THE UNIVERSITY *of* EDINBURGH
The Royal (Dick) School of Veterinary Studies

Global Agriculture and Food Systems

The Future of Livestock in Global Food Systems

Symposium 2025

Better lives through livestock

Role of livestock in livelihoods
Focus on lower income countries

Global Agriculture and Food Systems
Symposium 2025: the Future of Livestock in Global Food Systems

Edinburgh, 25th April 2025

Isabelle Baltenweck
International Livestock Research Institute

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

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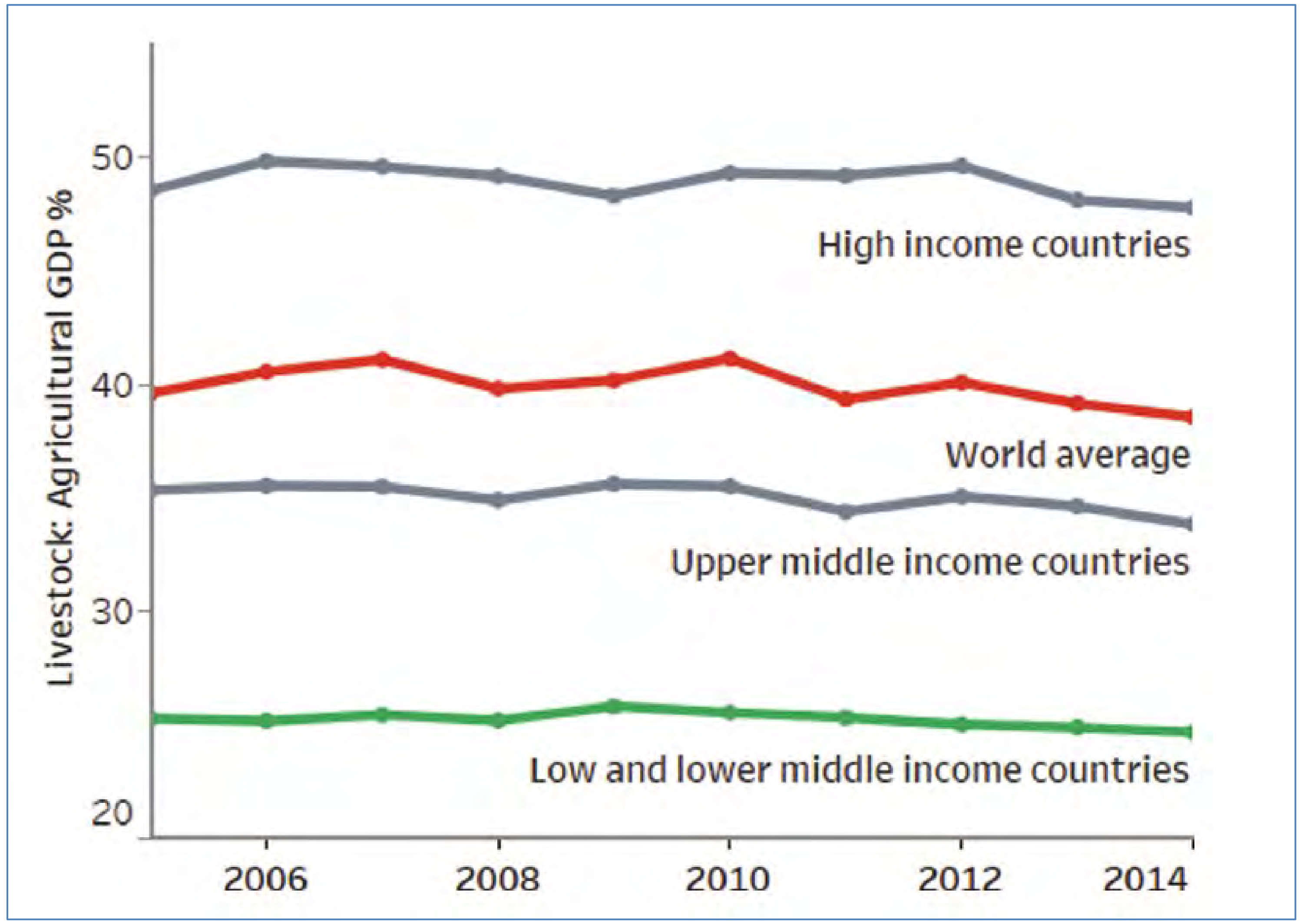
At national level: livestock contributes significantly to agricultural Gross Domestic Product—*everywhere*

Livestock contributions to agricultural GDP:
- **Global** average: **40%**
- **HIC** average: **50%**
- **LMIC** average: from **15–80%—**and this is growing

As economies grow, the proportion of:
- **agriculture's** contribution to total GDP **shrinks**
- **livestock's** contribution to agriculture GDP **rises**

Caveat! GDP measures **exclude** many **'hard-to-measure'** livestock functions (e.g. manure fertilizer, ecosystem services), especially important in LMICs.



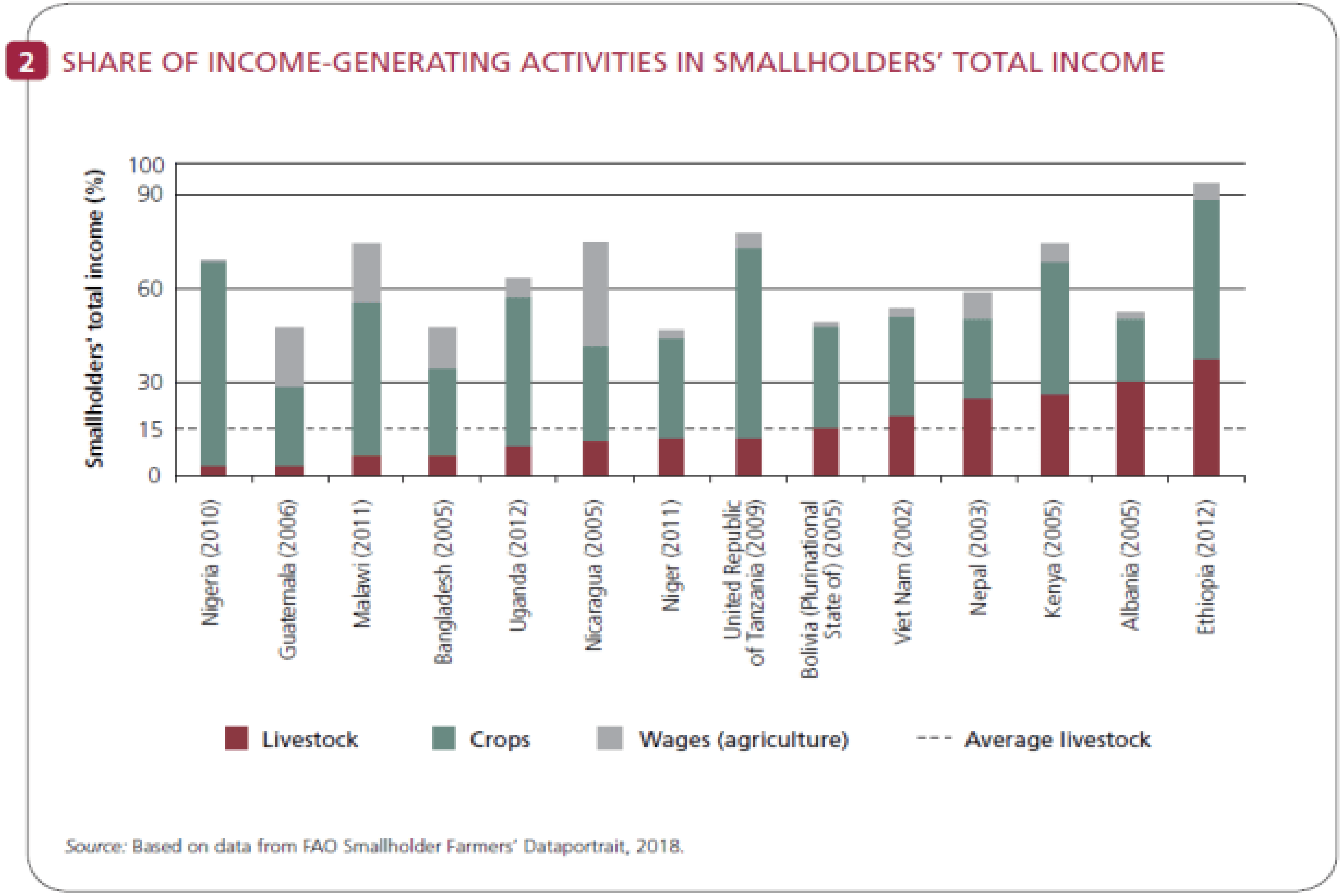
At household level, livestock contribute significantly to smallholder incomes

Across 12 LICs, livestock contributions to household incomes in 2011 were: **12%** on average (2–24% range)

Across 14 LMICs, livestock contributior to household incomes in 2018 were:

- **15%** on average
- With a range of highs in Ethiopia (37%), Albania (28%) and Kenya (25%) and lows in Guatemala (3%) and Nigeria (3%)

In pastoral systems, livestock income makes up at least **40%** of household incomes



Otte, Joachim et al; https://documents.worldbank.org/curated/en/101271468151472539/Livestock-assets-livestock-income-and-rural-households-cross-country-evidence-from-household-surveys; and FAO. 2018. World Livestock: Transforming the livestock sector through the Sustainable Development Goals. Rome. 222 pp. Licence: CC BY-NC-SA 3.0 IGO.

Resilience: livestock help insure pastoralist households against shocks

Livestock keeping is one of very few livelihood options in challenging settings such as drylands

- Nearly 200 million pastoralists produce food and generate incomes where crop farming is limited, risky or impossible

In Niger, most households (**60%**) rely on sales of animals to cope with food shortages or unexpected medical expenditures

In Kenya, pastoralist households covered by index-based livestock insurance (IBLI):

- were less likely (by **36%**) to be forced into distress sales of stock
- were less likely (by **25%**) to have to reduce the size of their meals
- were less dependent (**33%**) on food aid

Alary V., et al., 2011. Livestock's contribution to poverty alleviation : How to measure it? http://dx.doi.org/10.1016/j.worlddev.2011.02.008

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Livestock asset transfer programs & development impacts

Livestock asset transfer programs are positive mechanisms to improve rural livelihoods, resilience, and household nutrition

- Increased incomes in 6 LMICs by **5%**, livestock revenue by **13%** and food security by **4.4**% over 3 years [as part of a graduation program]
- Increased household dairy income in Rwanda (via a 'One cow per poor family' initiative) by **3–6 times**
- Enhanced resilience by **44%** and household assets by **125%** in Zambia (over 3.5 years)
- Other important livelihood indicators– capacity to save, reduced anxiety, enhanced nutrition and health

Table 1. Impact results from six studies

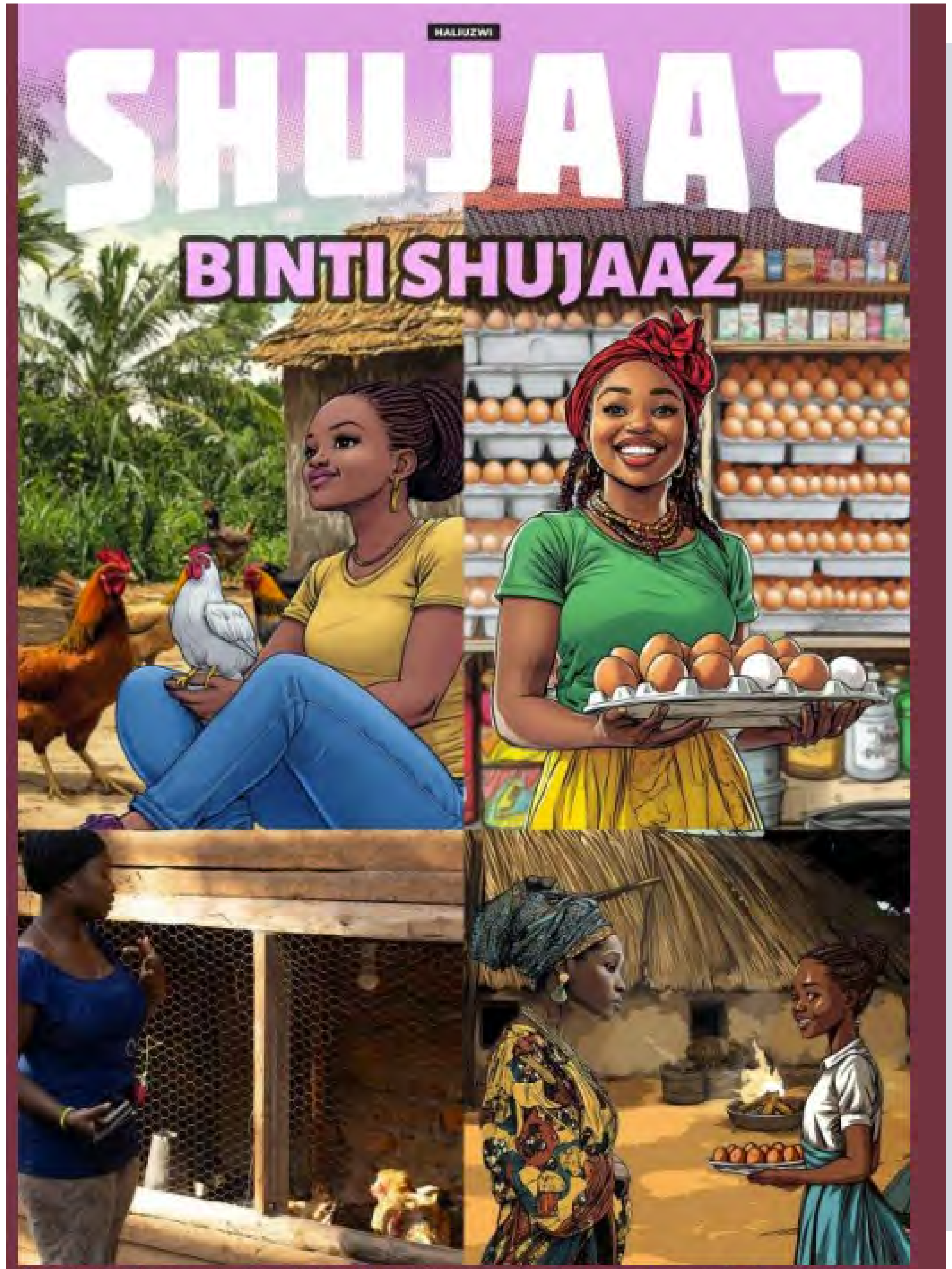
Income/consumption expenditure			
Consumption expenditure (per household)	5.1% increase	Over 36 months	6 countries, Banerjee et al, 2015
Consumption expenditure (daily/capita)	20% increase	Over 18 months	Zambia, Kafle et al, 2016
Consumption expenditure (weekly/capita)	59% increase	Over 42 months	Zambia, Phadera et al, 2019
Consumption expenditure (per capita)	Increases of 22% - goat keepers 29% - cattle keepers	Over 18 months	Zambia, Jodlowski et al, 2016
Livestock revenue (per household)	12.9% increase	Over 36 months	6 countries, Banerjee et al, 2015
Milk income (per household)	3 – 6 times that of hhs not trained	Point in time comparison with hhs not trained	Rwanda, Argent et al, 2014
Assets and savings			
Household assets (index)	9.2% increase	Over 36 months	6 countries, Banerjee et al, 2015
Household assets (index)	125% increase	Over 42 months	Zambia, Phadera et al, 2019
Household assets (index)	14% more than hhs not trained	Point in time comparison with hhs not trained	Rwanda, Argent et al, 2014
Household asset types	8% more types than hhs not trained	Point in time comparison with hhs not trained	Rwanda, Argent et al, 2014
Savings	13.6% increase	Over 36 months	6 countries, Banerjee et al, 2015
Food security and resilience			
Food security (index)	4.4% increase	Over 36 months	6 countries, Banerjee et al, 2015
Food security (self reported improvement)	Increased (dairy hhs only)	Over 18 months	Zambia, Kafle et al, 2016
Resilience (index)	44% increase	Over 42 months	Zambia, Phadera et al, 2019
Anxiety (index of symptoms)	57% decrease	Over 18 months	DRC, Glass et al, 2017
Nutrition and health			
Diet diversity (food groups per day)	+1 group 5.4 days per week- cattle keepers +1 group 3 days per week – goat keepers	Over 18 months	Zambia, Jodlowski et al, 2016
Diet diversity (food groups per day)	Increase of 1.2 on average	Over 18 months	Zambia, Kafle et al, 2016
Diet diversity (food groups per last 2 days)	Increase of 1.17 on average	Participants vs control hhs	Rwanda, Rawlins et al, 2014
Milk consumption	3 times more	Participants vs control hhs	Rwanda, Rawlins et al, 2014
Stunting among children (height for age)	18.4% less	Participants vs control hhs	Rwanda, Rawlins et al, 2014
Subjective health (score)	8.2% improvement	Over 18 months	DRC, Glass et al, 2017

Staal, S. and Wanyoike, F. 2022. Livestock keeping improves livelihoods in developing countries. Evidence of livestock impacts in sustainable development Brief 1. Nairobi, Kenya: ILRI. https://hdl.handle.net/10568/118449

Livestock for gender equity and social inclusion

- Most livestock in LMICs are raised by women, especially in rural areas, where two-thirds of livestock keepers are women
- Animals are often the only productive asset that women are allowed to own and manage
- Studies show that increasing women's roles in livestock management decisions is associated with positive impacts on women's welfare, increased livestock assets, reduced debt, and increased incomes, as well as decreased anxiety symptoms and improved subjective health scores
- But development interventions have mixed effects
  - Most asset transfer projects combined with extension had positive effects
  - Interventions focusing on output markets negatively impacted women's empowerment
  - Gender accommodative approaches had negative or unclear impacts on women's labour and workloads as the focus is often on increasing incomes

An example– addressing gender norms preventing women from participating in chicken business in Tanzania



Binti Shujaaz" means heroine in Swahili, a fitting name for the young women featured in the comic.

- Chicken business offers a rare and good income earning opportunity for young women
- New breeds– adapted to context yet more productive- are available. *How can they be leveraged for enhancing women's empowerment?*
- Restrictive gender norms are a barrier to women growing their businesses, getting necessary inputs, and accessing financial services and profitable markets
- Reaching remote women with a 'poultry package including marketing' is effective and increased empowerment was reported by women farmers and agripreneurs
- Addressing gender norms about women in chicken business at various levels is necessary for women to benefit from poultry business
- This includes working with a social media company, Shujaaz, to promote a positive image of women in chicken business along with men who support them and engage youth in norm-shifting conversations.

Campbell, Z. 2024. Binti Shujaaz: Young Women in Business in Tanzania. Poster prepared for the ILRI at Fifty, Nairobi, 29 November 2024. Nairobi, Kenya: ILRI. https://hdl.handle.net/10568/169430

Livestock in overall farming systems and socio-cultural roles

- Farm productivity & livestock in mixed system
  - Animal manure to maintain soil fertility
  - Animal traction
  - Animal feeding on crop residues
- Dowries & livestock used in many communities in Asia and Africa
- Prestige associated with livestock
- Livestock products for religious and social events

In conclusion, multiple pathways will take us to sustainable and equitable livestock futures

Identifying synergies and trade-offs across dimensions of sustainability is key
How do we include different voices in these discussions?

- Affordable, accessible, balanced, nutritious diets incl. the choice of milk, meat, eggs
- Healthy animals, safe food, healthy people
- Every citizen & nation is able to benefit fully from sustainable livestock systems
- Inclusive, fair and equitable livestock development
- Efficient, low-carbon livestock systems that enhance, not harm, environments
- A healthy planet, with rich biodiversity and sustainable water use

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INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CGIAR

The International Livestock Research Institute (ILRI) is a non-profit institution helping people in low- and middle-income countries to improve their lives, livelihoods and lands through the animals that remain the backbone of small-scale agriculture and enterprise across the developing world. ILRI belongs to CGIAR, a global research-for-development partnership working for a food-secure future. ILRI's funders, through the CGIAR Trust Fund, and its many partners make ILRI's work possible and its mission a reality. Australian animal scientist and Nobel Laureate Peter Doherty serves as ILRI's patron.

better lives through livestock

ilri.org

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- Make sure someone captures some notes on the flipchart

Global Agriculture and Food Systems Symposium 2025

Is Precision Fermentation a Farmers' Thing?

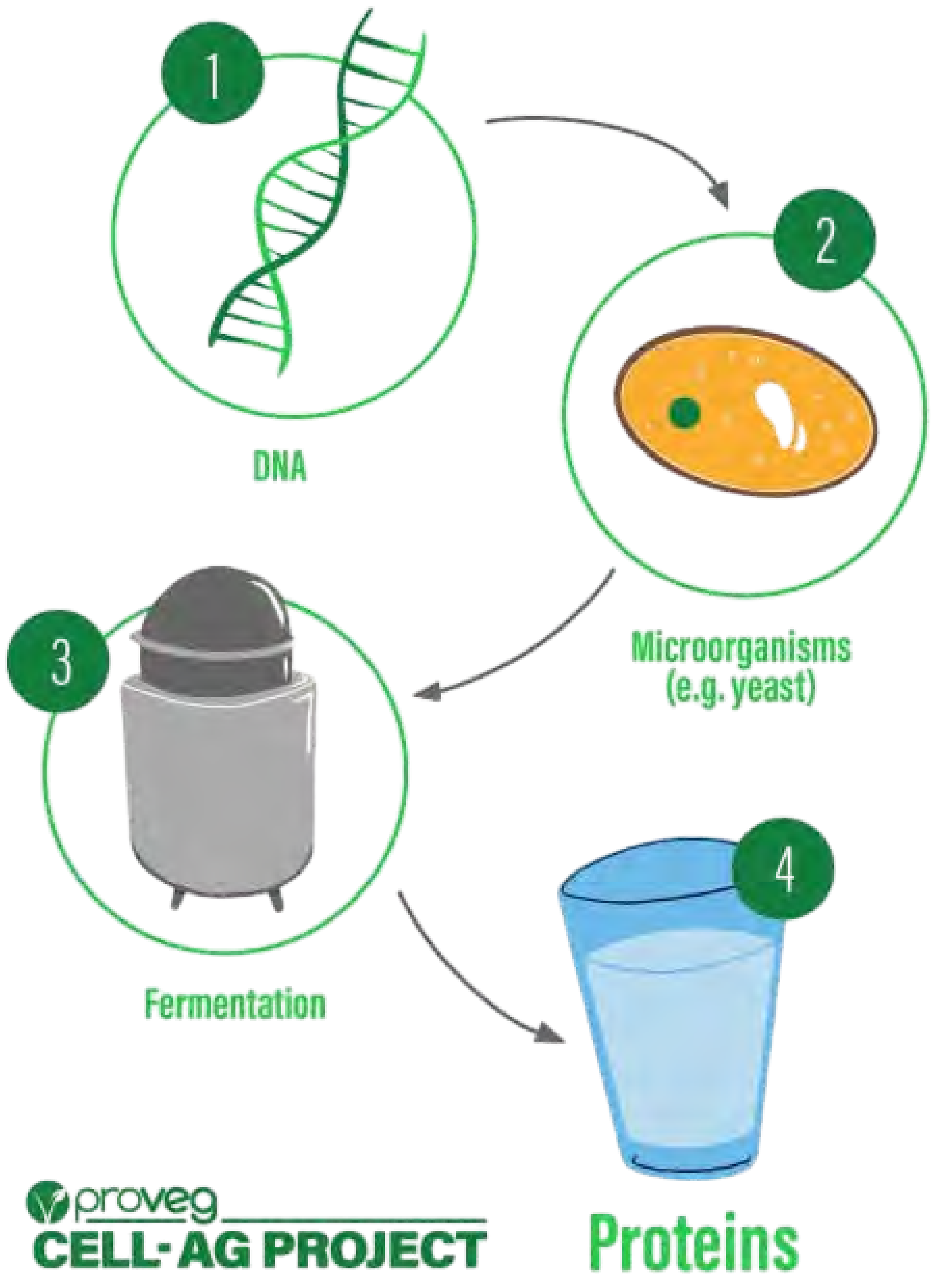
Integrating Dutch Dairy Farmers' Perspectives in Just Transitions

Dr. Mariana Hase Ueta

NWO
WAGENINGEN UNIVERSITY & RESEARCH

PRECISION FERMENTATION

- **New process** of production of **conventional foods** (milk, cheese,...)
- **Sustainable, safe and ethical** ?
- Discourse focused on **technology** and **markets**



Who participates in the process of the development of this technology?

BIG CHANGES IN THE HORIZON

CASEIN MICELLE

- Shifts protein production from **rural areas** to **fermentation labs**
- Involves different **relationships** (no cows)
- It demands **new professional expertise**

Who benefits from this new technology?

What happens to rural communities?

Who cares for the countryside?

What happens to the animals?

(Helliwell & Burton, 2021)

Dutch farmers at a crossroad

(DW, 2022)

- Social unrest in **opposition to the Dutch government's nitrogen strategy** for the transformation of rural areas (Government of the Netherlands, 2021)
- The idea that **"lab - grown food will soon destroy farming – and save the planet"** (Monbiot, 2020)
- The **portrayal of farmers and their lifestyle as incompatible with a future where fighting climate change** is a priority, and in this sense, would have to be on the losing end of change for sustainability (Räty et. al, 2023; Helliwell and Burton, 2021).

Temporality and the cost of opportunity

- The cost of conventional agriculture is increasing due to the **unpredictability of Climate Change**
- The **cost of not being part of the process**:
  - **Regulations will be built by and for other actors** (e.g. big companies)
  - **Lost of markets, new competitors**
  - **Dislocation of production chains**

(Globo Rural, 2024)

METHODOLOGY

Dutch Dairy Farmers
Family farms
Open to innovation

Interviews:

- Sample (n=15)
- Semi- structured interviews
- Farm visits
- Saturation point methodology
- Memories and individual perceptions

Intergenerational discussions:

- 2 groups (6 people)
- Interaction and contrast between different experiences of farming

(Hase Ueta, Robaey, Kunze, forthcoming)

Horizons of Change

How do the farmers remember **innovations in the past** ?

How do they **expect/fear the present** ?

How do they imagine their role in the **future of dairy production** ?

Horizons of Memory

Horizons of Expectation

Horizons of Imagination

Horizons of Change

- Making the entanglements explicit amid the tensions between the **Horizons of Memory** and **Horizons of Expectations** allows for paving the way for including them in possible futures, or what we call defining new **Horizons of Imagination**.
- These three horizons help give an empirical and normative account of change in the context of uncertainty and transformation.

A sustainable transition in food systems should prioritize the inclusion of different stakeholders in order to reach justice and autonomy

(Robaey et. al., 2022; Asveld et. al., 2023)

Circumstances

1 Financial

- self-funded/market rationale/trickle down rationale (having banks giving loans)
- funded by cooperative
- funded by government

2 Organizational

- individual (own farm for the whole process)
- produce feedstock for coop
- provide/rent land for another company to produce

3 Technology transfer

- invent own process and learn
- big business
- government regulated (extension type of relationship)

CONCLUSION

- **Time is key** : This technology is still in development, so there is still time for the farmers to be part of it.
- **Imagination** must be an active practice of bringing these **different perspectives together** .
- There is not one ideal sustainable future: so what are the **different visions of the future, and by whom are they being constructed** ?
- Bringing together these visions would lead to a more **inclusive, sustainable technology development** .

THANK YOU!

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This publication is part of the 'Animal - free milk proteins' project (with project number NWA.1292.19.302) of the NWA research programme 'Research along Routes by Consortia (ORC)', which is funded by the Dutch Research Council (NWO).


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2025 10 YEARS OF SCIENCE

Technological opportunities to enhance the role of livestock in supporting livelihoods

Professor Mizeck Chagunda

Director CTLGH Chair, Tropical Livestock Genetics

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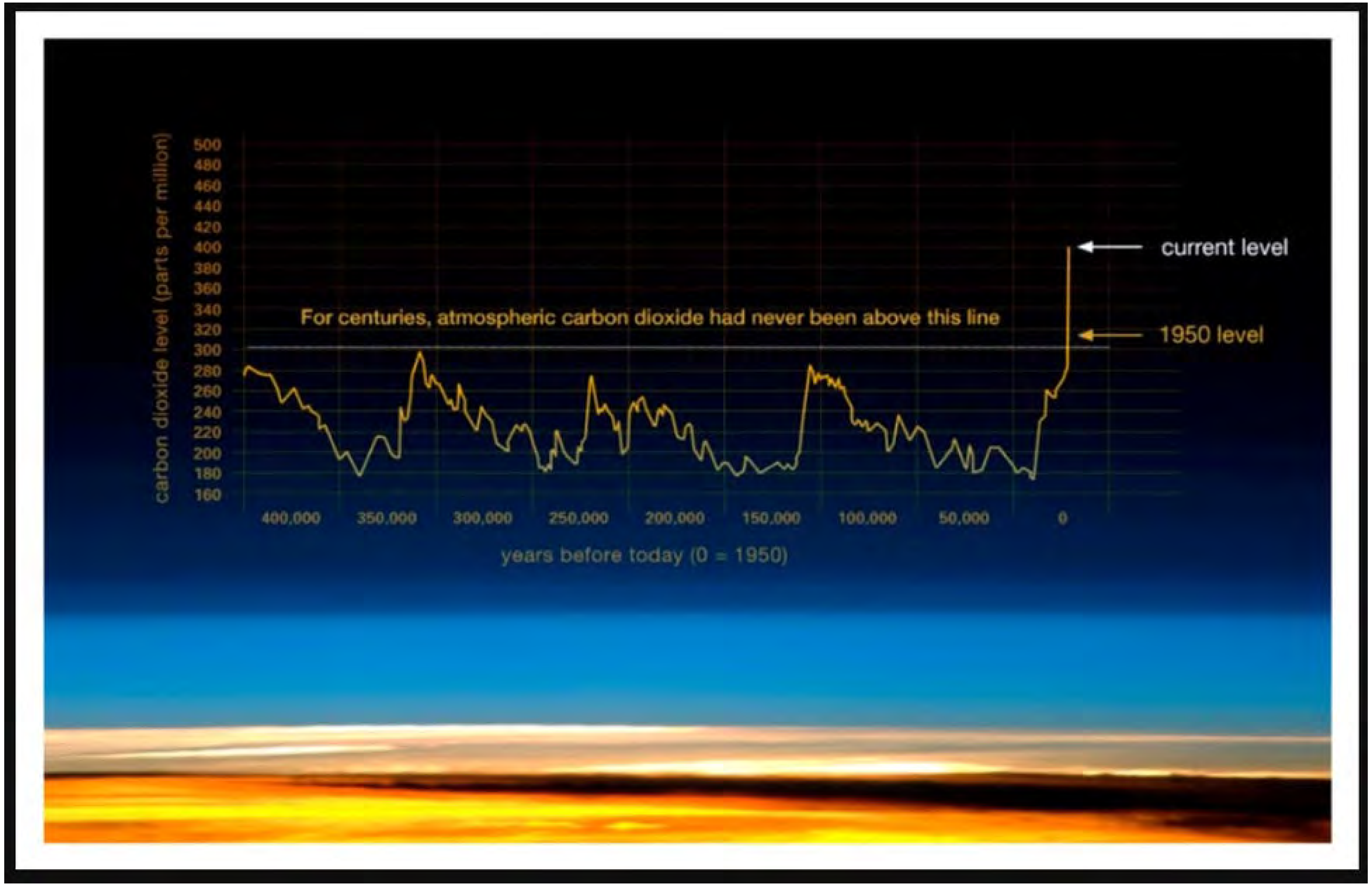
Some of the major global challenges

- Climate change
- Human Population growth
- Biodiversity loss
- Water quality and quantity variability
- A world of elevated atmospheric carbon dioxide levels

A world of elevated atmospheric CO_2



Carbon dioxide level over the past 400,000 years (NASA, Global Climate Changes, 2020)

Consequences

- Higher concentration of carbon dioxide stimulate photosynthesis, the process by which plants convert CO2 into sugars (carbohydrates) using sunlight.
- This increased carbohydrate production can lead to greater biomass and yields in some plants, particularly C3 plants like wheat, rice, and potatoes.
- Under elevated CO2, leaf non-structural carbohydrates (sugars and starches) increase by 30-40%.

Hideaki and Kousuke, 1998.; Taub,D., 2010); Thompson et al., 2017

But then ...

LETTER

doi:10.1038/nature13179

Increasing CO_2 threatens human nutrition

Samuel S. Myers[1,2], Antonella Zanobetti[1], Itai Kloog[3], Peter Huybers[4], Andrew D. B. Leakey[5], Arnold J. Bloom[6], Eli Carlisle[6], Lee H. Dietterich[7], Glenn Fitzgerald[8], Toshihiro Hasegawa[9], N. Michele Holbrook[10], Randall L. Nelson[11], Michael J. Ottman[12], Victor Raboy[13], Hidemitsu Sakai[9], Karla A. Sartor[14], Joel Schwartz[1], Saman Seneweera[15], Michael Tausz[16] & Yasuhiro Usui[9]

Dietary deficiencies of zinc and iron are a substantial global public health problem. An estimated two billion people suffer these deficiencies[1], causing a loss of 63 million life-years annually[2,3]. Most of these people depend on C_3 grains and legumes as their primary dietary source of zinc and iron. Here we report that C_3 grains and legumes have lower concentrations of zinc and iron when grown under field conditions at the elevated atmospheric CO_2 concentration predicted for the middle of this century. C_3 crops other than legumes also have lower concentrations of protein, whereas C_4 crops seem to be less affected. Differences between cultivars of a single crop suggest that breeding for decreased sensitivity to atmospheric CO_2 concentration could partly address these new challenges to global health.

experiments contribute more than tenfold more data regarding both the zinc and iron content of the edible portions of crops grown under FACE conditions than is currently available in the literature. Consistent with earlier meta-analyses of other aspects of plant function under FACE conditions[14,15], we considered the response comparisons observed from different species, cultivars and stress treatments and from different years to be independent. The natural logarithm of the mean response ratio (r = response in elevated $[CO_2]$/response in ambient $[CO_2]$) was used as the metric for all analyses. Meta-analysis was used to estimate the overall effect of elevated $[CO_2]$ on the concentration of each nutrient in a particular crop and to determine the significance of this effect (see Methods).

We found that elevated $[CO_2]$ was associated with significant decreases in the concentrations of zinc and iron in all C_3 grasses and le-

Why would this be?

- In crops like rice, wheat, and potatoes, elevated concentrations of atmospheric carbon dioxide reduces the concentration of protein, calcium, potassium, zinc, and iron.

- In some cases this reduction is by 8% on average.

- Diets that are deficient in minerals and other nutrients can cause malnutrition, even if a person consumes enough calories (Hidden Hunger)

- This reduction in the nutritional value of plants could have profound impacts on human health

Loladze, I., 2014

An Opportunity for livestock?

Nutrient	Deficiencies	Animal source
Vitamin A	Impairs immunity and hematopoiesis	Dairy, Liver, Egg yolk, Fish liver oil
Iron	Anemia	Meats , Fish
Zinc	Immunity	Meats, Fish
Calcium	Many severe consequences	Dairy, Fish
Riboflavin	Many severe consequences	Dairy, Organ Meats, Eggs
Vitamin B12	Many severe consequences	Animal Food Sources only (Algae)


But then…
…livestock contribute to and are victims of climate change

Livestock contribute to the global methane emissions

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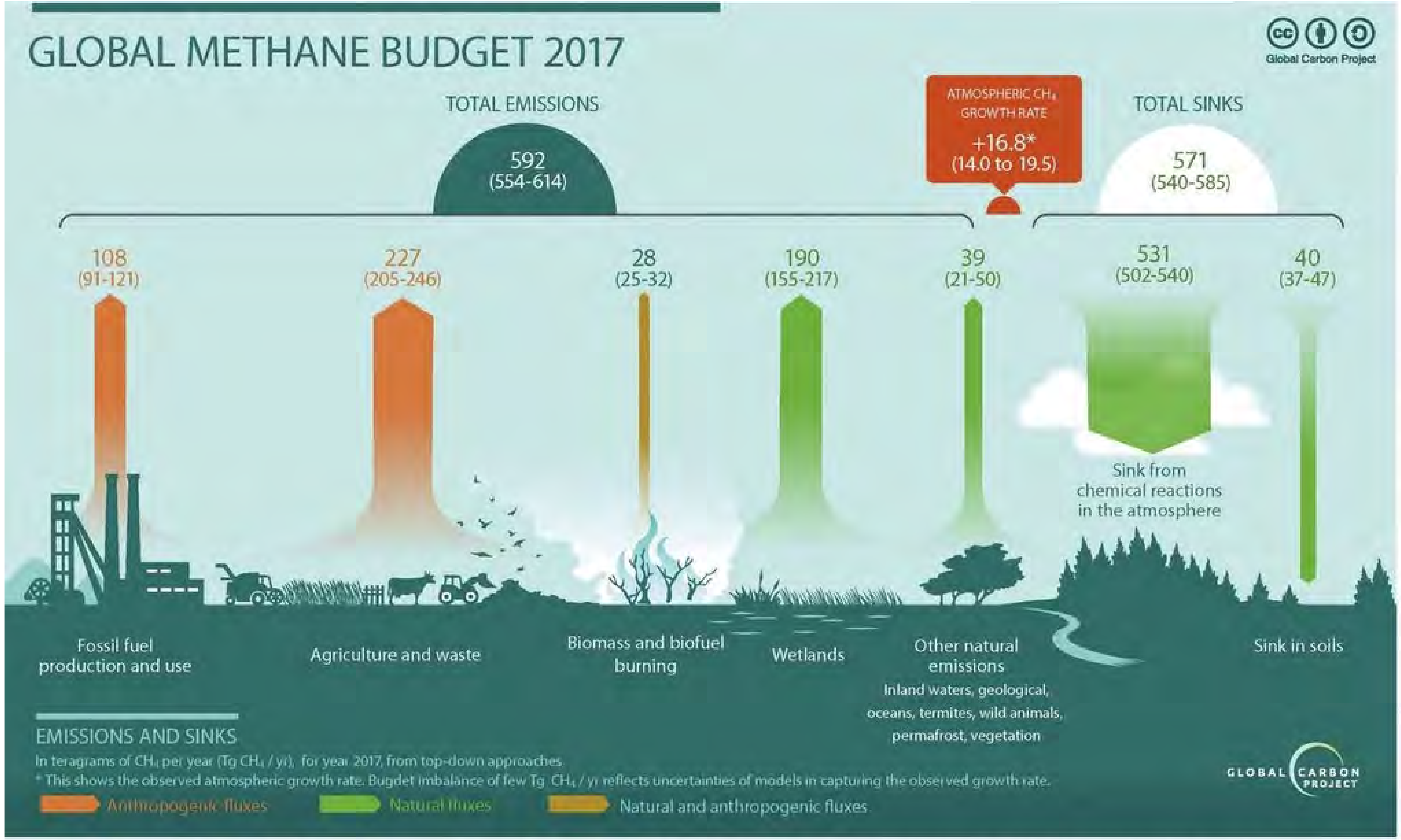

Infographic published with permission from the authors of "Increasing anthropogenic methane emissions arise equally from agricultural and fossil fuel sources." (Credit: Jackson et al. 2020, Environmental Research Letters)

The Guardian

„Anthropogenic methane arise equally from Agriculture and fossil fuel sources"

Methanogenesis

- Methane (CH_4) is produced as part of the normal digestive process in ruminants.
- Methane is formed in the rumen by methanogens (archaea) taking hydrogen and CO_2 produced by other microbes to form methane
- $4H_2 + CO_2 = CH_4 + 2H_2O$
- Other bugs include protozoa, fungi and bacteria
- 95% of methane emitted is exhaled through the mouth and nose

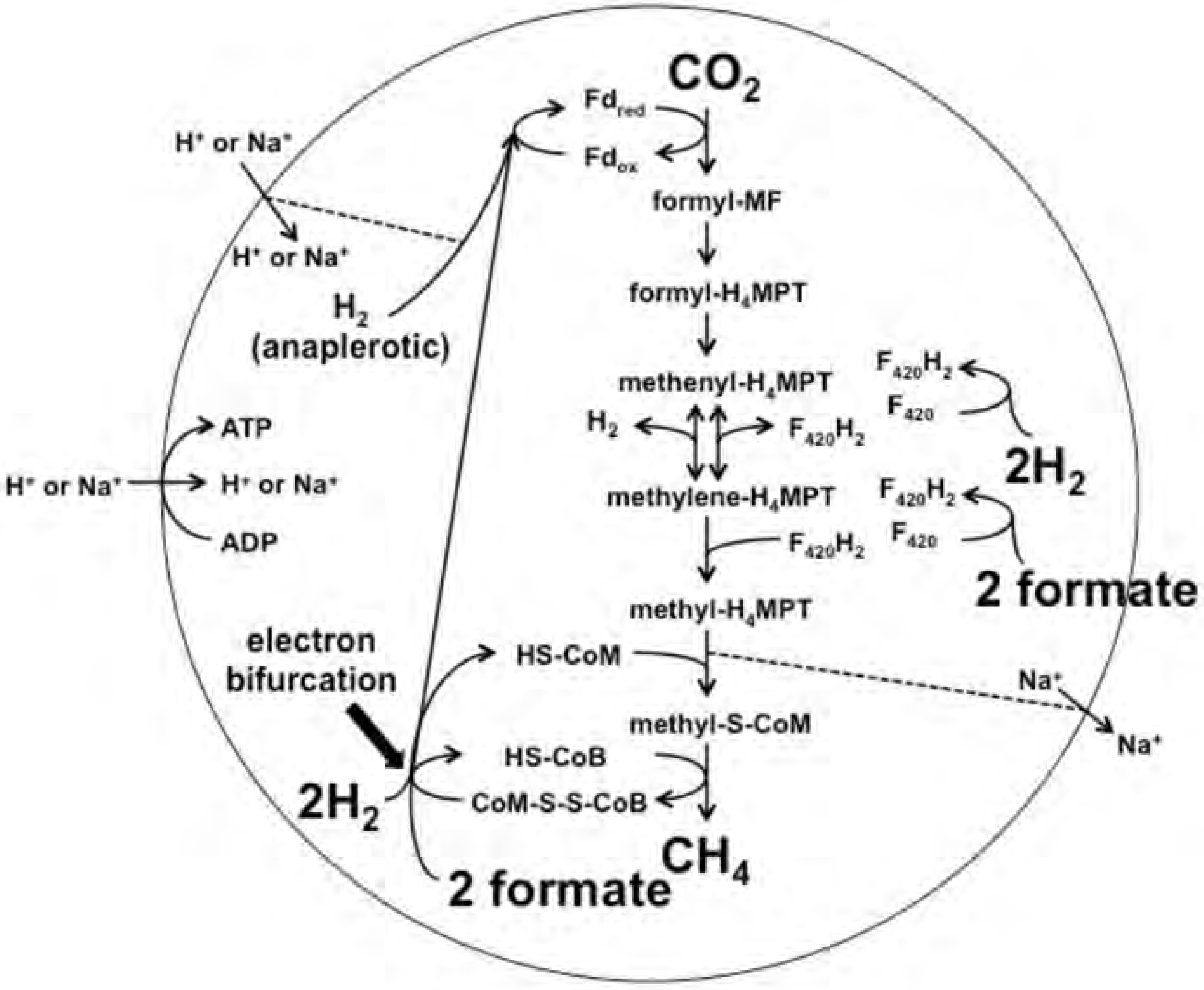

Diagram of Methanogenesis

Source: University of Washington Department of Microbiology

Victims

Need for technologies to enhance the role of livestock in supporting livelihoods

- To monitor and plan
- To measure and innovate
- To predict and mitigate
- For improvement and for conservation

Physical technologies

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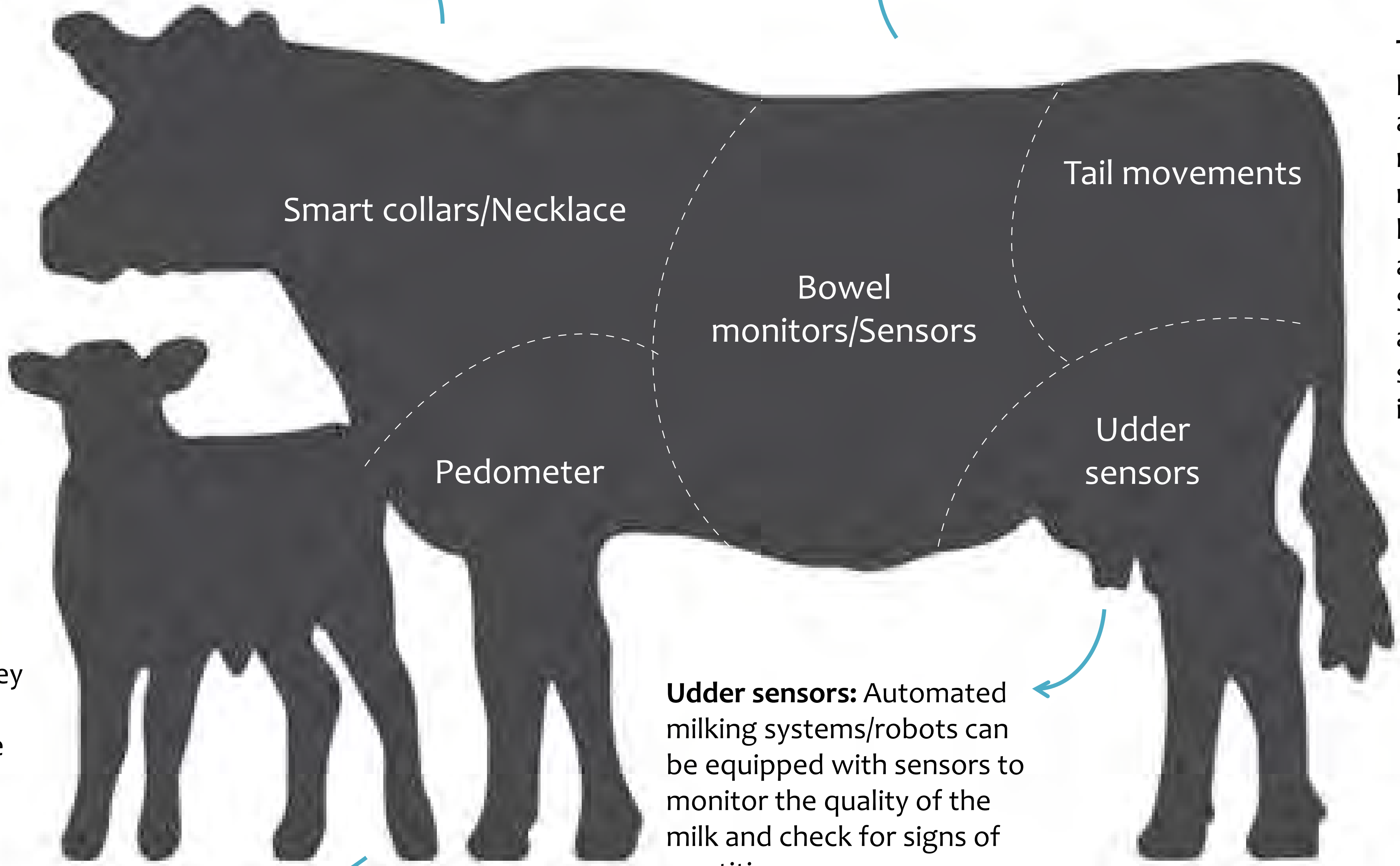
Smart/Satellite Collars: An RFID tag that monitors animal movement, temperature and feeding habits. The sensor can be used to detect health problems and to tell when an animal is on heat so that insemination can happen at an optimum time

Bowel monitors/sensors: A bolus type of sensor that is inserted into the animal's rumen to monitor acidity levels to help detect digestive problems and feed utilization efficiency

3D Digital and thermal cameras: Facial recognition and measures the weights and muscle mass of animals so that they are sold at their most beefiness. Records body temperature to monitor health/heat stress status



Tail movements: A birthing sensor attached to the tail to measure tail movements triggered by labour contractions and sends a farmer an SMS alert approximately two or so hours before a cow is due to calve.

Pedometers: Animals typically increase physical activities as they come into oestrus. The pedometer alerts farmers to the best time for insemination

Udder sensors: Automated milking systems/robots can be equipped with sensors to monitor the quality of the milk and check for signs of mastitis

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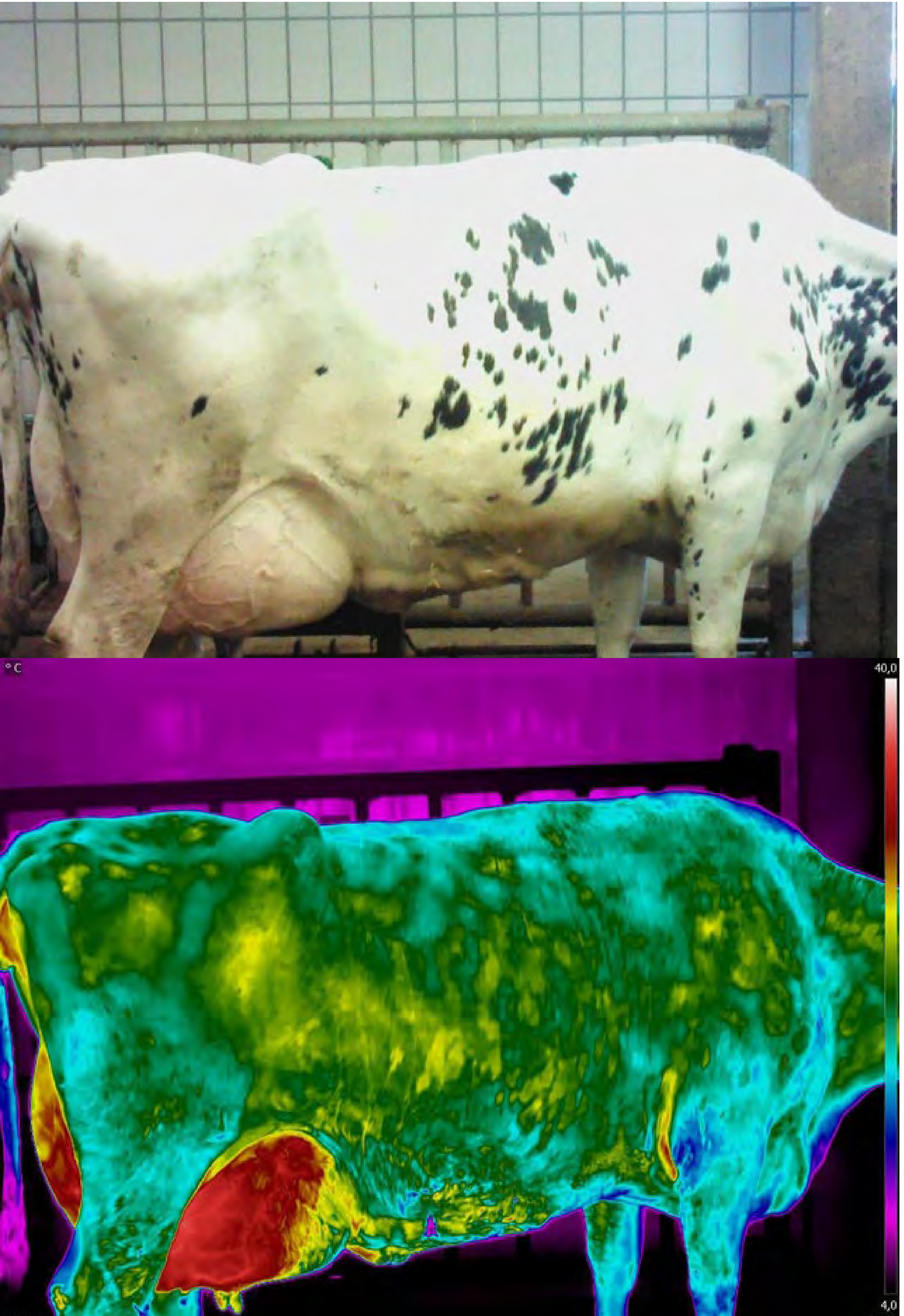
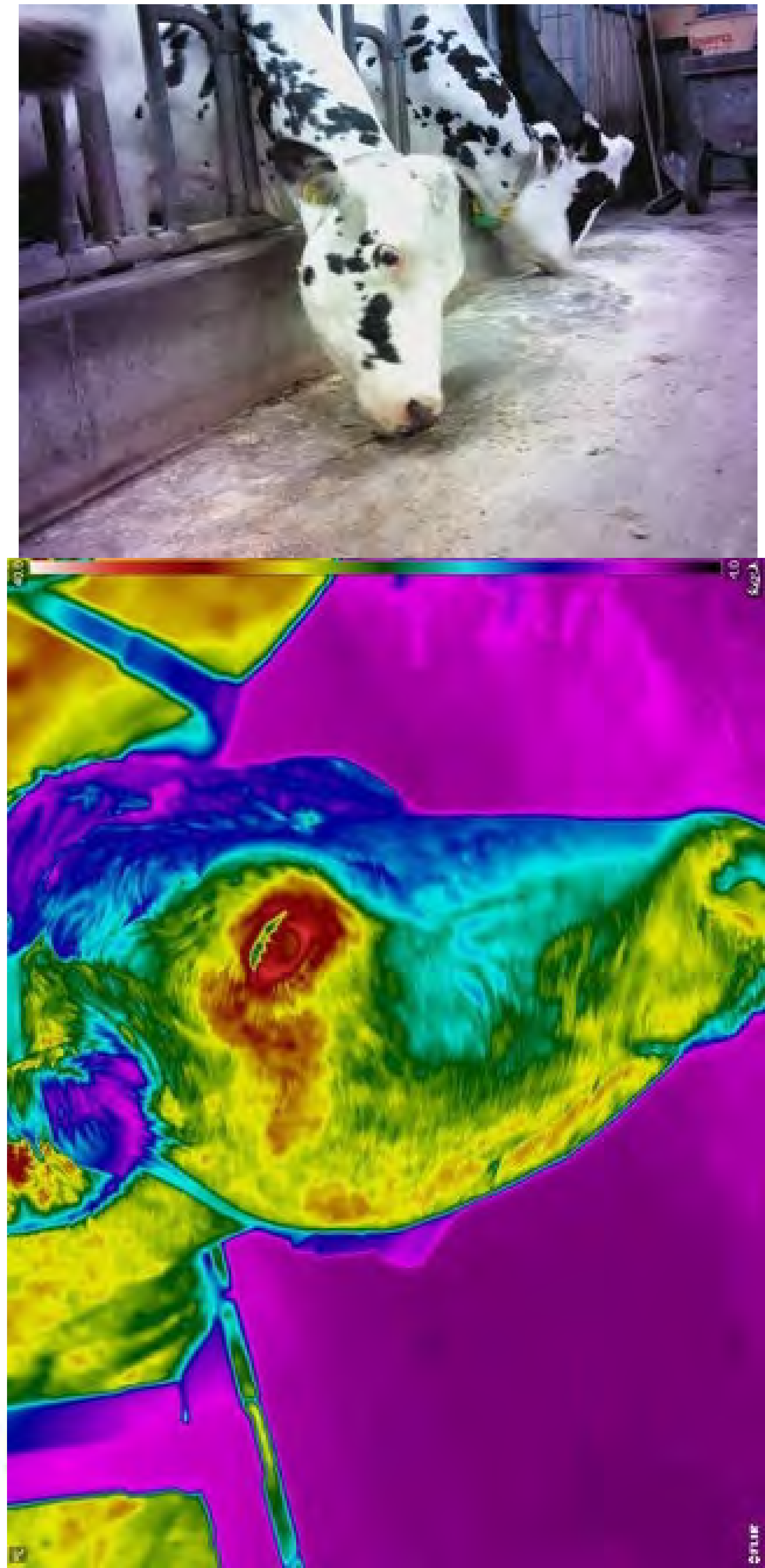
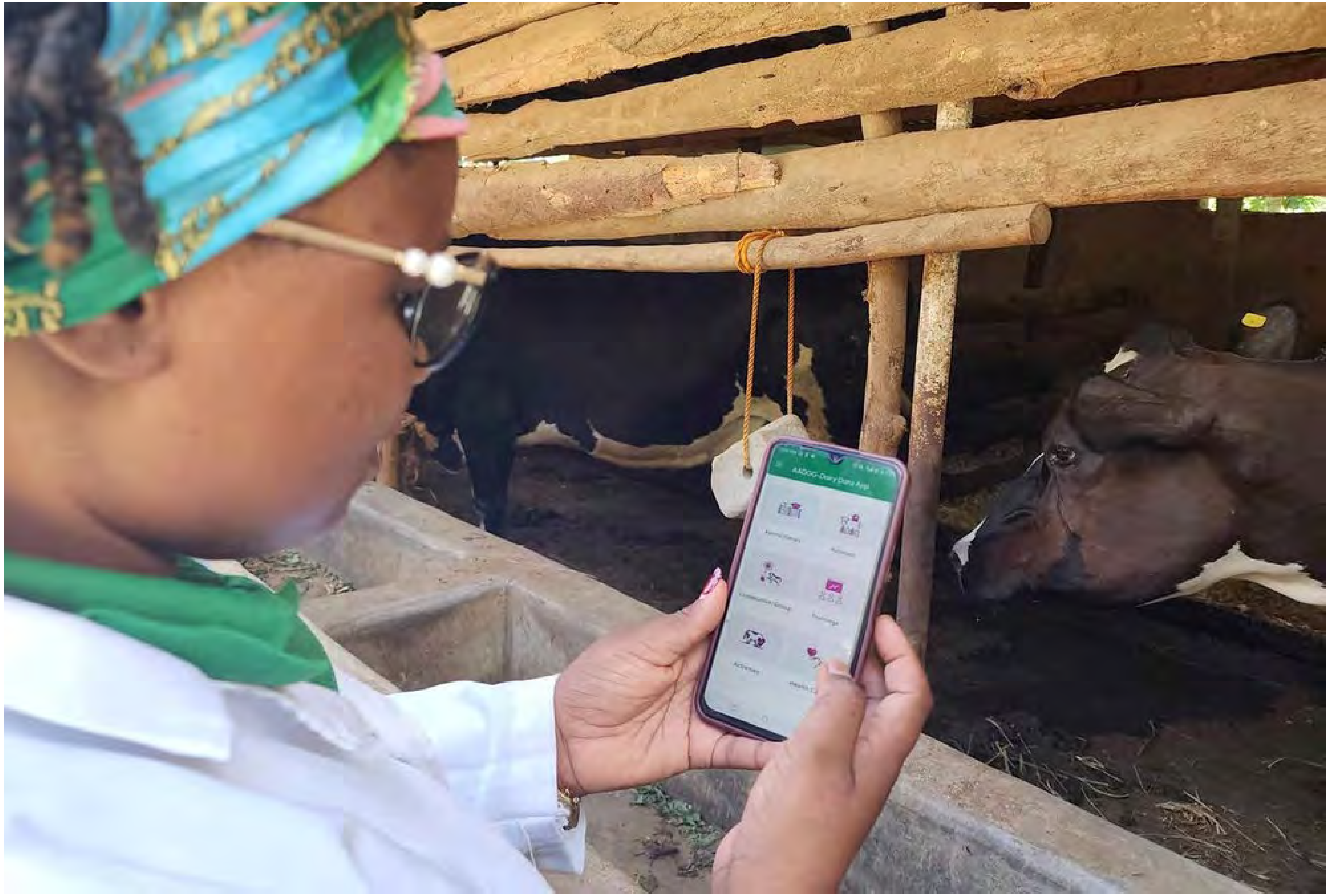


Use of technologies for phenotyping

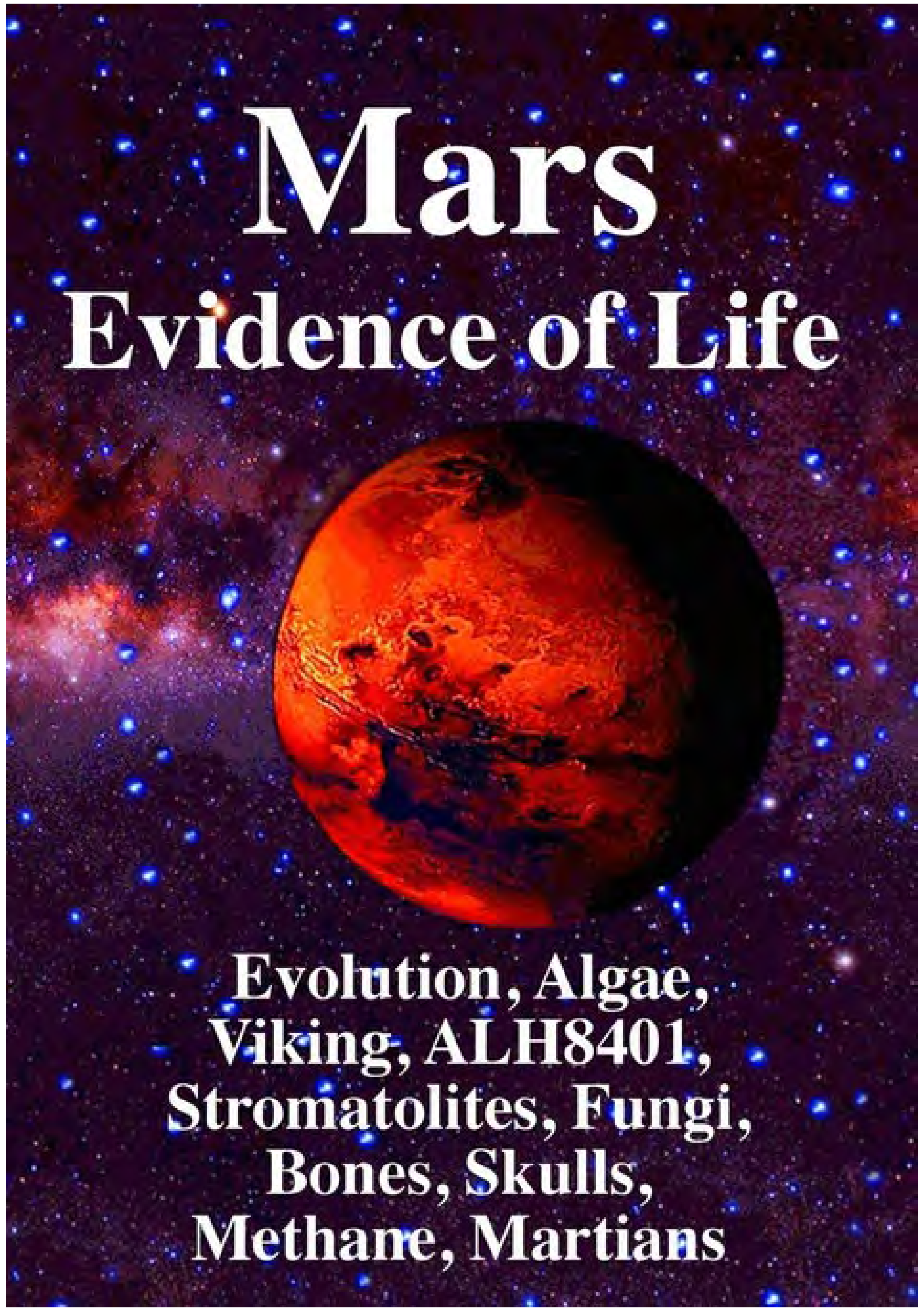
- Simple, non invasive technologies
- Robust data in a systematic way
- Promote/contribute to applied data science for animal science

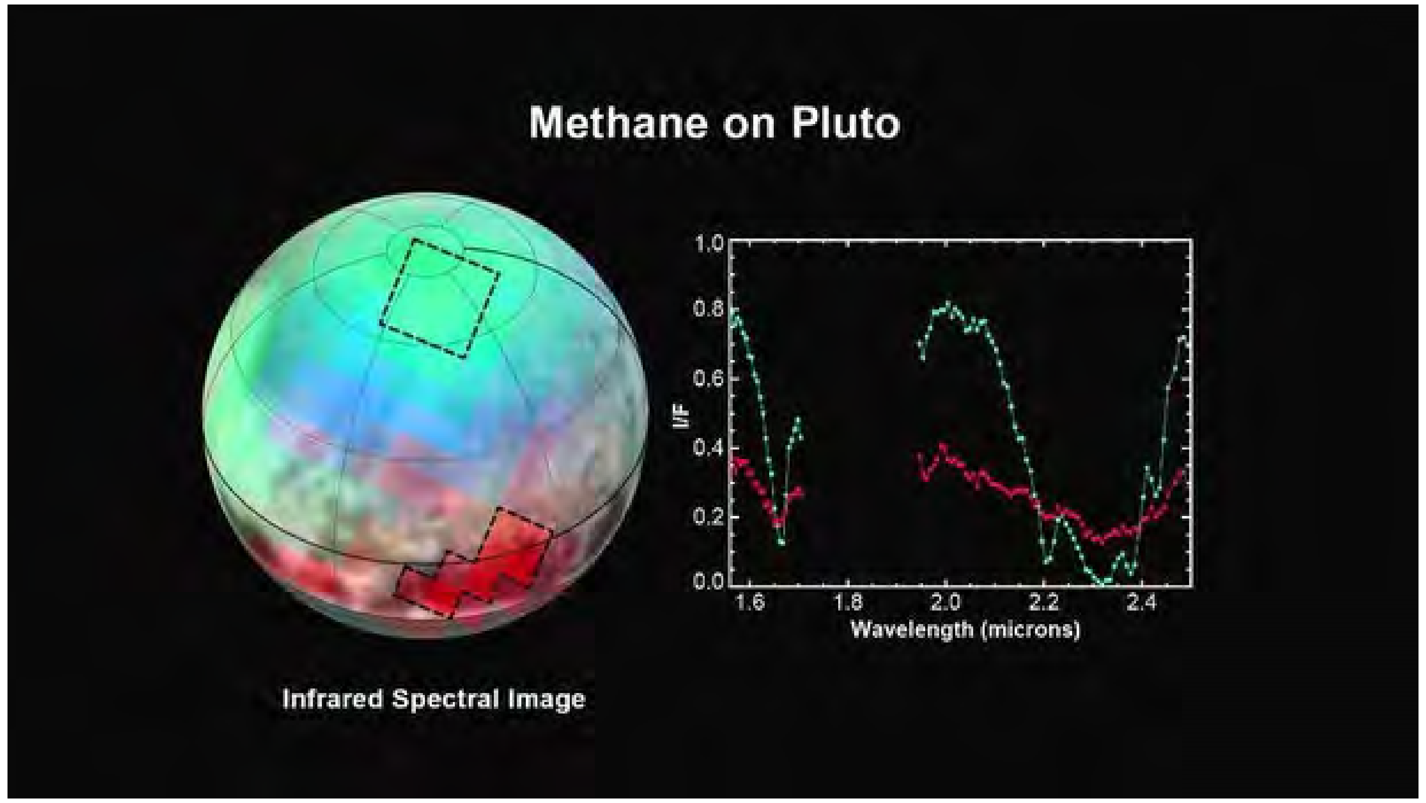


Software and Data

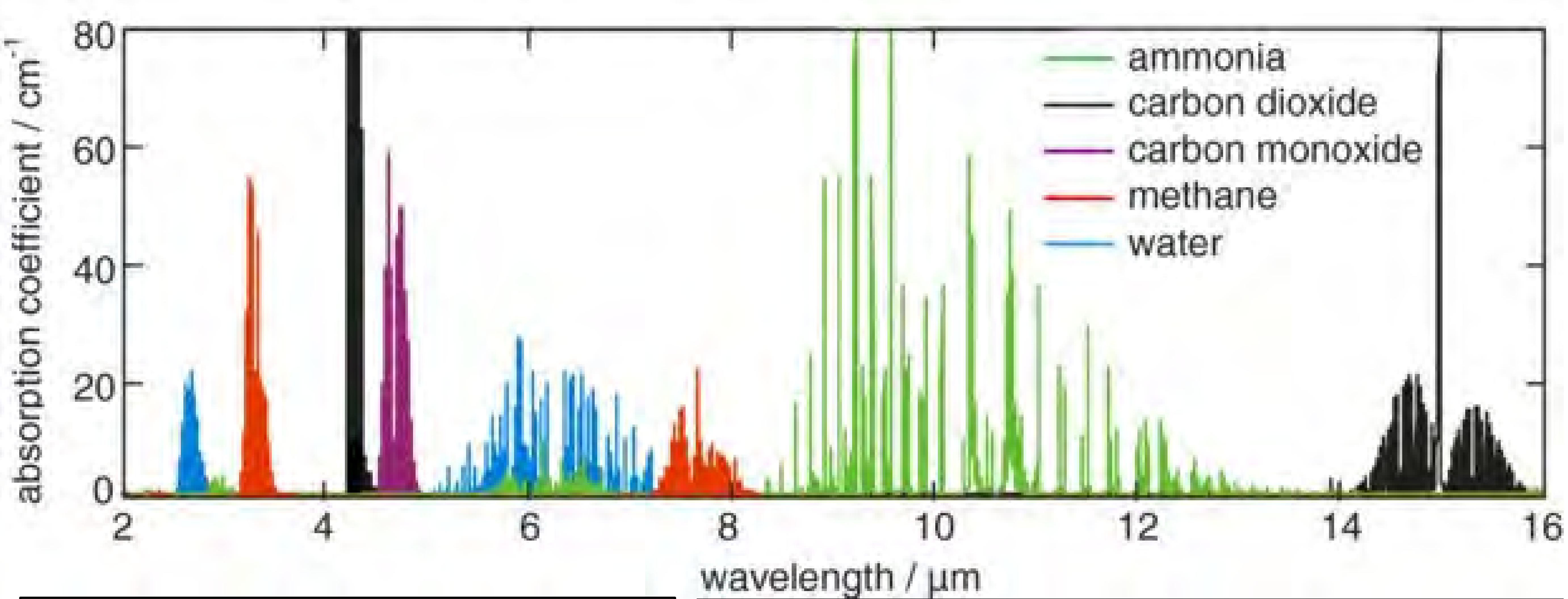


Methane Detection





Methane Detection



- **Two strong absorption bands** 3.3 and 7.6
- **Two other bands**

  1.64 and 1.70 (2v3 band)

Advantages of the 2v3 band

- Cost effective
- Coincide with InGaAs feed-back of the laser diode
- InGaAs diodes are readily tunable

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Laser Methane Detector

- Based on infrared absorption spectroscopy
- Using a semiconductor laser as a collimated excitation source
- Employs second harmonic detection of wavelength modulation spectroscopy to establish methane concentration

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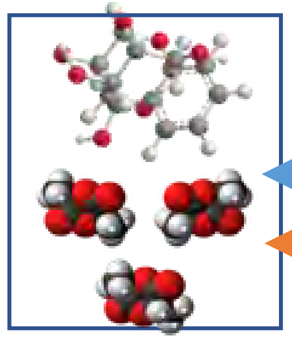
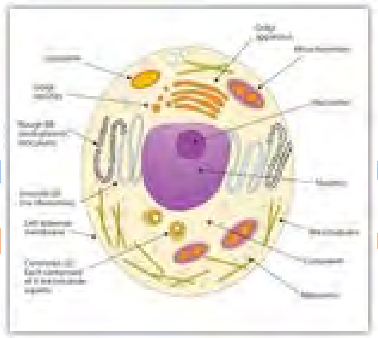
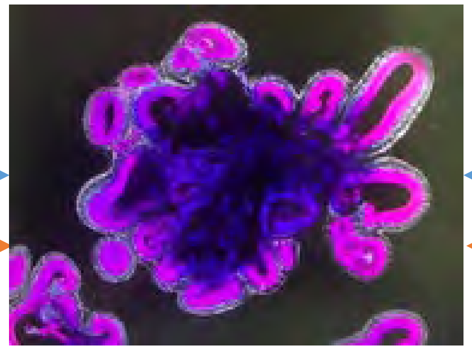
The toolbox and innovation strategies from Biosciences

Innovations, tools, data, decisions, products

microbiomes







molecules

cells

organoids

embryos

Animals/farms, systems (pastoral/extensive)

Global livestock systems

Innovations, tools, data, decisions, products

Pluripotent Stem Cells for Genetic screening

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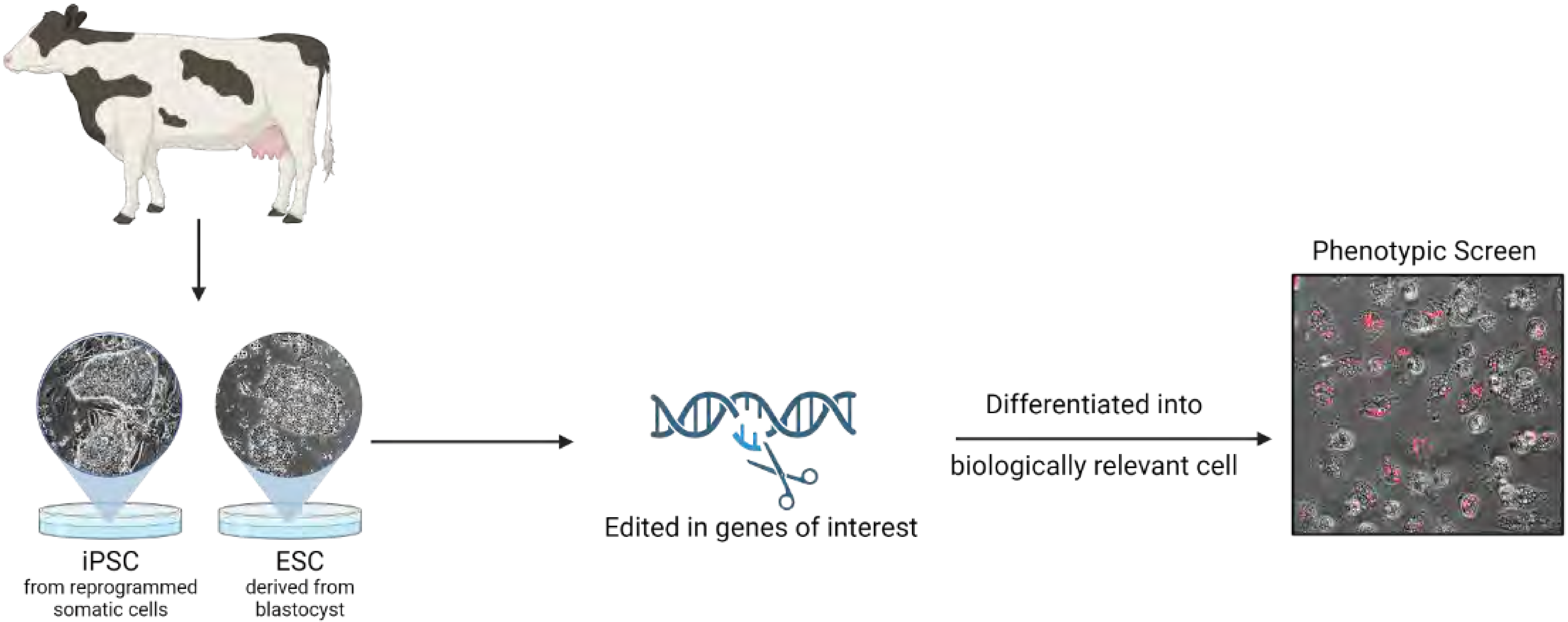

Drs Amy Findlay, Stephen Meek, and Jon Riddell
Burdon Lab

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Chicken Surrogate technology: Mcgrew lab

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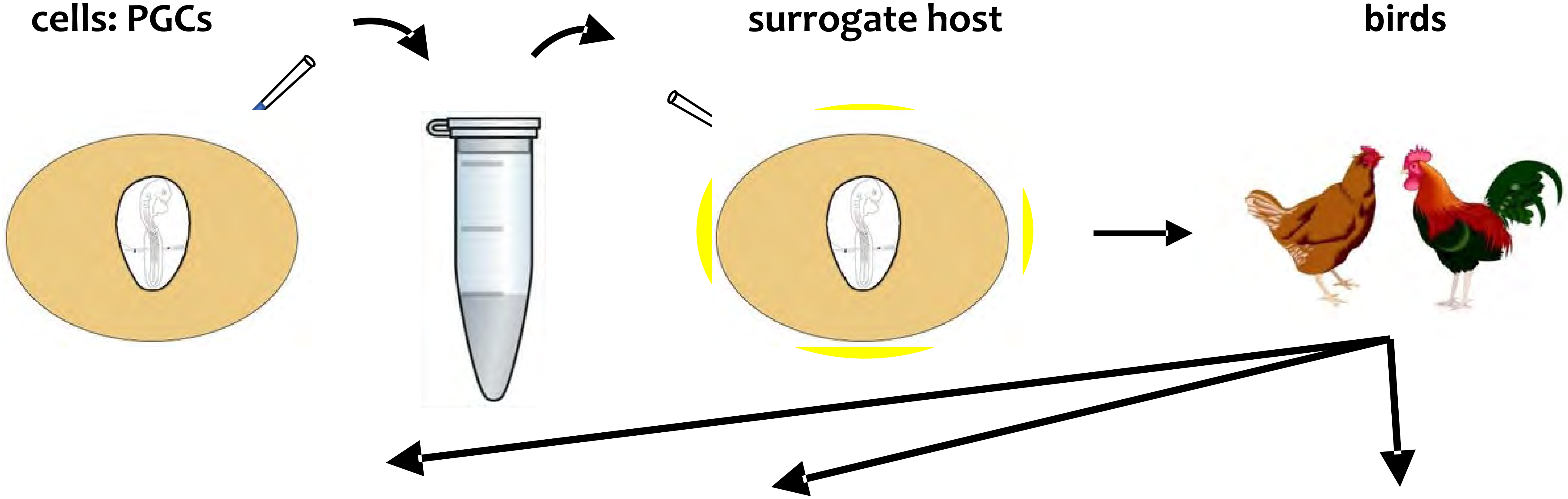
Isolate reproductive cells: PGCs

A sterile surrogate host

Surrogate parental birds



Conservation of local breeds

Disease resistant chicken

Farmer preferred 'phenotype'

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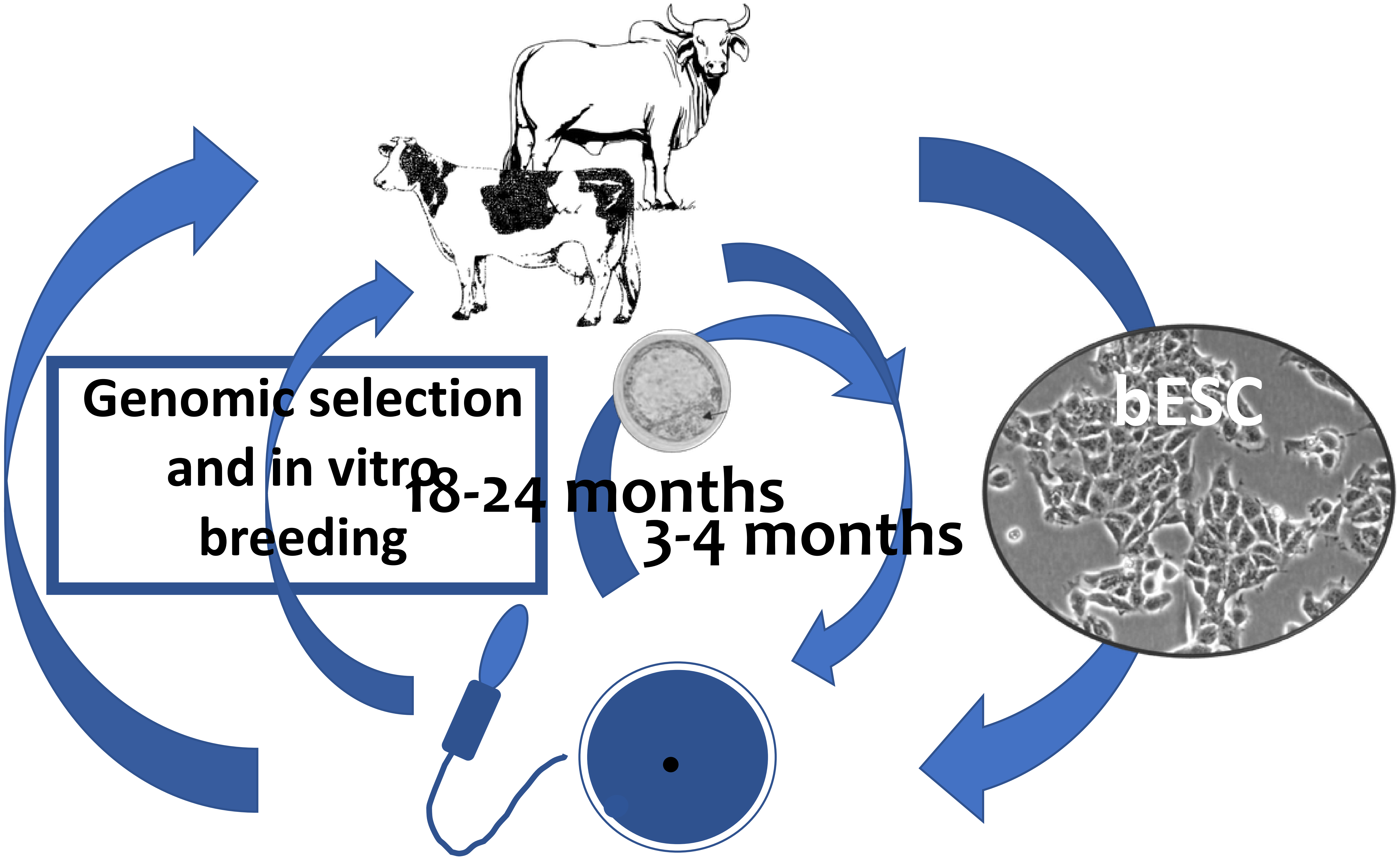
Future direction: in vitro breeding?



In conclusion

Based on current achievements and future progress, it seems very likely that a combination of **physical technologies, genomic technologies, biotechnologies, clear phenotyping** and **data** that will contribute to effective improvements in livestock resilience and productivity for sustainable livelihoods.

Thank you very much for listening.

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The Future of
Livestock in
Global Food
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Table Discussions

- Introduce yourselves
- Reflect on a new thing you learned, any surprises, any gaps?
- Agree on one or two high level questions for one of the speakers or for the whole panel

- Make sure someone captures some notes on the flipchart