IMAGING SCIENTISTS HELP DRIVE DEVELOPMENT OF VACCINES AGAINST MOSQUITO-BORNE DISEASES

With continued support from imaging facilities, Australian researchers leverage cryo-electron microscopy to validate and drive the development of a new vaccine platform for mosquito-borne viruses like dengue and Zika.

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Building on long-standing collaborations with Monash University imaging facilities, virologist A/Prof. Jody Hobson-Peters and her team at the University of Queensland have developed a groundbreaking vaccine platform to combat mosquito-borne flavivirus diseases—including dengue, yellow fever, Zika, West Nile, and Japanese encephalitis virus (JEV).

This new platform addresses major safety and manufacturing limitations found in existing vaccines. If successfully scaled, it could significantly reduce global health and economic burdens while contributing to several Sustainable Development Goals (SDGs, see below).

Rethinking Vaccines to address a Global Challenge

Mosquito-borne flaviviruses affect millions each year, posing severe health and economic risks in many parts of the world.

Traditional vaccines are typically created by weakening or inactivating dangerous viruses. While effective, this method is slow, costly, and carries safety concerns that complicate production and deployment.

To overcome these challenges, Hobson-Peters and her team turned to a new strategy using a virus they had discovered a few years earlier.

This Binjari virus is a flavivirus that only infects insects and poses no risk to humans. By replacing Binjari's surface proteins with those from harmful flaviviruses, the researchers created a hybrid virus—one that tricks the immune system into mounting a defense, but without the risk of actual infection.

This patented hybrid system acts like an “inverted Trojan horse”: on the outside, it mimics dangerous viruses closely enough to stimulate a strong immune response; on the inside, it's harmless.
What's more, the surface can be easily modified, allowing the same platform to target multiple diseases. This innovation fills critical gaps in vaccine technology, offering a safe, adaptable, and scalable solution.

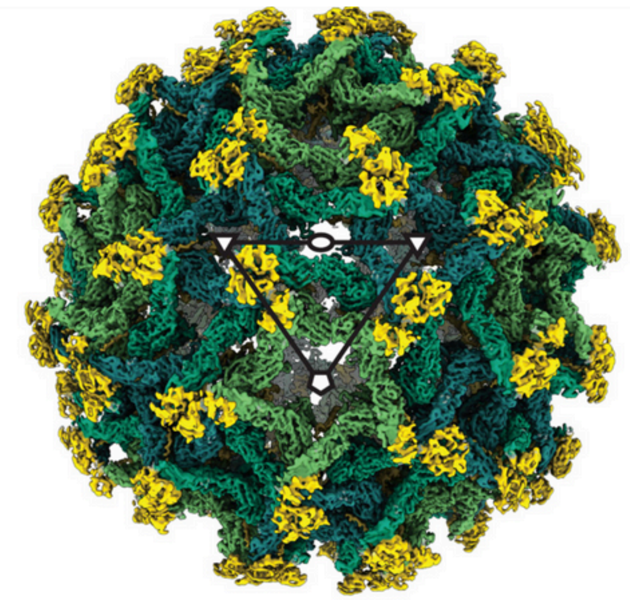

Image taken from: “The structure of an infectious immature flavivirus redefines viral architecture and maturation”, https://doi.org/10.1126/sciadv.abe4507

The Critical Role of Imaging Expertise

Designing this hybrid vaccine required researchers to see the virus structure in extreme detail—something only cryo-electron microscopy (cryo-EM) can provide. This complex imaging method requires years of experience to produce clear, usable data.

That's where the collaboration with Monash University's Ramaciotti Centre for Cryo Electron Microscopy came in. Dr Hariprasad Venugopal, senior microscopist at the Centre, led the imaging experiments and ensured their scientific reliability.

> To achieve usable images, *"our main effort is to make sure that at the time of imaging, we achieve the best possible results both optically and in sample preparation—getting the cleanest ice, the best particle distribution, and enough virus particles in each image to properly analyze,"* said Dr Venugopal.
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> *"We bring the high-end part—that is, the electron microscopy—and simplify it for people...all of those things go on in the background and help everyone."*

These contributions often go unseen but are crucial to scientific success. Years of accumulated knowledge from similar projects allow facility scientists to fine-tune each experiment, troubleshoot technical challenges, and adapt workflows to different biological systems.

Project Realization

The vaccine platform emerged through a highly collaborative effort backed by Australian government funding: including National Health and Medical Research Council (NHMRC) Grants (APP1164216, 2020–2023) of AU$1,043,871.49 (APP2004582, 2021–2024) of $1,149,487 and an Australian Research Council Grant (LP210301351, 2023–2027) of AU$969,141.

Teams led by A/Prof. Jody Hobson-Peters and Dr Daniel Watterson at the University of Queensland, alongside A/Prof. Fasséli Coulibaly at Monash University, used cryo-EM to validate the structural integrity of the Binjari-based vaccine particles. The expert technical work of platform scientists Dr Hariprasad Venugopal and Dr Lou Brillault was central to these achievements.

To accelerate impact, the team focused first on developing low-containment animal vaccines, which are faster to bring to market. This approach proved highly effective for Japanese encephalitis virus vaccines in pigs, with early trials showing remarkable success.

Key collaborators also include the Elizabeth Macarthur Agriculture Institute, QIMR Berghofer, Treidlia Biovet, the Centre for Crocodile Research, and PRI Farming all of which helped scale the project's real-world applications.

Project Outcomes and Impact

The hybrid vaccine platform has already delivered tangible results, including:

- **Protection against dengue, Zika, West Nile, and yellow fever** in mouse trials—laying the groundwork for future human vaccines.
- A **JEV vaccine for pigs** showing over 90% efficacy, helping to break the transmission cycle between pigs, mosquitos, and humans.
- A **West Nile virus vaccine for farmed crocodiles**, preventing skin lesions that cost the industry millions annually.
- Use of the hybrid virus particles in **rapid diagnostic tests** for flaviviral diseases.

Together, these outcomes support public health, enhance food security, and reduce economic losses. As mosquito-borne diseases continue to expand due to climate change, the platform offers a flexible, scalable tool for future challenges.

In A Nutshell

- Project Title: Vaccine technology supporting human and animal health
- Project Duration: Current funding 2020–2027 (ongoing collaborations)
- Key Resources Used: NHMRC and ARC Grants, Microscopy Australia's UQ and Monash facilities, interdisciplinary and industry collaborations.
- Impact: A transformative vaccine platform with applications in public health, agriculture, and diagnostics.

SDGs Addressed

- SDG 2: Zero Hunger – By improving animal health and agricultural output
- SDG 3: Good Health and Wellbeing – By developing vaccines for diseases of global significance
- SDG 13: Climate Action – By equipping society with tools to tackle climate-sensitive diseases

References/ further reading

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- MA News article and video Feb 27, 2024: “Vaccine technology to protect agribusiness”, https://micro.org.au/news/vaccine-technology-to-protect-agribusiness/; interviewed for the video: Prof Roy Hall and Dr. Jessica Harrison

→ discovery of Binjari virus and use as vaccine

- MA News article “New lateral flow test for mosquito-borne flaviviruses”