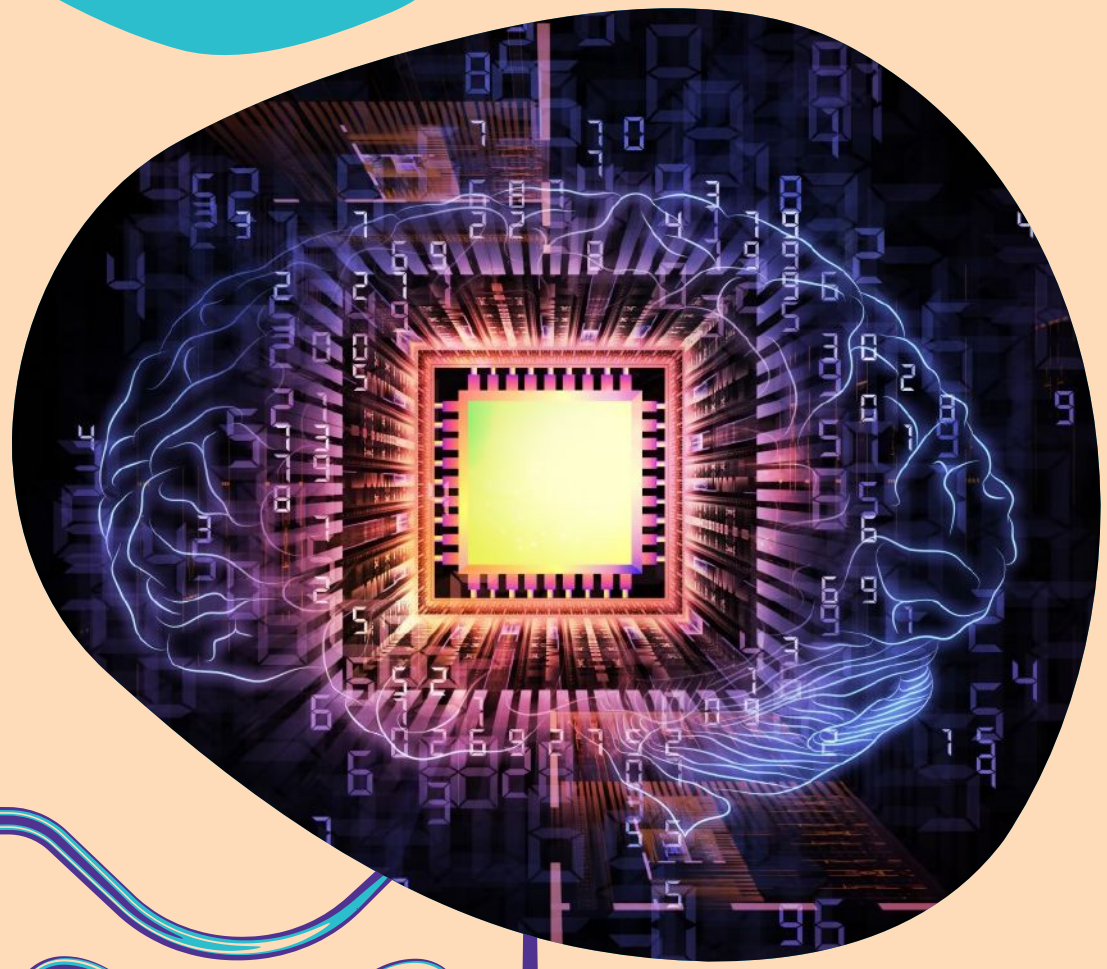


Neuromorphic systems @ Merck innovation center

Hannah Bürckstümmer
04th March 2020

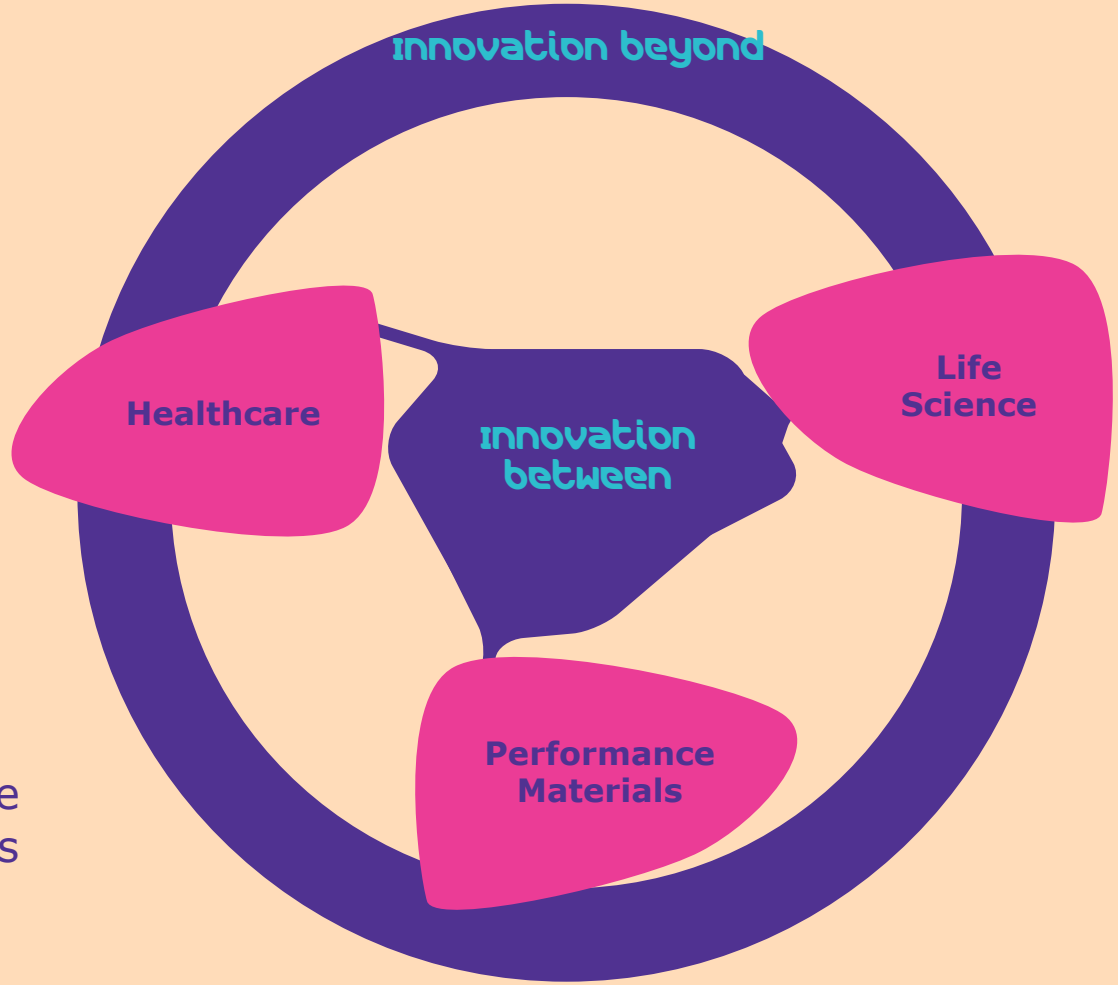
Merck

Complementing
business sector R&D and

driving cross & beyond sector innovation

to generate new business for Merck

In the Merck Innovation Center we identify innovative approaches at an early stage and scale them to viable new businesses. Ideas are grown into innovation projects based on assets of Merck.

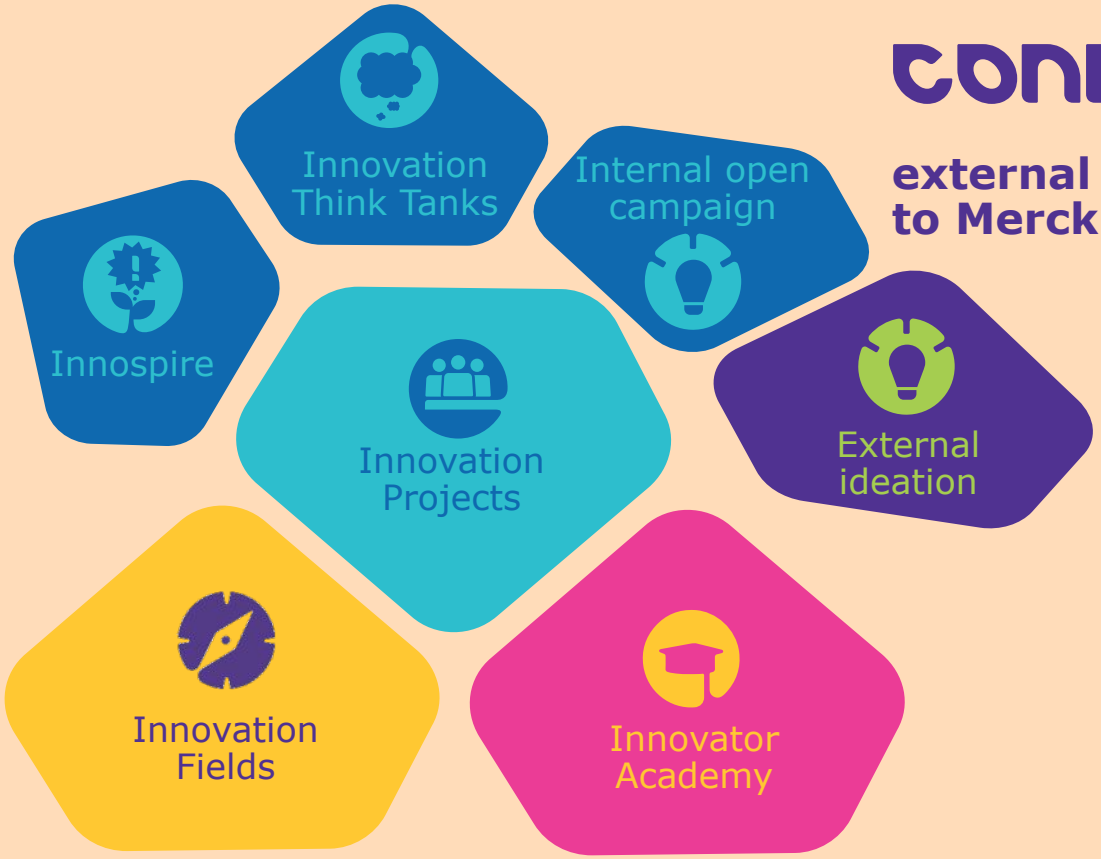


help ideas grow - and scale up to viable new business.

Beyond current boundaries.

foster

internal ideation, project inception and progress



connect

external ideas to Merck

set

strategic direction

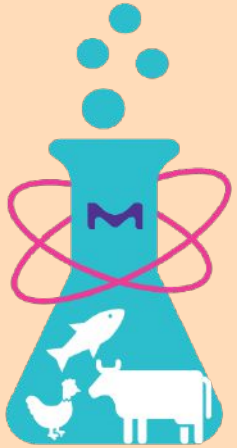
strengthen

innovator skills & innovation culture

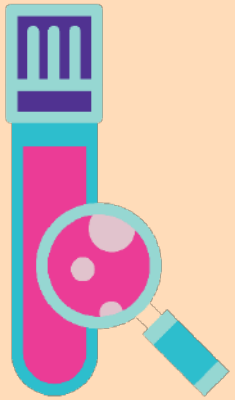
MERCK

Innovation fields provide

strategic direction



Clean Meat

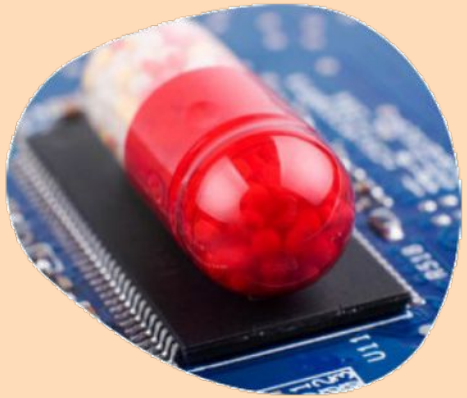


Liquid Biopsy Technologies

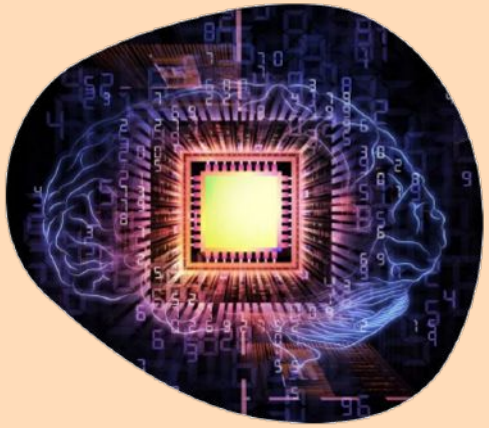
And we are always

exploring nascent areas

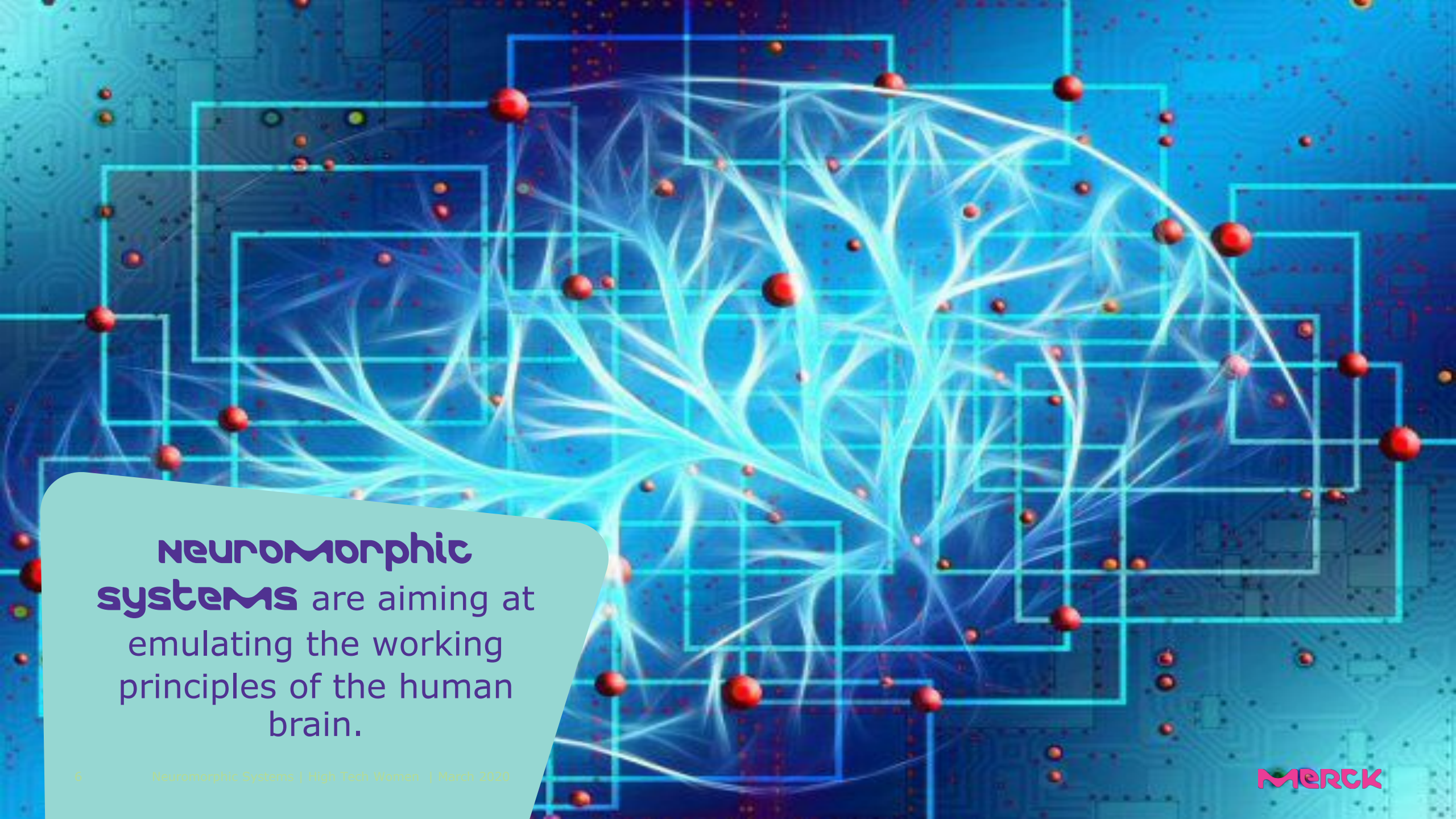
in science, technology or business
to analyze their potential for Merck



Bioelectronics



Neuromorphic Systems



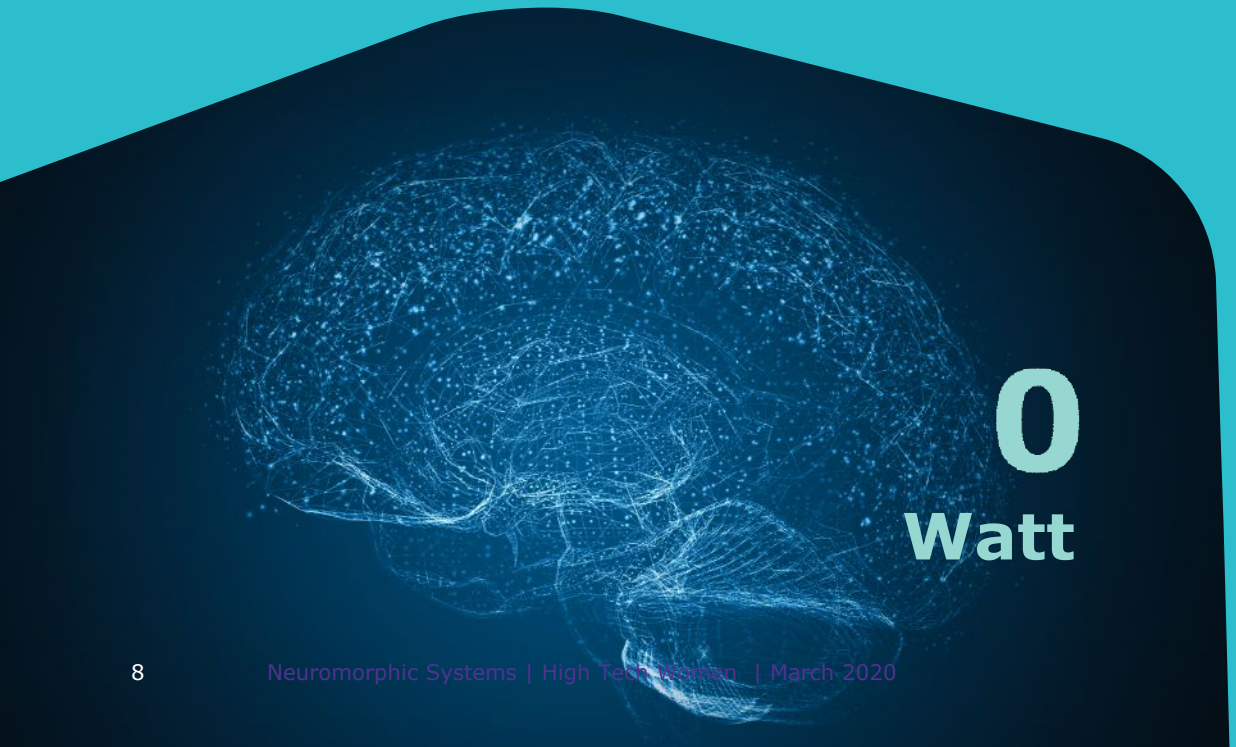
Neuromorphic systems are aiming at emulating the working principles of the human brain.

MERCK

why?

MERCK

HUMAN BRAIN VS. WORLD-CLASS SUPER-COMPUTER



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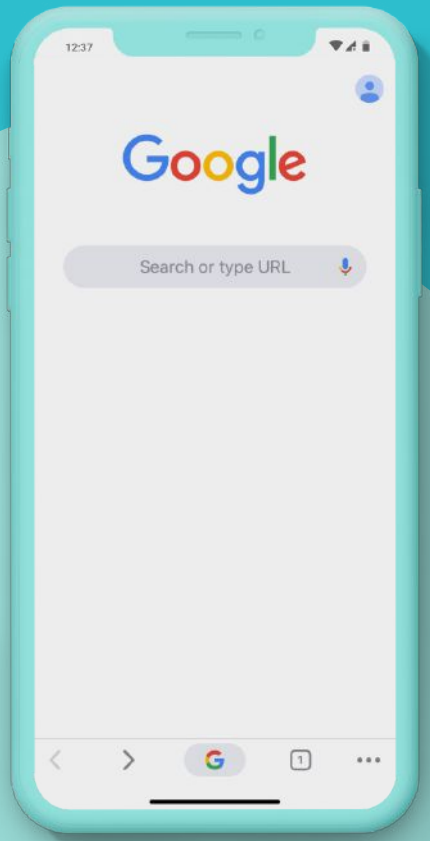
220 GOOGLE SEARCHES

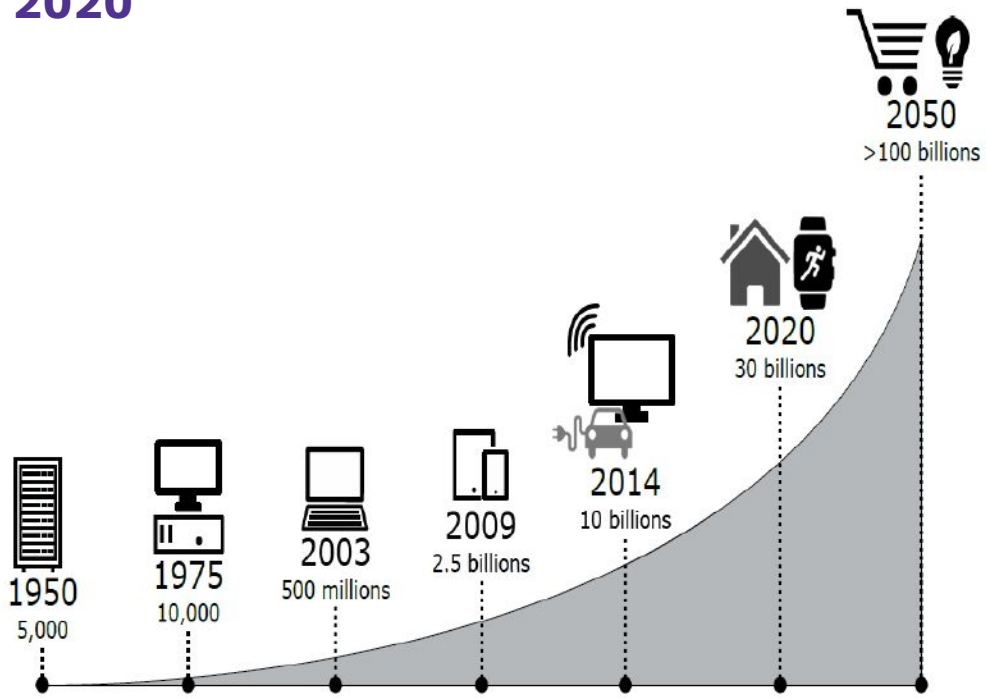


≙ BOILING 1L OF WATER

INFORMATION AND COMMUNICATIONS TECHNOLOGY

Data explosion at the edge
Moving from the cloud to the edge

30bn IoT devices fueling the edge 2020



Source: Maurizio Capra, Future Internet 2019, 11, 100

Airbus A-350 jet has over 6,000 sensors and generates **2.5 terabytes** of data each day it flies

Globally security cameras create about **2.5 exabytes** of data per day

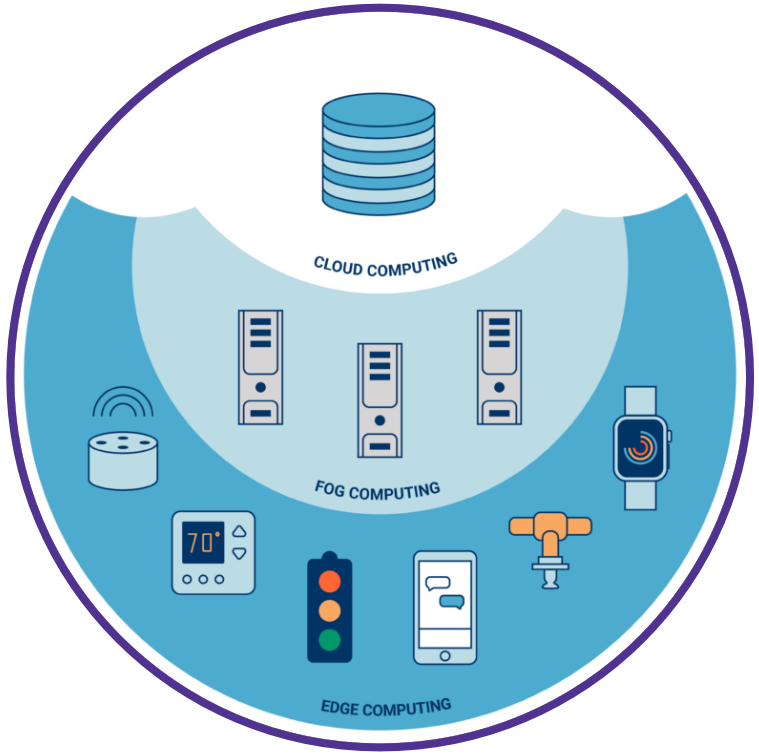
If everybody used their Android Voice Assistant for **3 min per day** they would have **to double** the number of data centers they owned.

Source: Deloitte, TMT Predictions 2020 ; Pete Warden, Google

The edge computing opportunity
Data processing at the point of origin

Advanced AI and **Edge computing**

Decentralized processing power at the source of data generation needs orders of magnitude higher computing efficiency



Major pain points

Autonomous driving

- Data volume vs latency
- Size and power supply

IoT Sensors

- Reliability
- Bandwidth
- Battery power

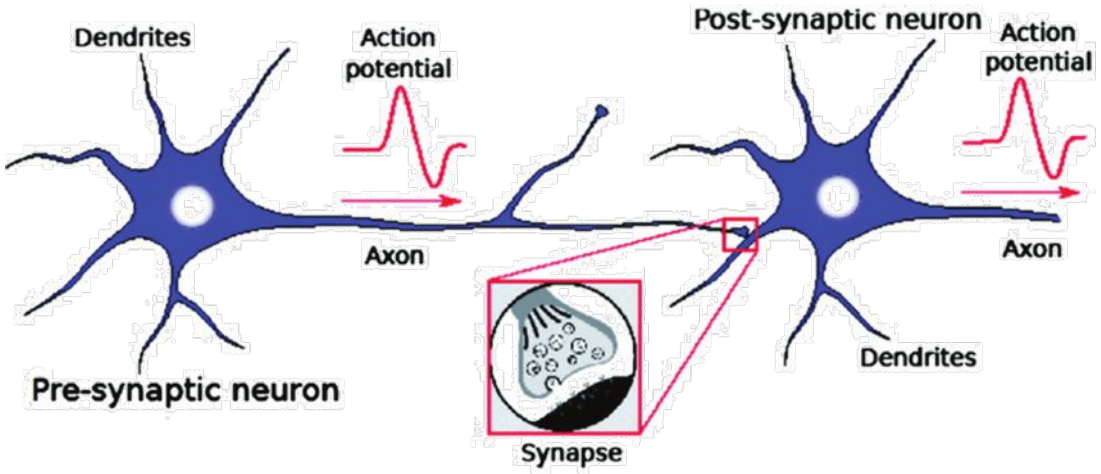
Smartphone

- Battery
- Privacy

HOW?

MERCK

Why mimicking the brain could make chips more efficient



Neuron information processing

1. Electric potential of –70 mV at static state
2. Changes, when signal is received from synapse
3. Spikes are formed above a critical threshold
4. Spike propagates along the neuron's axon to a synapse
5. If the spike meets certain criteria, the synapse transmits it to the branching dendrite of another neuron.

Digital-Analog Hybrid Computing

- Binary: Spike as units of information
- Analog: electric charge is accumulated like in capacitors

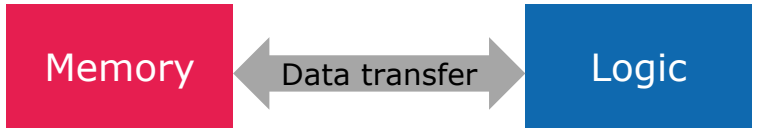
- **The brain is a mixed-signal system**
  - Local analog computing
  - binary-spike communication.

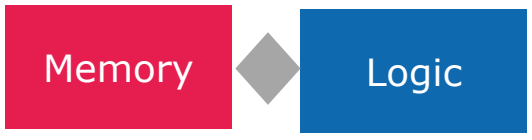
- **In-memory computing**
- **Asynchronous logic**
- **Connectivity and self-learning**
- **Parallelism**

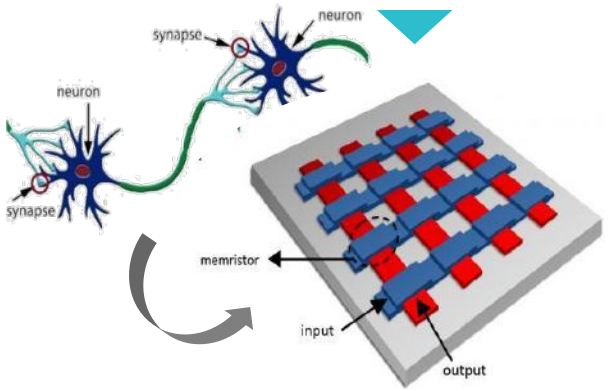
Simplified technology roadmap

		Key enablers		
		Software	Chip architecture	New materials
Current systems	Limited power efficiency Restricting edge applications	✓	x	x
>2020 systems	Higher computing power: **Near-memory** processing	✓	✓	x
>2022 systems	High computing power & low power consumption via **analogue in-memory** processing	✓	✓	✓

Memory & Heat wall, Moore's law







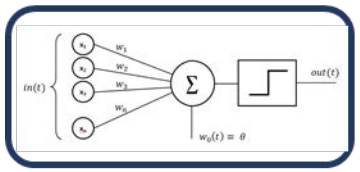
Memristive element = memory + resistor

Neuromorphic technologies are just at the beginning!

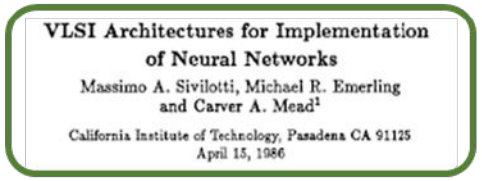
The second rise of AI yields the revolution in the hardware

1957 1986 1997 2010 2011 2012 2013 2014 2015 2016 2017 2018

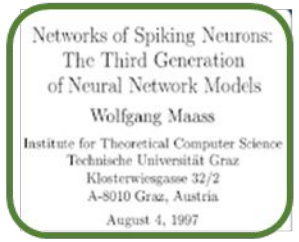
1957 Invention of Perceptron



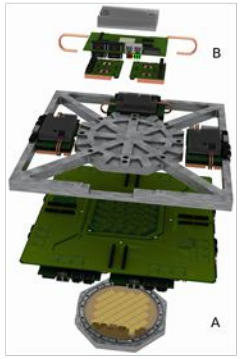
1986 Publication of "VLSI Architecture for Implementation of Neural Networks"



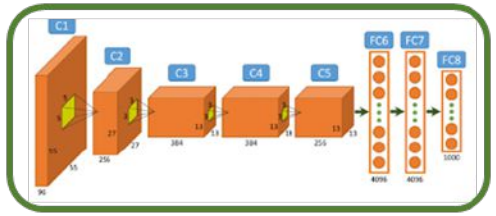
1997 Publication of "Spiking Neurons, The Third Generation of Neural Networks"



2010 BrainScaleS introduced by University of Heidelberg



2011 AlexNet wins ImageNet Challenge



2012 SpiNNaker introduced by University of Manchester

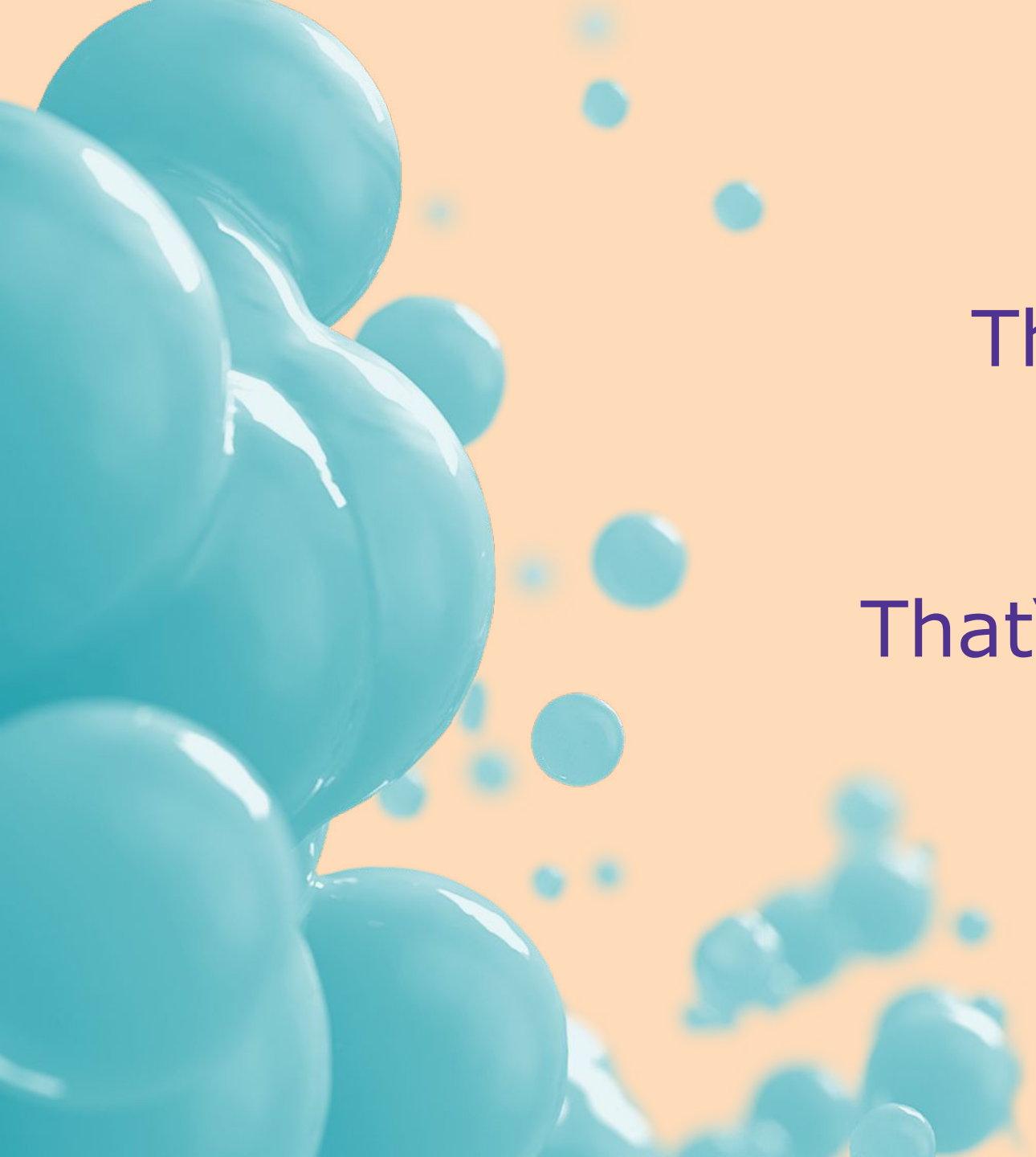
2013 IBM introduced TrueNorth

2015 aiCTX was founded

aiCTX AI Cortex

2017 Intel introduced Loihi

- Algorithm milestones
- Neuromorphic hardware milestones



That‘s how it’s done

That‘s what **I want** to do

Thank you!

MERCK