A framework for Genomics Aotearoa

The purpose of this document is to propose a structured framework for Genomics Aotearoa within which to develop details including strategic themes for research programmes. We who support this proposed framework (listed at the bottom of the document) want to work with all parties to produce a single cohesive response to meet the need for strategic action in the area of Genomics. We want to equip the NZ science system by building capability in this crucial area to deliver impact both internationally and to NZ society through Genomics technology and expertise. We have purposefully limited discussion on the specific research themes because the "Genomics Aotearoa" document authored by Dearden *et al* has already made steps in that direction. We think the next logical step would be to attempt to merge these efforts into a single draft proposal.

The Mission:

To transform bioscience in Aotearoa with world-leading genomics outcomes through research, partnership, and capability building.

Success will be measured by:

1. Delivery of world-leading science that utilises genomics and bioinformatics and development of high-impact genomic and bioinformatic technologies.

2. Partnerships of breadth and depth spanning basic research, applied research and industry R&D, leading to tangible and relevant outcomes for all participants.

3. Rapid expansion of genomics and bioinformatics capability in Aotearoa through a collaborative research-led training platform.

4. High-value integration and cohesion between genomics and bioinformatics practitioners across the country, including into sectors where there are opportunities for high-impact translational outcomes.

Specific targets for first term:

1. Three professorial level academics recruited to NZ in the first two years (at least one in genomics and at least one in bioinformatics)
2. $5 million additional (extra to SSIF) research contracts into organisation during first term

3. 20 postdocs newly trained in bioinformatics/genomics in first term, including at least three in clinical genomics research
4. 20 PhD studentships using genomics and bioinformatics started in first 3 years
5. 50% increase in the number of high-impact papers (>50 citations in first 5 years) for NZ genomics/bioinformatics publications by 2020
6. Establish a strategic translational research project with industry-based entities in one or more of the following areas: clinical genomics, agriculture, conservation/biodiversity.
7. Lead national review of undergraduate training in partner Universities in bioinformatics and genomics in first 2 years.
8. Establish nationally coordinated graduate training program in bioinformatics and genomics in first 3 years
9. Genomics/bioinformatics roadshows visit 50 high schools during first term

The Model:

1. Research Programmes

- Several Research Programmes will be established to provide research leadership in genomics and bioinformatics in Aotearoa.

- The research-specific mission of the Programme(s) is to produce world-leading genomics/bioinformatics research. This will be measured by publications, international connectedness, obtaining international funding, invitations to speak at international conferences, and visiting international experts.

- The Programme(s) should offer a vision for world-leading research together with a pathway for achievement that is based on synergies between the researchers involved, and that leverages linkages with existing research bodies, such as the Centres of Research Excellence, the National Science Challenges, NeSI, CRIs, etc.

- The Programmes will prioritize integrative research but may support individual research groups doing internationally excellent work on common themes. Priority will be given to research that contains a strong underpinning cross-sectional component, or that will produce critical underlying techniques or technologies.

2. Development of Partnerships

- The Programmes should be active in forming productive and collaborative partnerships between individuals and groups that have an interest in genomics and bioinformatics. These programmes will comprise a mixture of academic research collaborations, and projects in which genomics and/or bioinformatics methodology is being used in an applied setting with industry-based partners.

- The partnerships should leverage the expertise of all parties to achieve outcomes beyond the capabilities of individual groups, and that encompass areas where New Zealand can become world-leading and/or which are significant to the country.

- Formal partnership agreements should be in place, and all parties should benefit (e.g. through shared authorship/IP), as for other collaborative ventures.

- Resourcing should be available for travel/accommodation to facilitate this, and some of this should be dedicated to those from regions that do not host a programme.

- The partnerships will often include a component of the training outlined in (3).

3. Incubator Model of Capability Building

- People wanting to develop genomics expertise will relocate for a set period of time to a programme. They will take their idea and/or data and work on achieving the outcome they want (e.g. experimental design, analysis) on-site, with the assistance of Programme staff.

- The visitors are expected to attend group meetings/seminars/journal club to become imbued with genomics/bioinformatics culture. They then return to their group to disseminate their learnings.

- An obligation of the Programme(s) is to assist people undertaking on-site visits.

- Incubator visits may be available on a competitive basis, although a key underlying principle is that incubation programs are open to all areas of genomics, not just those being undertaken in the Programme(s).

- Incubator visits will be facilitated through provision of travel/accommodation resourcing, with some of this resourcing dedicated to those from regions that do not host a programme.

- The interaction should be collaborative, therefore the programme staff can benefit from authorship/IP, if appropriate, as for other collaborations.

- These are distinguished from Partnerships in (2) by the visitor undertaking the actual work, but with assistance from Programme staff. However, they may lead to Partnerships.

Structure and Operation

International Scientific Advisory Board:

There will be a scientific advisory board, consisting of international experts in bioinformatics and genomics. The board will input on the appointment and renewal of Programmes, based on their success in delivering all aspects of the mission.

Programme limits:

Programmes will be established on a four year term. Appointments to a Programme are for a maximum of two terms. This is based on the EMBL model, where the expertise then passes back to the home institute and openings for the development of other researchers are made.

Structural model:

Three structural models are possible: a centralized single site with existing critical mass and infrastructure; a small number of distributed sites; or a virtual centre.

- A single, centralized site offers the best opportunity to truly integrate researchers and research, is ideal for the incubator model, and provides a critical mass of researchers that avoids shallowness and duplication across sites. However, it may be impractical as most researchers will not want to relocate elsewhere, particularly as the positions are not permanent.
- A virtual centre is impractical for the incubator model, runs a significant risk of business-as-usual research without substantive integration, and will likely result in duplication and patchy distribution of expertise.
- A distributed site model appears the most practical solution. Given the experiences of NZGL, unless there is significantly more money, this will need to be limited to about three sites. Provision of money for travel to these sites by those outside is therefore critical to minimize haves/have-nots effects.

International excellence and connectedness

The success of the mission will crucially rely on establishing research programmes that are internationally excellent and connected. In developing Genomics Aotearoa research programmes and partnerships it will be important to leverage on existing international connections and establish new ones, especially to Asia Pacific, North America and Europe.

Region	Countries	Percentage of	% publications

		collaboration (Nature Index)	(Scopus analysis, doesn't add up to 100%)
Asia Pacific	Australia (10.89), China (4.2), Japan (2.67), South Korea	> 17.8	29.7%
North America	USA (25.73), Canada (3.45), Mexico	> 29.2	35.9%
Europe	UK (12.33), Germany (11.46), France (5), Italy (3.12), Netherlands (2.49), Sweden, Spain, Switzerland, Denmark, Belgium, Ireland	> 34.4	>58.6%
TOTAL		> 81.2	N/A

Asia Pacific connections

EMBL Australia (http://www.emblaustralia.org; including EML Australia Bioinformatics Resources) and Bioplatforms Australia (http://www.bioplatforms.com) are key targets for partnerships in Australia and are the main voices in ongoing conversations in Australia on their own national initiatives in genomics and bioinformatics.

European connections

European countries account for 5 out of the 10 most connected countries to NZ measured by existing science collaborations (UK, Germany, France, Italy, Netherlands; http://www.natureindex.com/country-outputs/new-zealand), and Europe is the single largest region of existing international connections for NZ scientists. One possible framework for the structural model of core Genomics Aotearoa operations would be under the auspices of EMBL associate membership. The features of EMBL associate membership that are synergistic with Genomics Aotearoa aims are:

- Explicit NZ government "skin in the game" (EMBL is an intergovernmental organisation, rather than a coalition of research institutes)
- Because it would be a truly national entity, it would provide a clear focus for national-scale cohesion, but unlike the significant national cohesion achieved by NZGL in terms of only "service work", EMBL membership would ensure the national cohesion was research led, operating at a level that is internationally competitive.
- EMBL associate membership would provide an additional route for international connectedness for NZ genomics researchers (eg. the EMBL Visitors Programme - both inbound and outbound, closer relationships with EMBL Australia in particular as well as European partners, student and postdoc overseas experiences that would not otherwise be achieved

- EMBL Associate Membership would help get more NZ bioinformatics and genomics researchers working in the best places overseas and then bringing their connections and expertise back to NZ.
- The need to work with EMBL to determine an acceptable structure will help Genomics Aotearoa be scientifically meaningful in an international setting.
- EMBL's rotating leadership model will:
  - help ensure succession planning and ensures leadership training
  - limits the long term load on any one individual,
  - ensures good leadership, management, governance and adequate resourcing, as a requirement of associate membership
- The acknowledgement (at least in the five main EMBL laboratories) that high-flying bioinformatics careers can include a proportion of "service" / "consulting"
- Having an EMBL model would mandate MBIE/University investment in "synthesis centre" or "incubator" activities.

Background

The use and integration of genomics, computational approaches and mathematical models into all areas of biology is proceeding at a rapid pace and no area in the life or health sciences is unaffected. Bioinformatics and Genomics are now central to practically all of biology and the life sciences. Cutting edge research and development in biology now routinely requires computation and complex data analysis, and many research teams are struggling to adapt. Despite its size, New Zealand has seeds of excellence, with several internationally leading research teams in bioinformatics and related areas of computational biology. This is especially true for the development of new mathematical and computational methods that have broad application, but also of cutting-edge application of statistical computing methods to genomic data. Yet this research expertise and the related technical skills are not widely available or coordinated in the NZ context. We believe that NZ already has all the elements needed to create transformative and rapid change in both basic and applied research. Genomics is an area where it is wise – and in fact essential – for NZ to continue to invest in, and the time is right to develop an alternative approach to the service-focused model that has been tried thus far. Looking at successful endeavours overseas, we believe the way forward is an integrated approach that focuses on the strong community of research leaders in bioinformatics, computational biology, and genomics.

Access to high quality data analysis is the elephant in the room

We envision a programme driven by dedicated research that develops and applies cutting edge computational methods for genomics and the life sciences. But to be of the broadest benefit to NZ, it must also have an explicit mandate to equip the NZ science system by enhancing genomic research capabilities through providing collaborative training to both the science community and industry. As with successful centres overseas such as SciLifeLab in Sweden, the EBI in the UK, or VLSCI in Australia, this will form an essential part of its remit of **research, partnership and capability building.**

High impact science in biology has shifted from small labs to team-based research, but this requires expertise, depth and stability of funding. NZ science and industry is vulnerable in this regard as many institutes and organisations have been slow to develop and sustain high quality data analytics and bioinformatics skills. Consequently there is often a boom-and-bust element to research teams and our genomics-based industries are underperforming.
Computational tools are now pervasive in all areas of biology, and work lacking computational components (in both academic research and industry) is increasingly low-impact and marginalised. We therefore see a need for a strategic approach to equip the broader NZ R&D community with genomic capabilities if it is to increase competitiveness and relevance. That requires building depth based on our expertise, and generating conditions for spillover effects, where institute-trained researchers subsequently integrate back into the community. This would drive bioinformatics and genomics research while also serving as a provider of high-quality genomics data analysis. Importantly, it would be an incubator of best practices for high quality genomics data analysis.

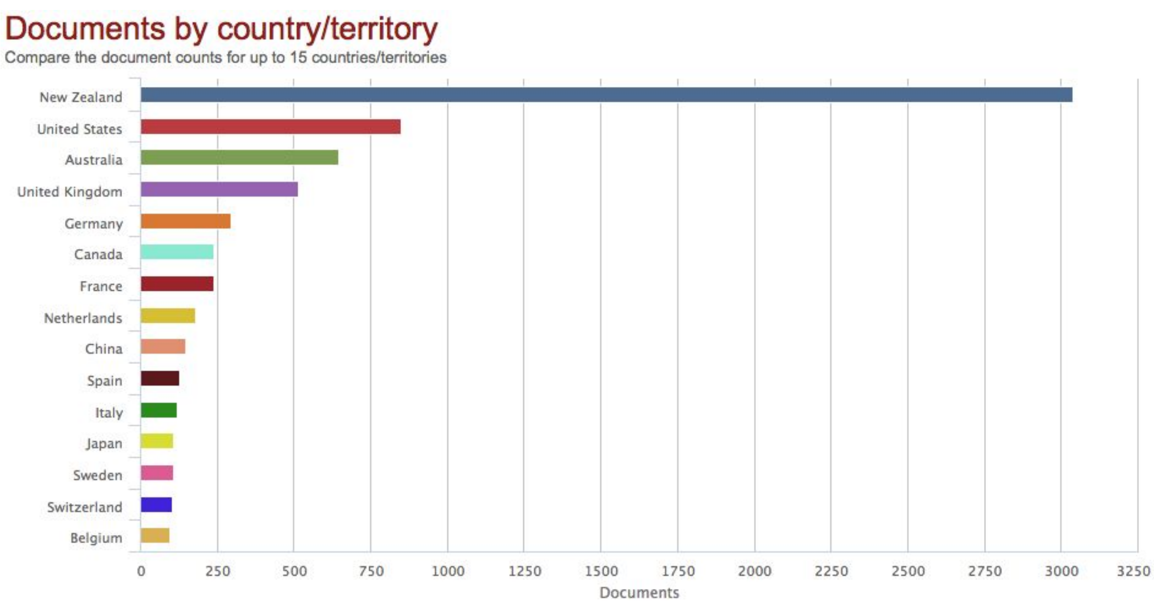
Scopus analysis of historical output (2011-2015 inclusive)

(TITLE-ABS-KEY (**genomics** OR **bioinformatics** OR **genetics** OR **"computational biology"** OR **"molecular evolution"**) OR SRCTITLE (**genomics** OR **genetics** OR **"computational biology"** OR **"molecular evolution"**)) AND AFFILCOUNTRY (**new zealand**) AND PUBYEAR > **2010** AND PUBYEAR < **2016**

Institute	**Documents**	**%**
University of Auckland	725+77	26.4
University of Otago	562+81	21.2
Massey University	473	15.6
University of Canterbury	227	7.5
Plant and Food Research	183	6.0
Others	711	23.4
Total	3039	100

Subject Area	**Documents**	**% of documents**
Biochemistry, Genetics, Molecular Biology	1825	60.1
Medicine	1739	57.2

Agriculture and Biological Sciences	1302	42.8
Immunology and Microbiology	468	15.4
Environmental Science	212	7.0



The affiliated countries to NZ research (2011-2015) by number of documents out of a total of 3039 documents (Scopus analysis).

Citation analysis (2006-2010 inclusive)

- 2274 documents
- 5-year citations (Scopus) = 21398
- 5-year H-index (Scopus) = 53
- 1 paper with >= 1000 citations (restricted to the 5-year period)
- 2 papers with >= 500 citations
- 3 papers with >= 200 citations
- 13 papers with >= 100 citations
- 59 papers with >= 50 citations
- 190 papers with >= 25 citations
- 261 papers with >= 20 citations
- 594 papers with >= 10 citations

Citation analysis (2011-2015 inclusive)

- 3039 documents
- 5-year citations (Scopus) = 35950
- 5-year H-index (Scopus) = 67
- 3 papers with >= 1000 citations (restricted to the 5-year period)
- 7 papers with >= 500 citations
- 16 papers with >= 200 citations
- 37 papers with >= 100 citations
- 112 papers with >= 50 citations
- 298 papers with >= 25 citations
- 391 papers with >= 20 citations
- 814 papers with >= 10 citations

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