



Department of Agriculture
LIVESTOCK BIOTECHNOLOGY CENTER

Animal Biotechnology in Global and Philippine Context

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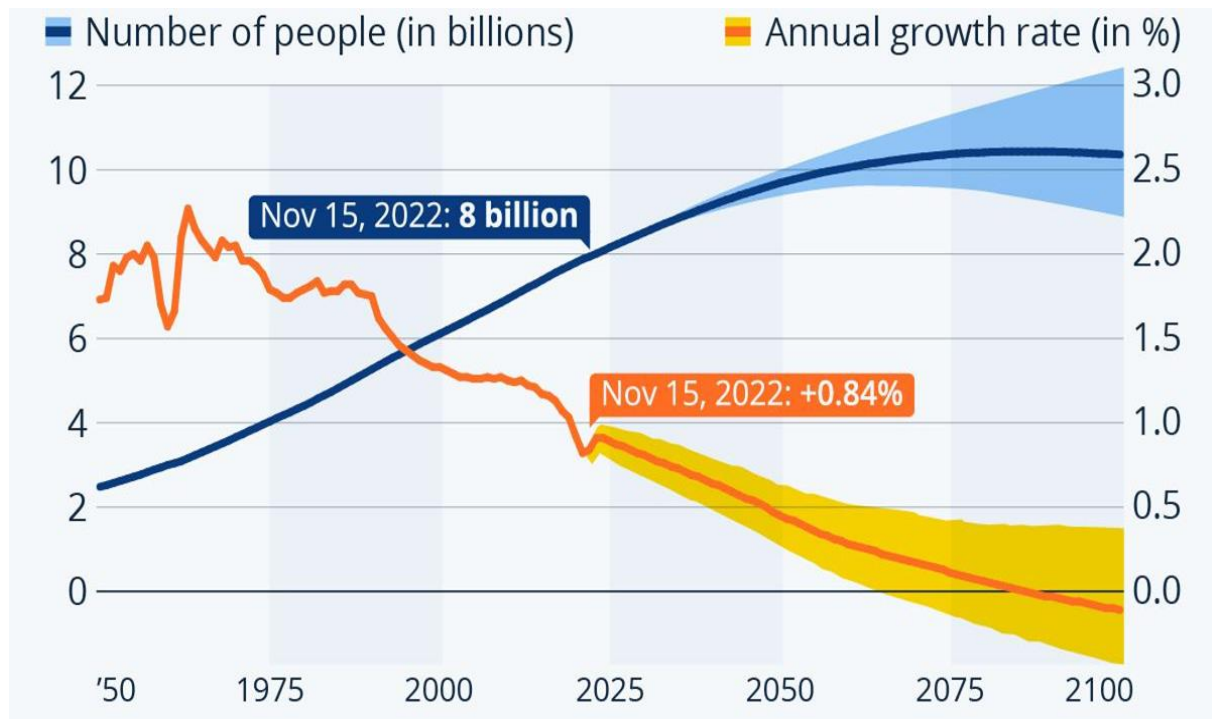


OUTLINE

- Overview of biotechnology applications in animals
- Genetically modified (GM) and gene-edited (GE) animals/ products
- Future of Animal Biotechnology in the Philippines
- Takeaways



The Global Challenge: Feeding the World Sustainably by 2050



Increase Food Production Without Expanding Agricultural Land

Reduce Growth In Demand for Food and Other Agricultural Products

Reduce Greenhouse Gas Emissions from Agricultural Production



Source: <https://www.statista.com/chart/28744/world-population-growth-timeline-and-forecast/>
Source: Dr. Mingala's PPT APEC 2023

FOOD: THE FACTS

<https://populationmatters.org/food-wa>



50% of the Earth's habitable land is already used for agriculture
(UN FAO, 2019)



Agriculture is the primary driver of deforestation, habitat loss and biodiversity loss
(IPBES, 2019)



The global food system is the single biggest contributor to climate change, responsible for around a third of all greenhouse gas emissions
(IPCC, 2019)

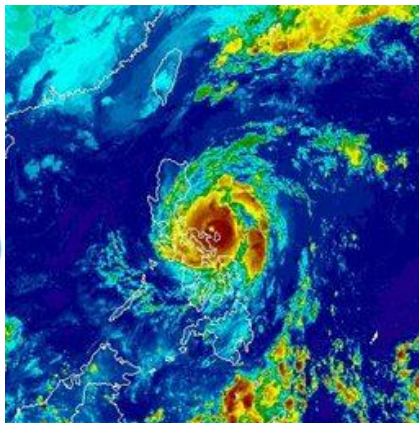
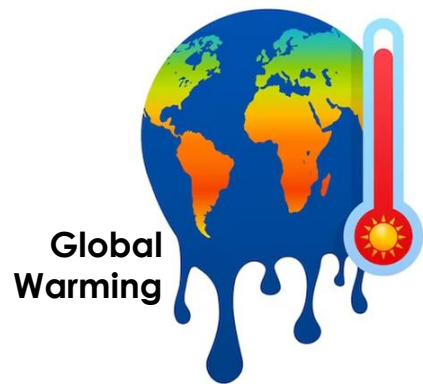
Humanity could require more food by 2100
(Depenbusch & Klasen, 2019)

80%

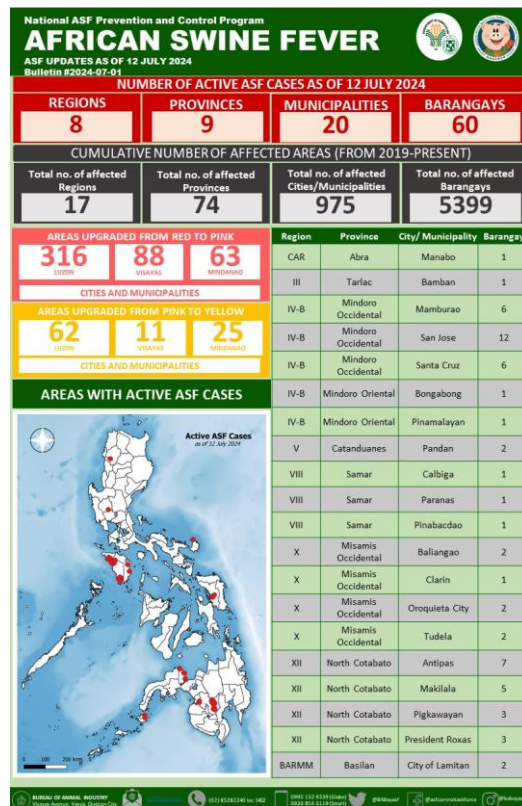
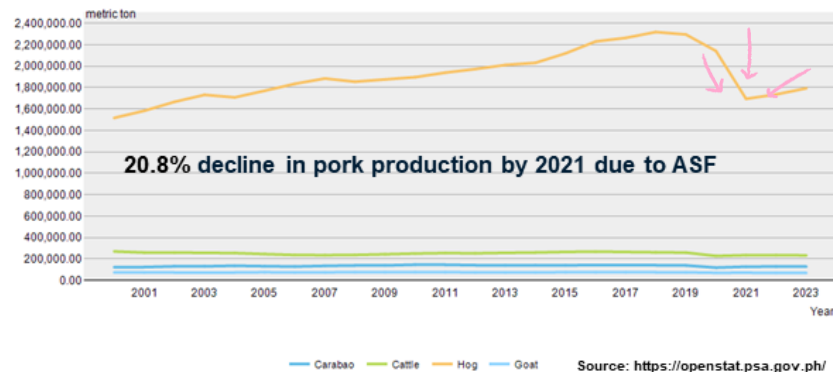


The number of people suffering from hunger and malnutrition has been increasing in step with the global population since 2014
(UN, 2020)

Current Challenges of the Philippine Livestock Industry



Annual Report: Livestock Production from 2000 to 2023



Antimicrobial Resistance



Current Challenges of the Philippine Livestock Industry

- High costs of farm inputs
- Lack of new breeding animals



What is BIOTECHNOLOGY?

Biotechnology is the manipulation (as through genetic engineering) of living organisms or their components to produce useful usually commercial products.

Source: Oxford Dictionary



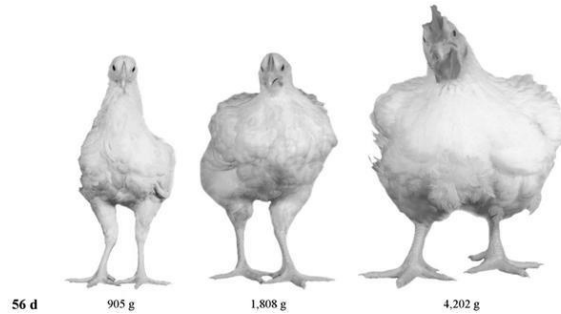
ANIMAL / LIVESTOCK BIOTECHNOLOGY

Has a long history, beginning as far as 8,000 years ago



Domestication and
Artificial Selection

Traditional Animal Biotechnology



Selective Breeding

'Wild' cow



'Beef' cow



What differences can you see?



**Modern Animal Biotechnology began only following
discovery of genetic code**



GMOs

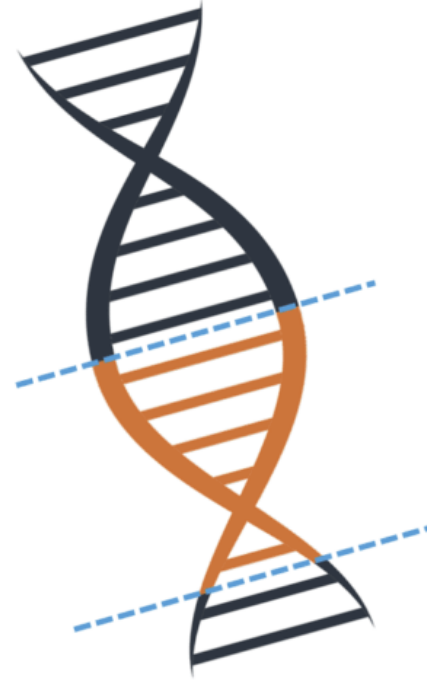
Technique: a foreign gene is inserted into the DNA strand.



Result: the crop takes on improved characteristics associated with the new gene and the genetic modification can be detected through tests.

CRSPR gene editing

Technique: gene is cut and its DNA is modified.



Result: the crop's DNA is changed, but tests cannot distinguish the genetically engineered crop from traditional techniques.



Source: <https://medecon.org/is-there-a-difference-between-a-gene-edited-organism-and-a-gmo-the-question-has-important-implications-for-regulation/>

APPLICATIONS OF LIVESTOCK BIOTECHNOLOGY



Climate Change and Disease Resilient or Resistant Animals

Increased Income for Livestock Food Producers



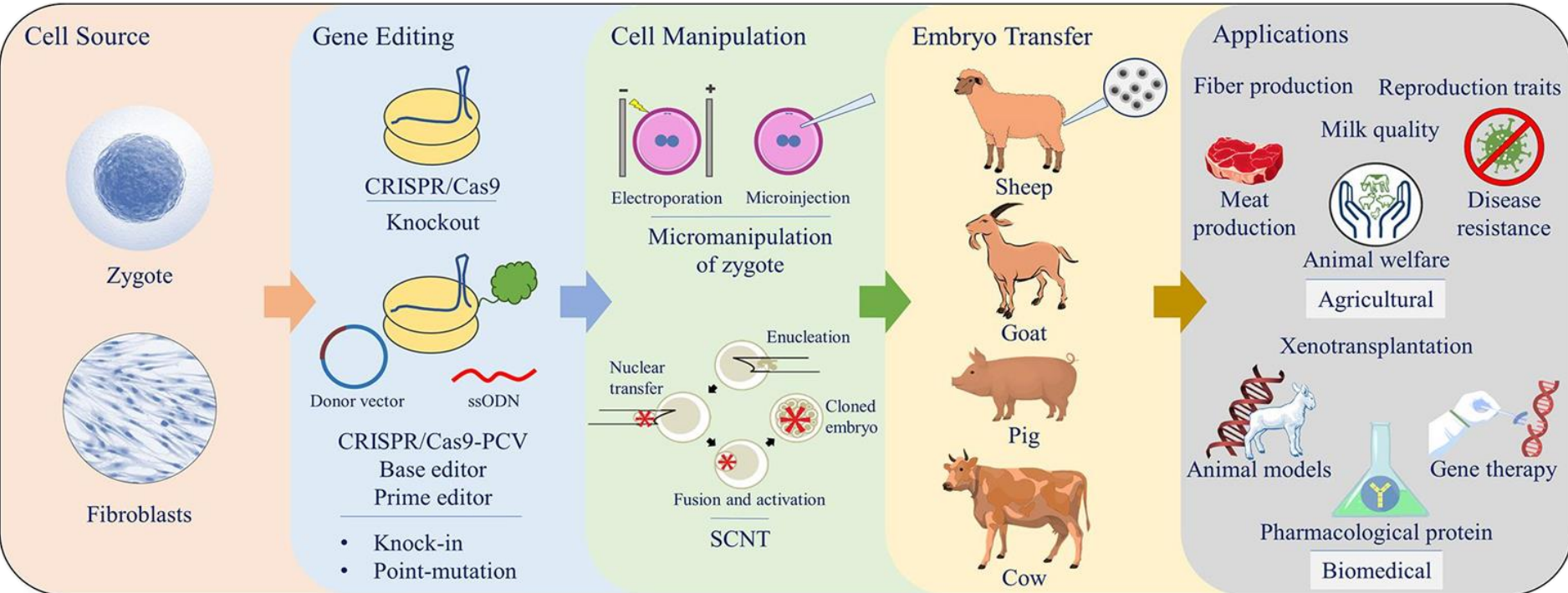
Doubling Food Production to meet the supply for demand

Proper Animal management

Rapid Diagnosis and Modern Disease Surveillance

Use of New Breeding Innovation as a Driver for Change in Livestock

Cell Mediated Genomic Editing



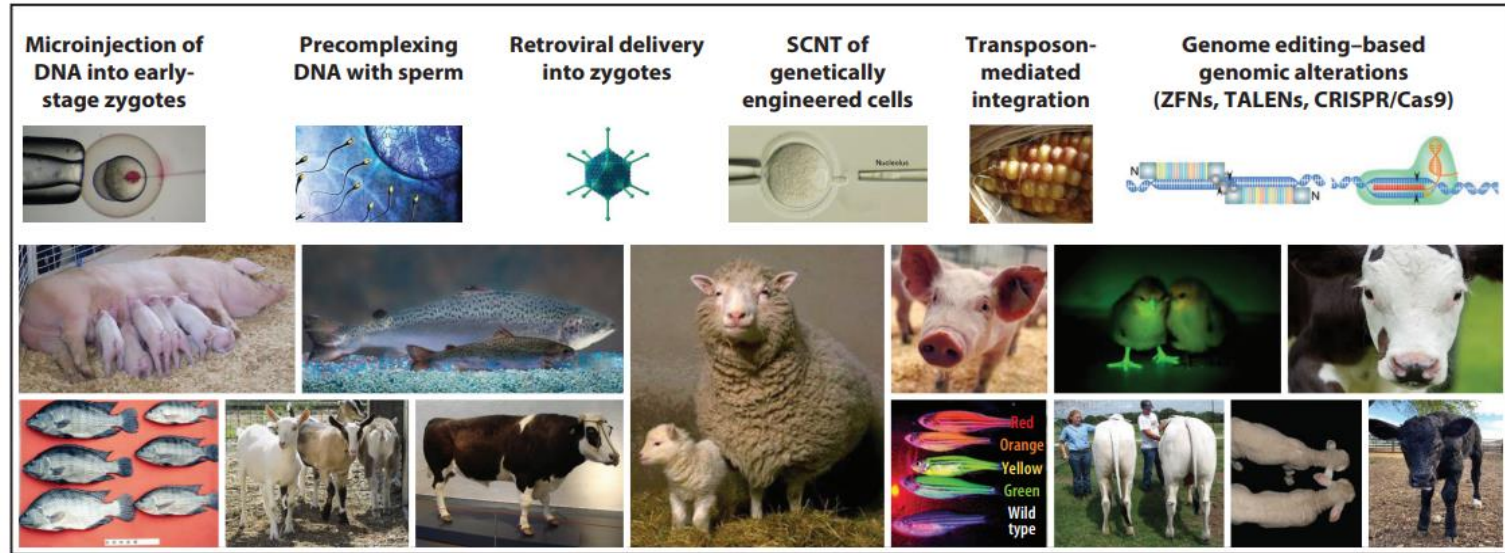
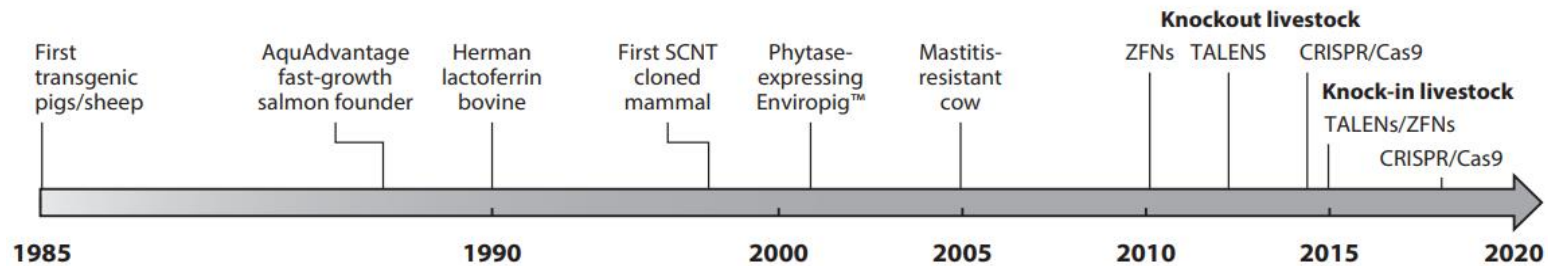


Figure 1

An abbreviated schematic history of 35 years of genetically engineered livestock featuring some of the well-known celebrities of the field. Abbreviations: CRISPR/Cas9, clustered regularly interspaced short palindromic repeat targeted by Cas 9 nuclease; SCNT, somatic cell nuclear transfer; TALEN, transcription activator-like effector nuclease; ZFN, zinc-finger nuclease.

Reference: Van Eenennaam et al., 2021. Genetic Engineering of Livestock: The Opportunity Cost of Regulatory Delay. *Annu. Rev. Anim. BioSci.* 9:453-478





Gene Edited Animals in the Pipeline



Littlejohn et al., *Nature Communications* 5: 5861 (2014)

- Intentional Genomic Alteration
- Slick hair coat – to better regulate their internal body temperature with an increased capacity of sweating

Source: ISAAA Inc., 2021



PMEL -/-

PMEL +/-

- Color diluted dairy cattle
- Lightening the coat color can reduce the radiative heat gain from exposure to the sun

Source: Goetz Laible, 2022

Gene Edited Animals in the Pipeline



- A typical horned dairy cow (right) and a genome-edited cow without horns that contains a DNA sequence found in hornless cattle (*Photo courtesy of Alison L. Van Eenennaam, Dept. of Animal Science, University of California-Davis*)

Source: ISAAA Inc., 2021

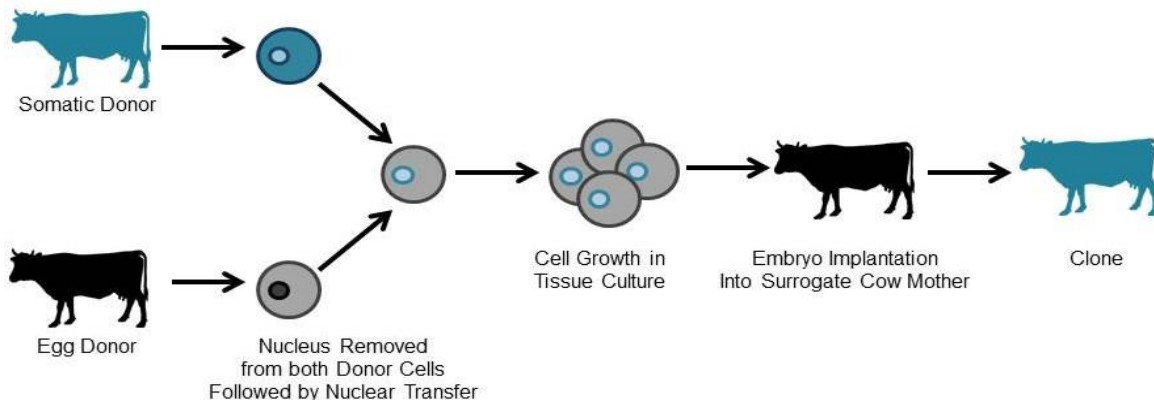
B2R Woodhill Complete A130-C2



- Red Angus
- Excellent milk production and have a strong maternal instinct
- Produces a highly desired carcass with excellent meat quality, due to the intra muscular marbling

Source: Goetz Laible, 2022

- Philippine Carabao Center has adopted the **SOMATIC CELL NUCLEAR TRANSFER (SCNT)**
- to develop/optimize a system for cloning through SCNT in water buffalo
- Buffalo clone embryos had been successfully produced *in-vitro*.



Gene Edited Animals in the Pipeline



- Porcine Reproductive and Respiratory Syndrome -resistant pigs

Source:

<https://www.ed.ac.uk/roslin/facilities-resources/larif/case-studies/industry-partners>



- Bird flu resistant chicken
- contain an extra gene that interrupts the transmission of bird flu

Source: <https://www.ed.ac.uk/roslin/news-events/latest-news/archive/2019/gene-edited-chicken-cells-resist-bird-flu-virus>

GENETICALLY MODIFIED ANIMALS

Genetic modification of an animal involves altering its genetic material by adding, changing or removing certain DNA sequences in a way that does not occur naturally



Source: Nature



FDA approves GalSafe pigs as first-of-its-kind intentional genomic alteration in line of domestic pigs for both human food, potential therapeutic uses

DEPARTAMENT

AGRICULTURA Y FORESTAL



Photograph: INTA (National Agricultural Technology Institute Argentina)

Rosita Isa – was born that expressed milk containing proteins present in human milk but lacking in cow milk



Photograph: Oxitec

A genetically modified male mosquitoes that carry a “self-limiting gene”; the offspring do not reach adulthood, reducing the spread of mosquito-borne diseases



Source: AgResearch Lab

GM cow Daisy, whose milk provides evidence that a genetic technique called RNA interference can work in large animals



Source: Manila Healthtek Inc.

Loop Mediated Isothermal Amplification (LAMP) Assay Kits for *Schistosoma japonicum*, *Leptospira* spp. and *Salmonella* spp.



Source: LMDP Project

Low-cost Portable Molecular Diagnostic Platform for Rapid Detection of Poultry Infectious Diseases

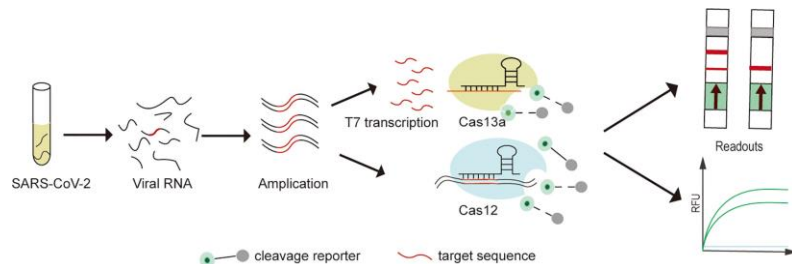


Source: Manila Healthtek Inc.

African Swine Fever (ASF) Detection Kit using Polymerase Chain Reaction (PCR)

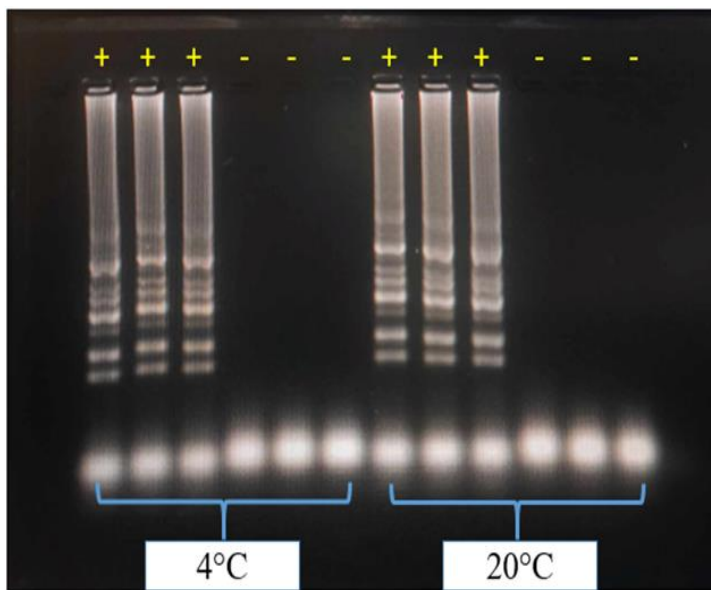
MOLECULAR DIAGNOSTICS

involves taking DNA or RNA, the unique genetic code found in cells, and analyzing the sequences for red flags that can pinpoint the potential emergence of a specific disease



Source: Frontiers in Cellular and Infection Microbiology

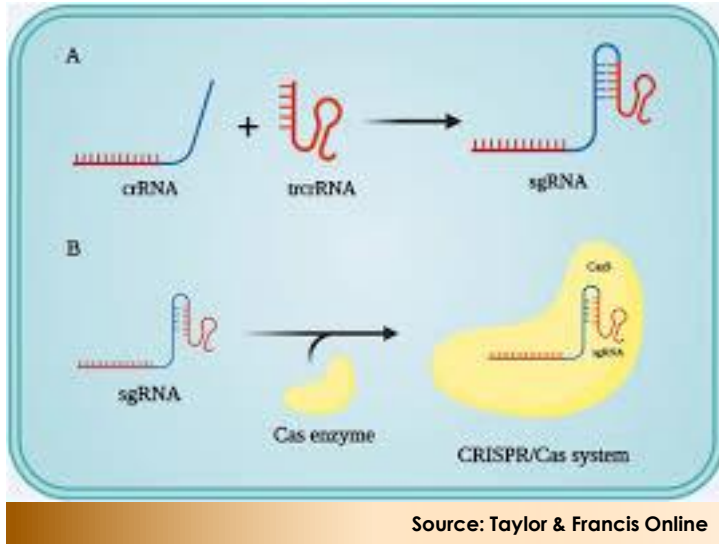
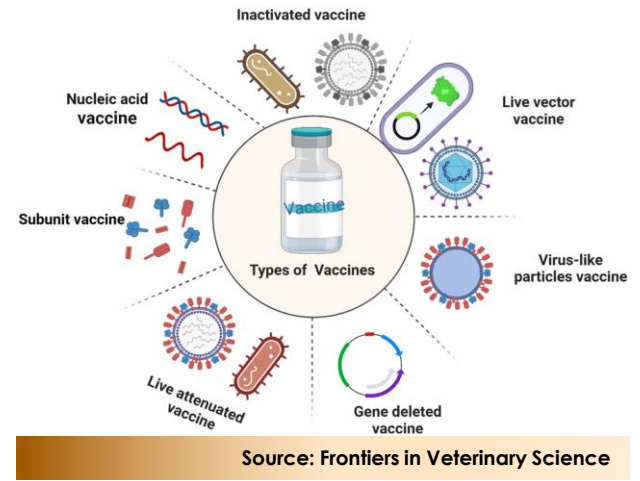
CRISPR/Cas System as a potential technology for the prevention and control of COVID-19 and other emerging infectious diseases



Development of a Prototype for Loop-Mediated Isothermal Amplification (LAMP) Assay for the Detection or Screening of Lumpy Skin Disease (LSD)

Agarose gel image depicting the master mix stored for six months at refrigerator (4°C) and freezer (-20°C).

Legend: + = positive control; - = blank



VACCINE DEVELOPMENT

The techniques of modern biotechnology such as genetical engineering and cell culture enable an effective, quick and economical development of vaccines



Application of CRISPR/Cas system in the vaccine development for viruses utilizing strategies like, knockout, knock-in, gene activation/deactivation, RNA targeting, and editing cell lines

FEED OPTIMIZATION

Biotechnology for feed improvement: value-addition to forage used as animal feed, production of feed additives and the manipulation of rumen microbes to improve feed utilization



Source: UPLB BIOTECH

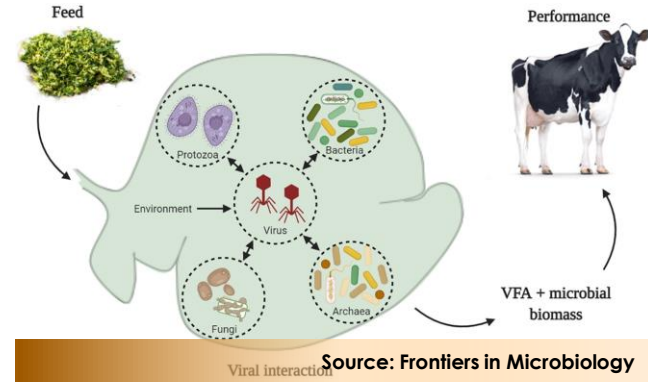
ImmunoDefense for Swine and Poultry: a multi-strain microbial feed supplement developed as an alternative to antimicrobials, and helps protect animal health and increases efficiency of nutrient utilization

DEAP-7



Source: UPLB BIOTECH

Protein Enriched Copra Meal (PECM): a feed ingredient with high digestibility and nutrient quality and used as a source of quality protein

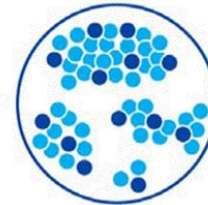


Genetic engineering of rumen microorganisms to improve animal gut health and performance



Probiotics

*Live microorganisms that confer a health benefit on the host when administered in adequate amounts.



Prebiotics

*Substrates that are selectively utilised by host microorganisms, conferring a health benefit.

Source: Research Gate

Probiotics and prebiotics are supplements improve gut health in livestock, which leads to better nutrient absorption and overall health



Source: Nutri-Crave

Nutri-Crave corn (right) is a non-GMO hybrid of yellow corn that has a higher nutritional value than regular yellow corn (left)



Source: UPLB BIOTECH

Detect Immediately by Probe System (DIPS™): a detection kit that utilizes the combination of immunodetection and DNA-based hybridization technology to identify the presence of *Salmonella* in select food matrices



Source: UPLB BIOTECH

DAS™ are rapid kits that utilize Polymerase Chain Reaction (PCR) technology for the detection of bacterial pathogens in food, water and animal feeds



Source: UPLB BIOTECH

Quixens® is a food safety detection kit that offers a quick and easy way to sense or detect the presence of harmful bacteria such as *E. coli* and *Salmonella enterica* in food, water, or animal feeds

FOOD SAFETY

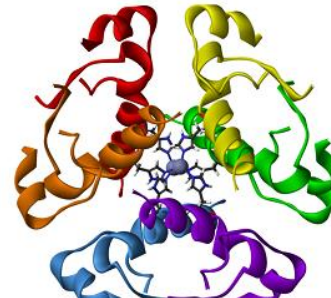
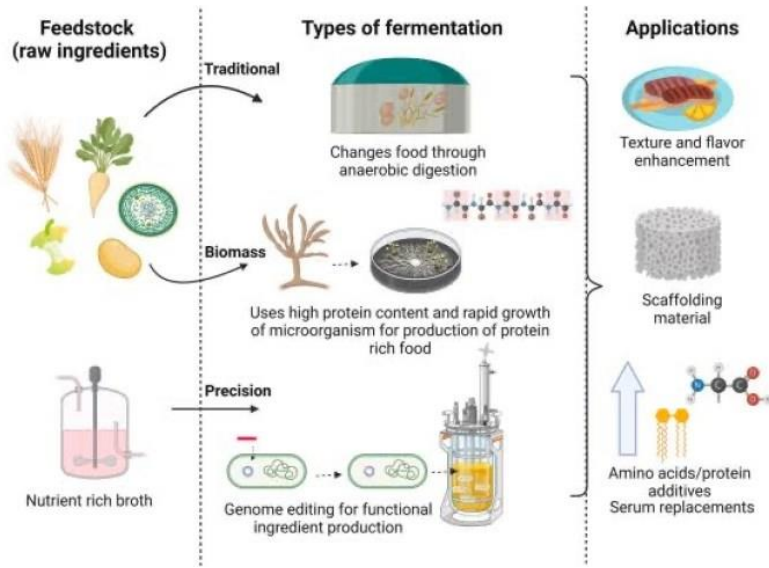
Possible roles of biotechnology in areas of food safety involve microbial contaminants, nutritional quality, natural antimetabolites, allergens, toxicants, and synthetic chemical residues



Source: Nature

FDA approves GalSafe pigs as first-of-its-kind intentional genomic alteration in line of domestic pigs for both human food, potential therapeutic uses





Source: Wikimedia Commons

Insulin was the first product made by precision fermentation – the antidiabetic medicine



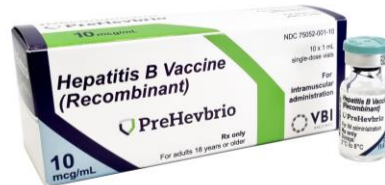
Source: Wikimedia Commons

Chymosin, the enzyme responsible for producing cheese from milk was successfully made through precision fermentation



Source: Perfect Day

"Animal-free" milk and cheese produced through precision fermentation



Source: McKesson

The hepatitis B vaccine is one of the vaccines that was developed using precision fermentation

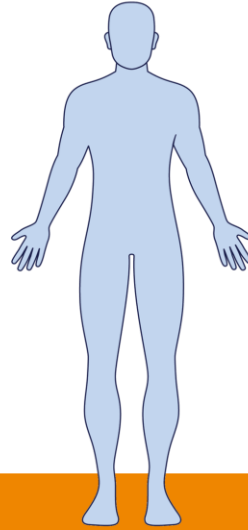
PRECISION FERMENTATION

involves engineering a micro-organism like yeast or fungi to produce an animal protein or fat, with the same taste, texture and nutrition as the real kind

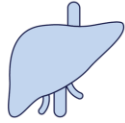
ORGAN
TRANSPLANTATION



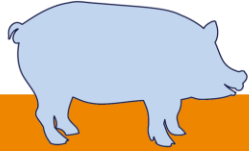
RECEIVER



XENOGENIC
Transplantation



DONOR



XENOTRANSPLANTATION

Biotechnology has played a crucial role in advancing xenotransplantation by addressing the challenges associated with immune rejection and disease transmission



Source: University of Maryland School of Medicine

World's second pig heart transplant on patient deemed ineligible for traditional heart transplant performed at the University of Maryland Medical Center



Source: Massachusetts General Hospital

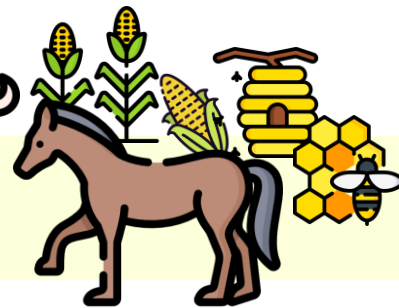
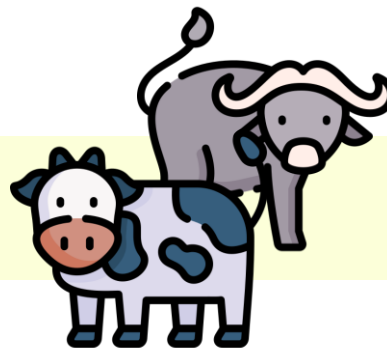
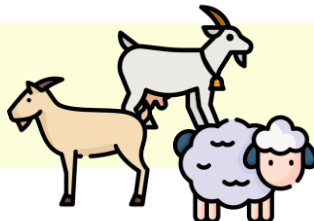
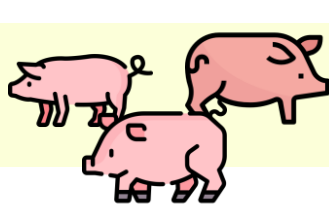
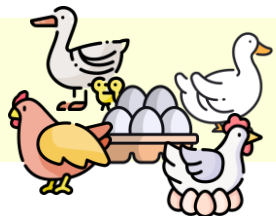
Harvard Medical School physician-scientists transplanting pig kidney at Massachusetts General Hospital

The background of the slide is a scenic landscape. In the foreground, there is a lush green field with some small white flowers. In the middle ground, there are rolling green hills and a few small buildings. In the background, there are more hills and a sunset sky with orange and blue clouds. The text is overlaid on a semi-transparent white rectangle in the center of the image.

What is the future of Animal Biotechnology in the Philippines?



CHALLENGES



- high cost of feed and input supplies
- disease outbreaks impacting production and supply (e.g., Avian Influenza, etc.)
- challenges in farm waste management and environmental impact

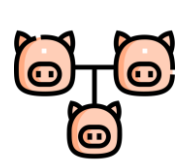
- African Swine Fever (ASF) outbreaks causing massive losses
- high cost of feed and production inputs
- poor waste management and biosecurity issues

- low productivity and lack of standardized breeding programs
- insufficient supply of high-quality meat and milk
- limited access to veterinary services and artificial insemination
- weak implementation of animal health programs

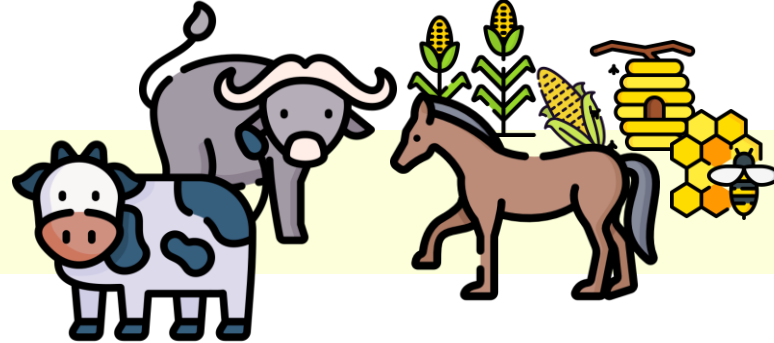
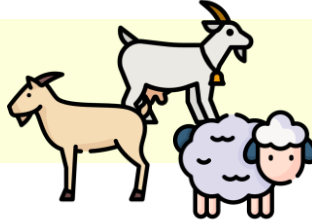
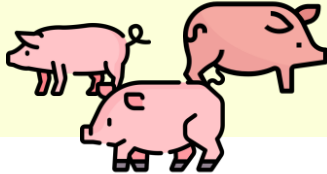
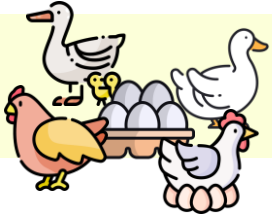
- high production costs, particularly for feed and maintenance
- high import dependency due to low milk production
- weak breeding program and limited genetic improvement

- climate vulnerability (e.g., typhoons, drought)
- high dependency to imported fertilizers and genetically modified seeds
- pest and disease management system





BREEDING STRATEGIES



- **genetic engineering** to improve disease resistance and egg production efficiency

- **genetic engineering** to introduce disease resistance (e.g., PRRS-resistant pigs)

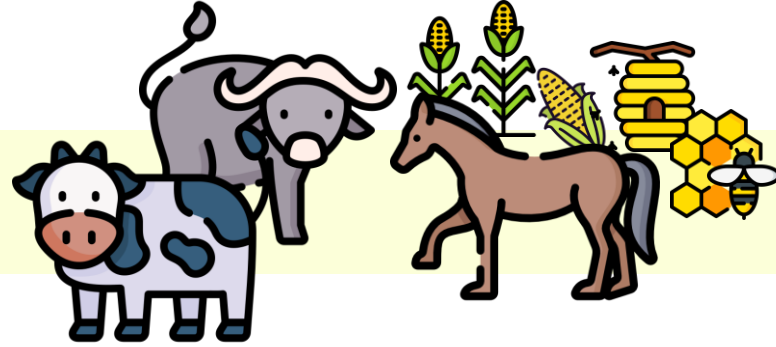
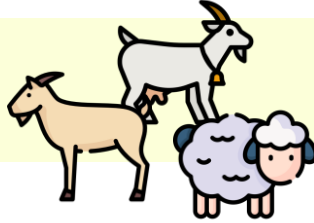
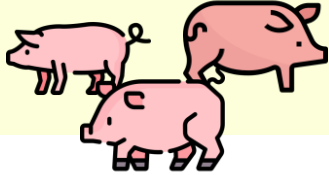
- **Marker Assisted Selection (MAS)** to improve meat yield and milk production traits
- **Assisted Reproduction Technologies (ARTs)** to improve reproduction efficiency (e.g., artificial insemination, embryo transfer)

- **Marker Assisted Selection (MAS)** to improve milk production traits
- **genetic engineering** to improve lactation efficiency
- **sexed semen technology** to increase productive females

- **genetic engineering** to develop drought-tolerant corn varieties



DISEASE MANAGEMENT



- **modern vaccine platforms** and **probiotics** to control disease outbreaks and reduce dependency to antibiotics
- **RT-PCR** and **CRISPR-based diagnostics** for early disease detection and control

- **biosensors** and **machine learning** for early detection of disease outbreaks
- **molecular-based diagnostic platforms** for point-of-care disease detection

- **therapeutics** and/or **vaccines** for major ruminant respiratory diseases

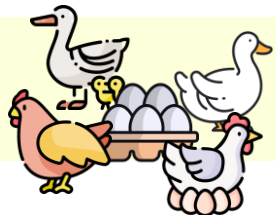
- **Sterile Insect Technique (SIT)** for the biological control of disease-causing vectors

- **biopesticides:** microbial-based pest control solutions

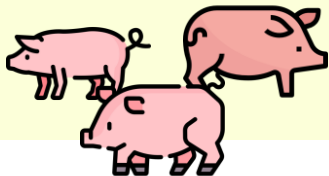




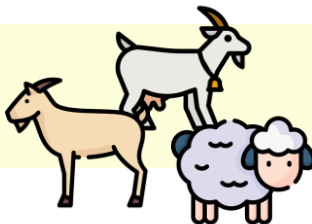
FEED DEVELOPMENT



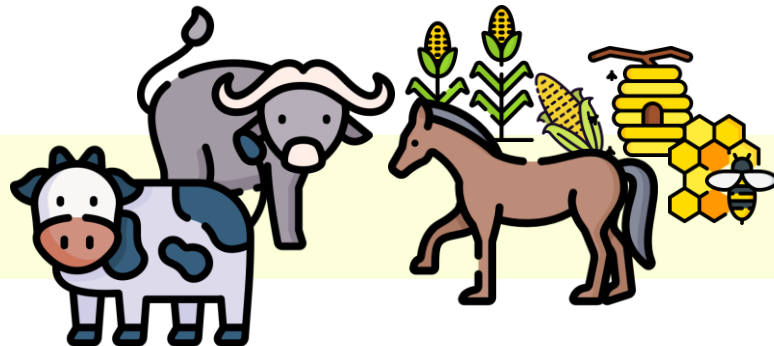
- **precision fermentation** to develop alternative feed sources, reduces waste and environmental impact



- **enzyme biotechnology** and **genetic modification** to develop feeds with enhanced feed conversion ratios

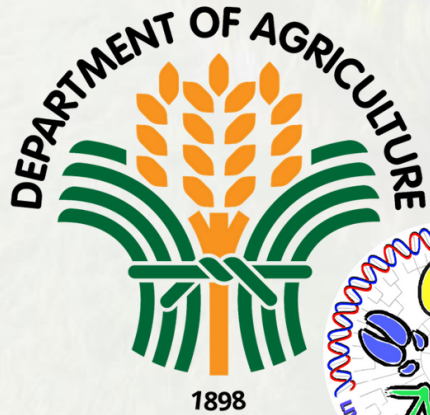


- **microbial feed-additives** and **probiotics** to improve nutrient digestibility



- **nutrigenomics-based** feed formulations to enhance growth efficiency and production

- Nitrogen-fixing bacterial inoculants as **biofertilizers** to reduce dependency on synthetic fertilizers



Department of Agriculture **LIVESTOCK BIOTECHNOLOGY CENTER**



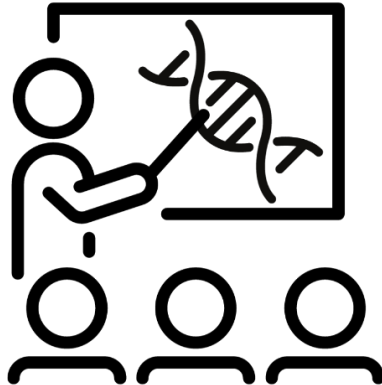
ROLES & FUNCTIONS OF THE CENTER



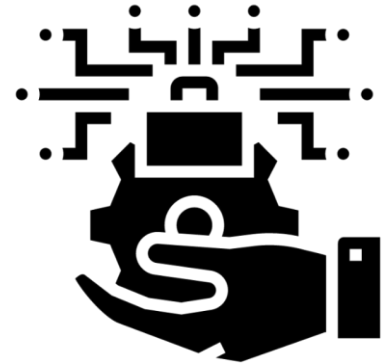
**Technology Development
& Innovation**



**Partnerships & Fund
Generation**



**R4D Biotechnology
Capacity-Building Service**



**Technology
Commercialization &
Management**



Technology Development

Disease Diagnosis Test Kits

- On-going Development:
- Leptospirosis, *Mycoplasma bovis*, *Mycobacterium avium* subsp. *paratuberculosis*
- Prototype Developed:
- Caprine Arthritis Encephalitis Virus, Lumpy Skin Disease

Intellectual Property Generation

Technologies under Utility Model registration

- QuickCare™ Dry LAMP Test Kit:
- Caprine Arthritis Encephalitis Virus
- Lumpy Skin Disease

Research Mentorship

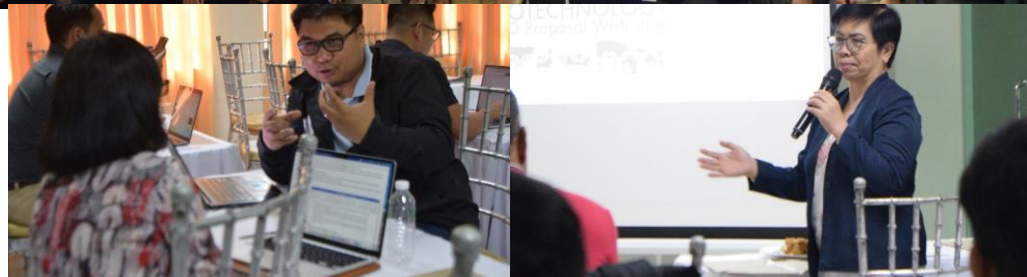


Research Students (Thesis / Dissertation)

- Undergraduate: more than 30 undergraduate students
- MSc: more than 15 graduate students
- PhD: more than 10 graduate students

Technology Development
& Innovation

LBR4D Research Proposal Writing Workshop conducted in collaboration with Cavite State University and the National Research Council of the Philippines



Collaborative Research Partnership on Developing Disease Diagnostic Test Kits for Transboundary Animal Diseases



Provision of Technical Expertise on Livestock Biotechnology Research



Innovation

Training Programs

Implemented Training Programs:

- Regional Livestock Biotechnology Symposium
- International Livestock Biotechnology Symposium
- Livestock Biotechnology R4D Proposal Writing Workshop
- Molecular Biology and Biotechnology Hands-on Training Workshop
- Capacity Building of ASEAN Biotechnology Researchers for Livestock Resiliency and Sustainability

Trained S&T Personnel

DA Bureaus and Attached Agencies:

- Bureau of Animal Industry, National Meat Inspection Service, National Dairy Authority, DA Regional Field Offices

SUCs & HEIs:

- CLSU, CMU, CTU, CvSU, SLSU, UEP, UPLB, etc.

International:

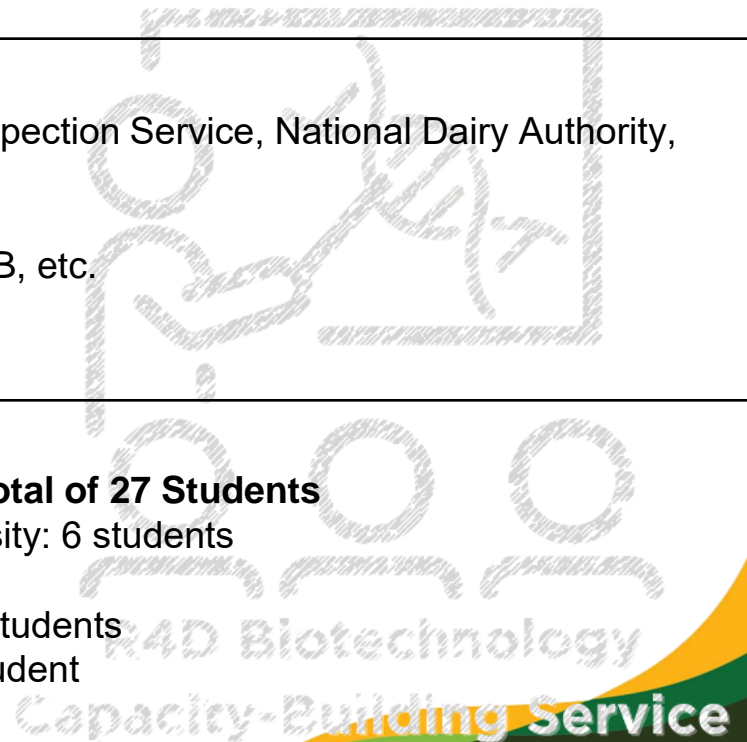
- ASEAN, Japan

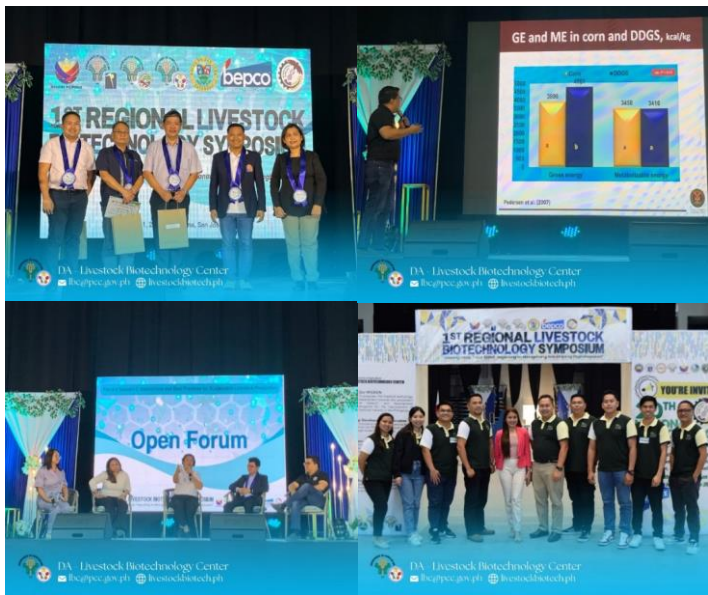
Consultancy and Mentorship



Student Internship Program (2023-2024): Total of 27 Students

- Don Mariano Marcos Memorial State University: 6 students
- Adamson University: 13 students
- Iloilo Science and Technology University: 7 students
- University of the Philippines Los Baños: 1 student





1st Regional Livestock Biotechnology Symposium – Luzon Cluster held in San Jose, Batangas, conducted in collaboration with LGU and BEPCO



Virtual Course on Molecular Biology Techniques and Regulations on Biotech (GM) Products



DA-LBC Student Internship Program for FY 2024 participated by undergraduate students from AdU, DMMMSU, and ISAT U and UPLB



Capacity Building of ASEAN Biotechnology Researchers for Livestock Resiliency and Sustainability



Capacity Building Workshop on Molecular Biology and Modern Biotechnology Tools for Livestock Research and Development



MOA / MOU Established

Local Institutes

- Iloilo Science and Technology University, Aurora State College of Technology, St. Luke's Medical Center, and many more...

International Institutes

- Taiwan Livestock Research Institute, Riken, Hokkaido State University, International Institute for Zoonosis Control, Chang Mai University, Hungarian University of Agriculture and Life Sciences

Research Supported

DA Biotech Funded Projects:

- Development of Climate Smart Microenvironment and Production of Thermotolerant Embryos for Climate Resilient Water Buffalo Production
- Development of Loop Mediated Isothermal Amplification (LAMP) Assay for the Detection or Screening of Lumpy Skin Disease
- Establishment of Sequencing Facility to Elevate the Research Capacities of Biotechnology Center's R4D Network
- and many more...

Local Funding:

- DOST Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD)

International Funding:

- Japan–ASEAN Integration Fund (JAIF)
- Japan Society for the Promotion of Science (JSPS)
- WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance (AGISAR)

Secured Grants



Partnerships & Fund



Local Partnership for the R4D Networks of Crops Biotechnology Center and Fisheries Biotechnology Center for the utilization of the DNA Sequencing Facility at Philippine Carabao Center



Local Partnership with Aurora State College of Technology on Biotechnology Research



International Partnership with Taiwan Livestock Research Institute on Biotechnology Research



Technologies Promoted

- **QuickCare™** Dry LAMP Test Kit for Caprine Arthritis Encephalitis Virus
- Low-cost Portable Molecular Diagnostic Platform for Rapid Detection of Poultry Infections
- **HECTOR®** Your Veterinary **HE**alth **InspeCTOR**
- **VLADIMIR®** Veterinary **LAMP-AI** Diagnostic Instrument with **Modular Integration** Realtime

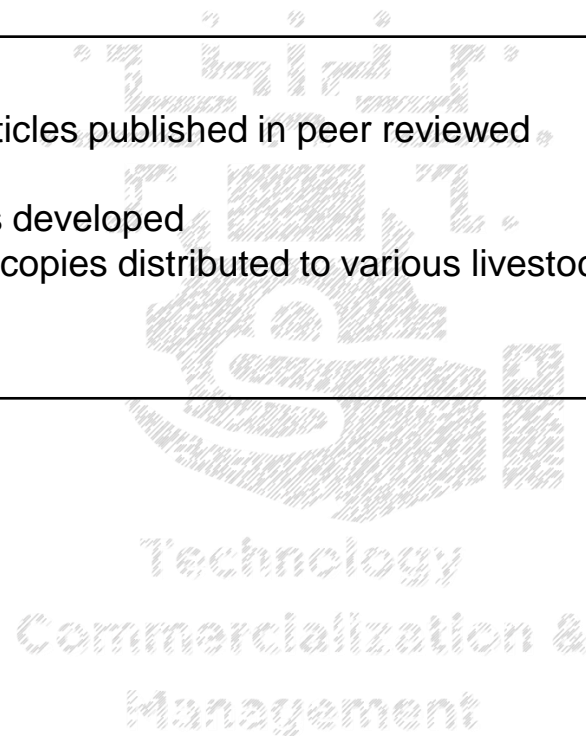
IEC Materials

- **Journal Publications:** more than 10 scientific articles published in peer reviewed journals
- **Developed IEC Materials:** at least 5 publications developed
- **Disseminated IEC Materials:** more than 10,000 copies distributed to various livestock industry stakeholders

Events Sponsored



- DOST–NAST Annual Scientific Meeting
- PSM Annual Convention
- PSAS Scientific Meeting and Annual Convention
- PSBMB Annual Convention
- and many more...





Packaging Label for the QuickCare™ Disease Diagnostic Test Kit for Caprine Arthritis Encephalitis Virus, developed through the funding of DA-BPO



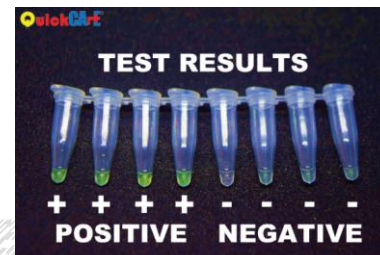
DA-LBC Technology Exhibit Booth at the 1st Regional Livestock Biotechnology Symposium – Luzon Cluster



DA-LBC Technology Exhibit Booth at the 61st PSAS Scientific Meeting and Annual Convention



Technology Catalog Developed for the QuickCare™ Disease Diagnostic Test Kit for Caprine Arthritis Encephalitis Virus



DA-LBC Technology Exhibit Booth at the 19th National Biotechnology Week held in Cebu City





Takeaways

- Exciting opportunities on the use of modern biotechnology in addressing pressing problems of livestock industry in the Philippines
- Multiple stakeholders (government, private groups, etc.) are working together to have the policies in place
- Adequate/sufficient funding for biotech, research, and innovation
- Strengthen Education and Public Awareness
- Spur interest in young generations to join the workforce of promoting modern biotechnology

THANK YOU

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