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The Case for Quad Co-operation In Biotechnology

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Executive Summary

The Quadrilateral Security Dialogue (henceforth referred to as Quad), between the United States, India, Japan, and Australia, was envisioned as an informal grouping of four states with common interests in the Indo-Pacific. In 2021, the Quad officially announced the establishment of over 10 working groups to bolster collaboration in multiple sectors. Biotechnology and its allied applications have been identified as a potential field for co-operation between the Quad. This intelligence estimate explores various tools and technologies in the life sciences domain that the Quad countries enjoy comparative advantages in and can pursue joint partnerships to develop the domain on a global scale. The document elucidates the different applications of existing technologies in life sciences that have socio-economic benefits and can help in human development. This document also provides an overall perspective of biotechnology's potential to be one of the driving forces for the Quad in the coming years.

We have identified the following areas with potential for co-operation:
A) Pandemic Research Hub
B) Sustainable Agriculture and Animal Husbandry
C) Vaccines
D) Gene Editing
E) Synthetic Biology
F) Computational Biology

Introduction

On 24 September 2021, leaders of the Quad discussed various avenues for collaboration at the summit held in the United States. A detailed classification and the Quad's priorities for the near future was provided through the Fact Sheet released by the White House. This fact sheet states that "*The Quad will monitor trends in critical and emerging technologies, starting with advanced biotechnologies, including synthetic biology, genome sequencing, and biomanufacturing. In the process, we will identify related opportunities for cooperation*".

Emerging applications of life science technologies are gaining global traction for their potential economic and strategic benefits. COVID-19 and other emerging infections have made the need for investments in health security measures apparent. Applications of biotechnology beyond health, fields such as bioenergy, marine biotechnology, consumer products, and nutritional security can also serve as levers of economic growth. Utilisation of the rich biodiversity, human resources, and technical expertise that the Quad together possesses can help further the national interests of all the four countries as well as fuel the overall development of biotechnology.

There is a lot of scope for increasing investment and knowledge sharing to promote research and development in biotechnology. Increased funding by the Quad for biotechnology research can help generate employment opportunities and create state-of-the-art products and services. A shift towards biotechnology-based research may also help tackle some of the pressing concerns facing the world; issues such as global health security or finding alternatives to fossil fuels.

The potential, both economic and strategic, of life sciences and technologies related to it has been recognised at the Quad summit. Analysing the benefits each biotechnology tool has to offer can help policymakers decide on specific areas of cooperation between the Quad states.

In the following section, we examine six areas where cooperation may benefit the Quad countries. For each of the six areas, we examine the rationale for cooperation, the strengths the Quad brings as well as the challenges it could face, and finally, ways to increase cooperation. The six areas are given as follows:

Pandemic Research Hub

Why should the Quad co-operate in this field?

The Quad countries are home to 1.8 billion people, approximately a quarter of the global human population. This region has also recorded a high number of infectious disease outbreaks and novel diseases (refer to Figure 1). The Quad countries are highly urbanised and well-connected with other countries. The emergence of a novel infectious disease or outbreak of a known disease in any Quad country or a region in its vicinity has the potential to spread globally (refer to Figure 2). A Pandemic Research Hub that can use a combination of technologies and approaches to undertake research for combating infectious diseases will be an asset not just for the Quad but the global community as well.

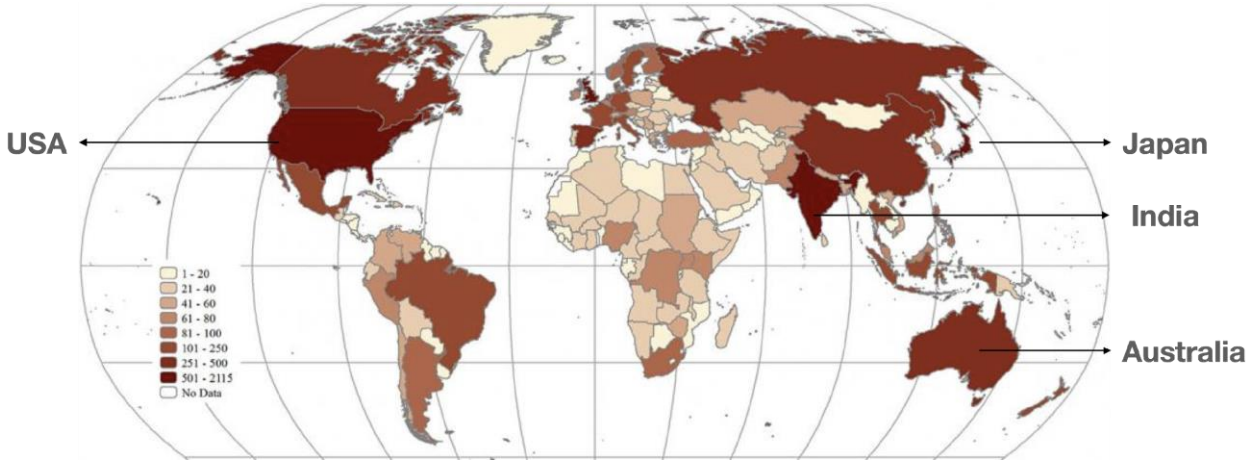

Figure 1: Global infectious disease: A global map plots cumulative outbreaks of human infectious disease since 1980.

Darker shaded nations had more outbreaks. USA, Japan, India, Australia for the Quad.

Image modified from: https://news.brown.edu/articles/2014/10/diseases

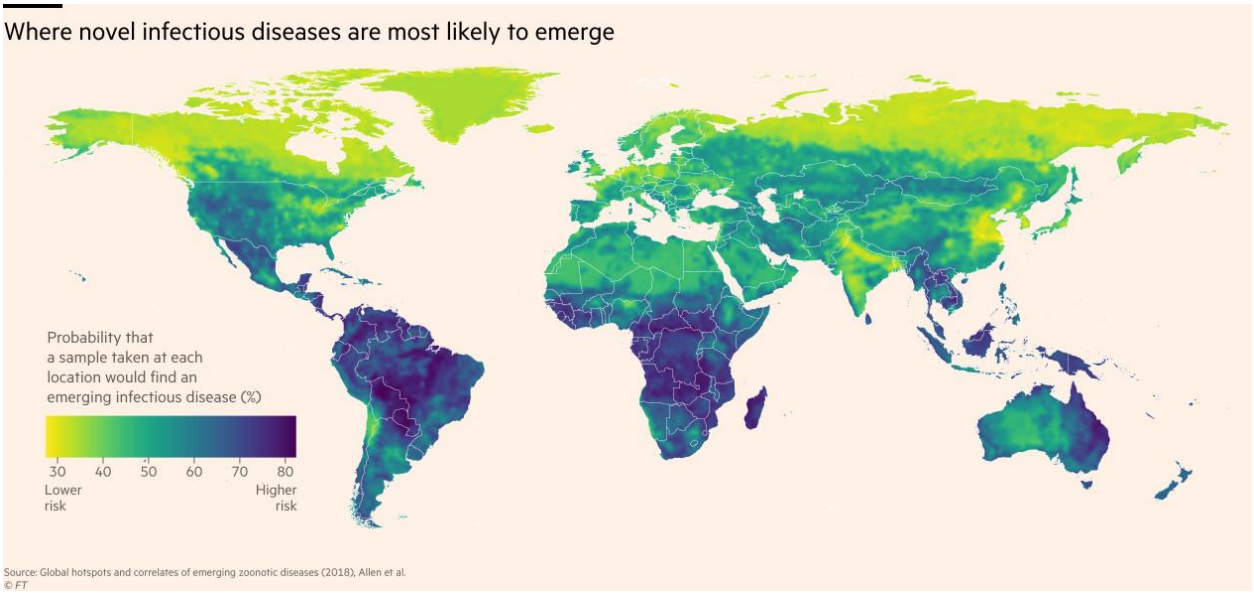

Figure 2 Where novel infectious diseases are most likely to emerge.

There is a moderate to high chance of such events occurring in QUAD countries.

Image modified from: https://www.ft.com/content/2a80e4a2-7fb9-4e2c-9769-bc0d9838245c

What are the Quad's strengths?

The Quad consists of several universities involved in hi-tech medical and technological research, and the presence of pharmaceutical and vaccine manufacturers. Moreover, a large number of students, especially from India, enrolled in Australian and American universities ensures a large pool of talented personnel already familiar with the educational and research norms of each country.

What are the Quad's challenges?

Sharing of intellectual property rights associated with research, data sharing in the domain of medical records and disease burden will need to be streamlined before the Pandemic Research Hub can work at optimal potential.

What can the Quad do to promote cooperation?

The development of interdisciplinary programs in epidemiology, disease modeling, and drug discovery amongst the universities and research institutes of Quad nations would create a skilled workforce to fast-track research. Streamlining of data localisation and data sharing agreements, especially of medical data, will enable tailored services.

Sustainable Agriculture and Animal Husbandry

Why should the Quad co-operate in this field?

Climate change has caused major disruptions in Quad countries as well as globally, from droughts and wildfires in California and Australia to erratic rainfall due to the increased frequency of storms in India and Japan. There is also a correlation between outbreaks of novel diseases and climate change. Three Quad countries - the USA, Japan, and India - are amongst the top 5 GDPs of the world.

Agricultural practices contribute to climate change and in turn, can be adversely affected by extreme weather events linked to climate change. The USA and India have vast areas of land under cultivation and are top countries when it comes to agriculture and animal husbandry. Climate change can impact food production. Hence, it is necessary to develop biotechnology-based solutions to maintain food security by enhancing research in agriculture and animal husbandry.

Biotechnology-based solutions to reduce emissions in agricultural and maintain food security can contribute towards this goal.

What are the Quad's strengths?

India has a rich biodiversity. Systematic genetic sequencing of Indian biodiversity can lead to discovery of hardy cultivars of crops or animal breeds. This combined with the biotechnological prowess of the Quad states, can lead to generation of new plant and animal varieties. These may be cultivated or reared using fewer polluting practices. They may even be hardy enough to withstand extreme weather events. For example, crops requiring less fertilisers and water, or animals less susceptible to heat strokes and infectious diseases.

Existing space and meteorological programmes of all Quad countries are advanced. Data from such programs will inform the strategy to implement agricultural and animal husbandry practices.

What are the Quad's challenges?

India has lower per-capita carbon emissions compared to other Quad members, though the total national emissions are large. Moreover, other Quad members have advanced economies that have historically used coal and non-renewable resources to achieve a high degree of economic growth. As witnessed during the COP26 of the United Nations Framework on Climate Change (UNFCC), there exists a wide disparity in discourses related to the funding required for climate change mitigation. Quad can serve as a platform to find an acceptable solution to the dilemma of funding. Part of the funding can be used to promote biotechnology-based solutions for climate change mitigation.

The way agriculture and allied activities are practiced in India versus the other Quad countries is different. Different strategies to implement biotechnology-based solutions will have to be developed for large-scale industrial farming versus agriculture on small landholdings.

What can the Quad do to promote cooperation?

Biotechnology-based solutions can reduce emissions from agricultural practices as well as develop new crop and animal varieties better suited to changing climatic conditions.

These can range from producing alternative fuels from agricultural wastes to genetically modified crops designed to fix more atmospheric carbon. Research into lab based alternative sources of meat need to be promoted to address the dual problems of food security and the polluting nature of animal husbandry. India's specific problem of nutritional security can also be challenged using similar approaches.

The promotion of biotechnology research in agricultural universities is required to develop such tools. The USA and Japan boast many of the top 50 ranked agricultural universities. The Quad structure should be used to give a boost to research at Indian agricultural universities.

Vaccines

Why should the Quad co-operate in this field?

Members of the Quad helped other states acquire vaccines either through direct exports (the United States and India) or providing the required finances (Australia and Japan) to developing countries. The ability to manufacture or finance vaccines was leveraged as a tool by multiple states to reinvigorate relationships with other countries during the pandemic. This can be seen through India's vaccine overtures towards its neighbours like Nepal with which it had a border dispute in the previous year.

What are the Quad's strengths?

All four Quad countries are producing WHO prequalified vaccines, demonstrating a capacity to manufacture quality vaccines for global use. The US and India have also supported vaccine research, creating indigenous vaccines for a wide variety of diseases. All four countries have also demonstrated a commitment to global vaccine distribution, as part of COVAX and GAVI vaccine alliances.

What are the Quad's challenges?

Differing intellectual property laws governing vaccine research may impede free sharing of knowledge and technology transfers between private companies of the Quad countries. This has been made apparent by the ongoing tussle over the IP waiver for COVID-19 vaccines at the World Trade Organisation.

What can the Quad do to promote cooperation?

The Quad can invest in furthering vaccine research to fast track the process of vaccine development. This can be done by setting up research institutes targeting potential diseases or studying newer vaccine delivery systems. These centres can work in analysing the root behaviour of certain pathogens to develop methods to counter their effects.

With improvement in access to vaccine research facilities, the manufacturing process can be streamlined, helping in the faster deployment of vaccination programmes. India and

the US can help set up vaccine manufacturing facilities in the Quad countries to diversify the supply chain remove any bottlenecks involved. The vaccine supply chain includes securing of all raw materials needed for vaccine manufacture. The process of vaccine research and securing their manufacturing will help the Quad become an export powerhouse in vaccines and eventually use vaccines as a diplomatic tool to build newer alliances.

Gene Editing

Why should the Quad co-operate in this field?

The application of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) technology has conferred humans with the power to alter certain biological and physical traits across plants, animals, and humans.

Currently, the most feasible application of gene editing in humans is the treatment of diseases through the correction of diseased genomes. Another major application of gene editing is the creation of genetically edited crops to improve nutritional security in each country. Gene editing can also boost the creation of drought and flood-resistant varieties of crops and fruits in response to extreme weather events linked to global warming.

Further, genetically modified bacteria to tackle oil spills and in the process of bioremediation are areas for the Quad to work together on, particularly given the long coastlines common to all Quad countries.

Usage of genetically modified microbial organisms in the treatment of industrial wastes can help states reduce their carbon footprint and achieve climate goals that have been set in recent summits. With the Indian Ocean constantly under the threat of excessive pollution and climate change, the Quad has the opportunity to use gene-editing technology to tackle major environmental issues for an open and environment-friendly Indo-Pacific.

What are the Quad's strengths?

Trials using CRISPR in humans have already begun in the US and India. The US, Australia, and Japan have also passed legislation regulating the use of gene editing in plants, with the US taking the most lenient stance of excluding genetically edited plants from regulatory oversight. There is a strong focus and incentive on researching gene editing applications in plants, animals, and humans in the Quad countries. The Quad countries also possess rich biodiversity, which can be harnessed appropriately to identify

targets for gene editing and trial genetically edited products across various climates and topographies.

What are the Quad's challenges?

With CRISPR being used to genetically modify human embryos, as done by a Chinese scientist in 2018, the question of the extent to which gene-editing technologies should be used still remains to be answered. The power of gene editing has triggered a debate on the potential benefits versus risks associated with using these technologies. The Quad has the opportunity to cooperate on gene editing to unlock these potential benefits while creating a roadmap for assessing its risks. It must be the responsibility of the Quad governments to ensure the progress of gene editing while keeping in mind the harms related to it and negotiating ethical concerns of individual countries.

What can the Quad do to promote cooperation?

The Quad, with its economic and scientific might, must look to facilitate gene editing research through increased funding and sharing of knowledge. The Quad can further work together to explore gene editing technologies for applications specific to the needs of each country, through the setting up of scientific committees. These committees can assess the benefits, risks, long-term impacts, and unintended consequences of using gene editing technologies. The alliance should propose a common regulatory framework on the use of gene editing technologies, with a focus on understanding the ethical considerations unique to each country.

Synthetic Biology

Why should the Quad co-operate in this field?

The developing field of synthetic biology seeks to design and construct new biological parts, devices, and systems along with redesigning existing systems. With the field still evolving, there is a major scope for identifying critical growth opportunities and segments in the long run.

There is a need for identifying potential applications which can serve as both economic and strategic assets in the coming years. Developing efficient pharmaceuticals with the help of synthetic biology can be an attractive idea for the Quad. This can alleviate dependencies on pharmaceutical supply chains, which are fragile during the COVID-19 pandemic. Cooperation in the field can also open up ventures to develop a suite of bio-based products (like antibiotics, vitamins, enzymes, organic acids, and performance materials) which can provide the Quad with a platform to become a formidable force in the business.

What are the Quad's strengths?

An important application of synthetic biology is its use in furthering the sector of clean energy. Breakthroughs the use of synthetic biology to manufacture biofuels and renewable energy sources can serve as potential alternatives to petroleum and other fossil fuels. Synthetic biology can also aid in the manufacture of 'Green Chemicals' from agricultural waste. With all the Quad countries championing environmental conservation, collaboration in synthetic biology can help in achieving internationally set sustainable development goals in the future.

What are the Quad's challenges?

The Quad countries might have to navigate licensing issues and patent rights when collaborating with each other on the different applications of synthetic biology. There have been many advancements made in the field especially by the private sector. All Quad

states might have to sign agreements on the transfer of these technologies between governments and private sector companies for better cooperation.

What can the Quad do to promote cooperation?

The Quad can collaborate in different applications of synthetic biology that lie at the intersection of interests of all four countries. The economic clout of the Quad can help streamline the process of patenting and licensing these synthetic biology applications that have been developed by the private sector. There can also be a framework by the Quad countries to create viable alternatives for critical issues like climate change using synthetic biology applications.

Computational Biology

Why should the Quad co-operate in this field?

The need for mathematical modelling systems and simulation software is at all-time high. Analysis of large data sets in the pursuit of credible research and development are driving the need for these systems . The field of computational biology uses these tools for the study of biological and ecological systems.

These data can help pharmaceutical companies in creating fast and efficient drug discovery methods. With events like the COVID-19 pandemic, these computational biology tools will help in better preparedness and responses to future public health threats. National epidemic intelligence agencies of the Quad can utilise the benefits that computational biology tools have to offer so that they can tailor their responses to disease outbreaks in a much more calculated way.

What are the Quad's strengths?

With the Quad countries playing home to a significant percentage of the global population, the availability and accessibility to biological data specific to humans should not be a problem. The constituent states of the alliance also have diverse ecosystems and are extremely rich in biodiversity. These diverse environments can help improve the effectiveness and efficiency of biological data models.

What are the Quad's challenges?

While ecological and biological diversity can be a strength, it can also be a challenge for the Quad countries to create models and computer networks that can maintain a high level of accuracy in ensuring the surveillance of different diseases. This can be due to several reasons. One is the easy access and availability of high-throughput computational environments that integrate large amounts of genomic and experimental data. Comprehensive tools and algorithms for knowledge discovery and data mining of biological data are yet to be developed on a large-scale basis. There is also the need for developing friendly user interfaces that provide tools necessary for the easy access,

navigation and visualisation of biological information. These require large, public scalable computational resources to handle the exponential growth of biological data.

What can the Quad do to promote cooperation?

The Quad can come together to build robust data-sharing models between the participating states for better access to important data, while ensuring the protection of human rights.

Other Potential Areas of Partnership

Regenerative Biology

The field of regenerative biology deals with the repair and restoration of cells or tissues. There have been major developments regenerative medicine. The Quad can tap into economic opportunities which are on offer from regenerative medicine technologies. It can also participate and spearhead research development for the treatment of various diseases, particularly those afflicting an aging population.

3D Bioprinting

3D bioprinting has become a developing technology in the regenerative space with the use of 3D printing technology to fabricate biomaterials that imitate natural tissue. The application of bioprinting for the creation of live, functional organs is underway. The Quad and its states working together to develop such tools can help provide safer healthcare solutions and meet certain organ requirements. With the 3D bioprinting market growing steadily, the Quad should evaluate its presence in the field for potential economic growth.

Biomechanics

Biomechanics is an alternative for regenerative medicine and organ transplantation. The ability to provide comparable mobility and health for the injured or diseased using biomaterials instead of metals has gained traction in recent times. The application of biomechanics has also been seen in the process of tissue engineering to treat pathologies like cancer. The Quad remains a suitable alliance to develop the field to help in furthering the understanding and analysis of the mechanics of biological systems.

Nanotechnology

Applications of nanotechnology have increased exponentially in the 21st century with the use of nanotech seen across all scientific fields. The Quad can form a

'Nanotechnology Dialogue' for increasing funding and improving the field's research for broadening the scope of applications of nanotechnology.

The use of nano sensors and nanobots for the process of drug delivery has already taken off and nanoprobes are being tested for the detection of proteins and other microorganisms in the body. Monitoring of cells, engineering of tissues, and other related uses of nanotechnology can help ease the burden on human precision in healthcare systems. The Quad has the necessary skills to ensure the growth of the field, especially in terms of its biological uses and applications.

Conclusion

Even as the Covid-19 pandemic subsides, life sciences will be a critical area of cooperation among members of the Quad. The expansion of the original mandate of Quad to include research in the field of biology is a definitive positive development. The combined technological and economic prowess of all the four countries can help a number of people who can directly benefit from increased co-operation. India specifically can get increased access to the latest bio-based technologies through this collaborative venture with the Quad. The human capital, biodiversity and pharmaceuticals industries on offer by all the Quad countries will all prove to be critical strengths for future cooperation in the biotechnology field.