Genome BritishColumbia
Leading ▸ Investing ▸ Connecting

The Future of Bio-Refining

Rahul Singh, PhD
Sector Manager - Agrifood and Natural Resources
Quesnel, September 20, 2019

Genome BC – who we are & what we do

*Genome BC is a **not-for-profit** organization supporting **world-class genomics** research projects, technology platforms and innovation initiatives. We connect **academia**, private **industry**, and the **public sector** to drive the growth of a world-class genomics research cluster and life sciences ecosystem to deliver sustainable **environmental**, **social** and **economic** benefits to BC, Canada and beyond.*

Vision

Genomics positively impacts life, every day.

Mission

Applying the power of genomics to pressing societal and economic challenges.

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Genome BC – who we are & what we do

- A catalyst for the life sciences cluster on Canada's West Coast.
- Cumulative portfolio of **over $1B** in more than **390** genomics research projects, and science and technology platforms.
- We invest in research, entrepreneurship and commercialization in key sectors of economic importance to BC and Canada.
- We transform knowledge of the ethical, environmental, economic, legal and social challenges and opportunities into sound policies and practices that enhance the impact of genomics.

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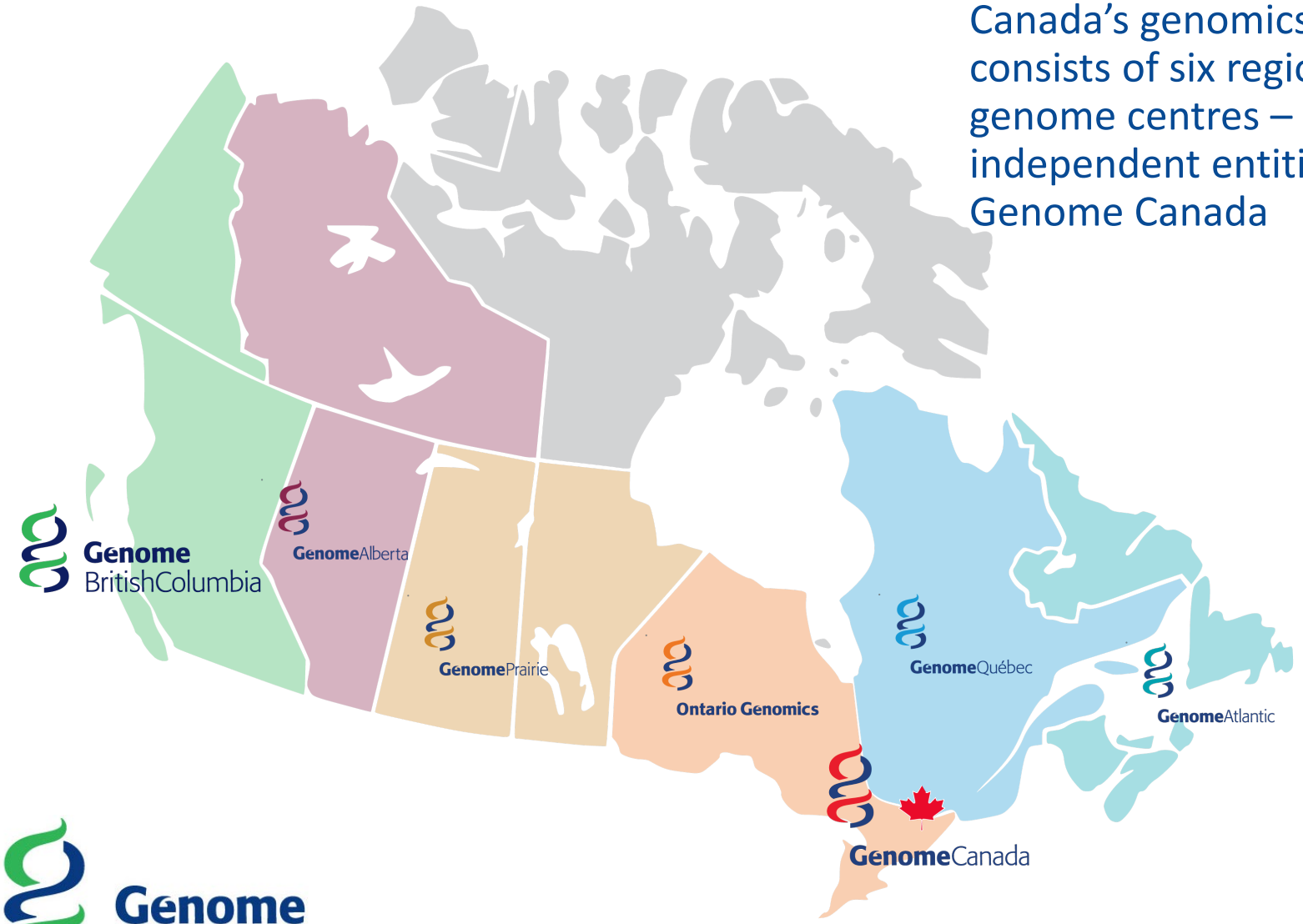
The Genomics Enterprise in Canada

Canada's genomics enterprise consists of six regional genome centres – all unique, independent entities – and Genome Canada



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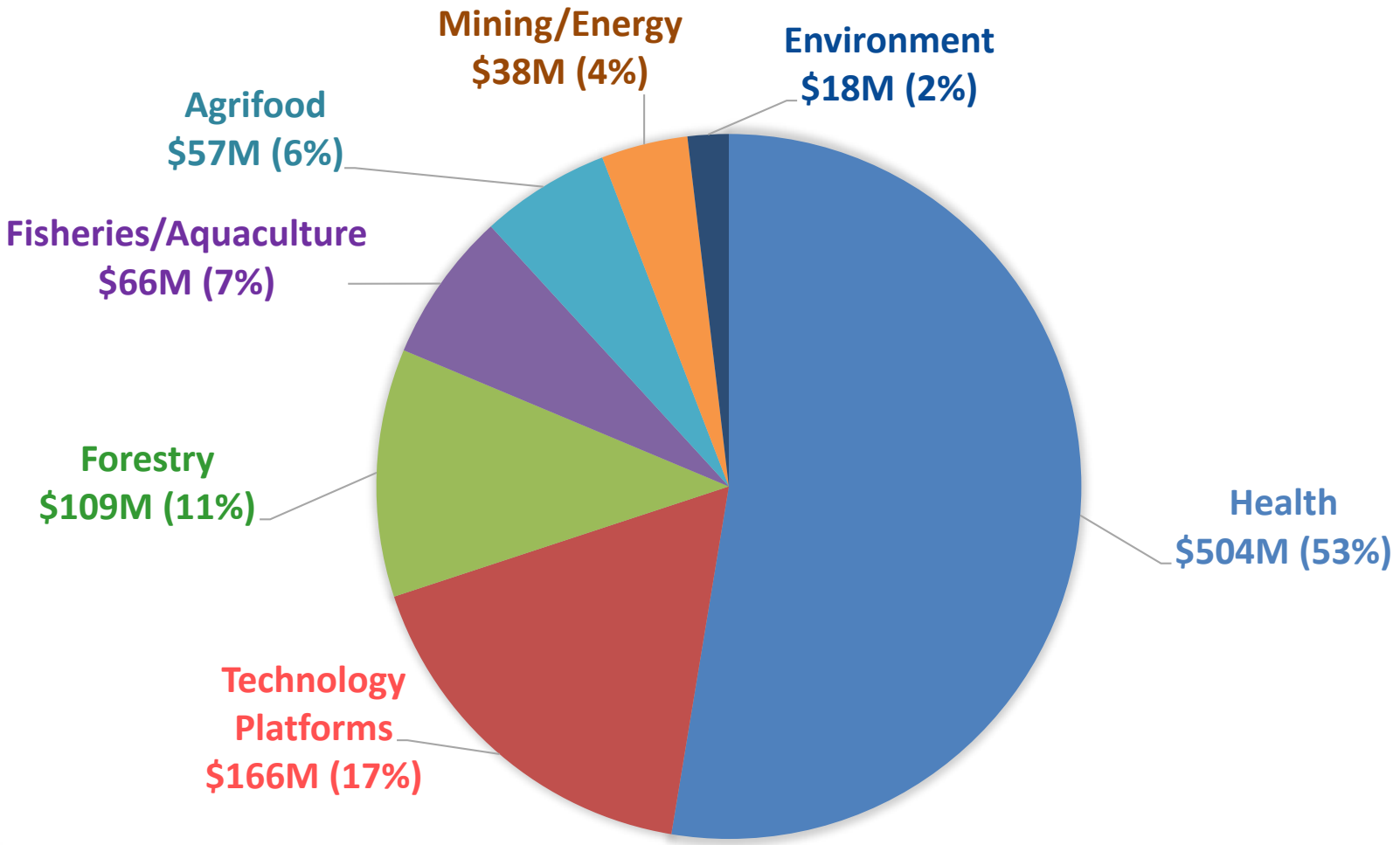
Genome BC's Cumulative Investment Portfolio



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IMPACTS

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Invasive Pests and Pathogens

- Invasive Alien Species (IAS) pose an increasing threat to the environment with often irreversible effects: the diseases caused by pathogens, along with the damage caused by IAS, are estimated to cost the Canadian forest industry around $800 million per year.
- Working with BCMFLNRO, a hand-held portable device is in final testing for CFIA inspectors to evaluate DNA samples “on the spot” mitigating the entrance of invasive species into Canada.
- Sudden oak death, now widespread in forests across Oregon, Washington and California, has been detected in BC nurseries, but has been kept in check by rigorous DNA testing.

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Forestry

27

DNA samples tested positive for pests and pathogens stopping the entrance of invasive species into Canada.

Climate Change

- Genomics is being used to inform reforestation strategies — to determine which seedlings to plant to match our changing climate.
- Seedlings are tested for climate-related traits (growth, heat, drought, cold tolerance, disease resistance) and their DNA is sequenced to identify genetic fingerprints of climate adaptation.
- This research informs the BC government's framework policy on climate-based seed transfer to enhance the adaptability of the 250 million trees planted annually for future climates.

Forestry

50k

genetic markers are being used by the BC Government's Forest Improvement and Research Management Branch to select resilient trees for new climates.

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BIO-REFINERIES FOR BIOECONOMY

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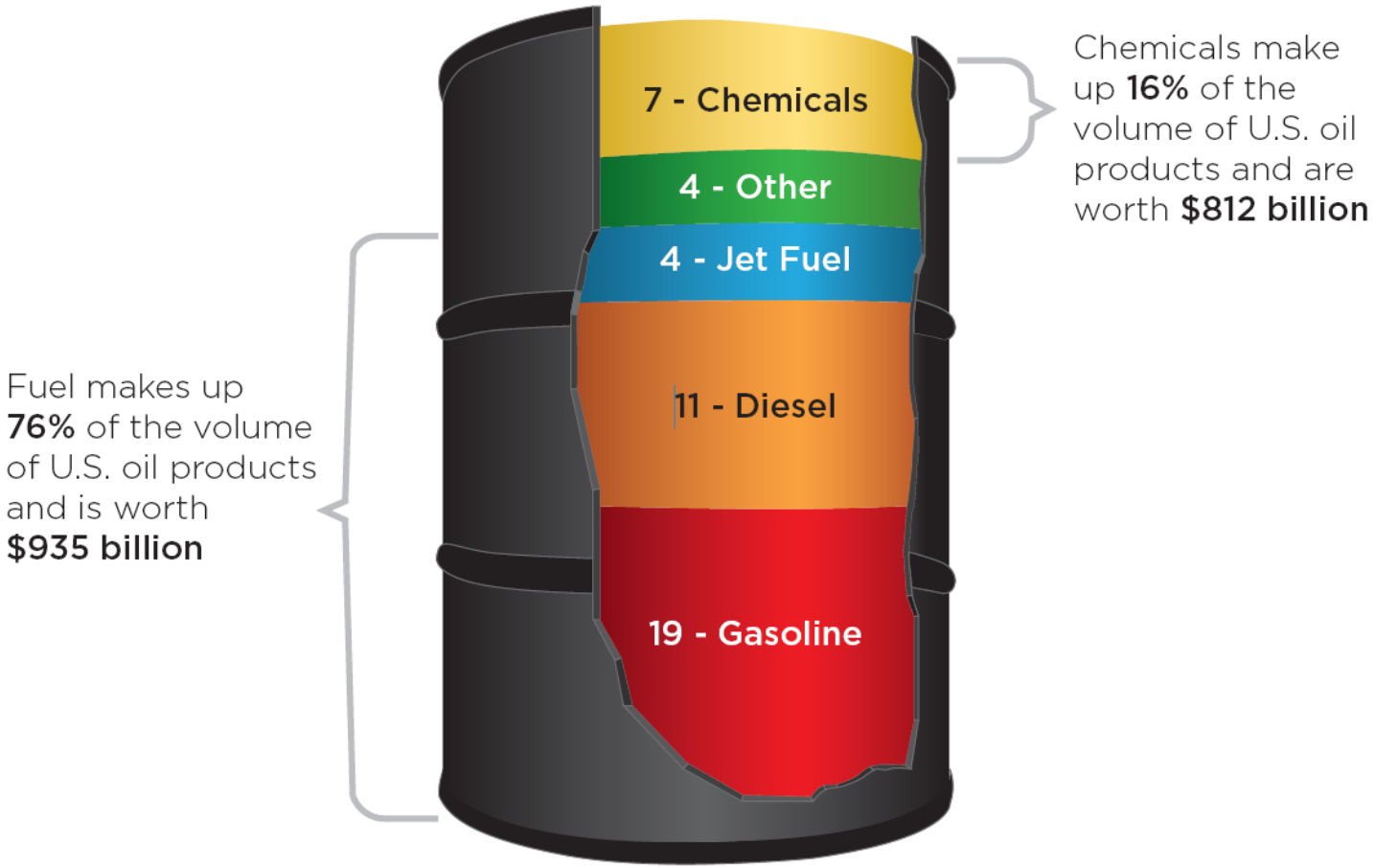
Refineries



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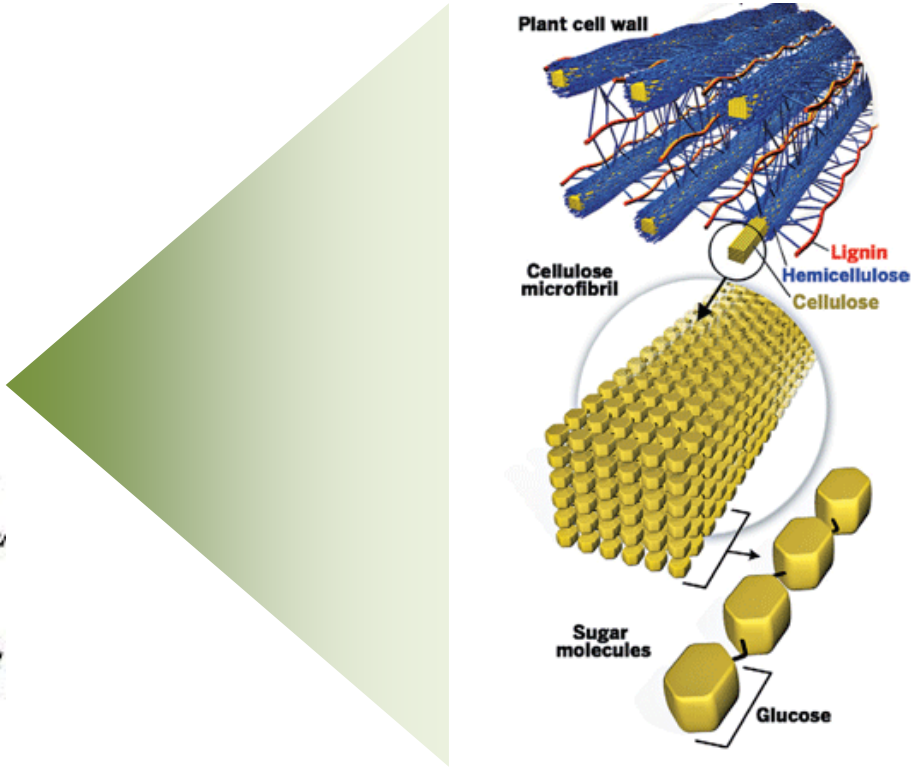
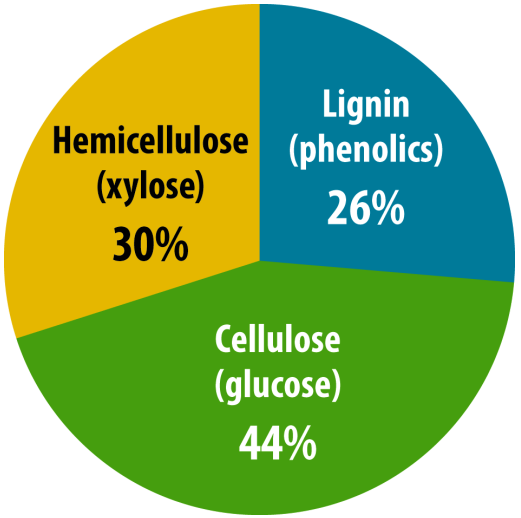
Source: https://www.energy.gov/sites/prod/files/2015/12/f27/bioproducts_to_enable_biofuels_workshop_report.pdf

Bio-Refining

Source: https://encrypted-tbn0.gstatic.com/images



Source: US-DOE



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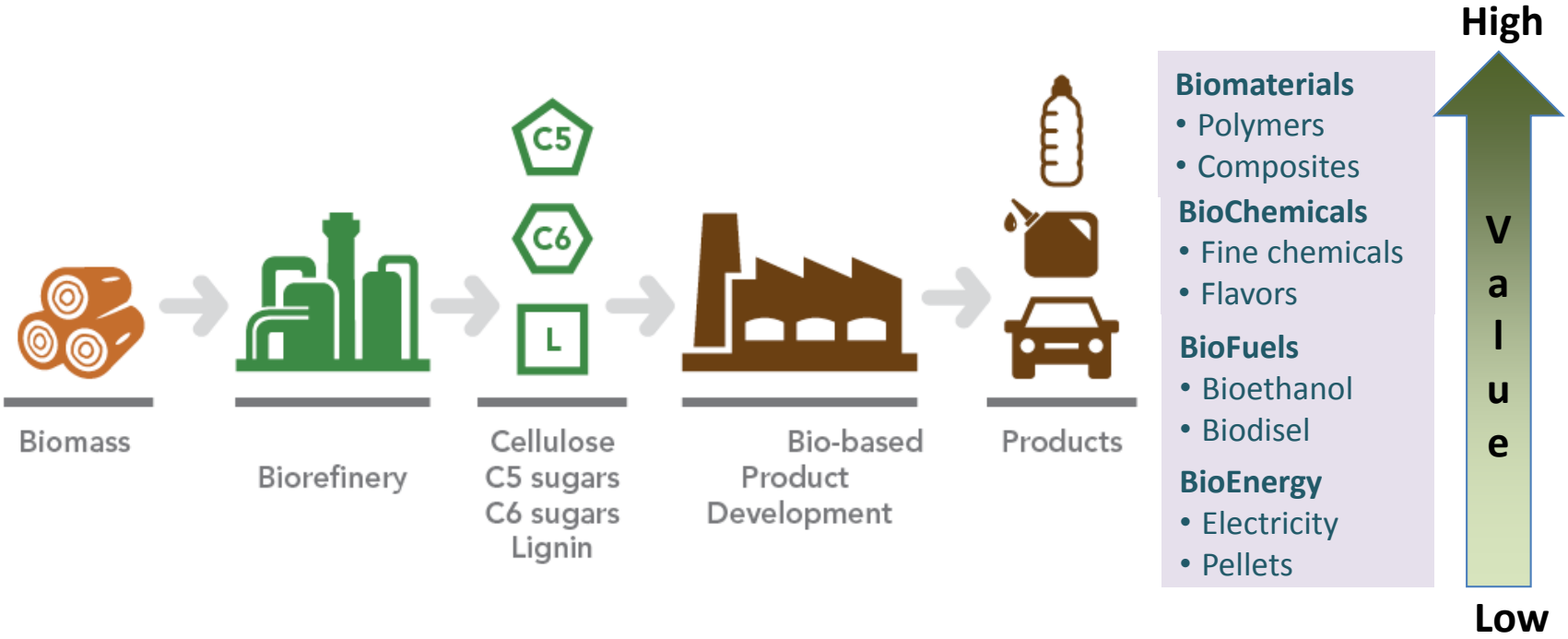
Integrated Bio-Refineries



- Capable of efficiently converting a broad range of biomass feedstocks into **commercially viable** biofuels, biopower, and other bioproducts.
- Like conventional refineries, they produce a range of products to optimize both the use of feedstocks and **production economics.**

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Source: https://labiotech.eu/features/biorefinery-review-europe-biobased/

MARKET

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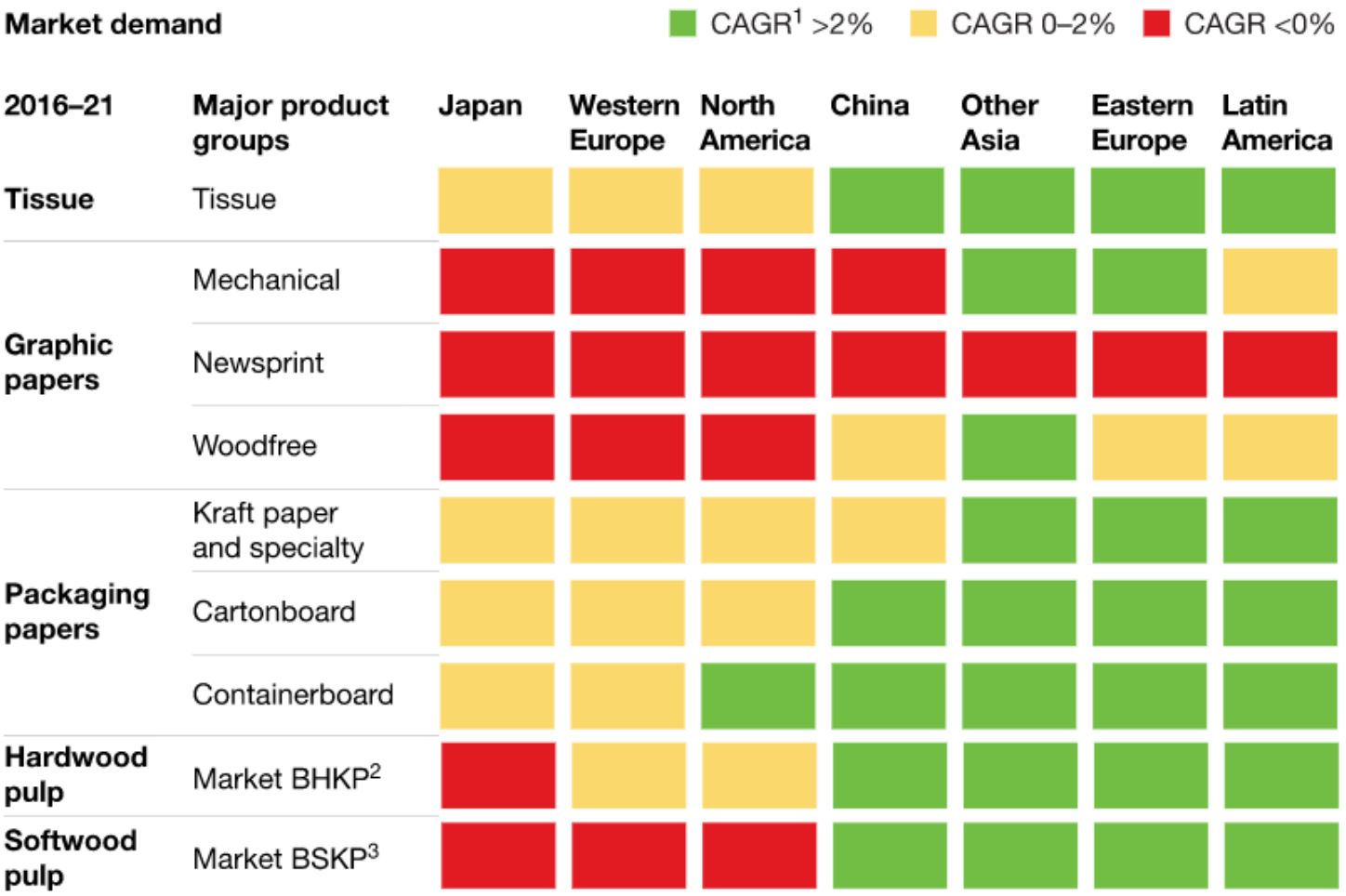
Pulp Market



[1]Compound annual growth rate.
[2]Bleached hardwood Kraft pulp.
[3]Bleached softwood Kraft pulp.

Global Market Potential for Emerging Bioproducts

CAGR of ~10% (~$50B) by 2023
(Source: https://www.greenbiz.com/)

CAGR of ~18.8% (~$68B) by 2024
(Source: https://www.locusresearch.com)

CAGR of ~12.5 % ($46B) by 2025
(Source: https://netcomposites.com)

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Non-Wood Forest Products (NWFP)

NWFPs are defined as wild and semi-wild non-wood forest species and products thereof (e.g. fruit trees, bushes, orchards)

COLD BREW SPRUCE TIP TEA

A truly refreshing Canadian flavour with a blend of Sitka, Englemann, and Black Spruce tips, which naturally contains antioxidants, resines, pinenes, and other micronutrients.

HAND-TAPPED BIRCH WATER

With a light, sweet flavour, Birch Water not only hydrates, but is clean and refreshing.

Sourced in Canada's boreal forests, Silver Birch sap naturally contains electrolytes phytonutrients, and minerals providing rejuvenation and hydration.

ZIRBENZ STONE PINE LIQUEUR

"Zirbenkugel" – a chocolate treat filled with pine liqueur (Photo: Konfiserie Kern).

Birch sap sparkling wine (photo: Birzi- Dzirkstoša Bērzu Sula)

Sweet Tree

Your own local from Quesnel!

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Source: Non-wood forest products in Europe: Seeing the forest around the trees

CHALLENGES AND OPPORTUNITIES

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Embracing New Technologies

Source: https://www.marketing91.com/

Source: https://i1.wp.com/cdn.cleverism.com/

Source: https://www.lithan.com/

Source: https://www.mca.org.uk

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Digital Transformation

Four elements are crucial to a digital transformation.

1 **Discover:** Understand where you are and where you want to go; create a road map

2 **Design:** Design and deliver first at small scale on limited projects and/or single site

3 **Deliver:** Deliver at a larger scale with a broader project portfolio, potentially at all sites

4 **De-risk:** Implement structure to reduce operational and financial risk over the long term

McKinsey&Company

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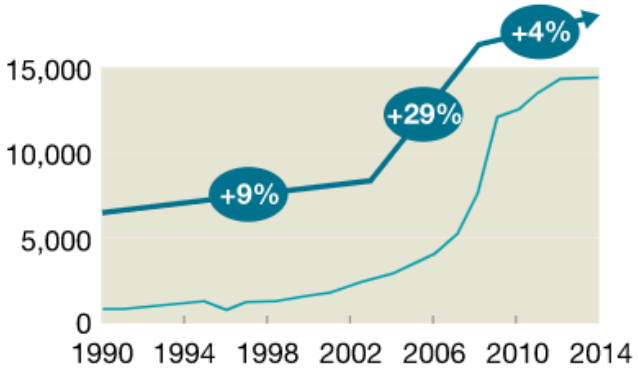
15 Years to Reach a Sizable Commercial Scale

First-generation ethanol,
million gallons per year

Installed capacity, United States,
1990–2014



Solar power,
megawatts per year

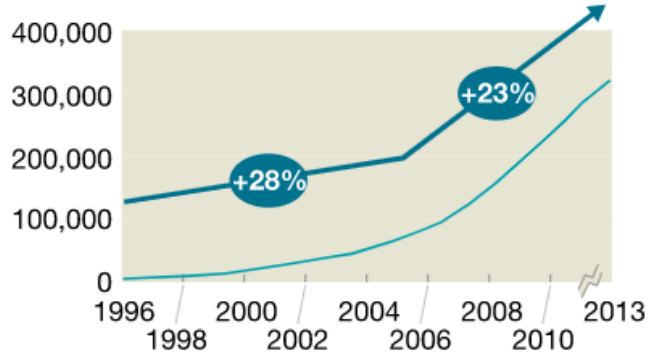
Installed capacity, global PV,[1] 2000–12

Shale gas,
billion cubic feet per day

Shale-gas production, United States,
2000–13

Wind power,
megawatts per year

Installed capacity, global,
1996–2013



McKinsey & Company

INNOVATION WITH CELLULOSE

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DESIGN DRIVEN VALUE CHAINS IN THE WORLD OF CELLULOSE DWoC

- DWoC was a multidisciplinary research collaboration project.
- Funded by Tekes (the Finnish Funding Agency for Innovation).
- The focus was on finding new and innovative applications for cellulosic materials.

Project partners:

- Technical Research Centre of Finland VTT
- Aalto University
- Tampere University of Technology
- University of Vaasa

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Source: https://cellulosefromfinland.fi/material-library/

DESIGN DRIVEN VALUE CHAINS IN THE WORLD OF CELLULOSE DWoC

The goals:

- Make Finland the source of **value-added cellulosic products** and **business concepts**.
- Accelerate the transformation of the current large-scale forest industry into a dynamic ecosystem for the bioeconomy containing **both large and small-scale businesses**.

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Source: https://cellulosefromfinland.fi/material-library/

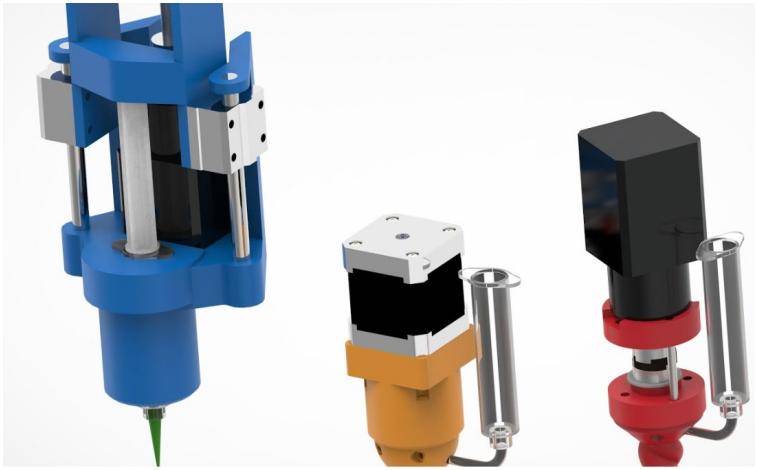
DESIGN DRIVEN VALUE CHAINS IN THE WORLD OF CELLULOSE DWoC

CONDUCTIVE (HEATING) NON-WOVEN TEXTILES AND 3D ELEMENTS

POTENTIAL APPLICATIONS:
numerous, such as, inside different structures, like boat cabin walls, car interior panels and office chairs.

3D-PRINTING OF CELLULOSE BASED MATERIALS BY NSCRYPT METHOD

POTENTIAL APPLICATIONS:
Strong and biocompatible cellulose-based prosthetics can be printed to fit each individual perfectly.



EXTRUDER FOR 3D-PRINTING CELLULOSE BASED MATERIALS

POTENTIAL APPLICATIONS:
Biomedical, such as wound dressings and scaffold raw material for cartilage tissue engineering

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Source: https://cellulosefromfinland.fi/material-library/

DESIGN DRIVEN VALUE CHAINS IN THE WORLD OF CELLULOSE DWoC

STRONG NANOCELLULOSIC TUBULAR STRUCTURES

POTENTIAL APPLICATIONS:
nanocellulose bike

CELLULOSE NANOFIBRIL FILMS

POTENTIAL APPLICATIONS:
excellent barrier against oxygen and grease e.g. for food packaging; as selective membranes for water purification.

FUNCTIONAL CELLULOSIC STRUCTURES ON FABRICS BY 3D PRINTING

POTENTIAL APPLICATIONS:
textiles with functionalities or visual effects

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Source: https://cellulosefromfinland.fi/material-library/

DWoC

DYED CELLULOSE NANOFIBRIL COATING AS PAINT

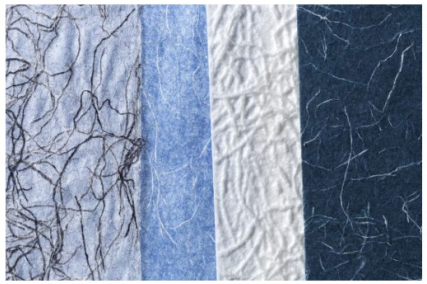
NEXT-GENERATION FIBRE FOAM RESEARCH ENVIRONMENT

DESIGN EXPLORATIONS WITH CELLULOSIC MATERIALS

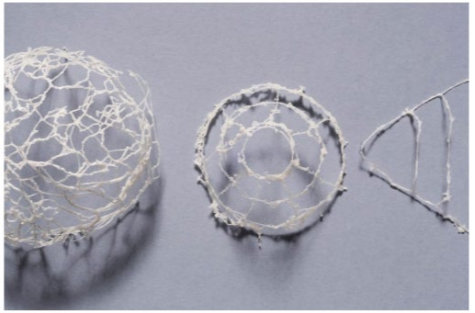
NANOCELLULOSE FILAMENTS FOR COMPOSITE REINFORCEMENT

CIRCULAR-KNITTED PULP FILAMENT

CASTED WOOD – EXPERIMENTS WITH WOOD DUST AND NANO CELLULOSE



FOAM FORMED NON-WOVENS FROM YARNS AND FIBRES



3D PRINTED LACE FROM PULP FILAMENTS

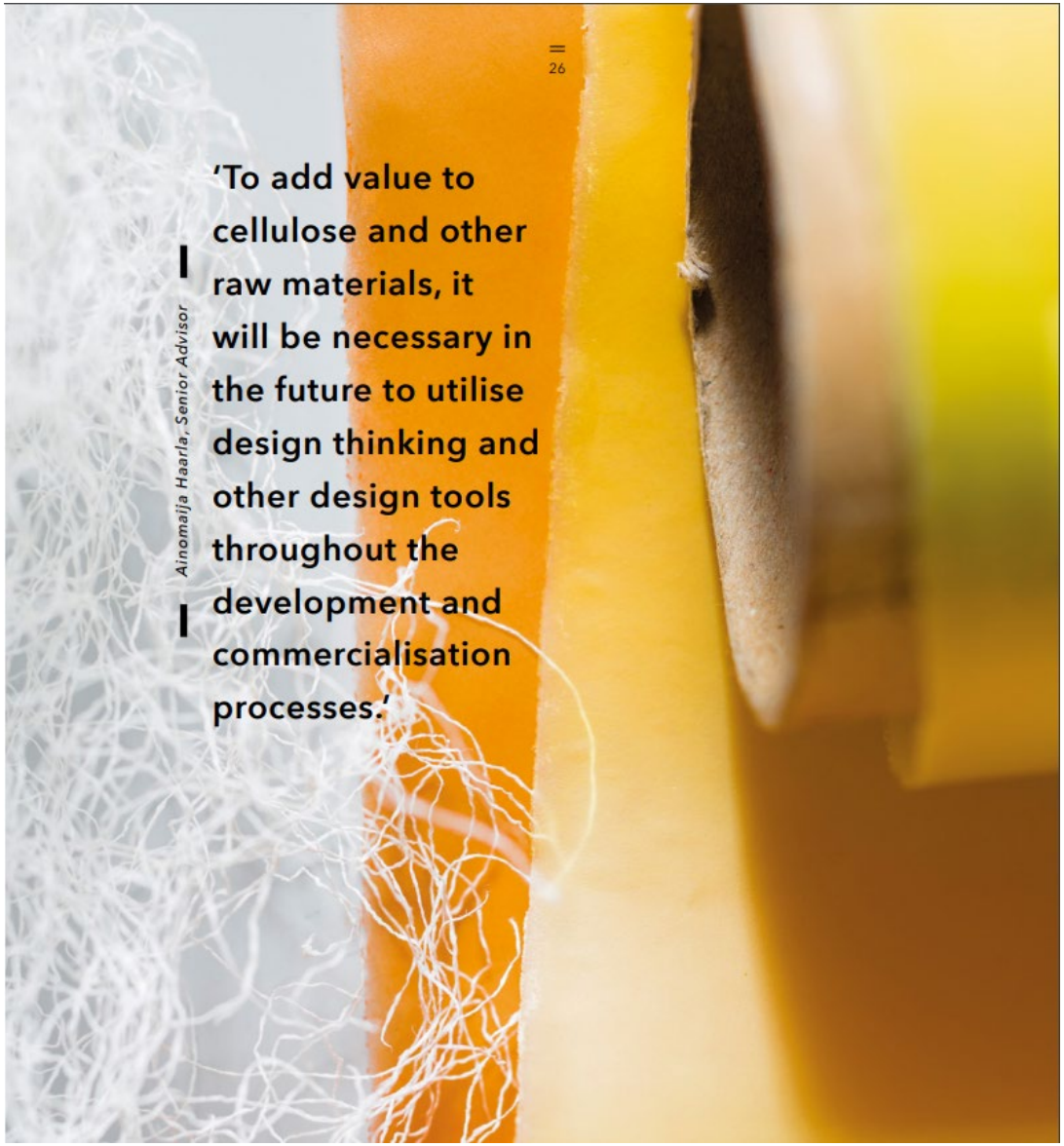
CELLULOSIC MATERIALS DYED BY USING NATURAL COLOURS

FABRICS FROM WASTE CELLULOSE – HOW TO WEAR OLD NEWSPAPERS

PULP FIBRE FILAMENTS

FOAM FORMED INTERIOR ELEMENTS

Source: https://cellulosefromfinland.fi/material-library/



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Source: https://cellulosefromfinland.fi

INNOVATION WITH LIGNIN

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Lignin

Market size for lignin and lignin-based products is expected to reach **$1.2B US** by 2024 at **7.2%** CAGR

Products: broad range of dispersing agents, performance chemicals and biomaterial.

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Source: Borregaard

Industrial Applications of Lignin

AGRICULTURE

ANIMAL FEED ADDITIVES

BATTERY ADDITIVES

CARBON BLACK DISPERSIONS

CERAMICS

CONCRETE ADMIXTURES

DYESTUFF DISPERSANTS

EMULSIONS

GYPSUM BOARD

Source: Borregaard

INDUSTRIAL CLEANERS & WATER TREATMENT

OIL FIELD CHEMICALS

INDUSTRIAL BINDERS

RESIN EXTENSION

ROAD & SOIL DUST CONTROL

PAPERSIZING

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Source: Borregaard

TOOLS AND TECHNOLOGY

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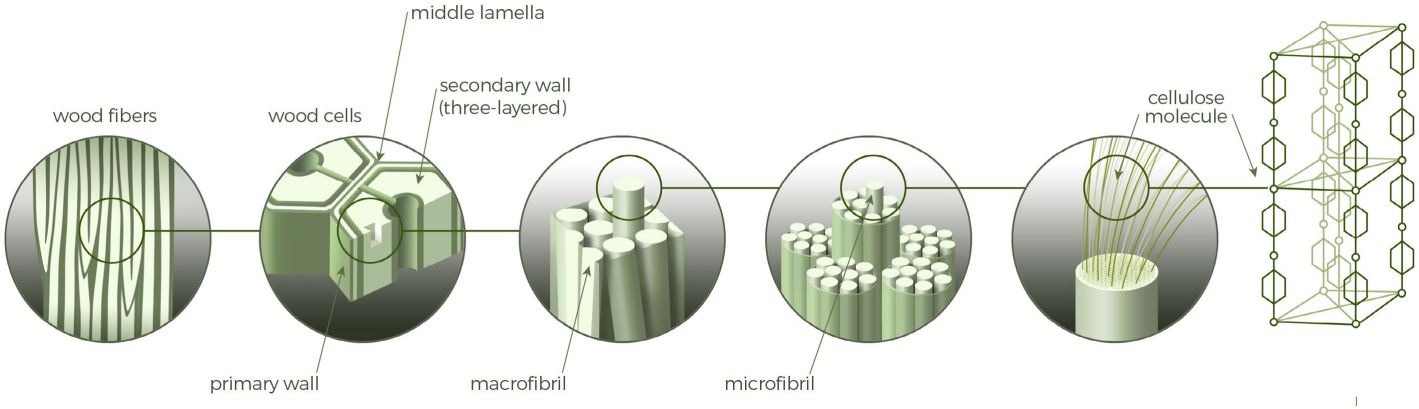
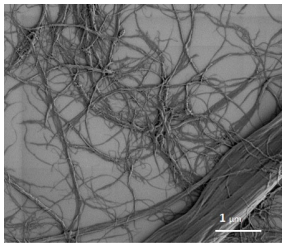
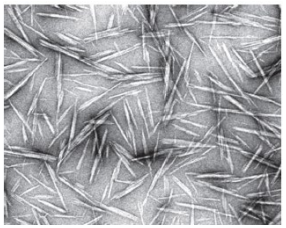
Nanocellulose – the next super material





Nano-fibrils



Nano-crystals

- Their size, shape and charge lead to unique behavior in solutions.
- Customizable for various applications due to high surface chemical reactivity.
- Applications at high temperatures due to heat stability.

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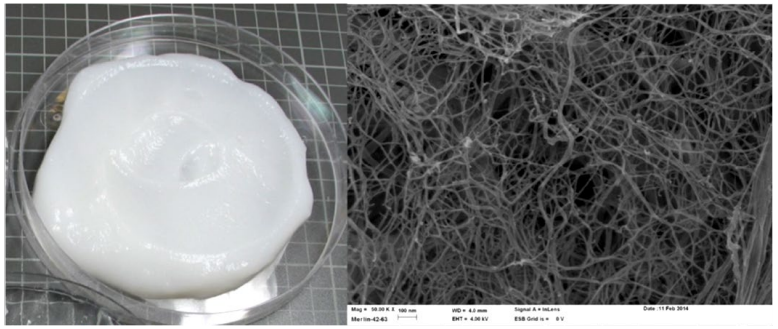
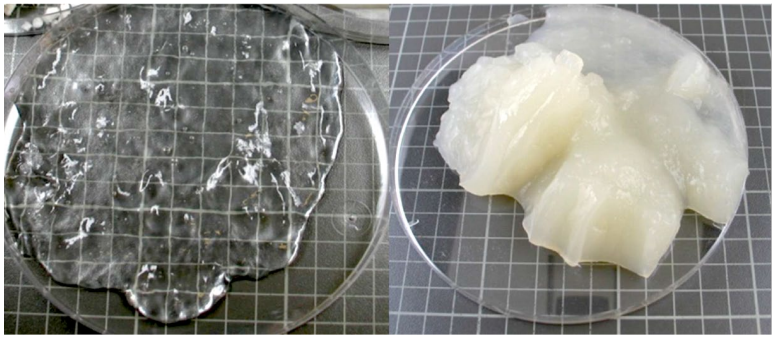
Source: https://www.celluforce.com/userfiles/images/graphique_Celluforce_WEB_2_EN.png; https://blog.exilva.com/microfibrillated-cellulose-or-nanocellulose

Technical Application of Nanocellulose

Light materials with increased strength
Fibre-based packaging and composites
Polymer composites
Strong yarns
Rheology modifier
Smooth, transparent films
Barrier materials
Substrates for printed electronics
Electronic displays
Coloured films
Medical applications
Hygiene products
Reactive networks
Membranes, Porous structures
Water absorbing, retaining and releasing materials





Market to Register Over 40% CAGR to 2024 and cross $1B

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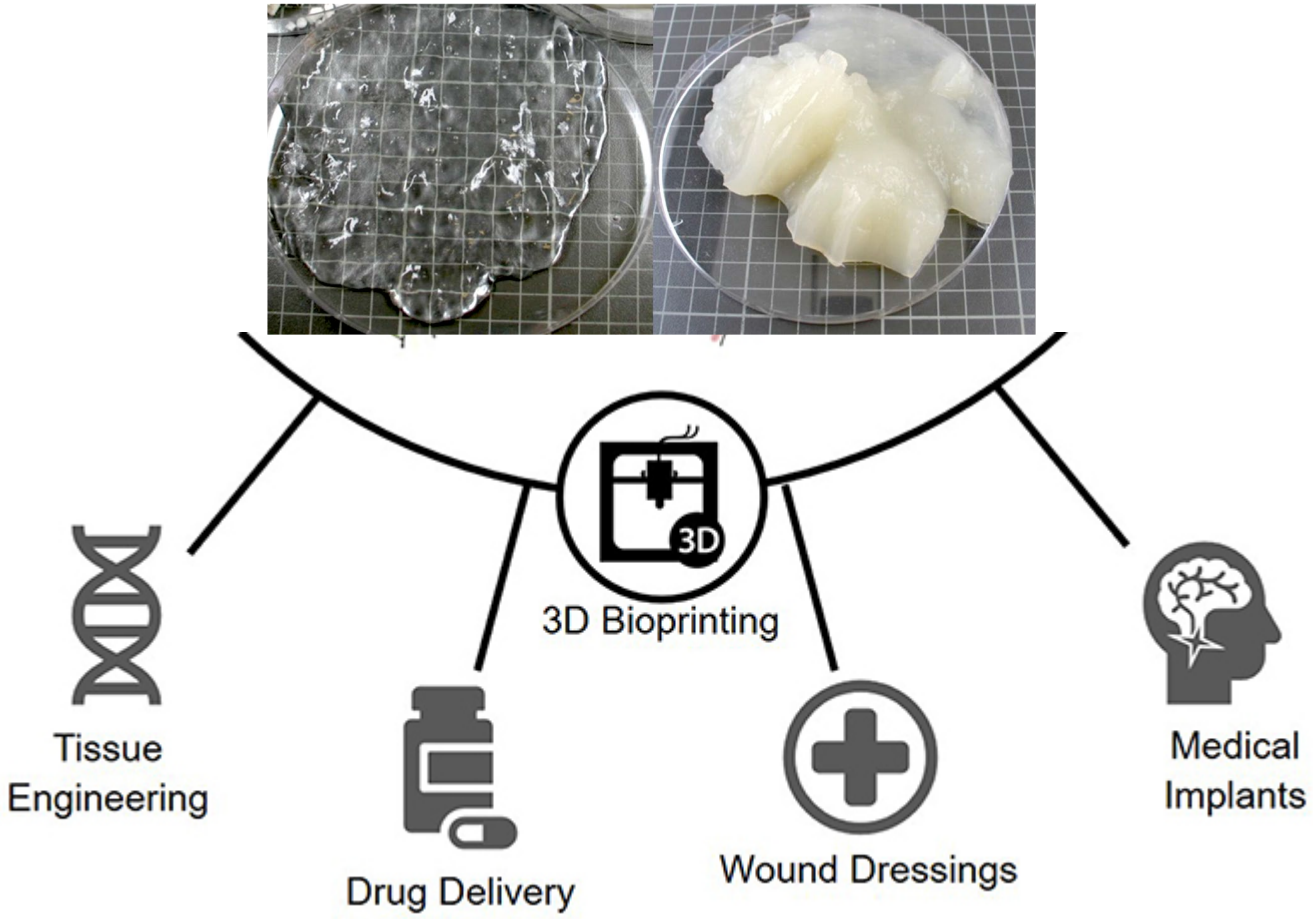
Source: https://cellulosefromfinland.fi/nanocellulose/

3-D Printing Using Nanocellulose



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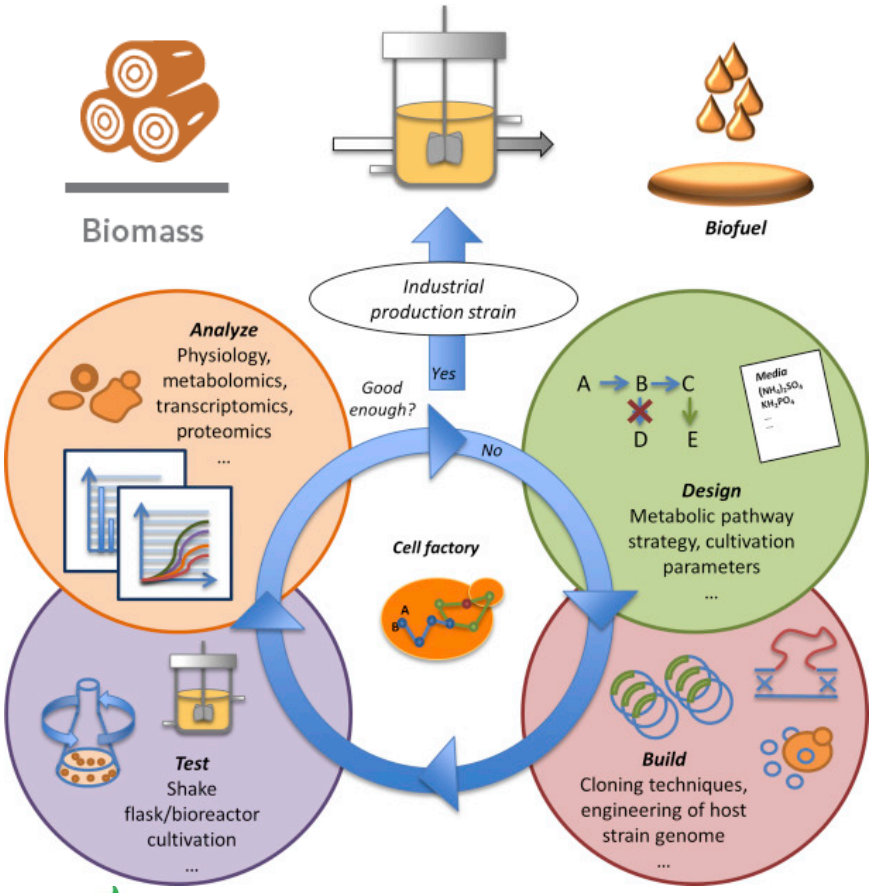
Source: https://www.ahajournals.org/cms/attachment/84374af6-8cea-49dc-8166-1b50688a4bd5/e006920fig09.jpg

Engineering Biology: biomass to bioproducts



- Engineer microorganisms for carbon-efficient, energy-efficient, and scalable conversion of sugars and aromatics
- To develop robust new microbial hosts that demonstrate conversion capabilities.
- Enable the process of engineering biological systems for biofuel and bio-product production.

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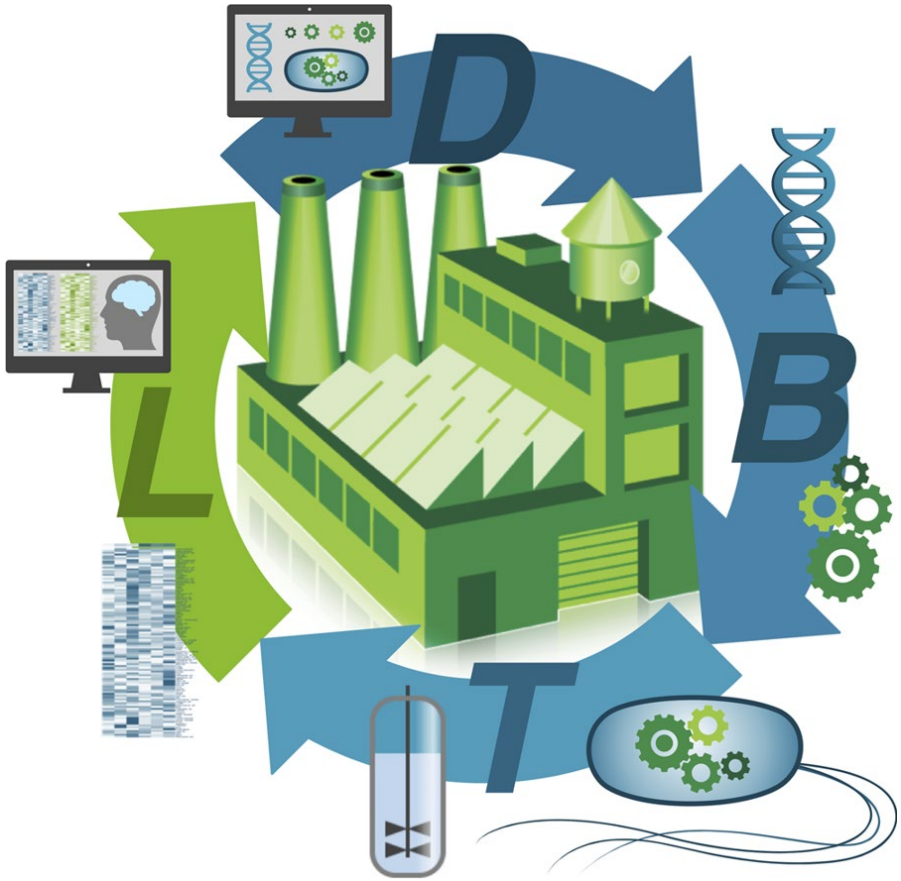
https://ars.els-cdn.com/content/image/3-s2.0-B978012804568800007X-f07-01-9780128045688.jpg

Biofoundry to Build Efficient Hosts



Credit: Christopher Johnson, DOE Agile BioFoundry, Golden, CO, USA

Foundry: a place where metal is melted and poured into special containers to obtain a certain shape.

A biofoundry – biological foundry – is a place that bends and shapes biology to serve a certain need or reach a goal - an integrated facility that can design, build, and test genetic constructs in high scale.

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Global Biofoundry Alliance

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Nature Communications **volume 10**, Article number: 2040 (2019)

INVEST IN…

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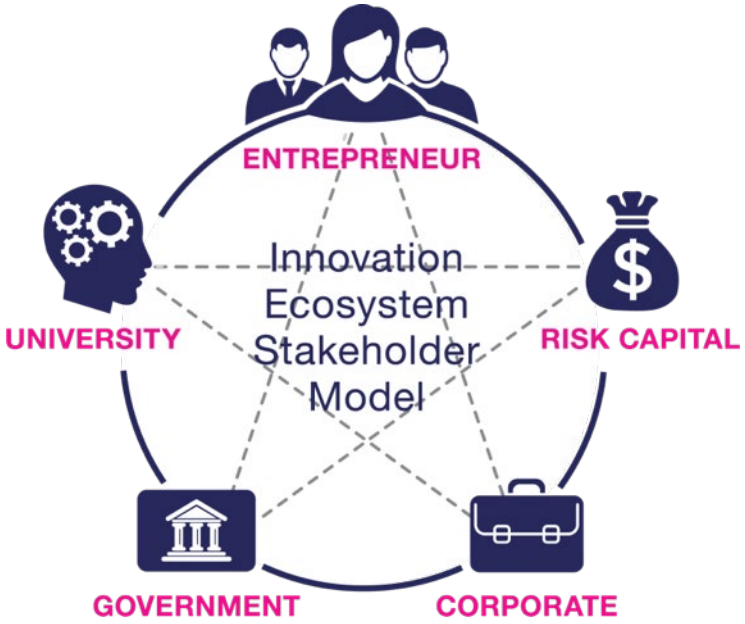
…Innovation Ecosystems for Regional Entrepreneurship



Innovation ecosystem connects key stakeholders:

- entrepreneurs **(First Nations, forest dependent communities)**,
- universities (as you'd expect), and
- risk capital providers (beyond just VCs),
- but also with key roles for government and large corporations.

Ecosystem relies upon the collective actions that these stakeholders take to contribute and share resources (talent, ideas, infrastructure, money, connections).

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Source: MIT Innovation Initiative

How can Genome BC help…

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Genome BC is Supporting

BC Pulp & Paper
BIO-ALLIANCE

FPInnovations

UBC

BRITISH COLUMBIA

Mitacs

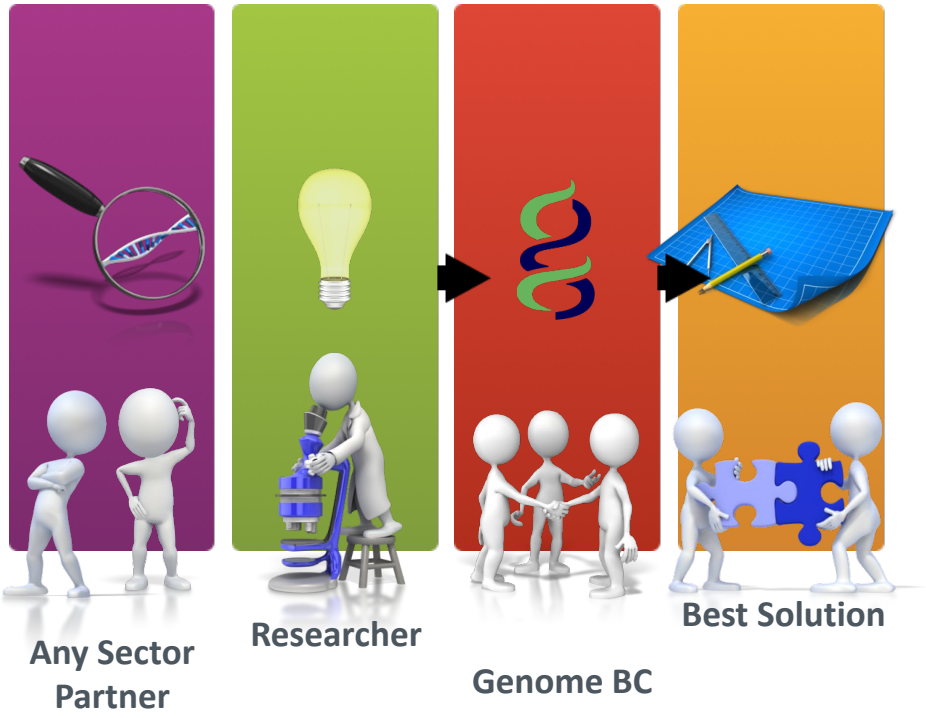
Genome BritishColumbia

Genome BC Funded projects:

- Upgrading lignin from black liquor
- Valorization of ash and biosolids

GeneSolve program

- Connects Sector Partners with researchers in BC



Budget: $100K to $500K

Project Term: 6 - 24 Years

Funding ratio: 1:1

Max GBC ask: $250K

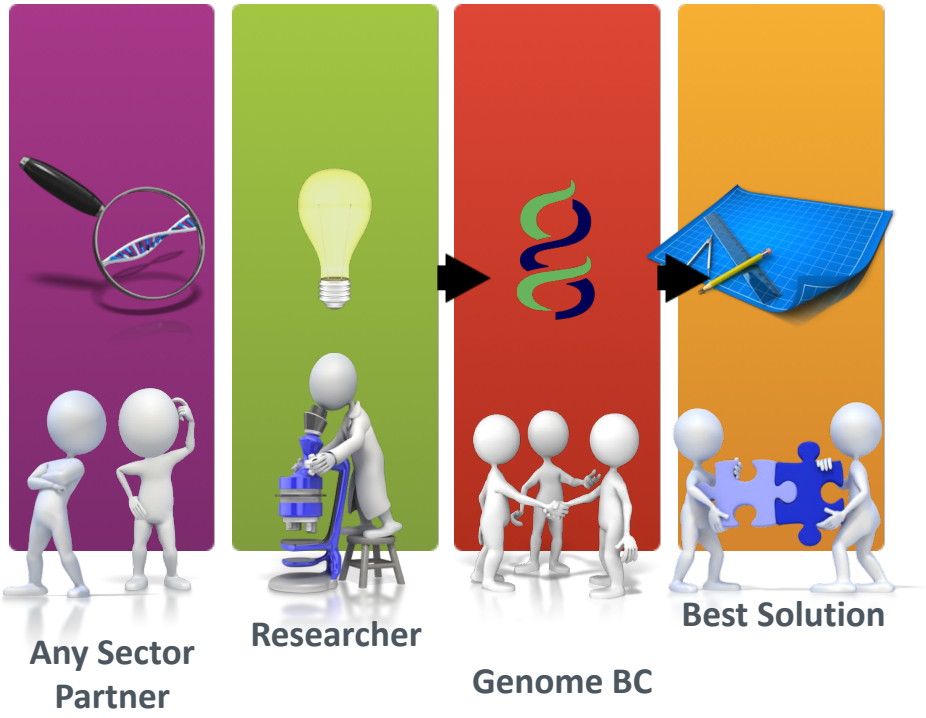
Intake: Rolling with fixed deadlines

Feasibility study, early/Late R&D stage

Genomic Applications Partnership Program (GAPP)

GenomeCanada

- Connects Sector Partners with researchers in Canada



Budget: $300K to $6M

Project Term: 1 - 3 Years

Intake: Rolling with fixed deadlines

Feasibility study/ Late R&D stage (POC)

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Large Scale Applied Research Projects (LSARPs)

GenomeCanada

- Supports genomics focused applied research with the long-term potential to address issues of strategic importance to Canada
- Upcoming Intake on Natural Resources and Environment

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