COLLABORATING FOR INNOVATION IN BIOLOGICS AND VACCINES

The NRC’s Human Health Therapeutics (HHT) Research Centre hosts the largest R&D team dedicated to biologics development in Canada. Through fundamental research and discovery, we’re dedicated to catalyzing business innovation and public health solutions for unmet medical needs. This includes:

- Multifunctional antibody-based therapeutics
- Disruptive technologies for cell and gene therapy
- Biomanufacturing platforms and automation
- Readiness innovation for emerging infections and vaccines

On behalf of the HHT management team, I invite you to discover the impact we can have together!
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The NRC’s core mandate is to foster science excellence, contribute to the public good, and promote business innovation.

Our expertise spans across a range of areas including immunobiology, translational bioscience and bioprocess engineering (bacterial, viral and mammalian cell expression platforms), as well as downstream processing and analytics to enable progression through the drug development value chain. Our aim is to build a strong pipeline of assets suitable for commercial exploitation, through collaborative research, technical advice and expertise, service agreements in bioprocess engineering, and product development and production for technology transfer to industry.

Meet with our experts today, and learn more about Canadian innovations with global impact!
FOCUS ON BIOLOGICS

In 2017, seven of the top 10 medicines contributing to patented drug sales in Canada were biologics.

Source: Patented Medicine Prices Review Board, Annual Report 2017 Government of Canada

PROGRAMS

Multifunctional Antibody-based Therapeutics

Indications
- Cancer
- Neurodegenerative diseases (e.g. Alzheimer’s, Parkinson’s)
- Inflammatory disorders

Technologies
- Monoclonal, single domain, bi-specific/multi-specific antibodies
- Antibody-drug (cargo) conjugates
- Chemical conjugation or fusion to couple NRC carriers with your antibodies, peptides, and growth factors
- High-throughput cell-based assays
- In vitro rodent and human blood-brain barrier models
- Portfolio of carrier molecules to shuttle biotherapeutics to the brain
- Preclinical testing and imaging of blood-brain barrier penetration and efficacy
- Immune monitoring, animal model efficacy
- Imaging agents, enzymes, and nanocarriers
- 3D microfluidic bioprinting
- Humanization of antibodies and molecular modelling

Disruptive Technology Solutions for Cell and Gene Therapy

Indications
- Cancer
- Genetic diseases
- Rare disorders

Technologies
- Synthetic biology-driven precision editing for universal cell platform
- Precision targeting for accurate and effective delivery at site(s) of disease
- Capacity-building for Canadian biomanufacturing and clinical pipeline
- Gene therapy vectors (genetic switches for controlled expression and process scale-up)

INITIATIVES

Biomanufacturing – Platforms and Automation

- Protein and vector production
- Process development and scale-up (up to 500 L)
- Purification
- Biophysical characterization

Vaccines and Emerging Infections – Readiness Innovation

- Carbohydrate, protein and lipid antigen target identification
- Virus, virus-like particle, vector, protein, and bacteria production
- Microbial expression systems (1500 L pilot plant)
- Immunomodulation: carriers, adjuvants and delivery systems
- Human immunology: high throughput, multiplex assays
- Multi-color flow cytometry
- Emerging infections animal models (BSL3)
Our ability to innovate is founded in collaboration. The NRC’s broad range of expertise gives our partners access to a full suite of assets, from research and discovery to biomanufacturing, purification and characterization, through to downstream analytics, technology transfer and IP management. We deliver impact for Canadians and global partners.”

– Lakshmi Krishnan, Director General, Human Health Therapeutics, NRC
Microbial fermentation
Stainless

Cell Culture
Stainless

500L
50L
20L
20L

Cell Culture
Single use

1500L
750L
150L
75L
20L

14L
3.5L
FACILITIES

Advanced analytical platform

Biophysical characterization
- Molecular weight and charge heterogeneity
- Post-translational modifications
- Purity
- Stability
- Solubility
- Aggregate formation

Mass spectrometry (MS)
- Structure and function analysis
- Post-translational modifications
- Carbohydrate and lipid moiety identification

Other services
- Targeted biomarker quantification and mass spectrometry “omics” approaches
- Development of novel methods for bioanalysis
- Advanced nuclear magnetic resonance (NMR) structural analysis of proteins and carbohydrates

Microbial fermentation pilot plant
- Production of peptides, proteins, enzymes, nutraceuticals, organic acids, polymers, polysaccharides and probiotics
- Bioprocess optimization and scale up to 1,500 L
- Bacteria and yeast systems: E. coli, M. extorquens, Pichia, Saccharomyces
- Pathogen cultivation facilities up to BSL 2
- Handling of methanol-oxidizing microorganisms
- Testing of new monitoring/control equipment and reagents
- Purification and analytical services
- Tech transfer to contract manufacturing organizations (CMOs)

Cell culture pilot plant
- Production of antibodies, proteins, viruses, and virus-like particles
- Proprietary suspension and serum-free cell expression systems for transient and stable production: HEK293, CHO, A549, VERO
- Process optimization and scale up of batch, fed-batch, and perfusion cultures up to 500 L
- In-process assay development
- Purification and analytical services
- Tech transfer to contract manufacturing organizations (CMOs)

Preclinical in vivo facility
- Validation of therapeutic targets and biomarkers for peripheral and central diseases
- Pharmacokinetic and pharmacodynamics studies in animal models
- In vivo vaccine safety and efficacy studies for infectious diseases (level 2 & 3)
- Efficacy and immune mechanism of action testing in syngenic, xenogenic, orthotopic and transgenic cancer models
- Development of novel in vivo imaging methods and contrast agents for molecular imaging
- Data packages to enable Investigational New Drug (IND) submissions
## IMPACT

### OUR CLIENTS

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>82%</td>
<td>Found unique offerings at the NRC</td>
</tr>
<tr>
<td>54%</td>
<td>Submitting IND next 3 years</td>
</tr>
<tr>
<td>56%</td>
<td>Pre-revenue</td>
</tr>
<tr>
<td>74%</td>
<td>&lt; 50 employees</td>
</tr>
<tr>
<td>$16.4M</td>
<td>Increased investments since interaction with the NRC</td>
</tr>
<tr>
<td>$108M</td>
<td>Increased market valuation since interaction with the NRC</td>
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### HHT IN NUMBERS

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>~340</td>
<td>Experts</td>
</tr>
<tr>
<td>4</td>
<td>Sites</td>
</tr>
<tr>
<td>2</td>
<td>Programs</td>
</tr>
<tr>
<td>3</td>
<td>Initiatives</td>
</tr>
<tr>
<td>35+</td>
<td>Candidates in the pipeline</td>
</tr>
<tr>
<td>3</td>
<td>Biosafety levels</td>
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</table>

> $45M

INVESTED IN HUMAN HEALTH BY THE NRC EACH YEAR
“Investments in foundational research today form the cornerstone of tomorrow’s breakthroughs. [Our] collaboration with the NRC should serve as a template—only through a combination of vision, expertise and teamwork will we arrive at the next generation of cancer therapies...”

- Dr. Ali Tehrani, President and CEO, Zymeworks

**MILESTONES – PROJECTS WITH THE NRC**

<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
<th>Company</th>
<th>Molecule/Technology</th>
<th>Indication/Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Licensed</td>
<td>Cansino</td>
<td>Ad5-based vaccine (NRC HEK293)</td>
<td>Ebola</td>
</tr>
<tr>
<td>2018</td>
<td>Phase 1-2a</td>
<td>VBI</td>
<td>Virus-like particle</td>
<td>Glioblastoma</td>
</tr>
<tr>
<td>2017</td>
<td>Phase 1</td>
<td>Formation Biologics</td>
<td>Antibody-drug conjugate</td>
<td>Solid tumours</td>
</tr>
<tr>
<td>2016</td>
<td>Phase 1</td>
<td>Zymeworks</td>
<td>Bi-specific antibody</td>
<td>Breast, gastric, and ovarian cancer</td>
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<tr>
<td>2016</td>
<td>Phase 2</td>
<td>Alethia Biotherapeutics</td>
<td>Monoclonal antibody</td>
<td>Metastatic carcinomas</td>
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<tr>
<td>2015</td>
<td>Phase 1</td>
<td>PREVENT</td>
<td>Vaccine</td>
<td>Streptococcus Group A</td>
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<tr>
<td>2015</td>
<td>Market</td>
<td>NPS Biopharmaceuticals</td>
<td>Hormonal therapy</td>
<td>Hypoparathyroidism</td>
</tr>
<tr>
<td>2012</td>
<td>Phase 3</td>
<td>Oncolytics</td>
<td>Oncolytic virus</td>
<td>Cancer</td>
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</table>
WHY PARTNER WITH THE NRC?
• Recognized expertise in biotechnology
• Track record of industry collaborations
• Extensive science & technology infrastructure
• Innovative health solutions for unmet medical needs

PARTNERING FOR IMPACT
• Enhanced ability to attract investment
• High-quality job creation
• Progression of products and technologies towards commercialization
• Increased business expenditures on R&D (BERD)

IDEAL PARTNER FOR SMALL AND MEDIUM-SIZED ENTERPRISES (SMES)

Our aim is to build a strong pipeline of assets suitable for commercial exploitation. When you collaborate with the NRC, you can look forward to working with an experienced team that’s backed by extensive technology and infrastructure assets. We work with firms of all sizes, with a particular focus on SMEs.

www.canada.ca/nrc-human-health-therapeutics

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