Five reasons for exponential hope

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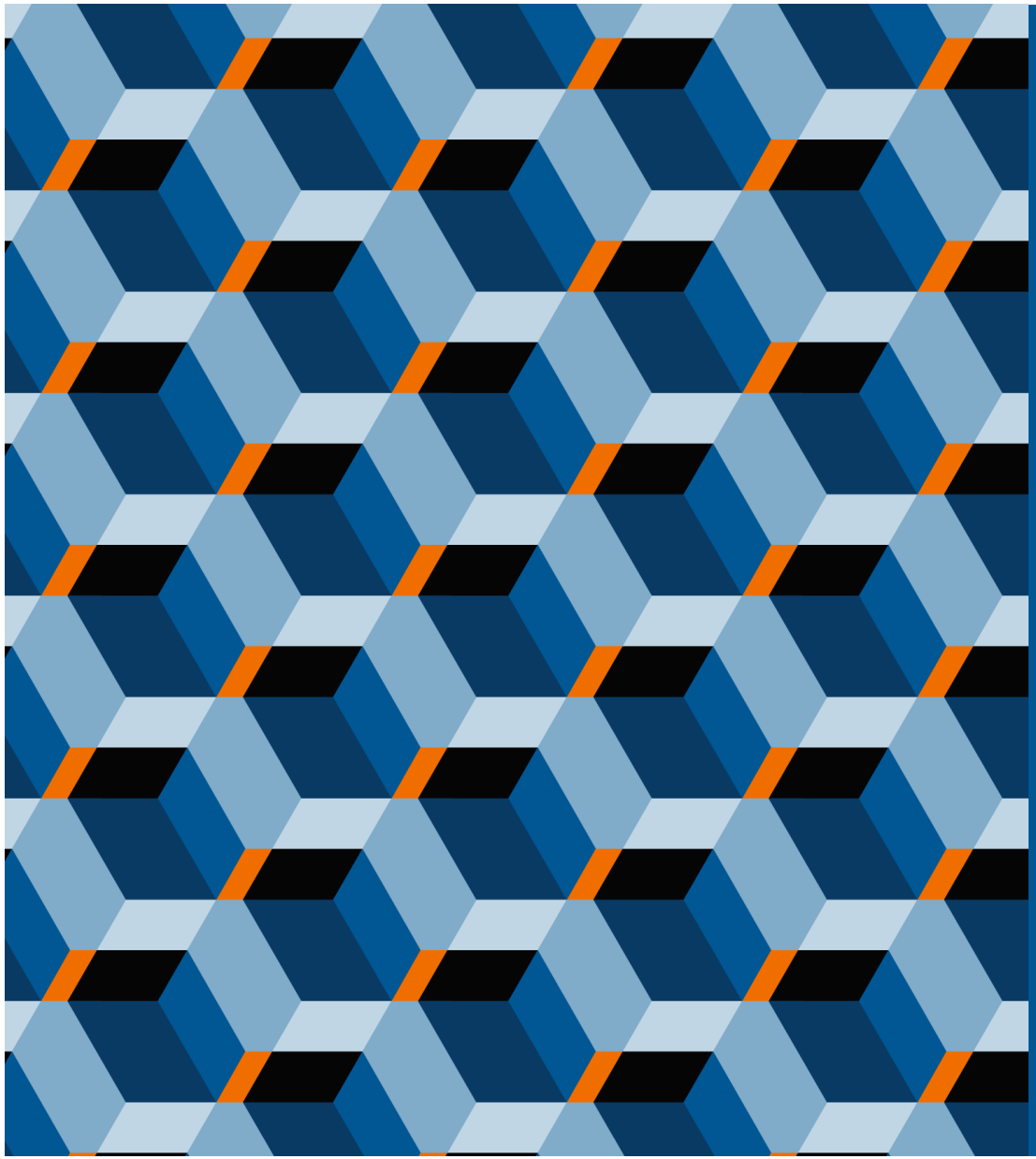
The 2020s are a pivotal time in history.

Every crisis is an opportunity for radical renewal.

Focus on opportunities that support long-term well-being, solve systemic problems and create sustainable growth.

Science and technology is the way to create sustainable growth and hope.



The Areas of Exponential Hope

Why exponential?

These areas, instead of creating incremental change, cause **paradigm shifts**, leading to real **performance**, **productivity and sustainability gains.**

Why hope?

These fields can help us **tackle global challenges** and give rise to new high-growth areas of competence that **create wellbeing, jobs and sustainable growth.**

The Areas of Exponential Hope

1. Biotechnology in food production
2. Quantum technology
3. Small nuclear reactors
4. Chemical plastics recycling
5. Optimising the use of materials

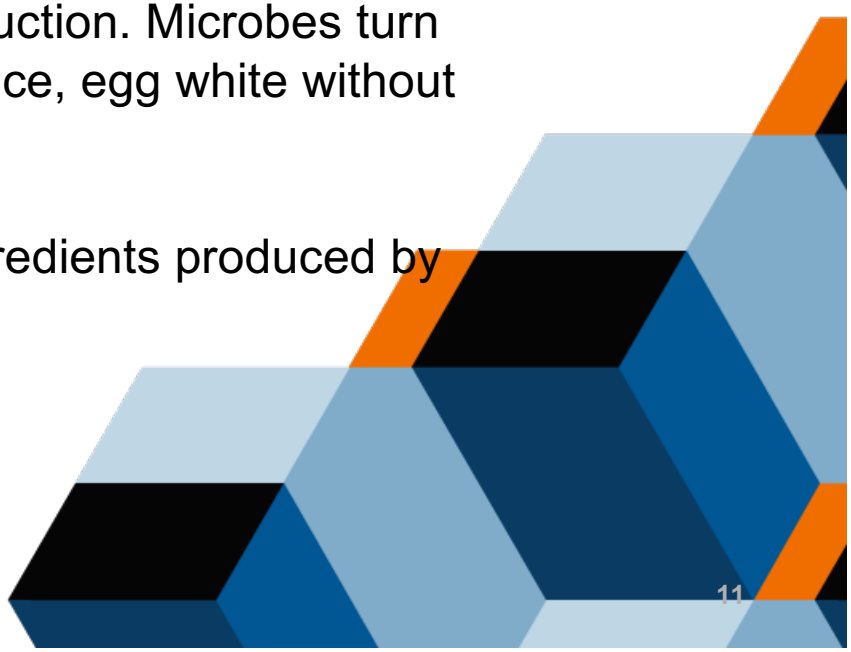
1. Biotechnology in food production enables sustainable growth in the food system.

Biotechnology in food production in a nutshell:

Challenge: How to feed **growing global populations** and **minimise negative environmental impacts** of food production?

Solution: **Cellular agriculture** means using single cell organisms and bioreactors instead of animals and fields for food production. Microbes turn feedstocks into sustainable food ingredients: for instance, egg white without chickens or milk proteins without cows.

Impact: **Sustainable food production.** New food ingredients produced by microbes and other cells. Cellular agriculture scales vertically, freeing up land to be returned to its natural state.



Concrete ways to apply:

1. **Eggs without chicken, milk without cows,** and other every-day food ingredients made by microbes instead of animals.

2. **New, sustainable foods from microbial mass** for consumers (e.g. Solein from Solar Foods – single cell protein).

3. **Food without fields.** Cell factories scale vertically, which frees up land for return to natural state.

4. **Food production in totally new places**, even deserts or space.

→ **Tasty and safe food** – made sustainably.

Case 1: Eggs without chicken

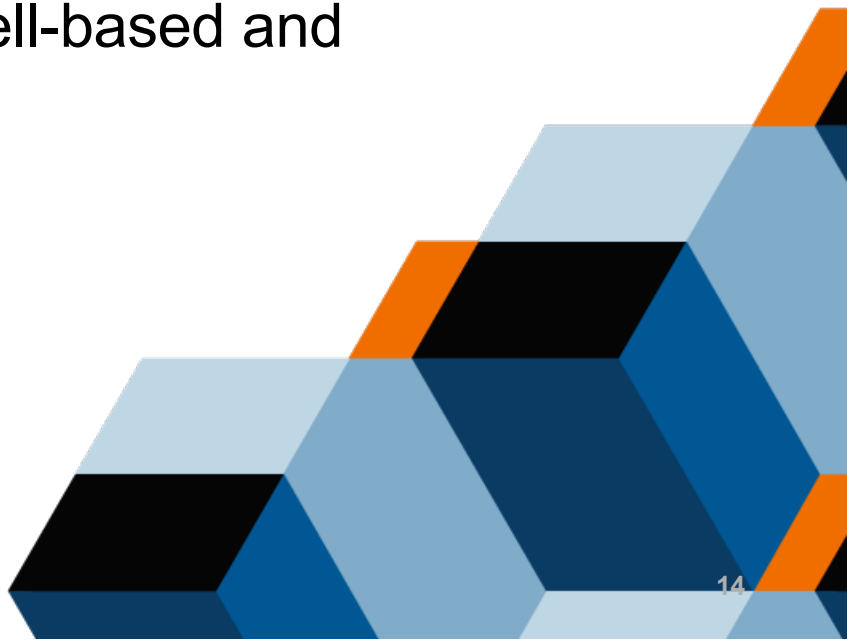
- **Egg protein** is integral to all food industries. As chickens account for one-third of the bird population on our planet, a profound change towards more **sustainable egg protein production is needed.**

- In the cell factories of the future, **microbes can produce egg white protein without chickens.**

- Initial calculations show that producing egg-white protein in a cell factory generates **75% less greenhouse gases** and uses **90% less land** than rearing chickens.

Why would this make sense in Finland:

- High-level food and biotech expertise and infra
- Open-minded consumer base for new food innovations
- Broad knowledge on production of both cell-based and microbe-based ingredients



2. Quantum technology can cause astonishing leaps in productivity.

Quantum technology in a nutshell

Challenge: Where to find the next **great leap in performance** after Moore's Law?

Solution: **Quantum technologies** can achieve an astonishing computing power, far surpassing super-computers of today. They can help us solve completely new kinds of computational tasks, like modelling complex molecules and systems.

Impact: They could enable extraordinarily **rapid development of medicines and vaccines**. Or be used to solve huge systemic problems like **hacking climate change and resource scarcity**.

Concrete ways to apply:

1. **Simulation of molecules, proteins and materials** with quantum computing will enable faster development of new medicine and materials.

2. **Quantum internet,** secured by quantum means with quantum computers as a cloud service.

3. **Sensors and sensing applications** will be improved by quantum technology.

2. Quantum technology

Why would this make sense in Finland:

- Expertise in electronics, superconducting circuits and sensors
- Quantum and low-temperature physics laboratories
- Functional 50-qubit quantum computer being built by 2024

Case 1: Quantum device manufacturing becomes an export industry

- Finland has **skills and infrastructure to manufacture quantum devices** from components for quantum computers
- An ecosystem of companies, universities, research organizations will grow to be a **significant export industry** with high added value and high-quality jobs.

Case 2: Quantum computing in big data analytics

- **Quantum technologies** can achieve an astonishing computing power, far surpassing super-computers of today. They can help us solve completely new kinds of computational tasks, like modelling complex molecules and systems.
- Quantum computers can use efficient quantum algorithms for complex analysis, utilizing big data.
- This enables **faster analysis of protein data.** The aim is to create **new bioprocesses** and **biomaterials,** and to **prescreen medical molecules**.

3. Small nuclear reactors make industry carbon neutral.

Small nuclear reactors in a nutshell

Challenge: How to supply **clean heat and energy** for industrial applications and create **carbon neutral industry**?

Solution: **Small modular reactors** provide a way to produce high-temperature heat and secure, low-emission energy without resorting to burning. Serial production will drive down costs. Safety is enabled by smaller size and simpler process.

Impact: **Industrial processes are decarbonised,** and reactors are also used to produce clean hydrogen and synthetic fuels, chemicals.

Concrete ways to apply:

1. **Heat** for **district heating** and **industrial uses**
2. **Production of hydrogen**
3. **Low emission energy for large-scale energy users** (e.g. industrial plants)
4. **A dispatchable energy source** to complement renewable sources.
5. **Reliable and clean energy** to fit society's and indystry's requirements.

Why would this make sense in Finland:

- Long tradition with safe use of nuclear energy
- Ambitious carbon-neutrality targets
- Advanced know-how in nuclear reactors
- Strong manufacturing industry and process industry

Case 1: Heat and hydrogen from small reactors

- Small nuclear plant provides **heat and hydrogen** to industrial site
- Heat can also be converted to **electricity**
- High temperature steam electrolysis can produce **clean hydrogen** more efficiently – to be used in **decarbonized industrial processes**.
- Lower temperature waste heat can be used e.g. for **district heating**

4. Chemical plastics recycling helps solve one of the world's most severe environmental problems.

Chemical plastics recycling in a nutshell

Challenge: Globally only about 10% of all plastics is recycled. How can we **raise recycling rates** and **tackle severe plastic pollution**?

Solution: **Chemical plastics recycling** breaks plastics down to its building blocks, so it can be remade into high-quality plastics. It enables the recycling of mixed waste plastic streams that can not be recycled with current, mechanical recycling technologies.

Impact: Thus, we can achieve **high plastic-recycling rates** and significantly **reduce greenhouse gas emissions**, as virgin plastic is replaced with recycled plastic.

Concrete ways to apply:

1. **High-quality plastic materials and products** (quality equal to virgin plastics, no value lost during the recycling treatment).

2. **Utilising new streams of waste plastic** as feedstock (reduce use of virgin fossil-fuels).

→ Fighting **plastics pollution,** lowering **greenhouse gas emissions,** creating **new business** from plastics recycling.

4. Chemical plastics recycling

Why would this make sense in Finland:

- Wide-spread collection and recycling system
- Strong expertise in biotechnology and thermochemistry for chemical recycling
- Know-how in breaking down plastics with enzymes
- Industrial-scale gasification and pyrolysis to recover the plastics building blocks

Case 1: Depolymerization through pyrolysis or gasification

- Traditionally **non-recyclable plastic waste can be recycled** into reusable plastic building blocks through **pyrolysis or gasification** technology.
- Recovered molecules are used to produce **plastics with same or better properties** than fossil-based plastics.
- Finland has **long-term expertise and infrastructure** for pyrolysis and gasification processes.

5. Optimising the use of materials enables sustainable resource consumption.

Optimising use of materials in a nutshell

Challenge: Materials are the key to developing a sustainable circular economy. But how can we **radically speed up** current “trial and error” **development of materials**?

Solution: Optimising the use of materials with **digital twins, virtual testing and optimising** materials to be sustainable, high-performing and competitive in cost.

Impact: **Minimising materials use and waste,** maximising product performance, properties and durability. This way we can ensure that the earth’s resources can sustain a growing population and mitigate climate change.

Concrete ways to apply:

1. **Sustainable materials** that enable circular economy.
2. **Digitally-designed ”super materials”** that exceed present ones in performance by several hundreds of percents.
3. **Computational materials engineering** replacing expensive, time consuming testing and shortening time-to-market.

→ Enabling **competitive business**, **new products** and **novel processes** that disrupt industries.

5. Optimising the use of materials

Why would this make sense in Finland:

- High-level of digitalisation
- Rock-solid expertise in materials science and engineering
- Physics-based modelling + AI-based solutions → Autonomous materials research
- Collaboration across businesses and research institutes for agile feedback

How to accelerate exponential hope?

- Take the long view: Put the Areas of Exponential Hope at the centre of innovation and industrial policy
- Build innovation, business and research infra: labs and experimental facilities
- Investment from public and private:
  In Finland, 100 million euros could jump-start R&D&I in these fields

We’ve jumpstarted the world before. We can do it again.

Let’s start today.

beyond
the obvious

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