

Making *Perfect* Life

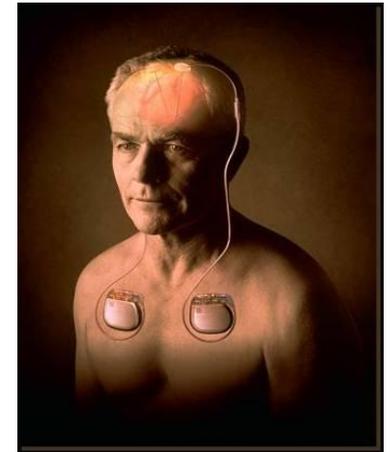
Bio-engineering (in) the 21st Century



Rathenau Institut

Human enhancement technologies

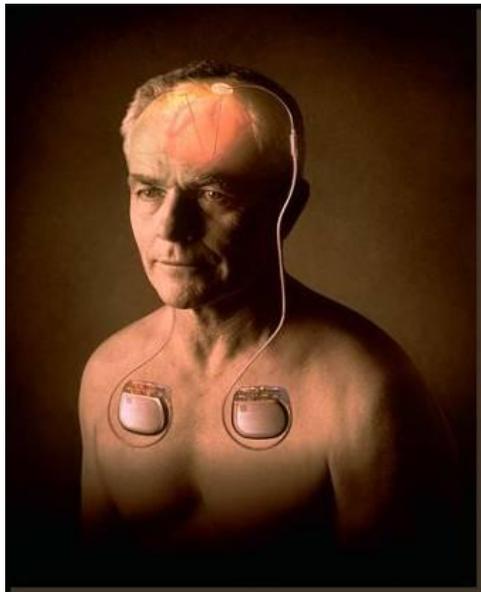
- Definition STOA Human Enhancement project: “Any modification aimed at **improving individual human performance** and brought about by science-based or technology-based interventions **in the body**”
- Distinction between
 - Non-enhancing (restorative or preventive)
 - Therapeutic enhancements
 - Non-therapeutic use
- Examples: gene therapy, designer babies, Ritalin, deep brain stimulation (DBS)



Improving human performance technologies – Intimate technologies

dynameer
verandering
in
de
technologische
wetenschap
en
wetenschap

Rathenau Instituut



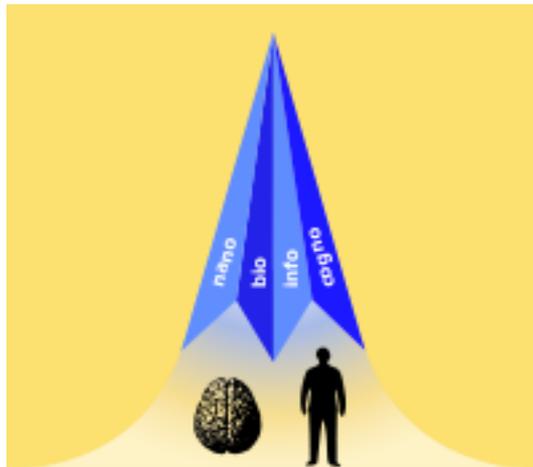
Quantified Self

Rinie van Est, Rathenau Instituut, *Conference on Human Enhancement*, Brussels, 26-4-2012, European Parliament (STOA) & Conference of European Churches & FP7 ETHENTECH project

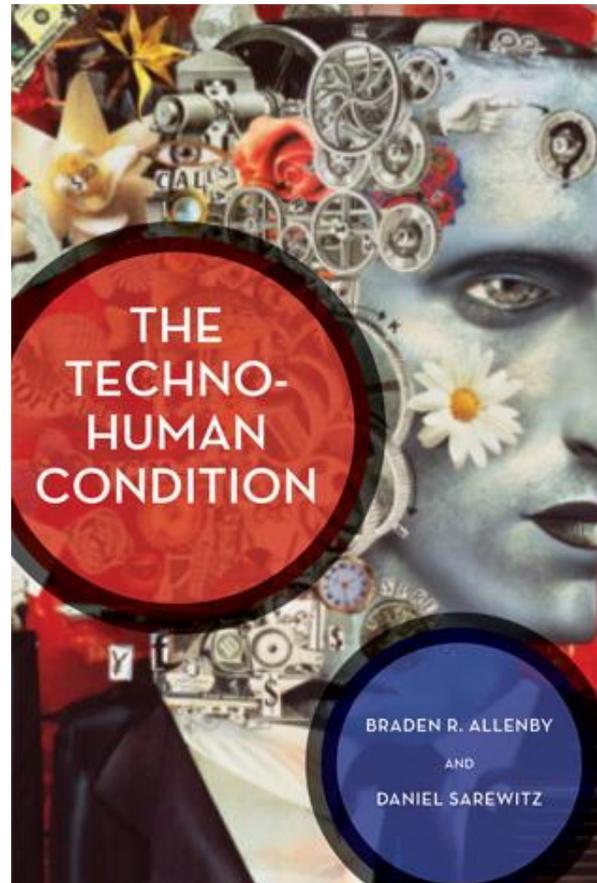
The techno-human condition

dyname kennis in
verandering in
de wetenschap
techno, de science

Rathenau Instituut



CONVERGING TECHNOLOGIES
FOR IMPROVING HUMAN PERFORMANCE
June 2002



Rinie van Est, Rathenau Instituut, *Conference on Human Enhancement*, Brussels, 26-4-2012, European Parliament (STOA) & Conference of European Churches & FP7 ETHENTECH project

Do you remember biotechnology?

dyna kennis in
verandering
in het gebied
de ontwikkeling
technologische wetenschap
van onderzoek
en ontwikkeling
van technologie
en wetenschap

Rathenau Instituut



Bull Herman

**Cloned sheep Dolly:
“First the sheep, than
the shepherd?”**

Rinie van Est, Rathenau Instituut, *Conference on Human Enhancement*, Brussels, 26-4-2012, European Parliament (STOA) & Conference of European Churches & FP7 ETHENTECH project

More bio-ethical issues coming up

dyname kennisgeving
verandering onderzoek
in de
debat
techniek
de science

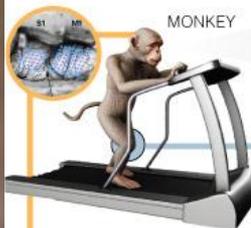
Rathenau Instituut



Moving by Thought

On Thursday, scientists used a monkey in North Carolina to control a robot in Japan.

1 A 12-pound monkey named Idoya was trained to walk upright on a treadmill.



2 Electrodes implanted in her brain monitored the activity of 250 to 300 neurons.

Source: Miguel Nicolelis, Department of Neurobiology, Duke University

3 The brain signals were processed and used to predict the monkey's leg movements, with 90 percent accuracy.

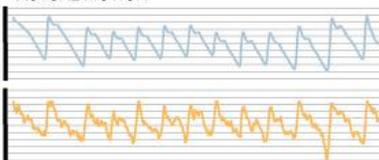
VIDEO SCREEN



5 The monkey watched the robot over a video link, and was rewarded when she made the robot walk. After an hour the monkey's treadmill was switched off, but her brain continued to control the robot, which continued walking.



ACTUAL MOTION



PREDICTED MOTION

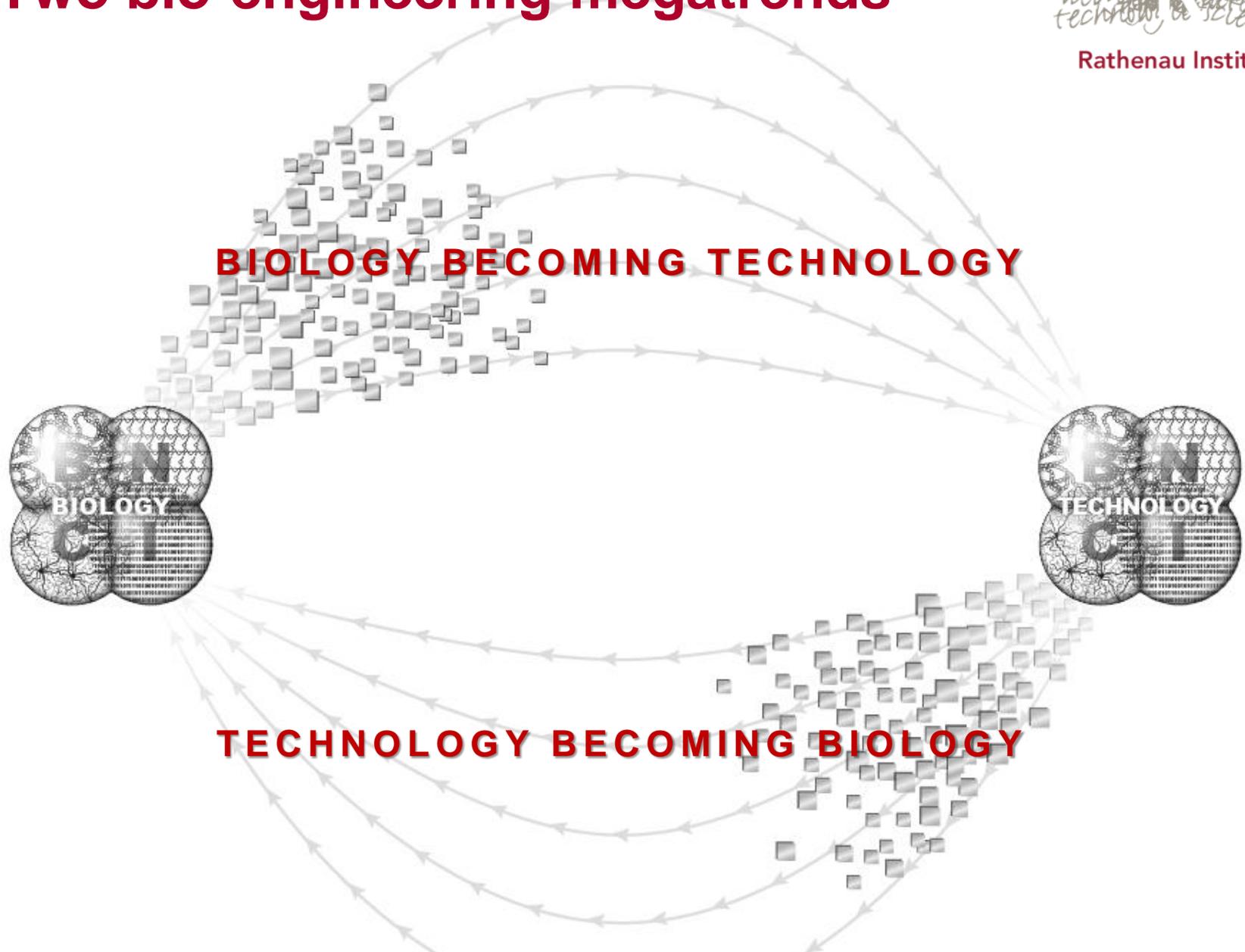
SIGNALS CONTROL ROBOT

4 Data was transmitted over a high-speed Internet connection from North Carolina to a robot in Kyoto, Japan.



THE NEW YORK TIMES

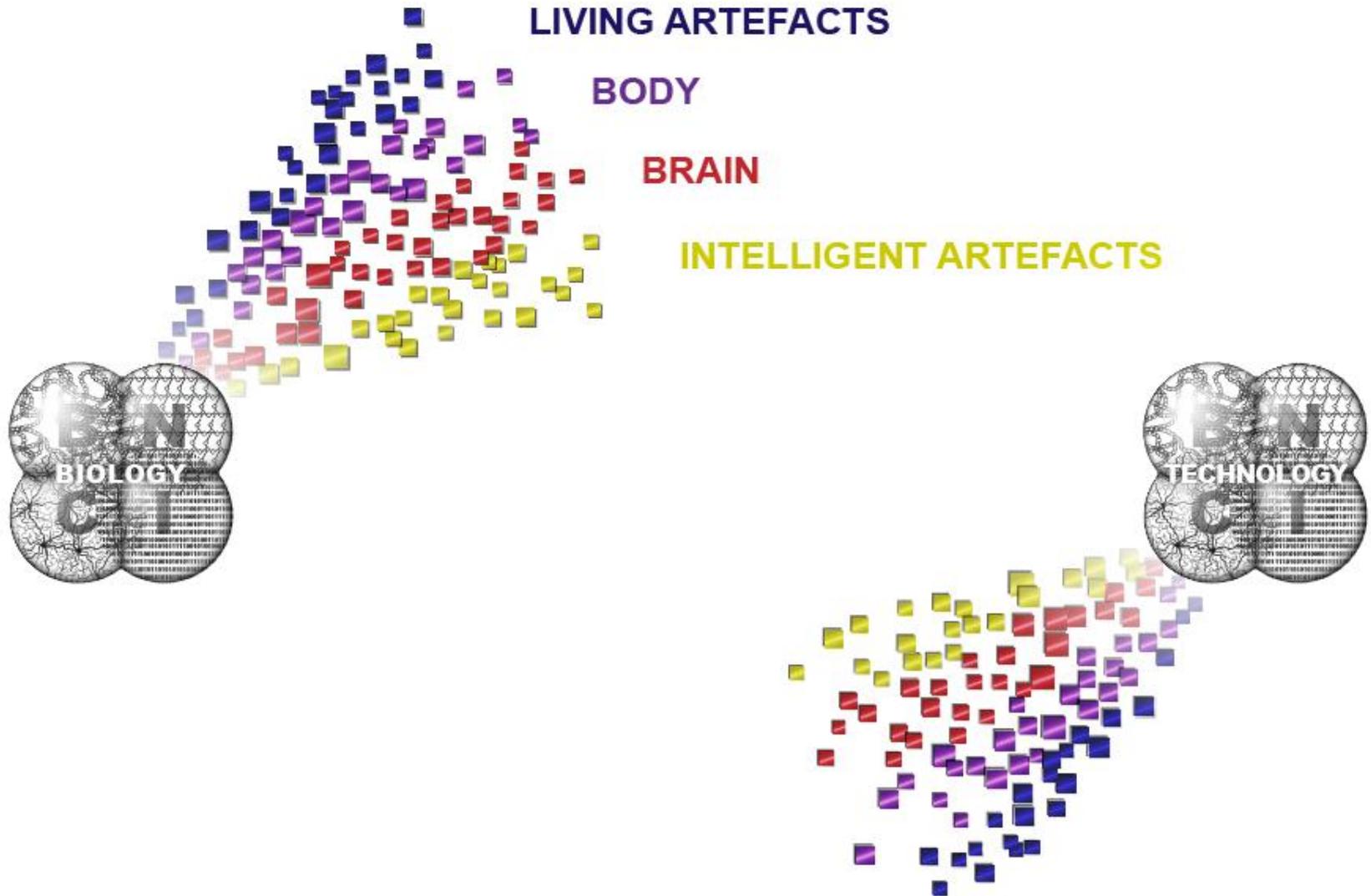
Two bio-engineering megatrends



Four fields of bio-engineering

dyname kennis in
veranderend onderzoek
in de
debat
technologische science

Rathenau Instituut

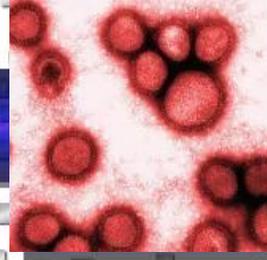


Engineering of living artefacts

verandering in kennis
in het onderzoek
debat
techniek
science

Rathenau Instituut

Top-down synthetic biology



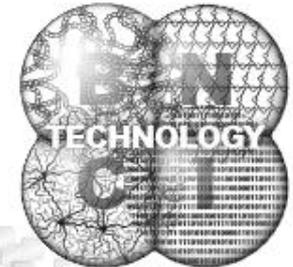
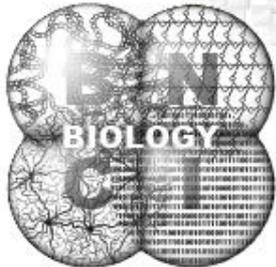
Spanish Flu Virus (2002)



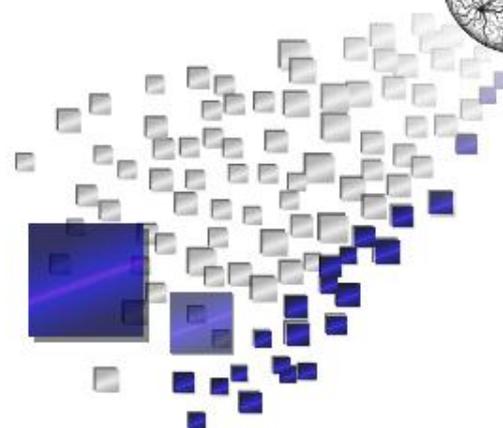
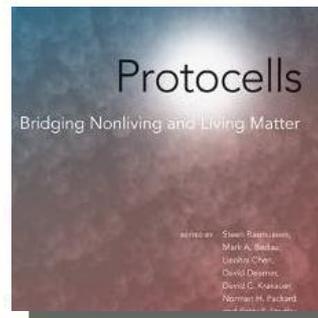
First bacteria with complete synthetic genome (2010)



Endy: "If you consider nature to be a machine, you see it is not perfect and it can be revised and improved" (Nature 24-11-'05)



Van Santen (2009): "The final goal is to build a microscopic factory that is self-sustaining and duplicates itself. This is not only an intellectual challenge but also offers interesting prospects for the pharmaceutical industry."

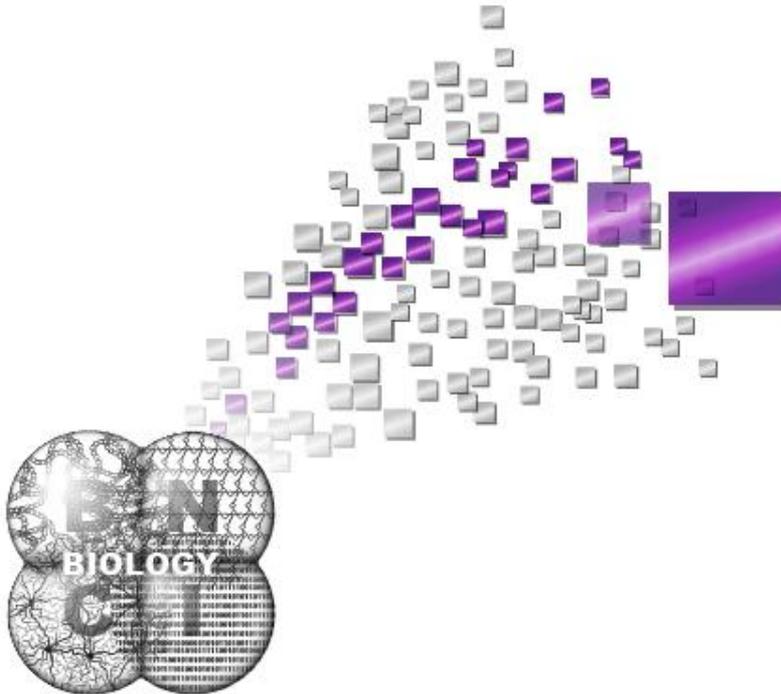


Bottom-up synthetic biology

Engineering of the body

dyname kennis in
veranderende onderzoek
in het gebied van
de menselijke
techniek & science

Rathenau Instituut

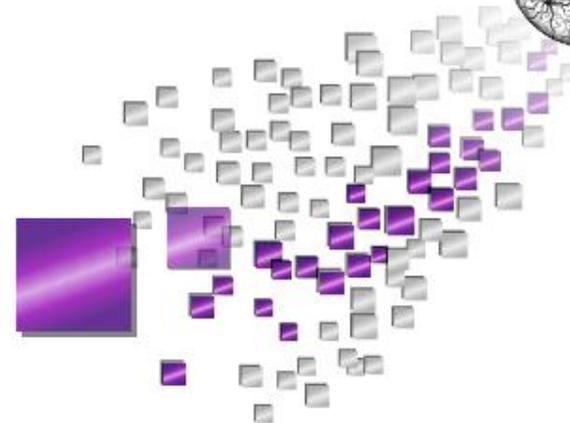
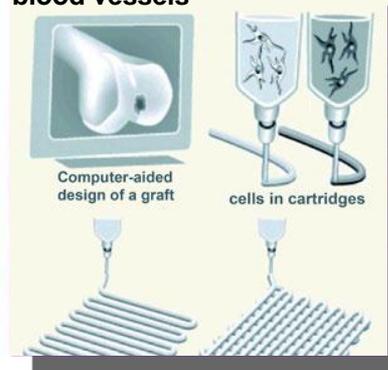


Biomarkers for Alzheimer's disease

Artificial heart valve



3D printing of artificial blood vessels



Engineering of the brain

dyna kennis in
veranderende
debat
technie
ING
onderzoek
SCHIEK
science

Rathenau Instituut

Forward engineering of the brain



Controlling movement

Deep Brain Stimulation

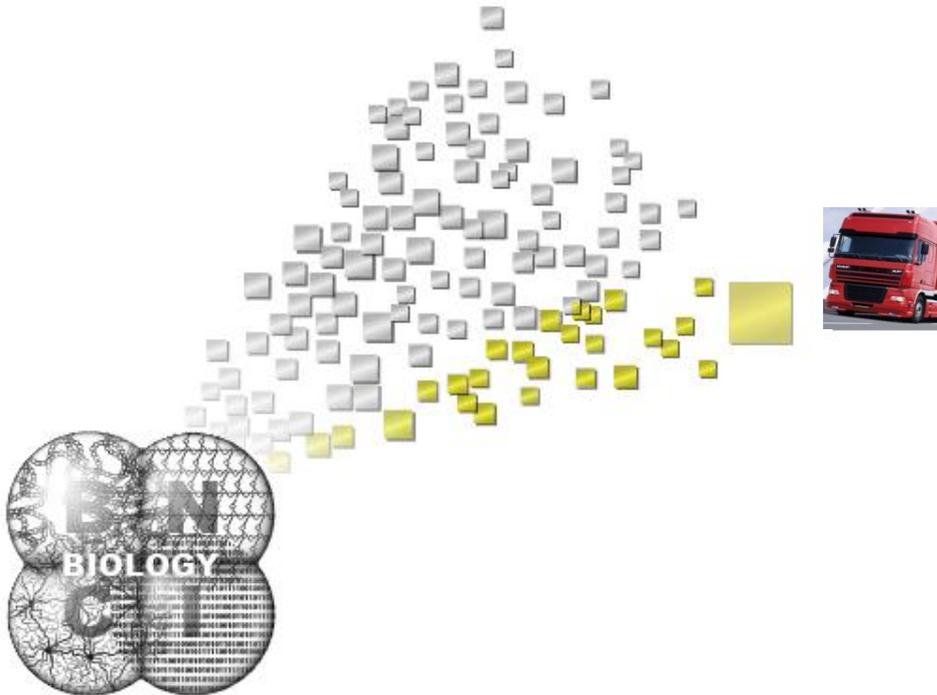


Reverse engineering of the brain

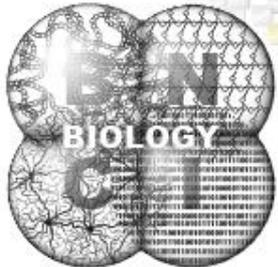
Engineering of intelligent artefacts

*dyname kennisgeving
verandering onderzoek
intelligentie
debat
techniek
science*

Rathenau Instituut



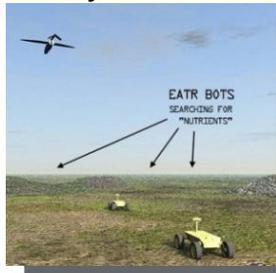
Persuasive technology



Pedestrian detection with full auto-brake



Military robot



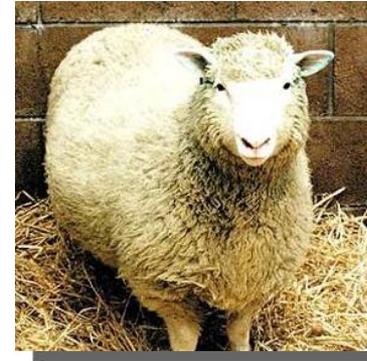
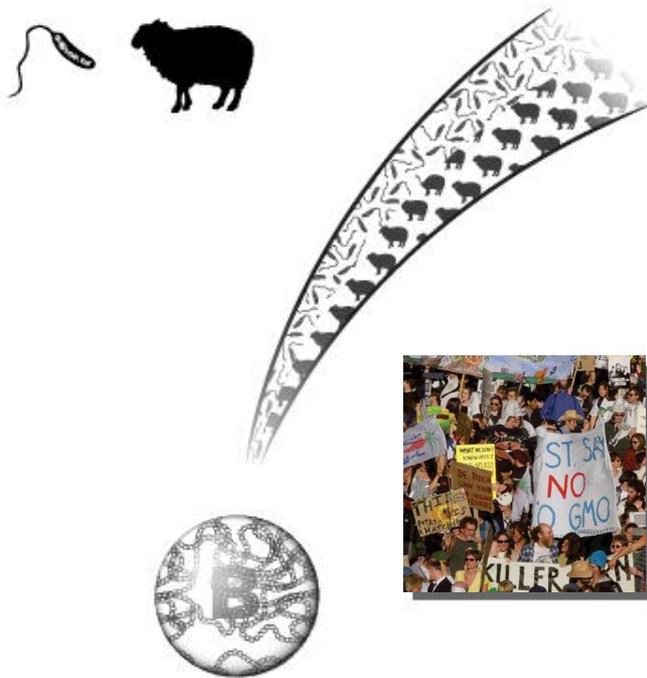
Chatbot



Familiar interventions in living organisms

ORNA kennis van
verandering in
delevenswijze
technologische
wetenschap
onderzoek
wetenschap
wetenschap

Rathenau Instituut

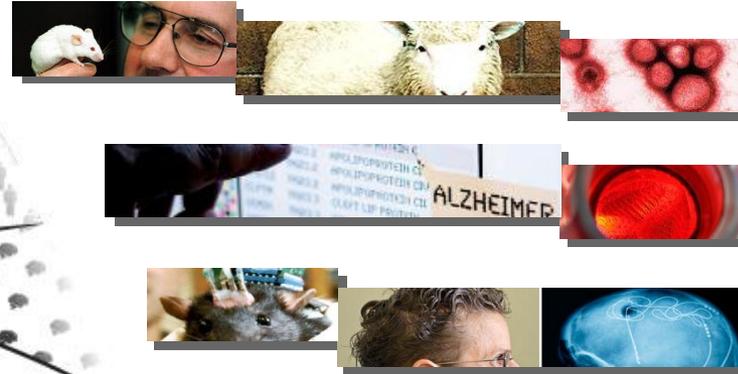
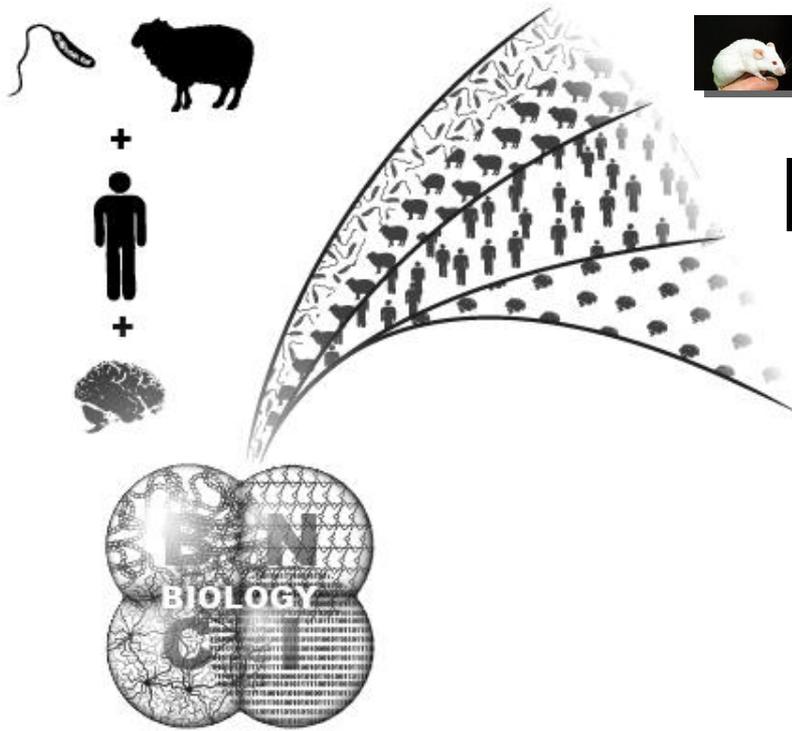


**Genetic
modification of
living organisms**

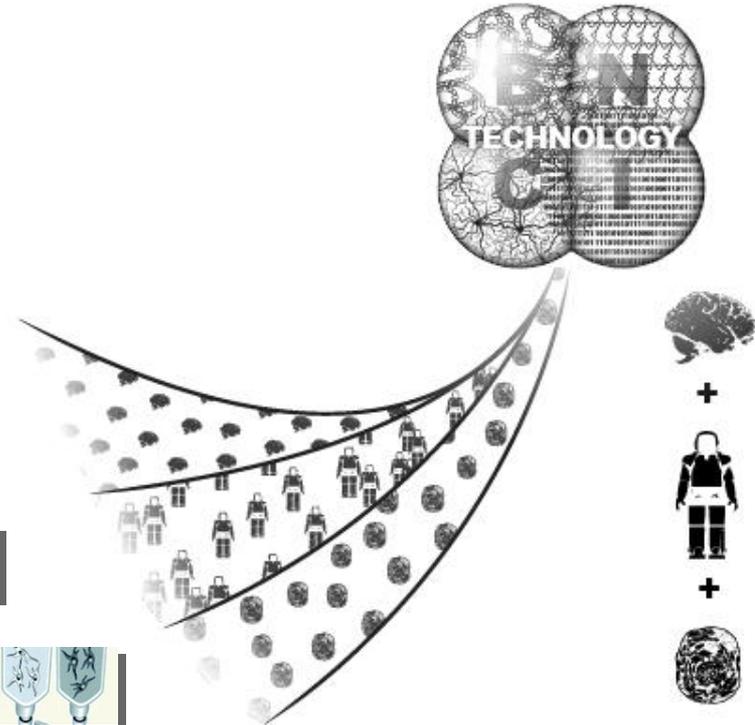
New interventions and artefacts

*dyname kennis in
verandering
in het
debat
technologische
wetenschap*

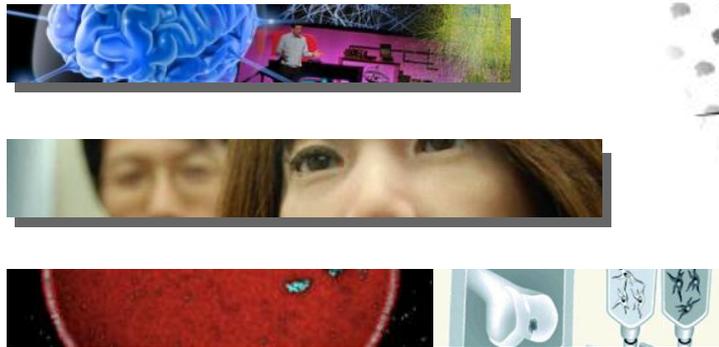
Rathenau Instituut



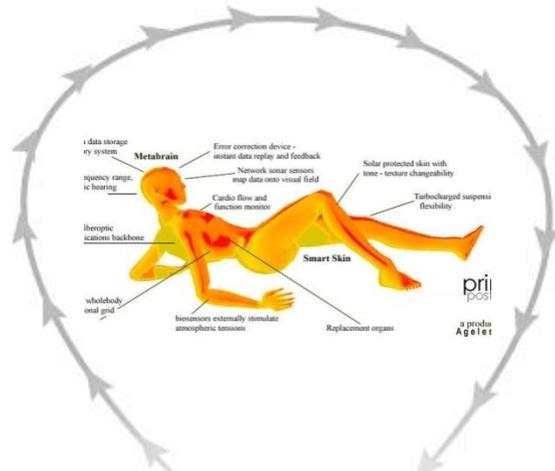
New types of interventions in living organisms



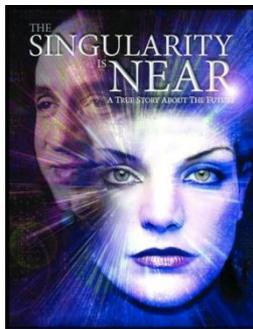
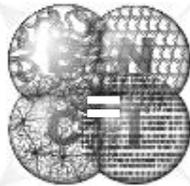
Bio-, socio-, and cogno-inspired artefacts



How to safeguard human dignity?



Biology = Technology



Challenges regulatory practices

- Safety
- Privacy
- Bodily integrity
- Informed consent
- ...

Challenging fundamental concepts

- Living and non-living
- Health and sickness
- Brain and machine
- Human and machine agency
- ...

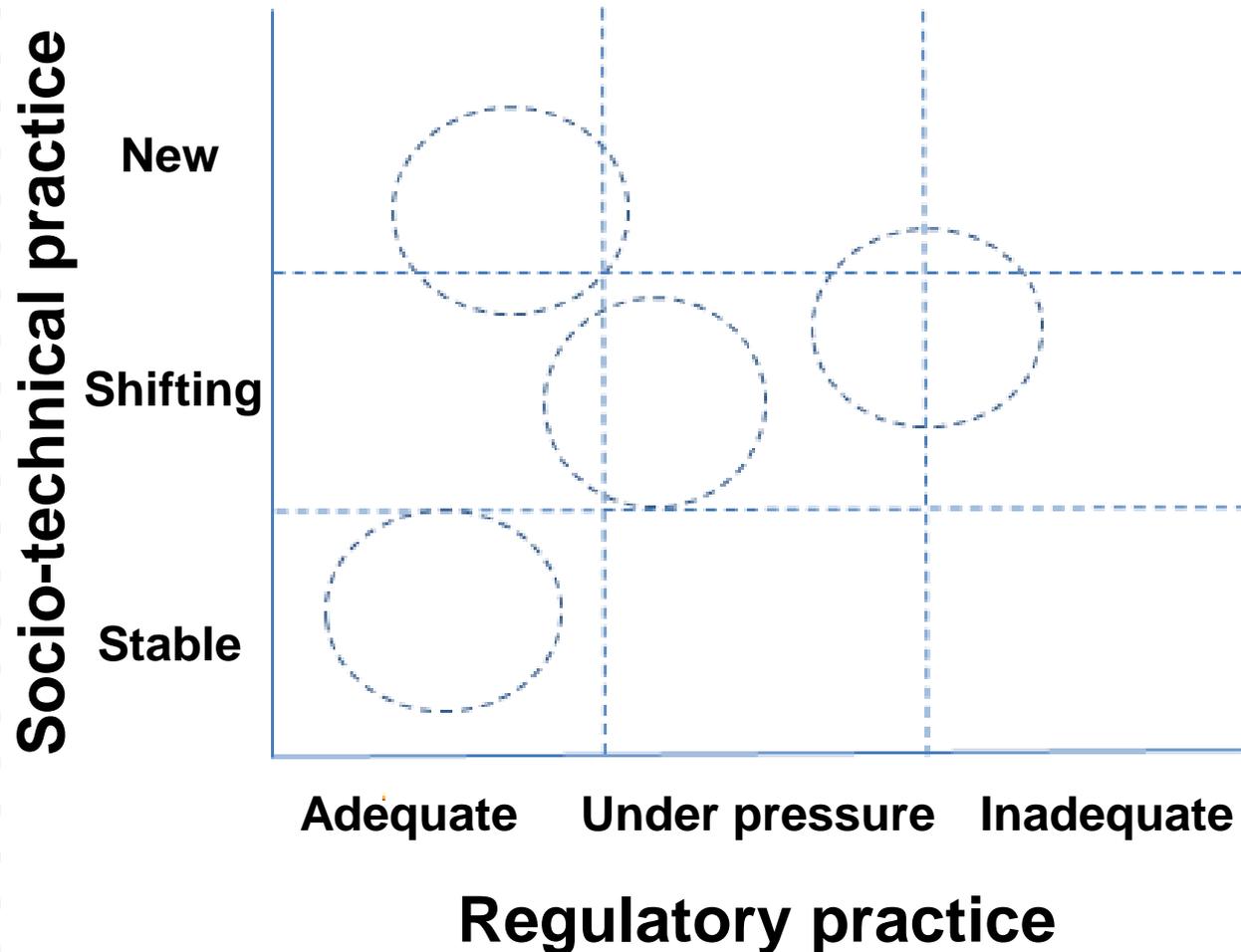
Four specific developments

1. Engineering of the body:
 - Whole genome sequencing & implications for privacy
2. Engineering of the brain:
 - Neuromodulation & regulation
3. Engineering of living artefacts
 - Synthetic biology & standardisation
4. Engineering of intelligent artefacts
 - Biocybernetic adaptation / Human-computer interfaces

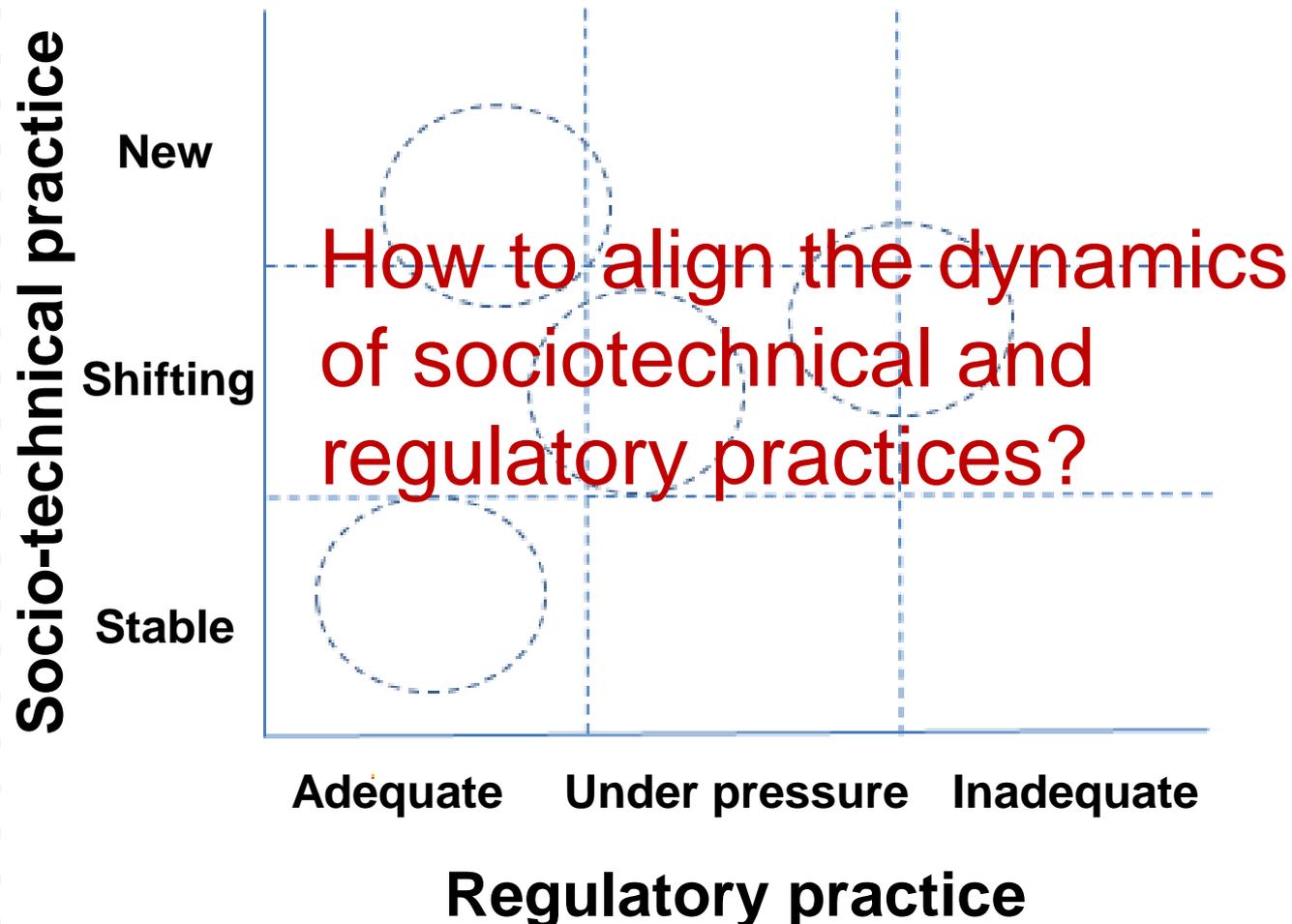
Trend towards neuromodulation devices

- Influencing the brain electronically or magnetically, instead of chemically
 - Sometimes better than pharmaceuticals
 - Regulatory pathways for medical devices are shorter than those of drugs (3-4 months versus 2-4 years)
- Two neuromodulation technologies
 - Invasive: Deep brain stimulating (DBS)
 - Non-invasive: EEG neurofeedback

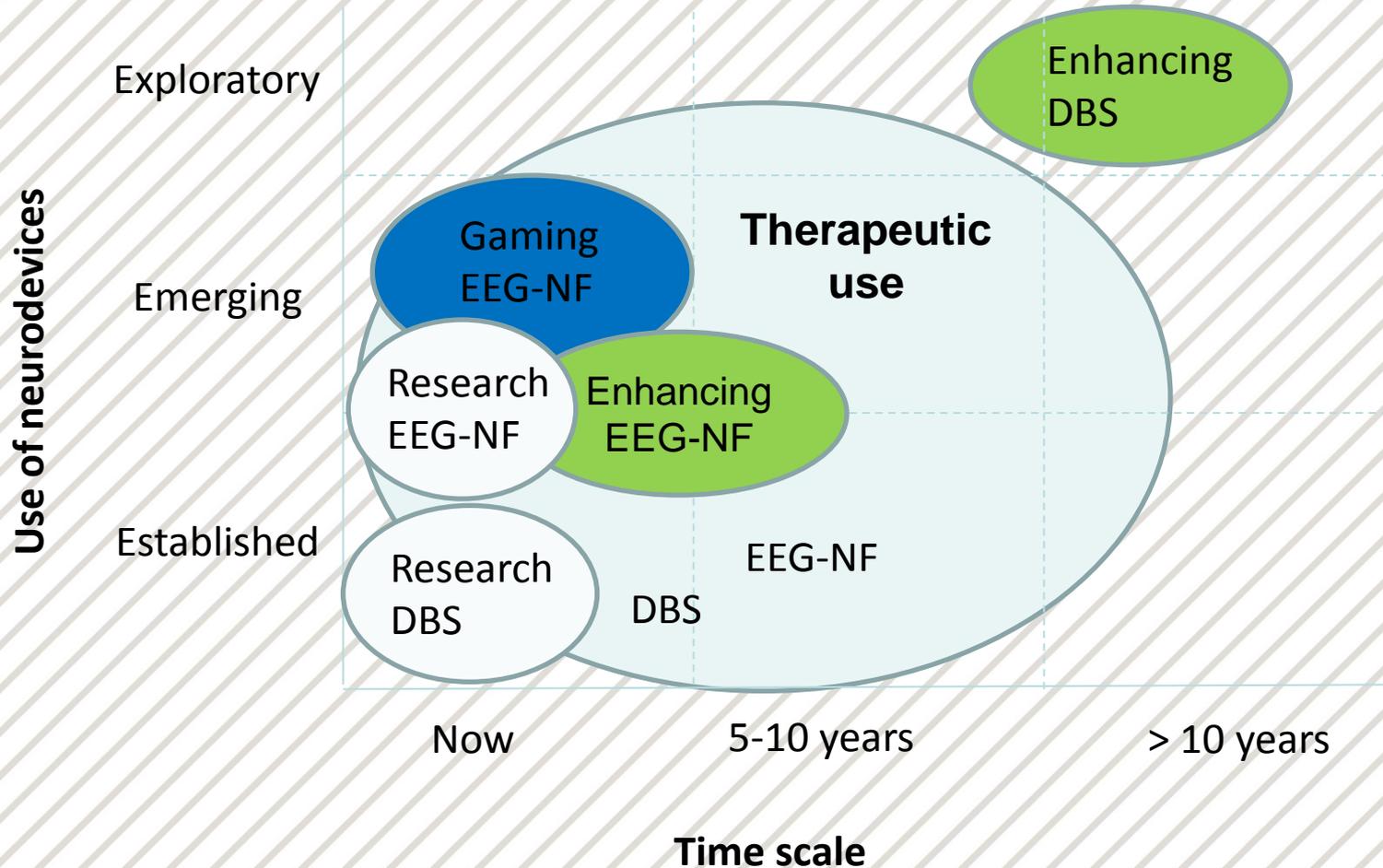
Dynamics of sociotechnical and regulatory practices



Central governance question



Timescale of neuromodulation practices



Socio-technical practice: Deep brain stimulation

- Mechanisms not exactly known
- In clinical practice since 1997, offered in hospitals only
- 75.000 people have a DBS system
- 10-40 % suffer from side effects, like mood changes, depression, hypersexuality, suicidality
- Shift from neurological (Parkinson's essential tremor, dystonia) to psychiatric indications (Obsessive-Compulsive Disorder, depression)
- No practice of non-medical use, although clinical experience with mood enhancing effects



Regulatory challenges Deep Brain Stimulation

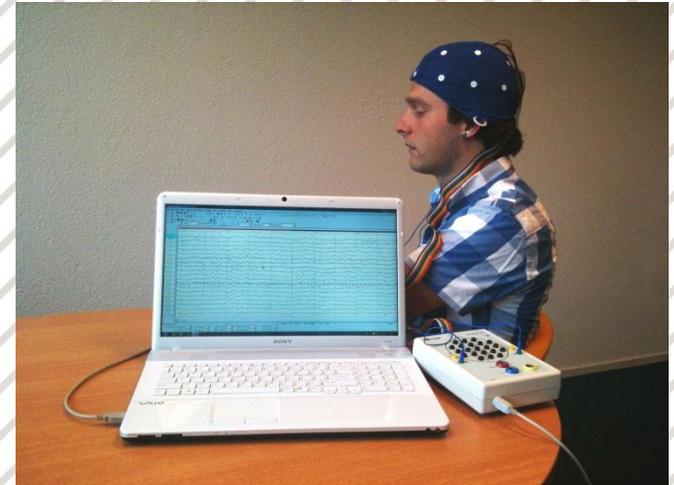


Rathenau Instituut

- **Therapeutic use: Active Implantable Medical Device Directive**
 - **European Group on Ethics (2005): “implantable devices for medical purposes should be regulated in the same way as drugs when the medical goal is the same”**
 - **EU Public consultation (2010): “adoption of pharmaceutical-like regulation ... would have an adverse effect on SME.”**
- **Enhancement**
 - **Long term (> 10 years)**
 - **If this technology is marketed by businesses who deliver DBS for medical use, technology has gone through Active Implantable Medical Device Directive trajectory**

Soci-technical practice: EEG neurofeedback

- Mechanisms not exactly known
- Alternative therapy since 1960s, offered in commercial private clinics
- EEG imaging technology assisted mental training
- Self regulation, requires active participation of patient
- Therapy for ADHD (efficacy not proven)
- Side-effects: relatively safe unless in case of unskilled use
- Experimental research: a.o. epilepsy, autism, learning disabilities, insomnia, anxiety, addiction
- Non-medical use: enhancement of cognitive, sports, artistic performance, gaming



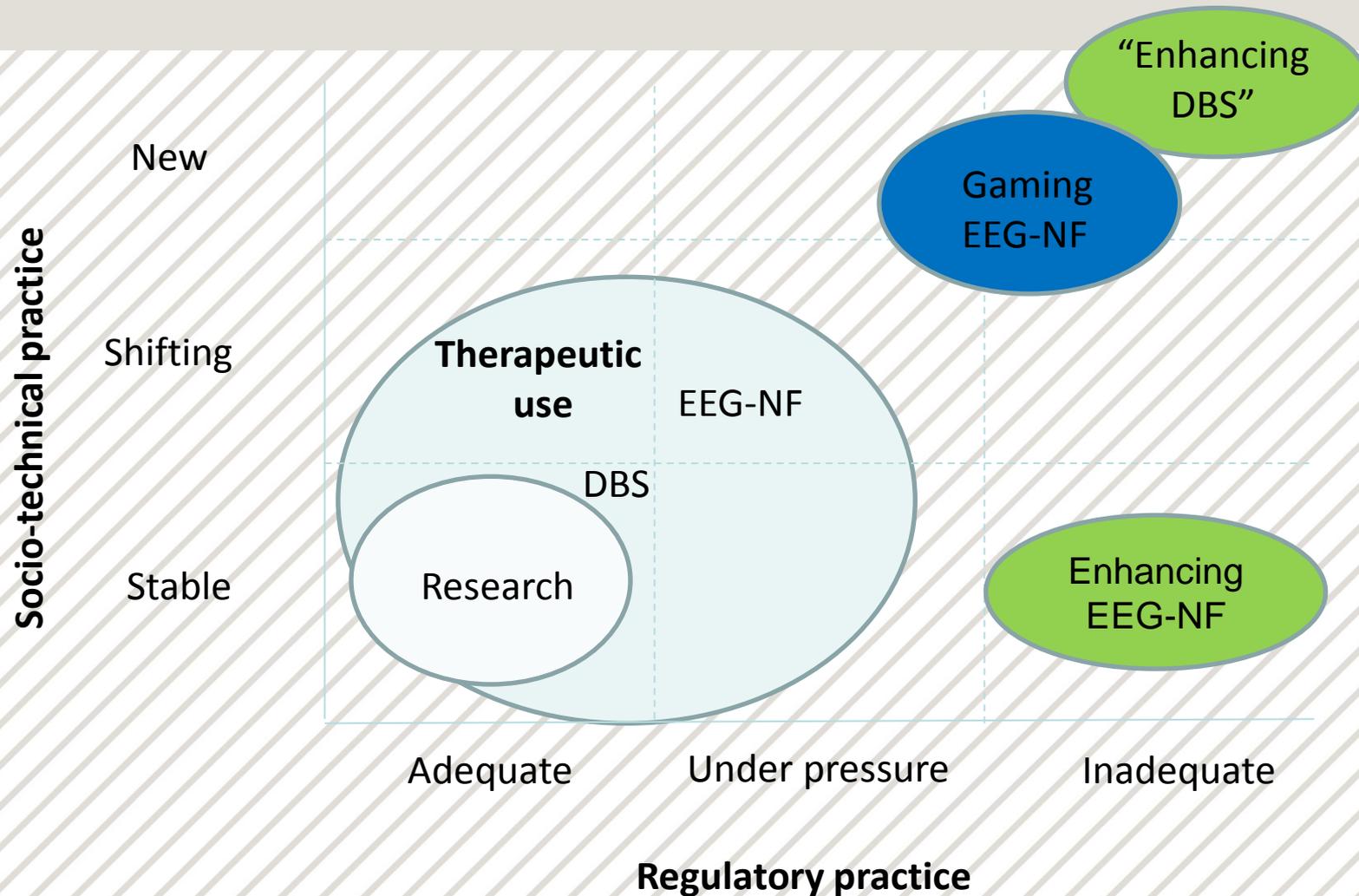
Regulatory challenges: EEG Neurofeedback



Rathenau Instituut

- **Therapeutic use: Medical Devices Directive**
- **Non-medical use (gaming & enhancement):**
 - **Technology is similar to EEG NF for medical use**
 - **But no Medical Devices Directive trajectory is needed**

Socio-technical and regulatory practices in neuromodulation

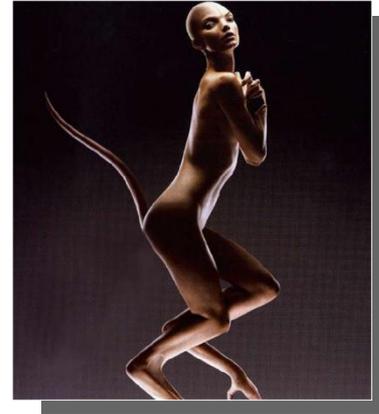


New moral & human identity issues

ORNA KENNIS
VERANDELT
INHAARDEN
DEBATEER
TECHNOL
ING
ONDERZOEK
WETENSCHAP
DE SCIENCE

Rathenau Instituut

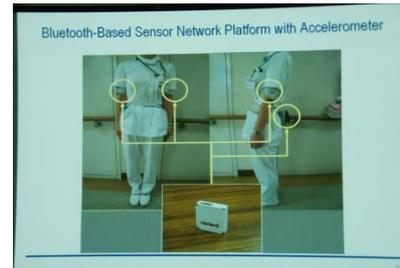
Human enhancement



Remote control



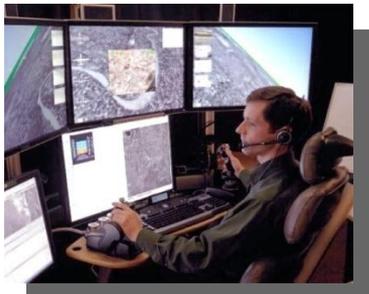
Animal (mis)use



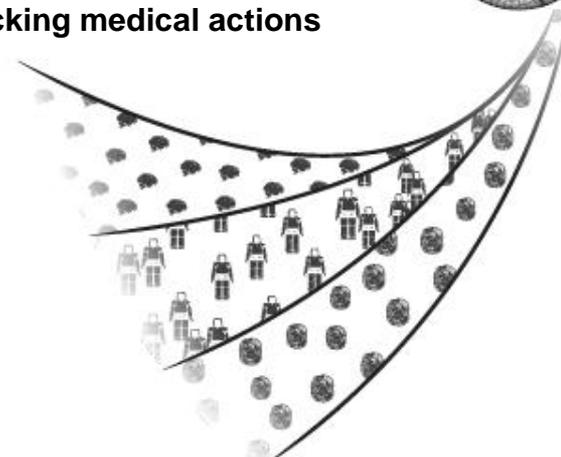
Tracking medical actions



Simulation of friendship



Remote killing /
Dehumanisation of the
enemy



Credits



MEPs

Malcolm Harbour
Vittorio Prodi

STOA

Vittorio De Crescenzo
Miklos Gyoerffi



Fraunhofer

Bärbel Hüsling



ITA

Helge Torgersen
Karen Kastenhofer

Markus Schmidt



KIT

Knud Böhle
Christopher Coenen
Michael Decker

Michael Rader
Leonard Hennen



Rathenau Instituut

Rathenau Institute

Ira van Keulen
Ingrid Geesink
Mirjam Schuijff
Dirk Stemerding

Presentation / project leader
Rinie van Est

Presentation graphics
Niko Vegt