

Cultured Meat and Emerging Technologies

December 10, 2013

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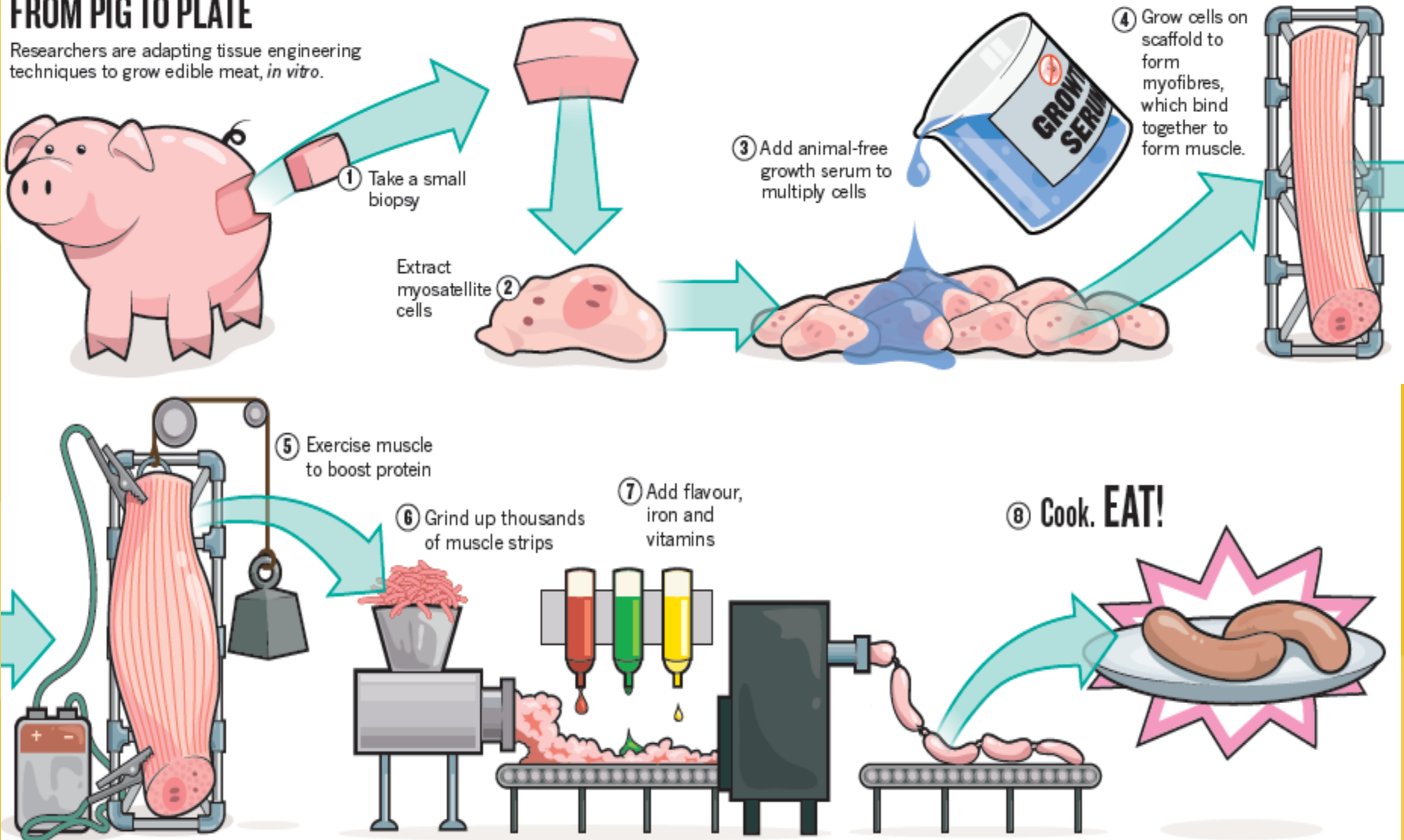
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Center for Earth Systems Engineering and Management

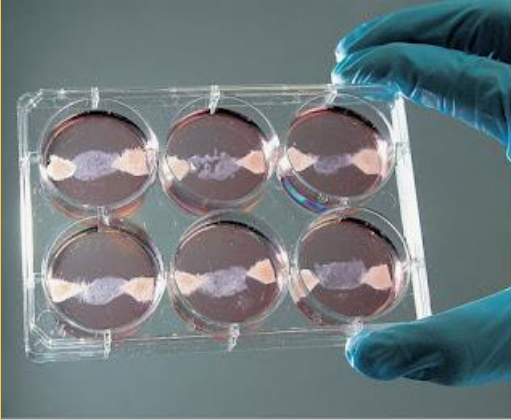
Cultured Meat

FROM PIG TO PLATE

Researchers are adapting tissue engineering techniques to grow edible meat, *in vitro*.



Cultured Meat



- Not yet commercially available
- Not yet reviewed by any regulatory bodies
- Prototypes have been cooked and consumed by researchers (August 5, 2013, latest)

Cultured Meat

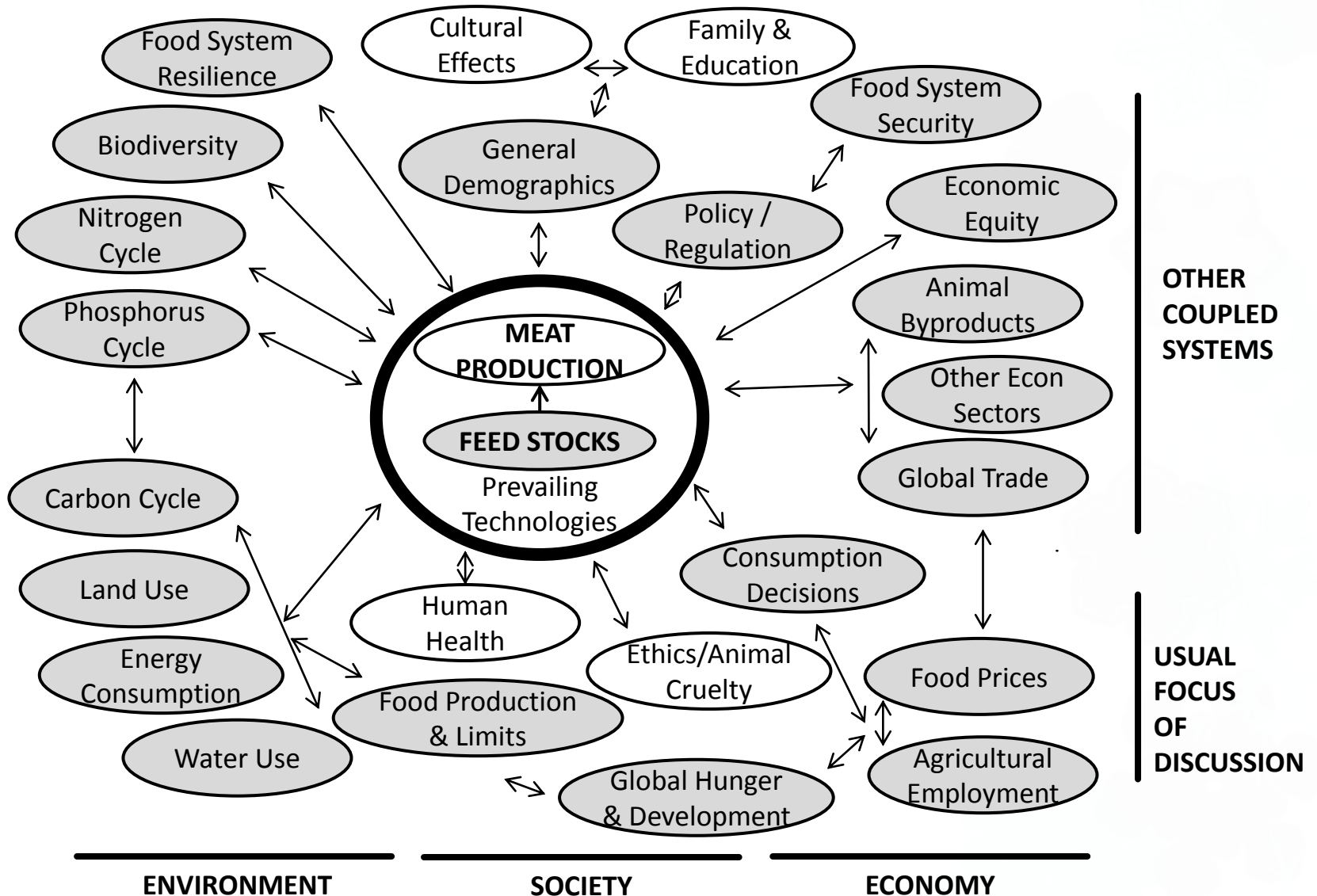


- Cruelty-free?
- Vegan-friendly?
- Non-GMO (some designs)?
- Solution for global hunger?
- Geoengineering (CO₂ and methane reduction technology)?

Embedded Water

- To produce:
 - 1 ton of vegetables requires about 1,000 cubic meters of water
 - 1 ton of wheat requires about 1,450 cubic meters
 - 1 ton of beef requires 42,500 cubic meters

Complex Implications



Cultured Meat: A Few Implications

- For thousands of years, food defined by available production technology (e.g., cow, pig, corn plant). Now food becomes design space.
- Design the human, food, and pharma as an integrated system.
- Personalized food design.
- Is cultured meat based on human stem cells cannibalism?

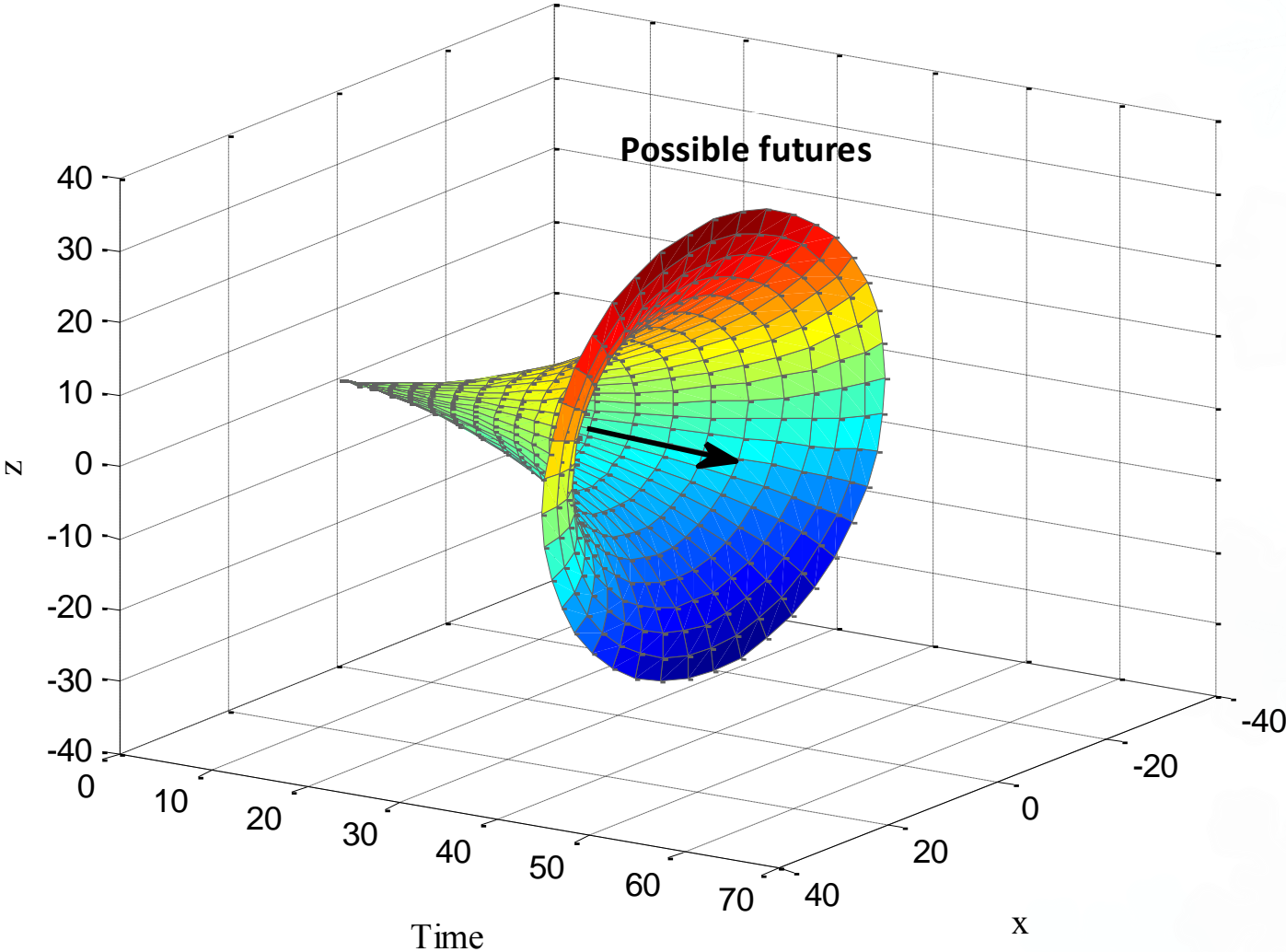
Cultured Meat as Earth Systems Engineering

- Age of human impact on global systems:
 - **Global climate change**
 - **Nitrogen**
 - **Biodiversity**
 - **Economy**
 - **Technology systems**
 - **Social and cultural behavior (mass consumption)**
 - **Water**

Broader Implications

- Technology systems such as cultured meat do not simply change the picture; they change the frame. They create new earth system states.
- That change will occur is certain; what it will look like is unpredictable and uncertain.

Project Social Future



Broader Implications

- The gale of creative destruction will become a hurricane, leading to greater political and social tension and conflict.
- Social and cultural dimensions are more difficult to analyze than economic and environmental.

Broader Implications

- Choosing not to innovate and change will not stop technological evolution; it will merely assure that someone else succeeds (cf EU effort to halt GMOs).
- As we design food, or implement any major technology system, we design the environment.

Broader Implications: Policy

- Policy or technological silver bullets are sub-optimal; substitute easily reversed or altered, low amplitude but high frequency decision-making, and technology portfolios.
- Encourage pluralistic dialog, rather than policy responses reflecting single ideologies (know when you're dealing with an ozone depletion event, where an environmentalist perspective is adequate, versus climate change).

Broader Implications: Policy

- Recognize that preliminary analyses are scenarios, not predictions, and use them to create policy option spaces.
- Don't implement policies based on scenarios, or dystopian and utopian hypotheticals.

Broader Implications: Policy

- Technology commercialization is critical phase, because it's where future paths are established by present choices.
- Practice continuous learning, guided by metrics that tell you when system has jumped the rails you thought it was on.

Technology Policy Matrix: Factory Food

| Technology Level \ Policy Response | Goals and Effects | Policy Response |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level I: As food | Create healthy food at reasonable price | Goals and technology align; therefore adopt technology. |
| Level II: As part of food system | Achieve desirable impacts on existing food import/export patterns, on associated income redistribution, and on food security | Implement technology, but technology alone may not lead to achievement of stated goal |
| Level III: As earth systems | Impacts on human design of integrated food/human/pharma capability; impacts on Earth systems of changes in elemental and hydrologic cycles; long term cultural implications of shifting from “food as nature” to “food as industrial” mental models? | Level I and Level III implications potentially in fundamental conflict. Might be effective food, but enable increasing population load with associated, less desirable, effects. Cultural implications of enforcing “terraformed earth” mental models unknown but likely to be substantial |

**“He, only, merits freedom and existence
who wins them every day anew.”**

(Goethe, 1833, *Faust*, lines 11,575-76)