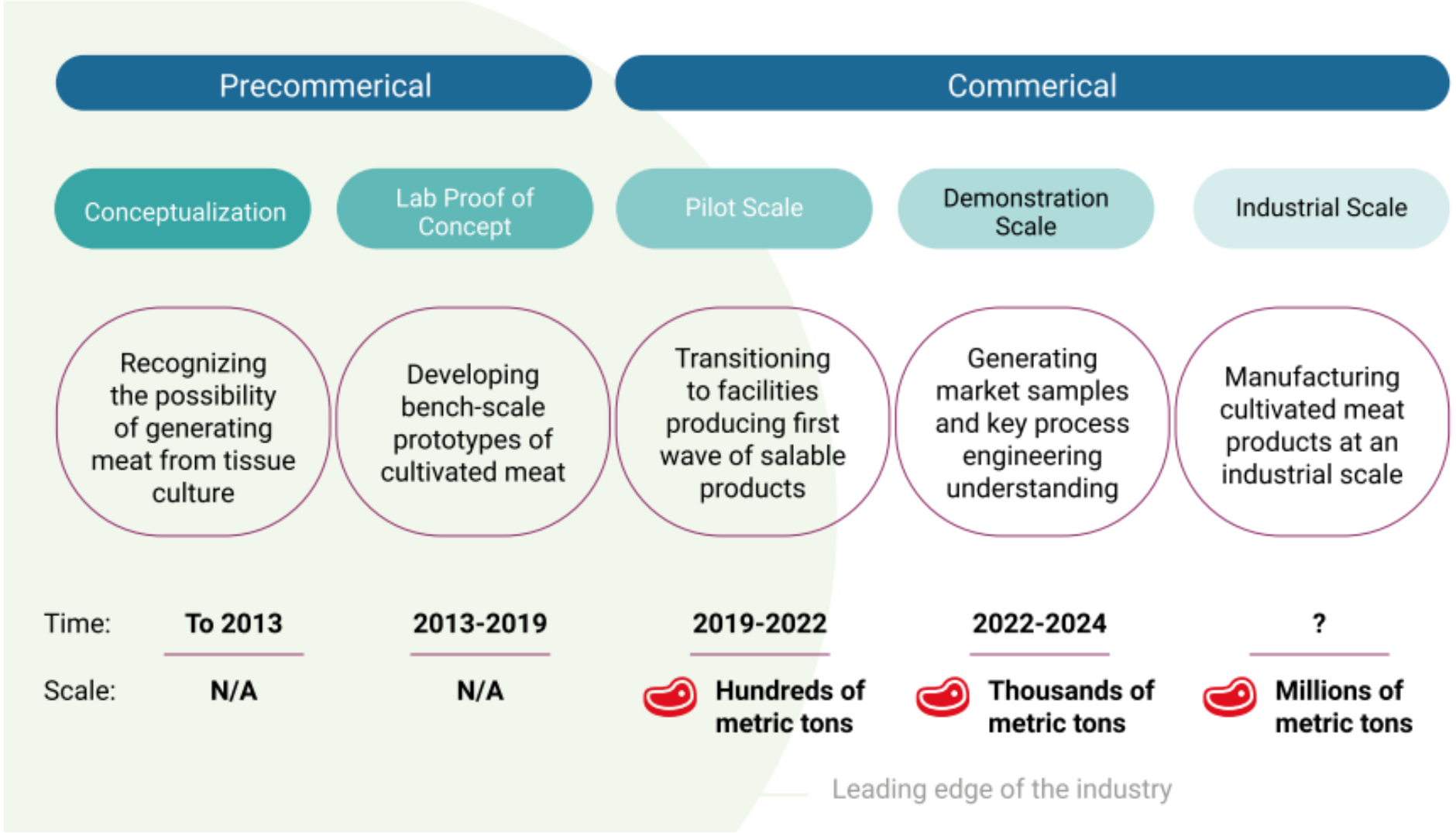
4 Validazione della tecnologia in laboratorio

3 Dimostrazione della prova del concetto

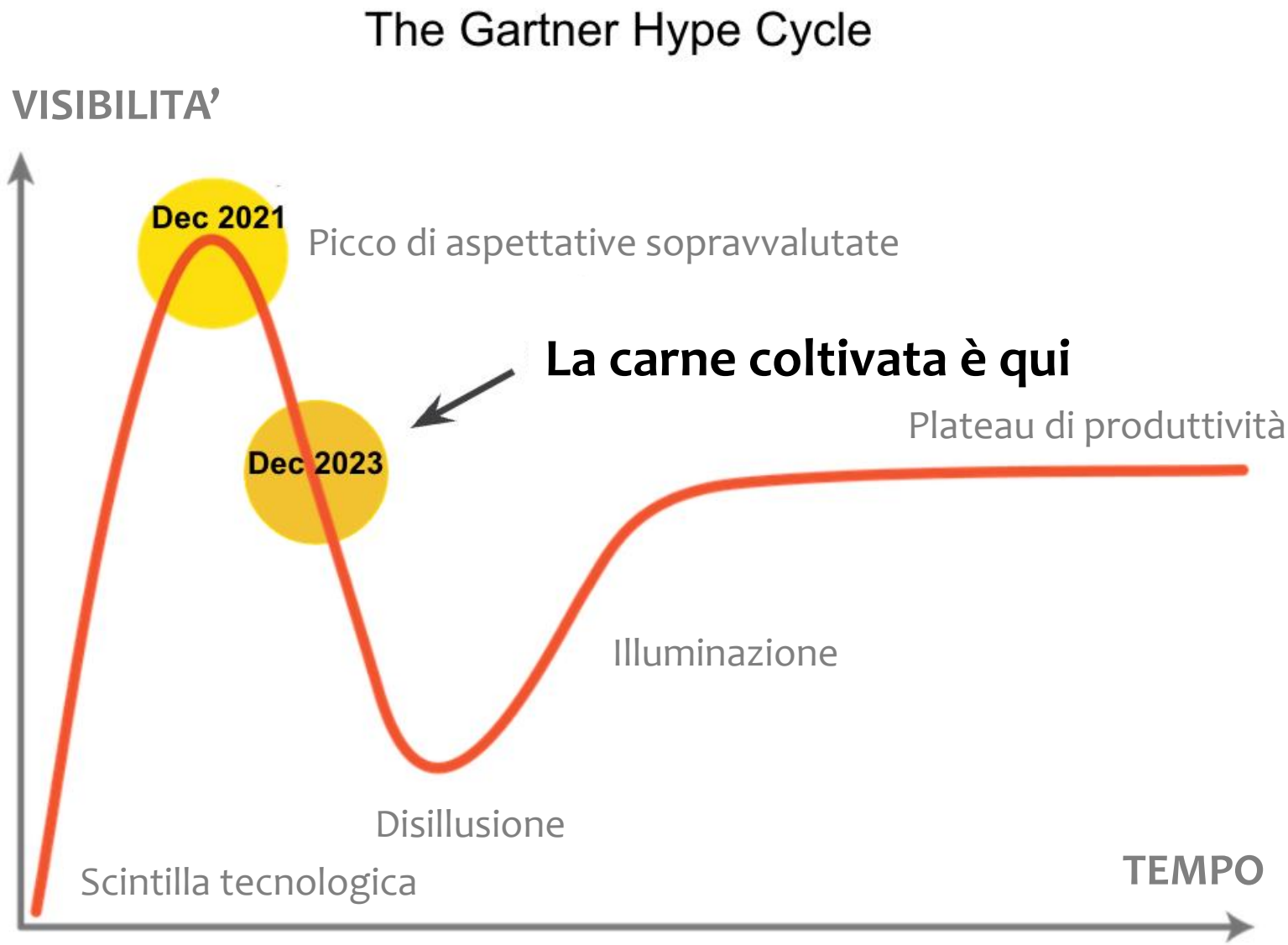
2 Formulazione del concetto tecnologico

1 Osservati i principi di base

La tecnologia non è pronta



C’è più hype che tecnologia



Conclusioni: la tecnologia ha potenziale

Tecnologia in via di sviluppo

- Produzione
- Sostenibilità

Scalabilità e regolamentazione da risolvere

- Integrazione con società

Necessità di investimenti pubblici

Grazie per l’attenzione!

Agricoltura Cellulare Italia

Agricoltura Cellulare Italia

Agricoltura Cellulare Italia

@cellularagricultureitaly

@AgricolturaCellulareItalia

www.cellag.it