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Strengthening Genomics Research Capacity in the Pacific to Address Regional Challenges

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The Pacific Islands are home to some of the world's most unique ecosystems, cultures, and biodiversity. From lush green forests, stewarded by vibrant indigenous communities, to spectacular coral reef systems and the ocean's deepest trenches, the Pacific is not only a global biodiversity hotspot but also a living laboratory crucial for understanding and addressing some of humanity's most pressing challenges, including climate change, ocean pollution, the legacies of nuclear testing, food security, public health, and sustainable development. Nevertheless, genomics research capacity, a vital scientific tool for studying this rich natural heritage and for addressing these challenges, remains limited or nonexistent across much of the Pacific. Without local genomics capacity, Pacific Island nations will remain dependent on external institutions for genome sequencing, data analysis, and scientific decision-making. Such dependency risks exploitation, and undermines national sovereignty, ethical and culturally respectful research practices, equitable benefit-sharing, long-term adaptive capacity, and the dignity of Pacific peoples as custodians of their knowledge systems.

This policy blog outlines how genomics can help address urgent regional priorities, including climate change, renewable energy, agriculture and food security, marine resource management, Indigenous knowledge systems, public health, and social and political stability of the Pacific region. It also identifies critical gaps in local genomics research capacity and presents the vision of the Pacific Academy of Sciences (PAS) for addressing these gaps. Furthermore, the blog outlines the strategic policy investments needed to turn this vision into reality.

Harnessing Genomics to Address Urgent Regional Challenges

Genomics and molecular biology provide detailed, high-resolution insights into the biological world, revealing how environmental challenges, diseases, and ecological changes impact species, ecosystems, and human populations. For the Pacific Islands, these tools hold significant and transformative potential to address issues across climate change, renewable energy, agriculture and food security, marine resource management, Indigenous knowledge systems, and technology, as well as the social and political stability of the region. These domains represent key priorities for Pacific Island countries and are essential for shaping the region's future and long-term regional adaptive capacity. Examples of how genomics has been applied to study and address these challenges are outlined below.

1. Climate Change and Adaptation

According to the United Nations, small Pacific Island nations are highly vulnerable to the impacts of climate change. Genomic approaches offer critical insights into how climate or environmental changes affect species and ecosystems by revealing genetic traits and molecular signatures that underpin vulnerability, resilience, and adaptive potential (Borevitz, 2021; Lancaster et al., 2022; Bernatchez et al., 2024). Such knowledge can form a robust evidence base to guide policymaking in fisheries, agriculture, food security, conservation, and other priority sectors to address the impacts of climate change.

2. Renewable Energy

The shift from fossil fuels to renewable energy is an urgent priority for Pacific Island nations, driven by both climate change vulnerability and national development goals (Pueyo & Haas, 2025). Advances in genomics and molecular biology are enabling the development of climate-resilient bioenergy plants and microorganisms by identifying genes and traits that improve yield, growth, and environmental tolerance (Lovell et al., 2021; Kumari et al., 2025). Given the Pacific's extraordinary biodiversity, genomics offers significant opportunities to advance discovery and sustainable biofuel production, reduce dependence

on fossil fuels, and strengthen renewable energy systems for the Pacific region.

3. Food Security and Agricultural Resilience
Food security remains a critical challenge in the Pacific Islands. Genomics offers a powerful tool to help farmers and scientists enhance agricultural efficiency and resilience. By understanding the genetic makeup of crops, new varieties can be developed that yield more, resist pests, and thrive under adverse environmental conditions (Nature Genetics, 2019; Campell et al., 2025).

4. Environmental Sustainability and Resource Management
The survival and prosperity of Pacific communities depend on environmental sustainability and responsible management of natural resources. Genomics equips scientists and local stakeholders with high-resolution biological data about species, crops, microbes, and ecosystems, enabling evidence-based decision-making. This information can guide policies for biodiversity conservation, sustainable agriculture, climate-change adaptation, and efficient natural resource management.

5. Marine Resource Sustainability
The Pacific Ocean is central to our identity as Pacific peoples, sustaining our lives, cultures, and economies. Genomics provides powerful tools to inform marine conservation, sustainable resource management, and economic innovation (Van Oppen et al., 2022). Its applications range from assessing coral reef health and resilience (McGrath, 2024), monitoring fisheries, and tracking environmental DNA (Miya, 2022) to studying microbial ecology (Heidelberg et al., 2010), understanding ocean health, investigating the impact of climate change (Thangaraj & Sun, 2025), and advancing blue biotechnology (Maldonado-Ruiz et al., 2024), among many others.

6. Social and Political Stability & Technology
The Pacific has long served as a site for genetic research, often led by foreign researchers. This history raises complex social, ethical, and political considerations, as national sovereignty is intricately linked to the control, use, and ownership of biological and genetic resources and data. Without local genomics capacity, Pacific Island nations risk external exploitation. Issues of informed consent, benefit-sharing, and intellectual property intersect with political governance (Mc Cartney et al., 2023; Robbins et al., 2023; Mc Cartney et al., 2024), often shaping whether Pacific and Indigenous communities have a meaningful voice in decisions regarding resource use and commercialisation. These dynamics carry significant implications for intergenerational justice and protection of Indigenous communities and cultural heritage. Building genomics capacity within the Pacific can help address these challenges.

7. Indigenous Knowledge Systems and Local Context
Genomics can complement Indigenous knowledge systems that have long guided traditional sustainable practices in fisheries, coral reef management, and agriculture across the Pacific. For example, in Kiribati and across the Pacific, fishers possess extensive Indigenous knowledge of fishing seasons, productive fishing grounds, trap and gear design, toxic marine organisms, and reef conservation practices (Singh et al., 2025). Genomic approaches can complement these traditional practices by enabling molecular identification of species, tracking species migratory patterns, monitoring toxic and endangered species, and informing conservation efforts. On land, genomics can also aid in strengthening the cultivation of resilient traditional crops such as bwabwai, taro, and te mai (breadfruit) (Zerega et al., 2015; Bellinger et al., 2020).

8. Public Health and Medicine
Genomics has become an indispensable tool in public health and medicine, with applications spanning both communicable and non-communicable diseases (Khoury & Holt, 2021). The COVID-19 pandemic highlighted the urgent need to strengthen genomics capacity in the region, where limitations in genomic sequencing and data analysis hindered timely pathogen detection and community-level surveillance (WHO, 2025). At the same time, genomics holds immense potential to improve the prevention, diagnosis, and management of non-communicable diseases such as diabetes, cancer, and cardiovascular diseases (Chikowore et al., 2021). In addition, the Pacific's nuclear testing legacy remains a major health and environmental concern for Pacific communities, with genomic and molecular approaches providing powerful tools to study these impacts and guide evidence-based monitoring and mitigation strategies.

9. Artificial Intelligence (AI)

AI increasingly intersects with genomics (Alharbi & Rashid, 2022). With the growing use of AI, Pacific scholars have emphasised the importance of developing regional leadership rather than being passive users (Brimble, Palaon & Singh, 2025). Strengthening genomics research capacity could empower regional AI leadership and inform ethical governance of AI in genetic research.

Gaps in Genomics Capacity Across Pacific Island Nations

Most independent Pacific Island countries lack the infrastructure for genomics research, education, and ethical oversight, including non-human fields such as marine or ecological studies. While countries like Fiji and Papua New Guinea have emerging capacities through basic molecular biology laboratories, these facilities remain limited and often depend on foreign collaborations to conduct DNA/genome sequencing (World Health Organization, 2025). Many Pacific Island countries including Kiribati, Nauru, the Marshall Islands, FSM, Palau, Tuvalu, Vanuatu, Solomon Islands, Cook Islands, Samoa, Tonga, and Niue lack genomic facilities. In addition, major regional universities do not offer academic degree programs to develop local genomics expertise. As a result, comprehensive regulations and ethical oversight for genomic research are non-existent or underdeveloped in Pacific Island nations.

Vision of the Pacific Academy of Sciences

PAS aims to strengthen regional scientific capacity, enabling Pacific communities to lead and benefit from advances in genomics across marine and terrestrial systems. Strategic priorities for achieving this vision include: **(1) Genomics Research Infrastructure & Education:** establishing a regional genomics/molecular hub linking universities, research centers, and networks to provide Pacific scholars with access to cutting-edge technologies, resources, and accredited academic programs aligned with the Sustainable Development Goals (SDGs). **(2) Regional and Global Collaboration:** fostering partnerships among Pacific universities, regional research institutions, and international genomics facilities to advance sustainable, multidisciplinary genomics research and advance the Pacific's "Blue Ocean" vision through shared learning and innovation. **(3) Responsible Genomics:** creating ethical and legal frameworks for the use of genetic resources and traditional or local knowledge systems, as owned by Pacific knowledge custodians, incorporating Pacific ways of knowing, values, and community perspectives to ensure research is ethical, respectful, and culturally grounded.

Together, these initiatives aim to build a holistic, sustainable, Pacific-led genomics ecosystem that bridges science, education, and the traditional knowledge of Pacific peoples, advancing a "Blue Pacific Continent" united by shared oceanic heritage and scientific excellence.

Conclusion

Strengthening local genomics capacity can empower Pacific nations to better understand and respond to climate change, support the development of renewable energy solutions, enhance agriculture and food systems, safeguard marine and terrestrial ecosystems, advance environmental sustainability, improve public health and medicine, complement Indigenous knowledge systems, and generate sustainable economic opportunities. This is not only a scientific endeavor but also a vital investment in the Pacific's future. Genomics can bridge tradition and innovation, ensuring that Pacific communities and ecosystems thrive for generations.

Policy Priorities

Realising this vision requires policy action in the following areas:

- Establishing a collaborative regional Genomics & Molecular Hub.
- Developing undergraduate and postgraduate programs in genomics and related fields.
- Equipping regional scientific research institutions with genomic sequencing and bioinformatics capabilities.
- Offering short-term workshops to strengthen local expertise in applying small scale genomic technologies.
- Supporting ethical, legal, and culturally grounded frameworks to ensure responsible genomics research.

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