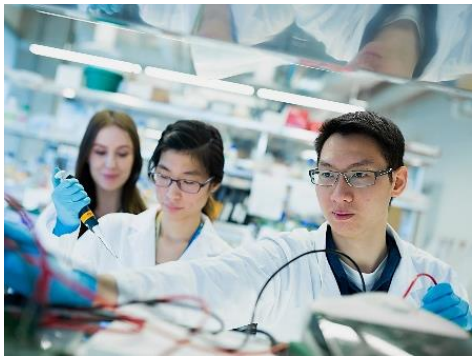
THE UNIVERSITY OF BRITISH COLUMBIA
Faculty of Medicine

LEADING PRECISION HEALTH

UBC Faculty of Medicine Position and Priorities to Enhance our Leadership in Precision Health Research and Education





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FOUNDATION

UBC's strategic plan, ***Shaping UBC's Next Century***[1], provides clear context and sets our collective vision to ***inspire people, ideas, and actions for a better world***.

In the Faculty of Medicine's strategic plan, ***Building the Future***[2], we reaffirm that the fundamental premise of social accountability is at the foundation of all that we do, supporting our vision to ***transform health for everyone***.

To meet this mandate and realize our vision, we continue to strive for leadership through living our principles of ***excellence, equity, engagement, and effectiveness***.

We know that the rapid increase in amount and type of information about each of us and about the mechanisms that influence our health will change health care. Meeting our social accountability mandate and realizing our vision require us to be at the forefront of this burgeoning field to build the evidential basis for practice changes and ensure new ways to maintain and improve health are accessible to everyone and support the whole system.

Specifically, one of our objectives is to ***enhance our leadership in precision health*** (PH), which also supports UBC strategies on collaborative research clusters, educational renewal, and interdisciplinary education.

To set our course towards enhanced leadership in PH, we scanned the PH landscape at UBC and in BC more broadly.

DEFINITION

A substantial portion of PH work over the past several years has focused on the individual and on using genetic information to improve health. UBC has shown and continues to show impressive strength in this area. More recently, the field has expanded to consider an increasing range of data and context specific to a given person (other 'omics, socioeconomics, environmental factors, etc.).

Further, powerful interactions among those factors are increasingly apparent, expanding PH to reflect complex relationships between micro and macro interventions and policy. Accordingly, personalized interventions focused on prevention and/or treatment are increasingly recognized to have population-level implications. UBC is in a strong position to lead this space, while continuing to lead and grow in more traditional areas of PH.

Given this context, we use the following working definition of precision health:

An individualized approach to maximizing health that engages patients and leverages genomic and other 'omic, biomarker, environmental, and/or socioeconomic information about a person to identify and implement a range of prevention and/or treatment actions, at the patient-, population-, and/or policy level.

LANDSCAPE

To inform our approach to enhancing our leadership in PH, we scanned the landscape by engaging 45 people active in PH at UBC and in BC more broadly.

The appendix summarizes the range of PH-related activities we heard about in the landscape scan. It is not an exhaustive list of all PH activity in BC, but it is a helpful cross-section of activity that illustrates our current breadth and leadership in PH.

PH activity by UBC-affiliated stakeholders summarized in the appendix is organized into the following categories, which are not mutually exclusive or definitive, but are intended to help the reader digest the information: Diagnostics, Prediction, and Biomarkers; Therapeutics; Microbiomics; Environment and Exposomics; Counselling and Behaviour Change; Data Science and Statistics; Health Economics; and Education and Capacity Building.

In addition to UBC stakeholders, we engaged people from other academic institutions, health authority- and university-affiliated research institutes and centres, government and not-for-profit sector, and industry.

THE WAY FORWARD

Guided by our vision and building on our social accountability foundation with the wisdom of those working in the field, we set the following priorities, which together are intended to enhance UBC's collective leadership in PH.

Coordination and Platform Support

Due to the scale and diversity of PH activities at UBC, it is challenging for anyone to maintain an up-to-date picture of who is working on what. This can lead to missed opportunities for collaboration and the possibility of gaps or redundancies in the PH research landscape.

In addition, while vibrant activity across the spectrum of PH is a strength, with such a broad field, there is potential for us to spread efforts too thin. Improved coordination can help us identify the right PH areas on which to focus our resources, maximizing our leadership potential.

Also, while there appears to be strong connections and collaboration among researchers in Faculty of Medicine departments, schools, centres, and institutes and with some other Faculties, such as Pharmaceutical Sciences, Land and Food Systems, Applied Science, and Science, there are opportunities to expand these connections and create new connections with other Faculties and Schools.

These inter-Faculty connections can be particularly important when considering GE^{3}LS (Genomics and its Ethical, Environmental, Economic, Legal, and Social).

Given this context, to capitalize on collaborative and synergistic opportunities, avoid gaps and redundancies, enable focus within the broad PH field, and leverage areas of expertise across UBC, the Faculty of Medicine will:

1. *Facilitate collaboration and coordination of PH activities* by creating a PH structure through which the Faculty can set PH direction and enable physical and virtual collaboration.
2. Through the PH structure and core platforms, *identify and support areas of existing, unique strength within PH as well as emerging areas* where we have the potential to collectively lead the field.
3. *Strengthen, maintain, and build inter-Faculty collaboration*, in particular with the Faculties of Pharmaceutical Sciences, Land and Food Systems, Applied Science, Science, Law, Arts, and the School of Business.

There are various forms the PH structure referenced in priorities 1 and 2 could take, but its function will be to enable the Faculty of Medicine to organize PH initiatives, facilitate collaboration (in person or online), connect researchers with areas of strength, bridge disciplines, coordinate access to platforms and biobanks, enable new platforms where needed, and ensure equity of access to these resources across BC.

Communications and Engagement

A significant aspect of leadership is how we are perceived. In order to enhance our image as a leader in PH, the Faculty of Medicine will:

4. *Develop and execute a UBC Faculty of Medicine PH communications plan* that includes, for example, creating and maintaining a website to highlight noteworthy PH activities and dedicating an issue of *Pathways* to PH.

Furthermore, engagement with patients, their families, and the public is a major thrust of health research today, and is particularly important in the field of PH.

Progress towards another research-related objective of the Faculty of Medicine's strategic plan, which is to embed and extend our patient-oriented research capacity, will also support effective patient engagement in PH research.

Education

As PH is such a broad field with many sub-domains ranging from medical genetics to data science and from nutrition to microbiology, there are many education programs and courses that support continued focus on many aspects of PH. However, there are few educational offerings that tackle the over-arching field of PH. This represents an opportunity for the Faculty to lead.

Recognizing this opportunity, the Faculty of Medicine has entered into a Memorandum of Understanding with Genome BC to enhance the working relationship between the two parties and explore opportunities to plan, develop, and deliver educational programs in 'omics.

In support of this, Genome BC developed an education asset map that catalogues clinical genomics resources available to BC Healthcare Professionals in order to identify what could be leveraged and what is missing. To support this work and to build our leadership in PH education more broadly, the Faculty of Medicine will:

5. *Collaborate with Genome BC* in order to accelerate the process of identifying and pursuing PH-related educational opportunities.

6. *Choose and create PH educational program(s)* where a need exists, for example a graduate certificate program in PH tailored to graduate students and researchers, and/or a continuing professional development program tailored to practicing clinicians including residents.

7. *Liaise with UGME Committee to review PH content in the MD curriculum and to identify opportunities to integrate new PH content* where needed and feasible, through, for example, the Flexible Enhanced Learning courses and/or theme content.

Although perhaps outside of the Faculty of Medicine, continuing to build education programs in data science, including statistics and machine learning, will be of significant benefit to advancing UBC's leadership in PH.

Capacity Building

One of the key levers that the Faculty of Medicine can use to enhance our leadership in PH is to continue to allocate human and financial resources to PH-related activities.

Importantly, we have an incoming Canada 150 Research Chair in Functional Genetics, UBC created the President's Excellence Chair in Precision Oncology, and multiple Canada Research Chairs in PH-related fields have been or are being awarded.

Also, through faculty renewal investments, we are hiring a full-time, tenure-track Associate Professor in Medical Genetics to develop the first PhD program in Genetic and Genomic Counselling in North America.

Similarly a project that will create a service that allows cutting-edge research in the single cell genomics field was funded through the Strategic Investment Fund. This will help maintain UBC's dominance in genomics and open novel paths to implement PH. The service will make available a library of reagents enabling the concomitant determination of transcriptomes and surface proteomes on thousands of single cells.

Further, UBC is a Founding Member of Canada's Digital Technology Supercluster, which presents an opportunity to collaborate with other organizations and obtain funding for a wide range of projects including PH projects.

We applaud these significant steps that will contribute to enhancing our leadership in this field. Building on this strong position, the Faculty of Medicine will:

8. *Prioritize strategic recruitment of additional leaders in this field*, including those who can bridge the gap between fundamental sciences and clinical/public health application.

9. Actively *collaborate with Digital Technology Supercluster partners* to advocate for, propose, and undertake PH-related projects.

Translation into the Health System

Although the Faculty of Medicine's core mandate is research and education rather than direct health care delivery, we are a key partner in the health system.

We acknowledge that implementation of PH in the health system must be a collaborative effort across many partner organizations, including the BC Government, Health Authorities, clinicians, and private companies. As such the Faculty of Medicine will:

10. *Engage our health care system partners to support the appropriate, stepwise translation of PH knowledge, tools, and techniques* in a way that is beneficial to BC and beyond, supported by research findings about PH feasibility, analytic and clinical validity, clinical utility, and affordability.

IMPLEMENTATION

The Dean and Dean's Executive endorsed this approach on December 5, 2018. Now, initial efforts are directed towards creating a PH structure (priority 1) and advancing the education-related priorities (5, 6, and 7).

Creating a PH Structure

The approach to creating a PH structure begins as follows:

- Review and validate the functions that the PH structure is intended to fulfil;
- Identify structure options, map them against the needed functions, and engage our research community in validating/adjusting the options;
- Estimate one-time and ongoing resources required to achieve each option; and
- Analyse options in terms of which functions they fulfil relative to cost, and recommend an option to the Dean and Dean's Executive for consideration and decision, including resource allocation.

Once the structure is selected and resources are allocated, the work of creating the structure can proceed.

Enhance PH Education

The approach to enhancing the Faculty of Medicine's PH education offerings begins as follows:

- Establish a working group with representatives from research and education, including the new Associate Dean, Graduate and Postdoctoral Education;
- Gather detailed information about existing programs and courses at UBC that include PH content, and review the Genome BC asset map;
- Analyze the information to identify potential opportunities for new program development or program renewal;
- Select the best option and develop a new or renewed program proposal, including budget analysis and program leadership; and
- Seek approval to proceed with the new or renewed program development and implementation.

In parallel with the work listed above, the approach to incorporating PH content into the MD curriculum begins as follows:

- Engage Undergraduate Medical Education (UGME) leadership in discussion about the possibility of encouraging or soliciting PH-related FLEX projects to be made available to MD students;
- Engage the Curriculum Management Unit to identify any existing PH-related content already in the MD curriculum; and
- Recommend to the UGME Committee that a new PH theme be created with content threaded through the cases in the spiral curriculum.

Other Priorities

With these foundational elements in place, our focus will shift to the other priorities.

We at the UBC Faculty of Medicine are committed to ongoing focus on this growing field in order to enhance our leadership in PH, which is a key component of *transforming health for everyone*.

APPENDIX: LANDSCAPE SCAN FINDINGS

This appendix summarizes the range of PH-related activities underway by the 45 stakeholders who participated in the landscape scan by interview (38) or survey (7), of 67 invited.

Many of the activities are related, and there are multiple potential categorization methods that could be used. Rather than develop a complex tagging and categorization taxonomy, we grouped the activities into categories that helped conceptualize the range of activities.

This is not an exhaustive list. There are many other PH-related activities underway at UBC and in BC that are not captured here. Also, the activity areas are summarized and may not fully capture the depth and breadth of the activity. Similarly, as this is a dynamic and rapidly evolving area, we recognize that the landscape will quickly change, and part of our vision is to create a network that can engage that exciting ecosystem.

Activity by UBC-affiliated Stakeholders

Diagnostics, Prediction, and Biomarkers

Using 'omics and biomarkers to develop and improve accuracy of diagnostic and predictive methods.

- Conducting whole genome sequencing of patients with rare diseases (in particular cognitive-related conditions) to improve diagnosis (Jan Friedman).
- Using genome sequencing to identify specific gene defects that cause rare immune deficiencies in children (Stuart Turvey).
- Testing single amino acid changes and their impact on protein function in a gene that is strongly-linked to autism in order to understand how the various mutations impact phenotypes in multiple model organisms, with potential for understanding relationships between individual gene mutations and disease expression, and ultimately treatment outcomes. Also, building towards a saturation mutagenesis approach to understand impact of all potential mutations of many disease-associated genes (Kurt Haas & UBC Functional Variomics Group).
- Advancing predictive and preventative approaches to exercise prescription based on metabolomics and proteomic biomarkers combined with physiological markers (Robert Boushel).
- Ensuring appropriate reference data is available to effectively diagnose genetic disease/conditions in Indigenous population to reduce health care disparities (Laura Arbour; Anna Lehman; Dean Regier).
- Identifying mutant genes in neurologic disorders from neurodegeneration to diagnosing neurometabolic disorders in neonates (Matthew Farrer).
- Using biomarkers to examine metabolism of vitamins and related metabolites to assess vitamin status, and to examine metabolomics due to pre-symptom nutritional inadequacies, with a focus on maternal and child health (Yvonne Lamers).
- Developing multi- and trans-omic biosignatures that can serve as actionable biomarkers to improve management of patients, and those at risk of becoming patients, and in support of more efficient drug development processes (Bruce McManus).
- Developing biomarkers to improve care and diagnosis of patients with COPD (Don Sin).
- Understanding differences in the way the immune system develops early in life and how differences determine someone's predisposition to asthma and other autoimmune diseases (Bill Mohn).
- Using wearable technology to understand a person's physiology and characterize normality, detect presence of abnormality, and identify precisely when there is a change from normal to abnormal in order to pinpoint the start of gene expression and inform prevention and prediction (Kendall Ho).
- Using artificial intelligence to gather more and better data from MRI and CT scans and combining it with other patient-specific data to improve diagnosis and outcome prediction for multiple sclerosis (MS) and chronic obstructive pulmonary disease

(COPD) patients (Roger Tam, Associate Professor, Department of Radiology and School of Biomedical Engineering – as reported by Bruce Forster).

- Advancing the field of radio-omics by using artificial intelligence to maximize the amount of detail that can be gleaned from images, much of which cannot be detected by the human eye, and combining that data with other patient-specific data to improve diagnosis and outcome prediction (Arman Rahmim, Associate Professor, Departments of Radiology and Physics/Astronomy – as reported by Bruce Forster).
- Developing a deeper understanding of how molecular, cellular, and tissue structure and organization relate to normal and diseased tissue function to enable personalized medicine (Bruce Forster; Biomedical Imaging and Artificial Intelligence Research Cluster).
- Improving early disease diagnosis through exosome detection and isolation, which enables understanding of disease propagation, achieving early diagnosis, and developing potential disease treatments through regenerative medicine and drug delivery (Cluster of Research Excellence in Exosome Isolation[3]).

Therapeutics

Focusing on using 'omics analysis to improve treatments.

- Developing personalized, genetically engineered T cell therapies for cancer immunotherapy (Robert Holt).
- Using biomarkers (genomics, proteins) to analyze cancer to better match treatments and prognosticate outcomes, recurrence, and time to death (Martin Gleave).
- Using comprehensive genomics to study genetic abnormalities of individual cancers to understand what might be driving cancer growth and enabling the cancer to resist treatment, and to identify or develop treatment strategies targeted to the specific patients' cancer (Marco Marra; Dean Regier; Personalized Oncogenomics Program).
- Developing therapeutics focused on a specific type of prostate cancer (Marianne Sadar, Professor, Department of Pathology and Laboratory Medicine; Distinguished Scientist, Michael Smith Genome Sciences Centre, BC Cancer Agency – as reported by Robyn Roscoe).
- Developing personalized cell-based therapies using biomarker discovery and validation (Megan Levings).
- Understanding the functions and roles of proteins and enzymes in disease pathogenesis and how to target therapeutics towards them (David Granville).
- Developing highly-predictive tests to alert people in advance of cancer drug therapy about their individual risks based on their genetics (Bruce Carleton).
- Understanding how physical activities can be prescribed, maintained, monitored, and implemented across the lifespan to improve outcomes (Teresa Liu-Ambrose; Physical Activity for Precision Health Research Cluster[4]).

Microbiomics

Focusing on studying the bacteria found in and on the body and its relationship to health outcomes.

- Characterizing the vaginal microbiome to understand the diversity in groups of women and develop a more nuanced characterization to distinguish the range of normality and abnormality, and linking the makeup of the microbiome to health outcomes (Deborah Money).
- Characterizing the maternal microbiome and linking it to the infant gut microbiome to determine whether it is the maternal microbiome that seeds the infant's gut microbiome and whether it is influenced by the mode of delivery (Deborah Money).
- Understanding the structure of gut microbiome to predict asthma risk in children and change the gut microbiome to prevent asthma (Stuart Turvey; Bill Mohn).
- Understanding how changes in gut microbiome of cystic fibrosis patients correlates with different measures of health and illness (Corey Nislow).

Environment and Exposomics

Focusing on relationships between environment (range of things to which someone is exposed), 'omics, and health outcomes.

- Using genomics (especially gene-environment interactions) to inform a personalized view of risk to environmental (typically inhaled) threats, and identify individual- and/or population-level interventions (Chris Carlsten; Sara Mostafavi).
- Understanding the interaction between pollution and exercise in order to individualize recommendations about how much exercise on a given day is appropriate based on symptoms and pollution levels (Mike Koehle).
- Understanding dietary bioactive compounds and how they can contribute to cancer prevention or support other anti-cancer therapies by effecting epigenetics (Barbara Stefanska).
- Understanding individual or subgroup responses to environmental threats due to non-genomic factors such as age, sex, exercise, etc. (Chris Carlsten; Jordan Guenette).
- Studying the impact of environmental exposures that modify genome expression, particularly when confronted with disease and/or treatment (Martin Hirst, Associate Professor, Department of Microbiology and Immunology; Head of Epigenomics, Michael Smith Genome Sciences Centre, BC Cancer Agency – as reported by Robyn Roscoe).

Counselling and Behaviour Change

Focusing on relationships between human behaviour, 'omics, and advising individuals how to leverage this to prevention and treatment. There is often some overlap with Diagnostics and/or Therapeutics.

- Leveraging genetic counselling as an effective way to enable behaviour change, which is a key component of using 'omics information to prevent health problems (Jehannine Austin).
- Delivering the largest genetic counselling training program in Canada (Jehannine Austin, Department of Medical Genetics).
- Examining the impact of personal whole genome sequencing on the practice and field of Genetic Counselling (Alison Elliott, Clinical Associate Professor, Department of Medical Genetics; Investigator, BC Children's Hospital Research Institute – as reported by Robyn Roscoe).
- Understanding how exercise (frequency, intensity, type) can be used to promote outcomes like brain health and minimize decline in patients who already have a condition, and how the efficacy of exercise depends on genotypes that may moderate benefits of exercise (Teresa Liu-Ambrose).
- Examining several biomarkers and how they correspond with nutritional outcomes in order to inform nutritional recommendations (Crystal Karakochuk).
- Investigating how metabolic signatures relate to the etiology of cancer and how metabolic signatures associated with healthy lifestyle behaviours might help prevent diseases and cancers (Rachel Murphy).
- Developing algorithms to support prescribing decisions based on the individual, recognizing that there are individual variations in responses to drugs (Martin Dawes).
- Applying pharmacogenomics by working with community pharmacists to engage patients to collect saliva samples, analyzing genetic information, and providing information back to the pharmacists in a standardized way to inform adjustments to prescriptions, either directly by the pharmacist or with the family physician (Corey Nislow).
- Understanding the genetic reasons for why a disease/condition occurs in a certain person at a certain time in order to understand the broader condition and what to expect for the person and their family (Laura Arbour).
- Analyzing clinical data of patients who suffer serious adverse reactions to medication to determine genetic factors at play and to avoid adverse reactions (Colin Ross).
- Supporting shared decision making about hereditary cancers by developing methods to interpret genomics information in a way that patents can understand and incorporate patient preferences in clinical decision making (Dean Regier).

Data Science and Statistics

Focusing on data science and analytical methods used to understand large, complex datasets needed to study 'omics and related factors.

- Developing algorithms and interpretive models to analyze large genomics data sets to identify why certain biomarkers lead to certain outcomes (Sara Mostafavi).
- Developing data systems to support PH, including linking existing data and incorporating research findings (Kim McGrail).
- Building data science models that enable analysis of genetic, genomic, proteomic, metabolomics, imaging, clinical, and administrative data (Raymond Ng).
- Analyzing rare, undiagnosed diseases in children and using genetic and multi-omic analysis (Anna Lehman).
- Applying natural language processing and artificial intelligence to better mine genomic data and discover linkages between an individual's disease, model organisms, and vice versa (Inac Birol, Professor, Department of Medical Genetics; Distinguished Scientist, Michael Smith Genome Sciences Centre, BC Cancer Agency – as reported by Robyn Roscoe).
- Creating a system-wide, data-driven solution to harness the power of 'omics biomarkers in optimizing health and minimizing disease. Using innovative and interconnected platforms for secure data collection and sharing, "multi-omics" analysis and integration, and real-world biomarker testing to enhance personalized diagnostic and therapeutic development for heart and lung diseases[5] (Bruce McManus, Data Analytics and System Science to Optimize Heart and Lung Health Research Cluster).
- Taking an interdisciplinary approach to solving major, persistent problems in radiation oncology to positively impact cancer care in Canada, leading to fundamental contributions in the areas of personalized radiation therapy, improved radiation therapy efficacy, and next-generation imagining for tumour delineation (Cluster of Research Excellence in Medical Physics and Data Analytics[6]).

Health Economics

Focusing on questions about affordability and value-for-money of PH methods.

- Investigating value-for-money questions about PH interventions, specifically related to asthma and COPD (Mohsen Sadatsafavi).
- Analyzing cost effectiveness of PH and whole genome transcriptome analysis to assess sustainability and proportionality between costs and benefits (Dean Regier).
- Conducting multi-country analyses of the economics of rare diseases (Dean Regier).
- Analyzing cost effectiveness of treatments for relapse lymphoma, and engaging patients and the public in decision aid development (Dean Regier).
- Measuring patient-reported outcomes in pharmacoeconomic trials and assessing cost-effectiveness of treatments (Aslam Anis).

Education and Capacity Building

Focusing on leveraging education to build PH capacity and deepening PH understanding.

- The UBC Faculty of Medicine and Genome BC entered into a memorandum of understanding "to enhance the working relationship between the Parties, and to particularly explore opportunities for the planning, development, and delivery of specific educational programs in omics."[7] (Roger Wong; Catalina Lopez-Correa, Genome BC).
- Delivering PH-related graduate programs related to medical genetics, bioinformatics, and genome sciences technology, such as the Interdisciplinary Oncology Program[8], the Genome Science and Technology Program[9], and the Bioinformatics for Health Sciences Program[10] (Marco Marra, Jan Friedman, and others at the Michael Smith Genome Sciences Centre, BC Cancer Agency).
- Compiling educational resources that can increase knowledge and capacity in genetics and genomics within the medical oncology community (Marco Marra; Personalized Oncogenomics Program).

- Developed PH curricular content that could be integrated into the Flexible Enhanced Learning courses of the MD program, although it has not been integrated (Bruce McManus).
- Seeking to hire a tenure-track Associate Professor in Genetic and Genomic Counselling in order to develop the first PhD program in Genetic and Genomic Counselling in North America (Department of Medical Genetics with the BC Children's Hospital Research Institute and the Provincial Health Services Authority).
- Appointed a Canada Research Chair Tier 2 in Precision Cardiovascular Disease Prevention, focused on genetic aspects of cholesterol levels, cardiovascular disease, and pharmacogenomics[11] (Liam Brunham, Assistant Professor, Department of Medicine, UBC Faculty of Medicine; Principal Investigator, UBC Centre for Heart and Lung Innovation).
- Created a President's Excellence Chair in Precision Oncology, focused on "use of serial sampling to characterize evolution of cancers on treatment to identify and target emerging resistant driver pathways"[12].
- Awarding a Canada Research Chair Tier 1 in Pediatric Precision Health (reported by Rob McMaster and Michelle Wong).
- Supporting ongoing PH research and further development through recruitment and collaboration (Michael Coughtrie).
- Prioritizing disease and prevention care opportunities, sources funding for them, and implements and commercializes them. (Pieter Cullis).
- Studying existing research on economic, ethical, and environmental factors pertaining to precision health (Duva Karunakaran, undergraduate student in Integrated Sciences).

Activities by Other Stakeholders

Academic Institutions

- Profiling 3500 healthy children in Canada based on genomic, epigenomic, microbiomic, transcriptomic, social, socio-economic, psychological, and environmental data to identify factors that are predictive of developing allergies and asthma (Fiona Brinkman, SFU).
- Using machine learning to identify trends in large datasets relevant to PH (Fiona Brinkman, SFU).
- Developing software to integrate microbial, epidemiologic, and lab data to track infectious diseases (Fiona Brinkman, SFU).
- Studying healthy elderly populations to understand more about disease resistance, the ability of different people to recover from disease and respond to treatment, and lifestyle factors (Angela Brooks-Wilson, Professor, Biomedical Physiology and Kinesiology, SFU; Head of Cancer Genetics, Michael Smith Genome Sciences Centre, BC Cancer Agency; Professor, Department of Medical Genetics, UBC – as reported by Robyn Roscoe).
- Developing technologies to detect circulating tumor DNA, which allows monitoring re-emergence of disease following treatment in an individual patient (Ryan Morin, Associate Professor, Molecular Biology and Biochemistry, SFU; Scientist, Michael Smith Genome Sciences Centre, BC Cancer Agency – as reported by Robyn Roscoe).
- Applying artificial intelligence and data analysis techniques to interpret population genomic information at an individual level and individual genomic information for therapeutic determination (Steven Jones, Professor, Molecular Biology and Biochemistry, SFU; Head of Bioinformatics and Co-Director, Michael Smith Genome Sciences Centre, BC Cancer; Professor, Medical Genetics, UBC – as reported by Robyn Roscoe).

Health Authority- and University-affiliated Research Institutes and Centres

- Engaging in several research projects and programs in PH, including the POG program, the Centre for Clinical Genomics, the PROFYLE program, the CAPTUR clinical trial, and the Terry Fox Canadian Comprehensive Cancer Centre Network (TF4CN) pilot program. Also engaging with participants in the Canada's Digital Technology Supercluster in the area of PH (Robyn Roscoe, Michael Smith Genome Sciences Centre, BC Cancer Agency).
- Developing a PH strategy at BC Children's Hospital Research Institute (BCCHRI) through internal/external scans to identify and leverage strengths and opportunities which support areas that BCCHRI is, and could be, national and international leaders (Russell Bonaguro, BCCHRI).

Government and Not-for-Profit Sector

- Informing Ministry of Health policy that determines which tests are approved and funded, and if funded whether publically or privately (Carolyn Bell, BC Ministry of Health).
- Affirming that "the Ministry of Health must take a view of policies, practices and services that will benefit and provide the best outcomes for the people of the province and make decisions that support effective, accessible, safe and equitable health care for all British Columbians", and that "Ministry policies, planning and decision making are ideally informed by strong, unbiased evidence" (Research and Knowledge Management Strategy[13], BC Ministry of Health).
- Conducting outreach, education, and communication to advance use of genomics in health. Also, using genomics to improve disease prevention, screening, diagnosis, treatment, and prognosis (Catalina Lopez-Correa, Genome BC).
- Developing an asset map with the Faculty of Medicine and others to identify tools, courses, and programs that exist in order to identify opportunities (Catalina Lopez-Correa, Genome BC).

Industry

Note: Some of the activities listed in other sections are also related to industry activities.

- "Creating competitive and innovative digital technology solutions for Canada's top industries." "The Digital Technology Supercluster facilitates and funds ambitious, collaborative technology leadership projects that develop products and platforms." It "selected health, natural resources, and industrial sectors as the starting point, recognizing the strength of these industry sectors in British Columbia." PH is one of three initial core program areas in which members can propose projects. Of the five phase 1 projects, two are related to PH:
    - Dermatology Point-of-Care Intelligent Imaging Network (Change Health Care, Metaoptima, Careteam, TELUS Health, UVic)
    - Tailored Health Pharmacogenomics (TELUS Health, Lifelabs, GenXys, Genome BC, UBC)
- Observing significant growth in companies focused on using artificial intelligence and radio-graphs to augment workflow of radiologists and pathologists and thereby improve diagnosis and treatment (Corey Nislow, Creative Destruction Labs).

[1] https://strategicplan.ubc.ca/
[2] http://stratplan.med.ubc.ca/
[3] https://research.ok.ubc.ca/about/research-excellence-clusters/exosome-isolation.html
[4] https://research.ubc.ca/about-vpri/initiatives/research-excellence-clusters/current-research-excellence-clusters
[5] https://research.ubc.ca/about-vpri/initiatives/research-excellence-clusters/current-research-excellence-clusters
[6] https://research.ok.ubc.ca/about/research-excellence-clusters/MPDAC.html
[7] Memorandum of Understanding between UBC Faculty of Medicine and Genome BC, signed November 3, 2017.
[8] https://www.iop.ca/
[9] https://www.grad.ubc.ca/category/academic-unit/genome-science-technology-program
[10] http://www.bioinformatics.ubc.ca/
[11] https://www.med.ubc.ca/new-canada-research-chairs-appointed-in-the-faculty-of-medicine-3/
[12] https://academic.ubc.ca/precision-oncology
[13] https://www2.gov.bc.ca/assets/gov/health/conducting-health-research/putting-our-minds-together-research-and-knowledge-management-strategy.pdf