Soft Nano Science/Technology

Jon Otto Fossum

Norwegian University of Science and Technology - NTNU
Trondheim
Norway

Norwegian University of Science and Technology - NTNU

Oslo-Trondheim
~45 min by plane

Norwegian University of Science and Technology - NTNU

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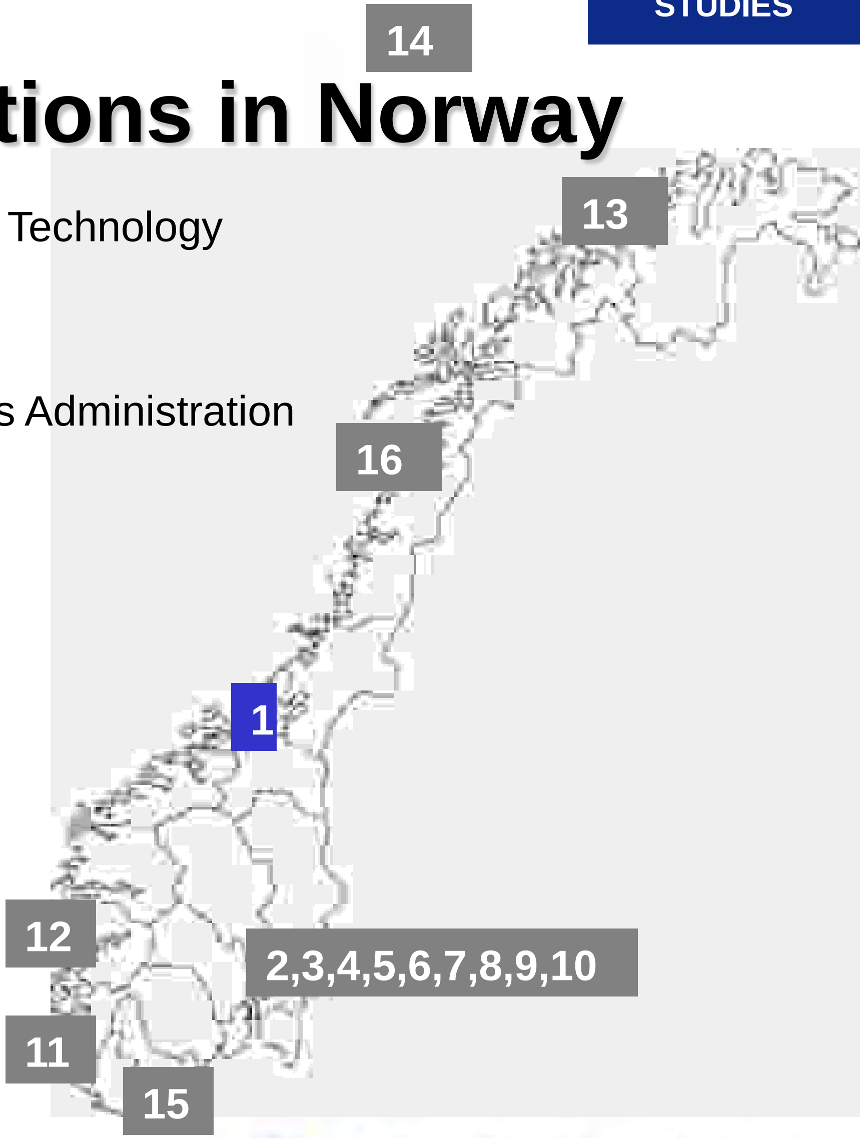
Foto: Carl-Erik Eriksson

University-level institutions in Norway

1) **NTNU** – Norwegian University of Science and Technology
2) University of Oslo
3) Norwegian University of Life Sciences
4) Norwegian School of Economics and Business Administration
5) Norwegian School of Sport Sciences
6) The Oslo School of Architecture and Design
7) The Norwegian Academy of Music
8) The Norwegian School of Veterinary Science
9) UniK – University Graduate Centre, Kjeller
10) The Norwegian Lutheran School of Theology
11) University of Stavanger
12) University of Bergen
13) University of Tromsø
14) The University Centre in Svalbard
15) University of Agder
16) University of Nordland



NTNU – Trondheim
Norwegian University of
Science and Technology

Norway has ~ 5 million inhabitants

Academic history

1217	Schola Cathedralis Nidrosiensis
1760	Royal Norwegian Society of Sciences and Letters
1910	Norwegian Institute of Technology (NTH)
1922	Norwegian Teachers' College [in Trondheim] (NLHT)
1950	SINTEF (the Foundation for Technical and Industrial Research at NTH)
1955	Norwegian Academy of Technological Sciences (NTVA) (Trondheim)
1968	University in Trondheim (UNIT)
1973	Trøndelag Music Conservatory
1974	Department of Medicine (from 1984: The Faculty of Medicine)
1979	Trondheim Academy of Fine Art
1980	Norwegian College of General Sciences (AVH) (previously NLHT)
1994	University Colleges in Sør-Trøndelag, Gjøvik and Ålesund are established
1996	Norwegian University of Science and Technology
2010	Trondheim celebrates 250 years as an academic city
2016	University Colleges in Sør-Trøndelag, Gjøvik and Ålesund merge with NTNU

University for technology and the arts

Norway's primary institution for educating MSc/PhD-level engineers and scientists.

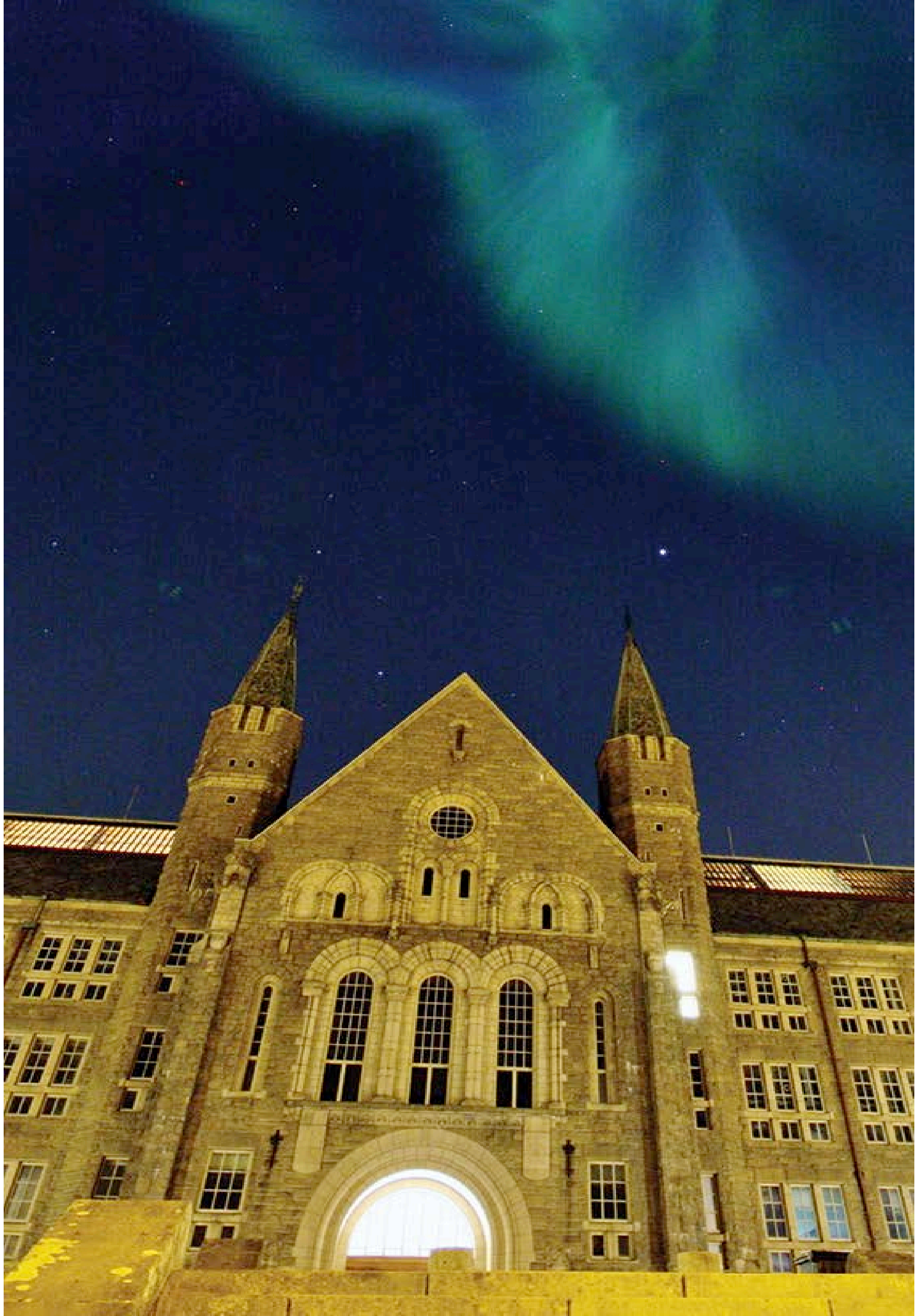
Also comprehensive programmes in social sciences, teacher education, the arts and humanities, medicine, architecture and fine arts.

NTNU – Trondheim
Norwegian University of Science and Technology

Fields of study

- MSc-level Engineering and Architecture
- Aesthetics, Fine Art and Music Studies
- Medicine, Health and Social Studies.
- History, Religion, Culture and Ideas
- Sport Sciences
- Information Technology and Informatics
- Teacher Education
- Media Studies and Communication
- Economics and Administration
- Pedagogy
- **Mathematics and Natural Sciences**
- Social Sciences and Psychology
- Languages and Literature

- 14 faculties and 70 departments and divisions
- Premises: 734 000 square metres either owned or rented.

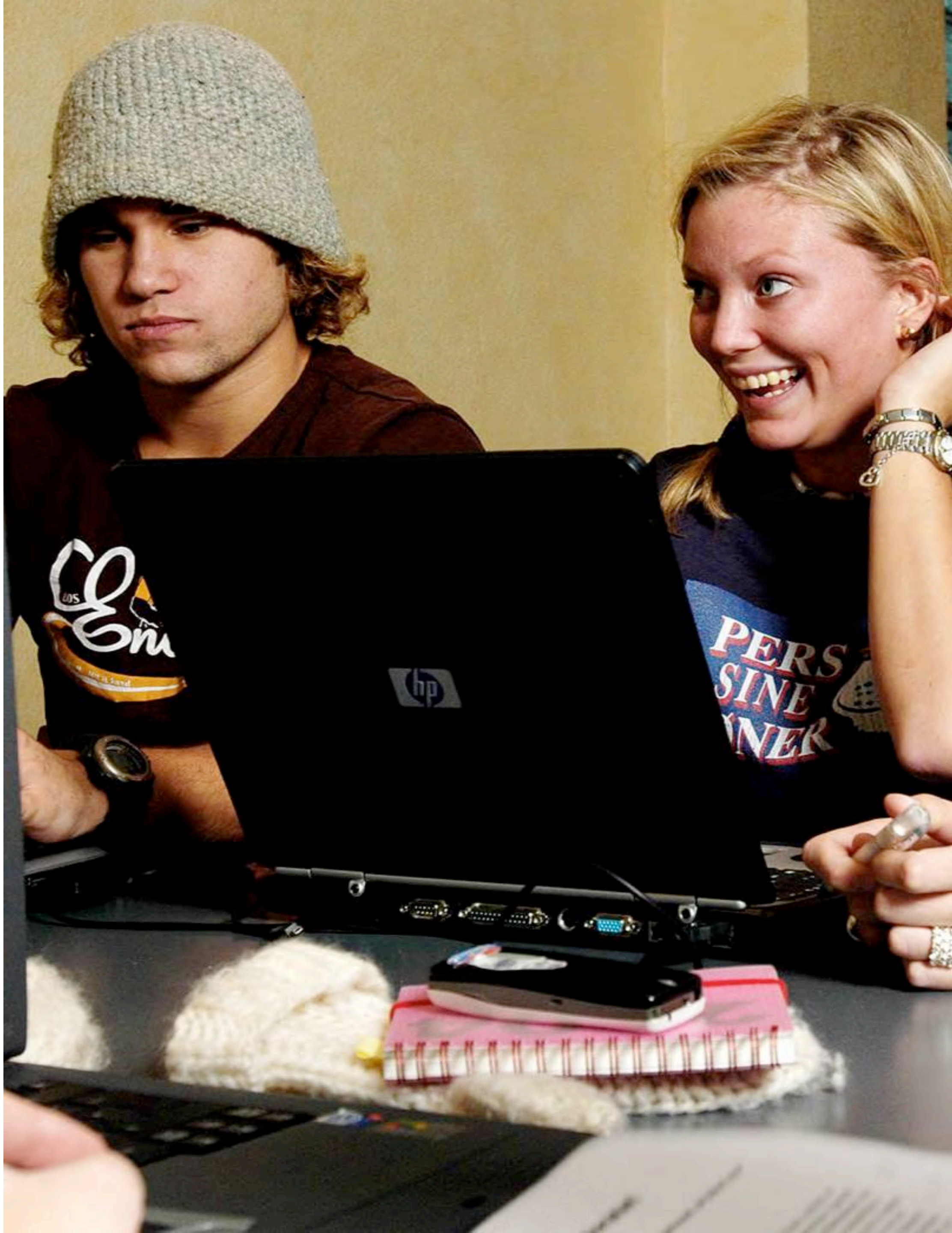


Aurora
Borealis

Northern Lights

Studies

- 40 000 students.
- 6553 graduated with a completed degree in 2014.
- 6000 participants in continuing education courses with credit in 2014.
- 3000 international students.
- 340 doctoral degrees awarded in 2015.



Research and industry partnerships

- PhDs: 340 doctoral degrees awarded in 2015.
- Approximately 120 laboratories.
- Norway's largest participant in the EU's Horizon 2020 (H2020).
- University Library with 17 library branches, 2 million printed books, 950 000 e-books, 16 000 electronic journal subscriptions, 3 000 printed journal subscriptions and 450 databases. More than 3 million downloads of full-text articles.

STRATEGIC RESEARCH AREAS 2014–2023

NTNU
Norwegian University of Science and Technology

ENERGY

HEALTH

OCEANS

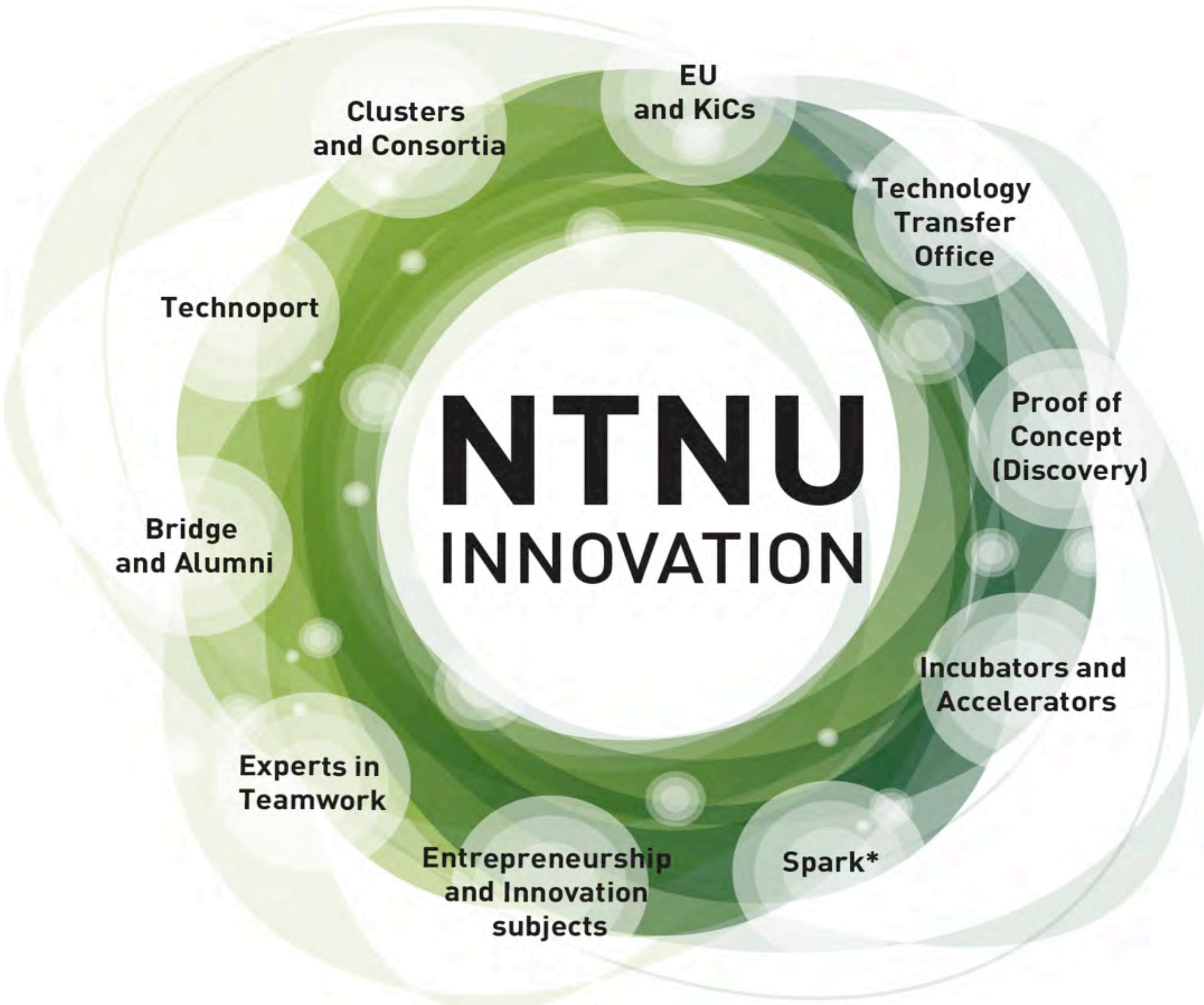
SUSTAINABILITY

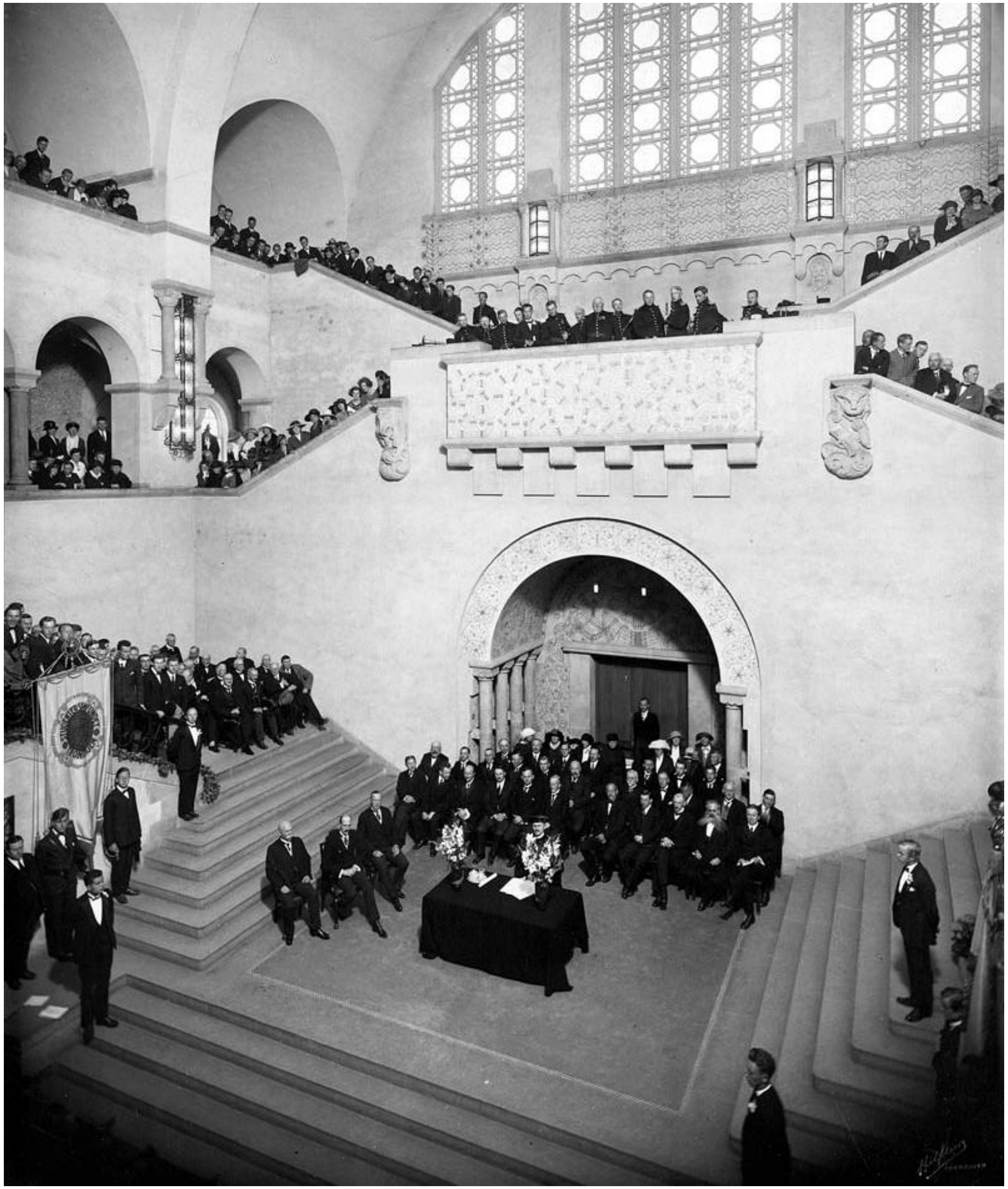
2014 Nobel Prize

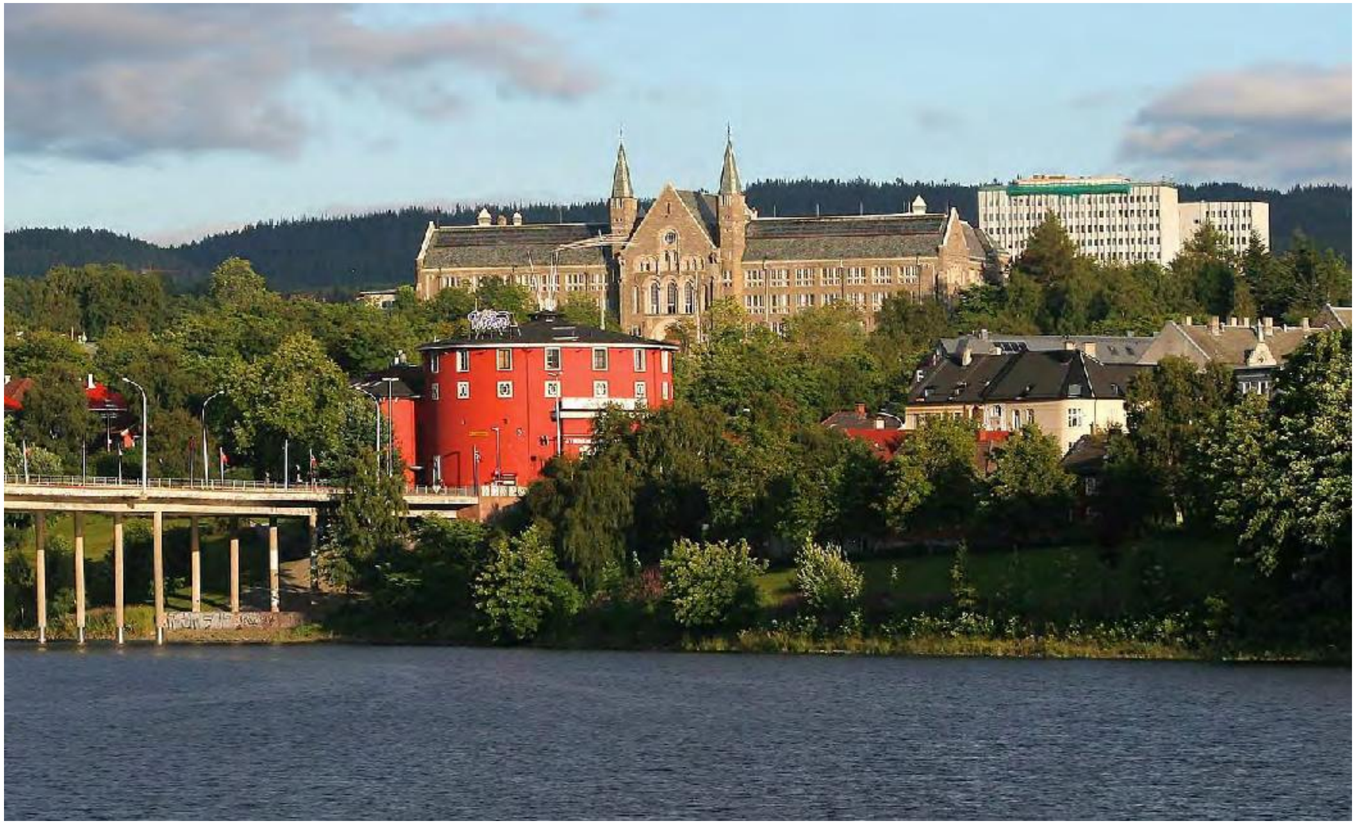
NTNU professors May-Britt Moser and Edvard Moser were awarded the 2014 Nobel Prize in Physiology or Medicine for their discovery of cells that constitute an “inner GPS” in the brain.

An international university

- Main themes: Europe, China, international mobility, international researcher education.
- Approximately 350 international MoUs for cooperative research and teaching efforts.
- 11 % of NTNU's students are international students.
- 41 % of NTNU's graduated PhDs are international students (2012)
- Students and employees from more than 90 countries.


NTNU
INNOVATION
EU
and KiCs
Clusters
and Consortia
Technology
Transfer
Office
Technoport
Proof of
Concept
(Discovery)
Bridge
and Alumni
Incubators and
Accelerators
Experts in
Teamwork
Entrepreneurship
and Innovation
subjects
Spark*



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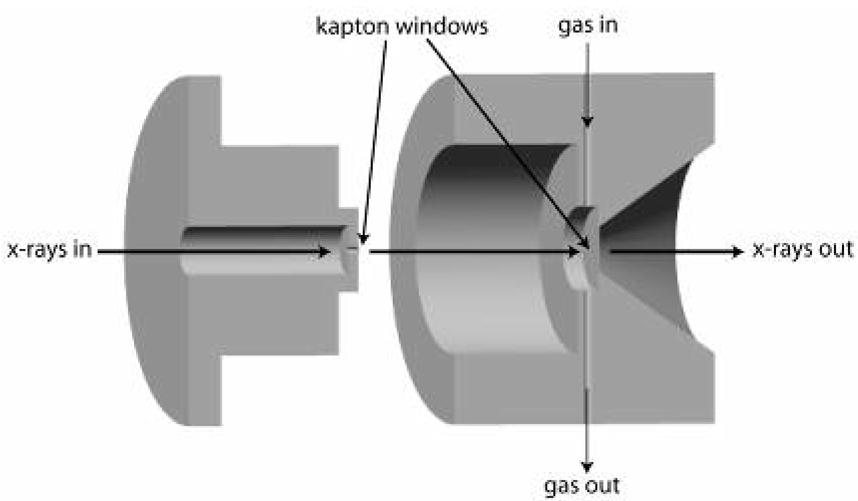
Laboratory for Soft and Complex Matter
Studies at NTNU, Trondheim, Norway:

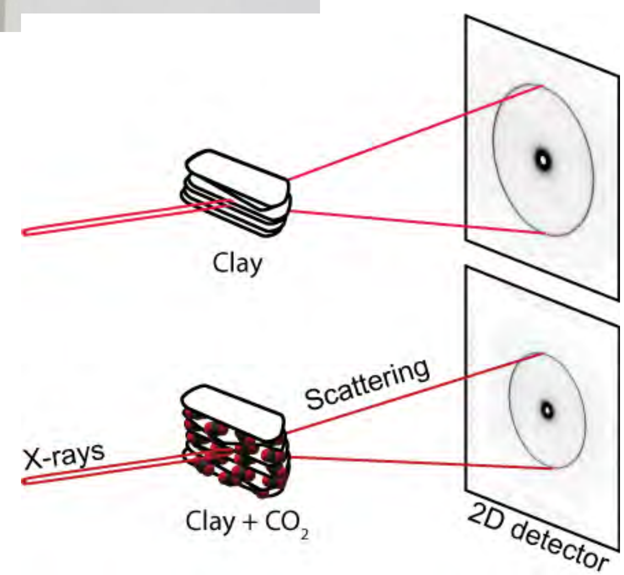
http://folk.ntnu.no/fossumj/lab

Our research is focused on probing and understanding how nano-/meso-/micro-structures in complex composites of natural materials manifest themselves in macroscopic material properties and functionalities.

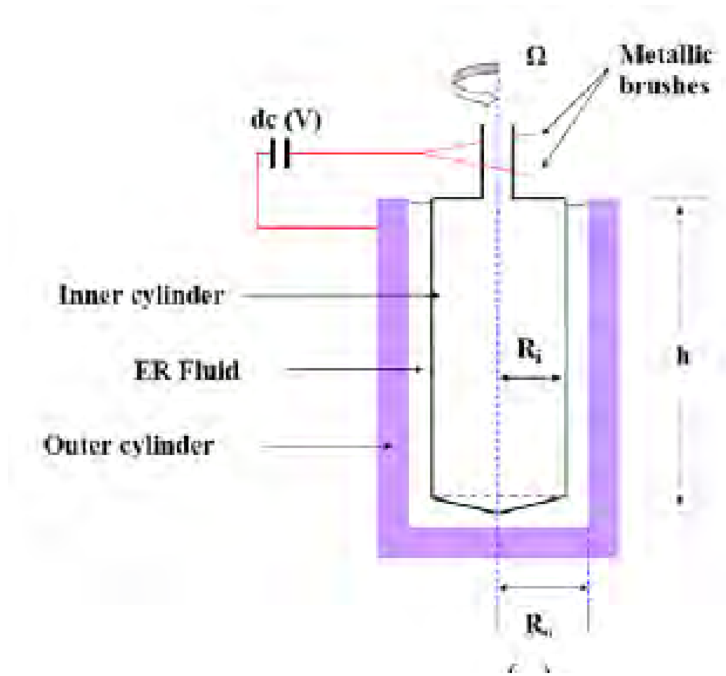
Nano-scale tools:
AFM, Small-Angle X-ray Scattering: SAXS, etc.



Home made sample cell



Macro-scale tools:
Physica MCR 300 Rheometer, etc.



Fluid:

Flows and takes shape of container

Solid:

Does not flow and keeps its own shape

Soft matter:

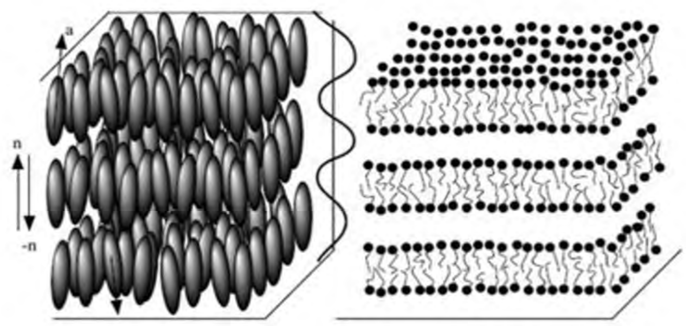
If left alone:
Does not flow and keeps its own shape

If disturbed:
Flows and takes desired shape

Soft matter:

Materials which are easily deformable by external stresses, electric or magnetic fields, or even by thermal fluctuations.

Soft materials are typically shear-thinning, i.e. they posse which they are elastic materials, and above which they are v



These materials typically possess structures on the nanoscale; the structure and dynamics at nano-/meso-scopic scales determine the physical properties of these materials.

The goal of soft matter research is to probe and understand how nano-/meso-structures translate into macroscopic properties and behaviors.

Researchers study natural, synthetic and biological materials in this context.

Interests extend from fundamental physics to technological applications, from basic materials questions to specific biological problems = Multidisciplinary field.

The tools used include light, X-ray, neutron scattering, microscopy, rheometry, microfluidics, special purpose table-top experiments, numerics, theory.

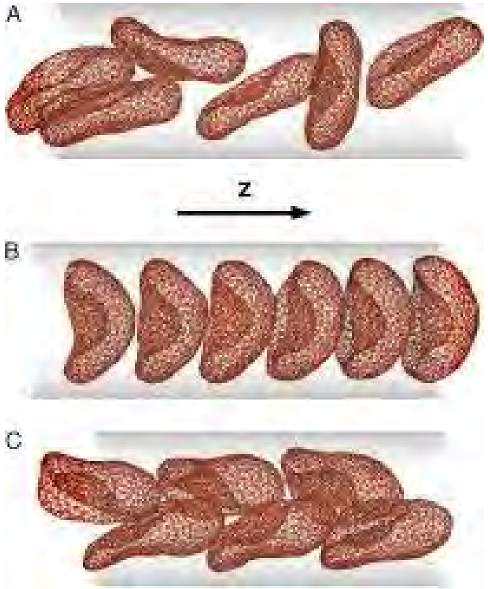
The founder of soft matter science:

Pierre-Gilles de Gennes

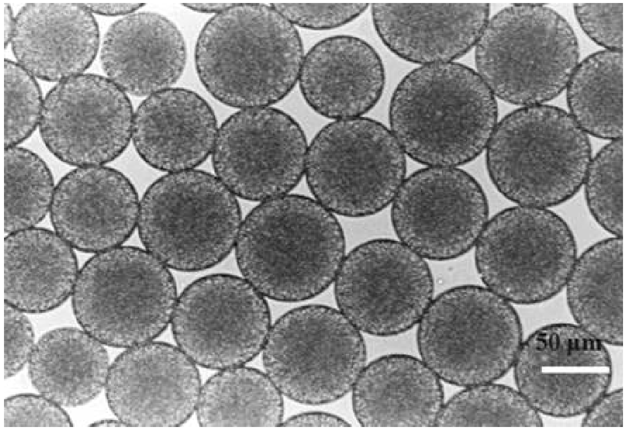
French physicist : 1932 –2007,
Nobel Prize laureate in physics in 1991

Food is Soft Matter

Biomatter is Soft Matter



Cell elasticity and deformation in flow



Monodisperse Emulsions

The study of drops of one fluid in an immiscible fluid

18 materialstoday APRIL 2008 | VOLUME 11 | NUMBER 4

Designer emulsions using microfluidics

We describe new developments for the controlled fabrication of monodisperse emulsions using microfluidics. We use glass capillary devices to generate single, double, and higher order emulsions with exceptional precision. These emulsions can serve as ideal templates for generating well-defined particles and functional vesicles. Polydimethylsiloxane microfluidic devices are also used to generate picoliter-scale water-in-oil emulsions at rates as high as 10 000 drops per second. These emulsions have great potential as individual microvessels in high-throughput screening applications, where each drop serves to encapsulate single cells, genes, or reactants.

Rhutesh K. Shah[a], Ho Cheung Shum[a], Amy C. Rowat[a], Daeyeon Lee[a], Jeremy J. Agresti[a], Andrew S. Utada[a], Liang-Yin Chu[a,b], Jin-Woong Kim[a,c], Alberto Fernandez-Nieves[a,d], Carlos J. Martinez[a,e], and David A. Weitz[a,f]*
[a]*School of Engineering and Applied Sciences, Harvard University, Cambridge, MA 02138, USA*
[b]*School of Chemical Engineering, Sichuan University, Chengdu, Sichuan, 610065, China*
[c]*Amore-Pacific R&D Center, 314-1, Bora-dong, Giheung-gu, Yongin-si, Gyeonggi-Do, 446-729, Korea*
[d]*School of Physics, Georgia Institute of Technology, Atlanta, GA 30332, USA*
[e]*School of Materials Engineering, Purdue University, West Lafayette, IN 47907, USA*
[f]*Department of Physics, Harvard University, Cambridge, MA 02138, USA*
*E-mail: weitz@seas.harvard.edu

Monodisperse emulsions

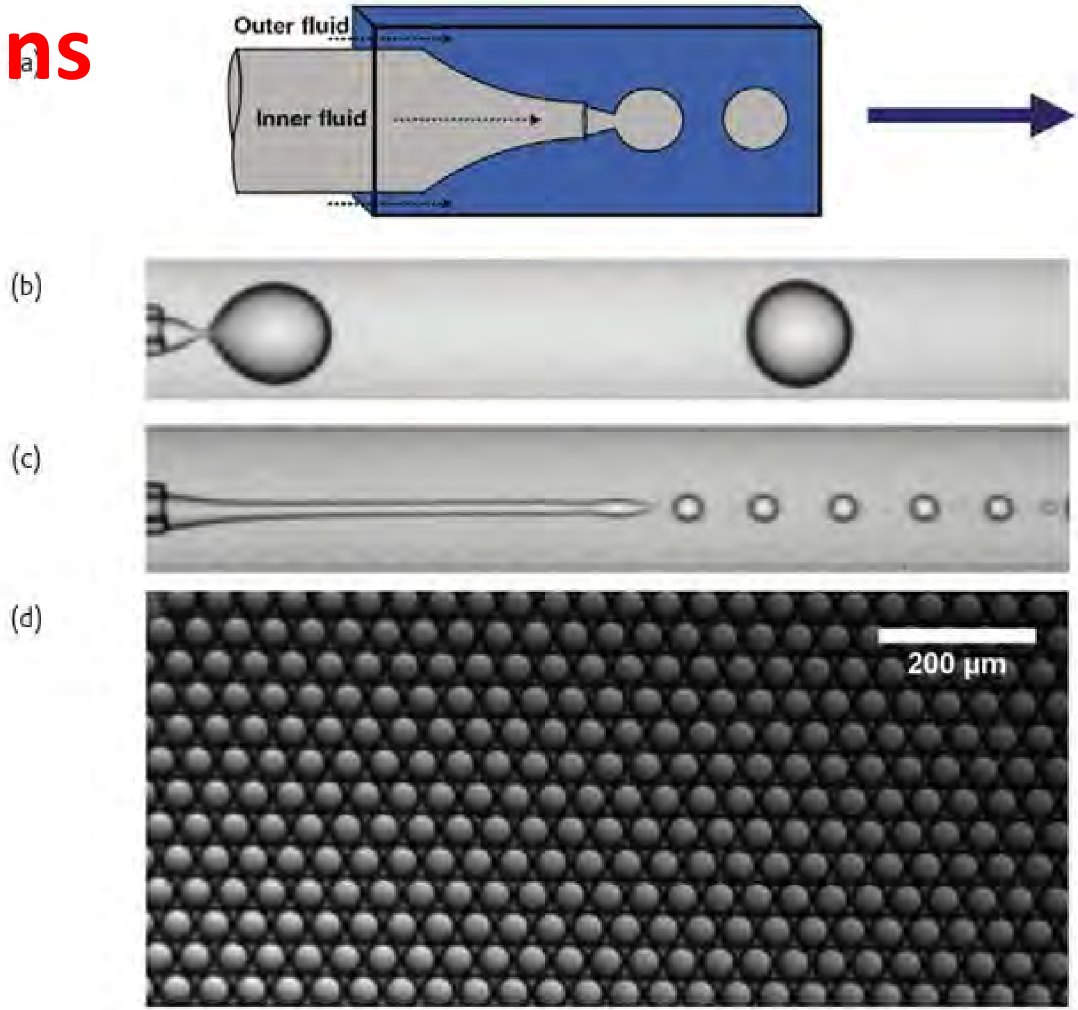
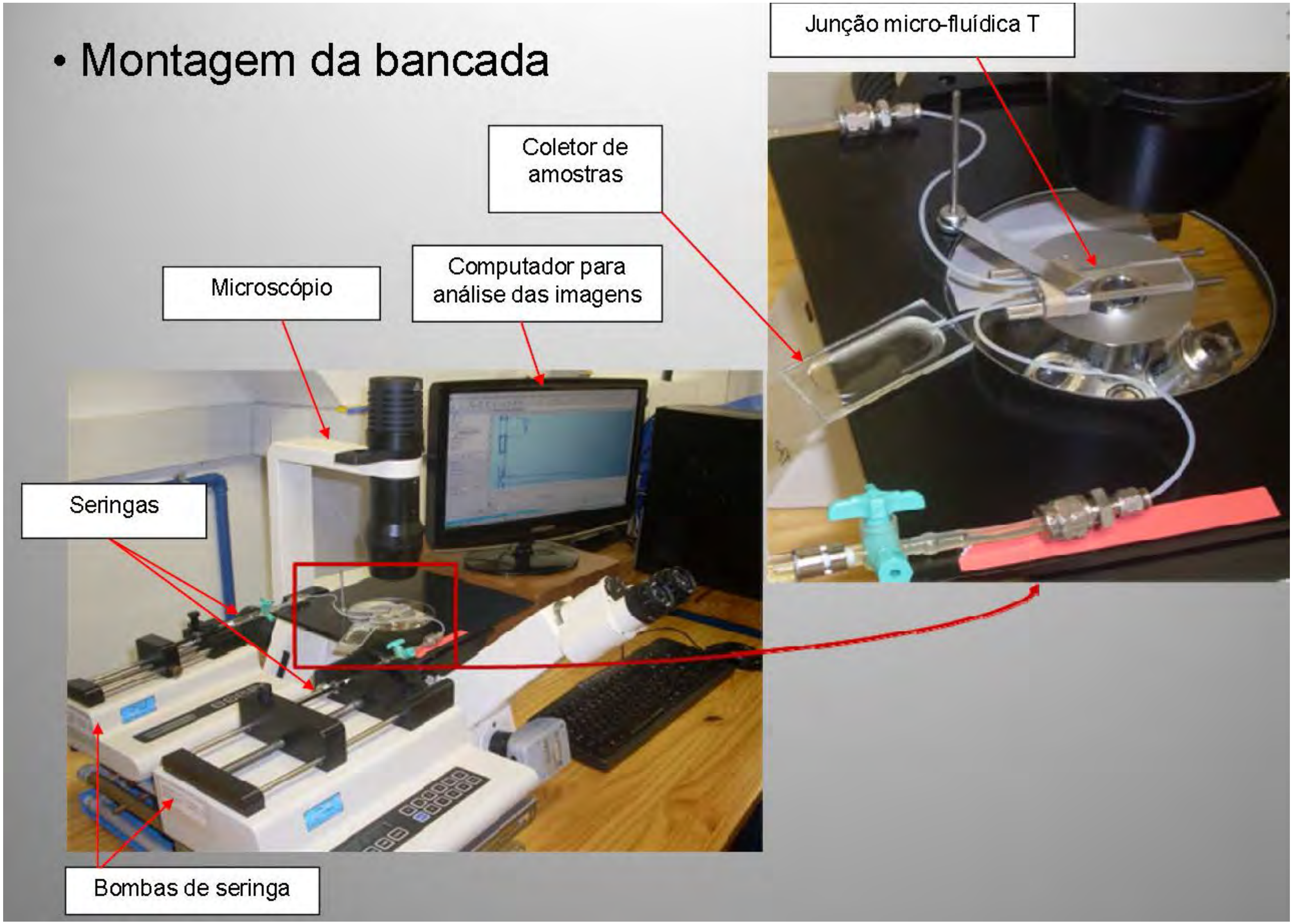
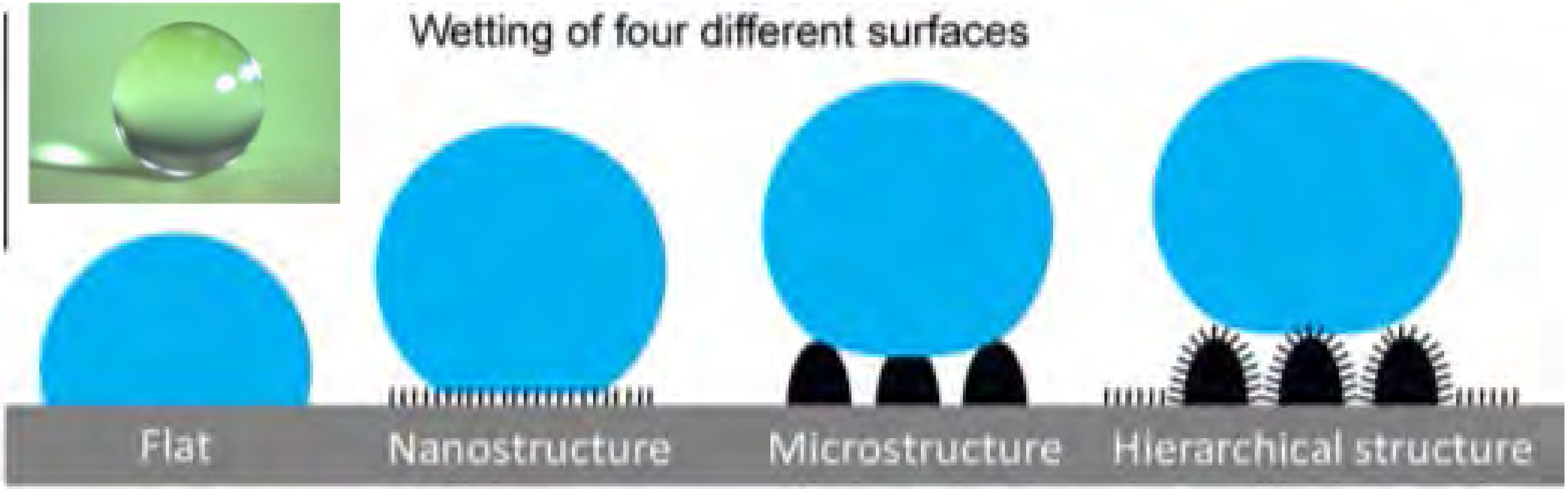


Fig. 2 Single emulsions in a co-flow microfluidic device. (a) Schematic of a co-flow microcapillary device for making droplets. Arrows indicate the flow direction of fluids and drops. (b) Image of drop formation at low flow rates (dripping regime). (c) Image of a narrowing jet generated by increasing the flow rate of the continuous fluid above a threshold value while keeping the flow rate of the dispersed phase constant. (d) Monodisperse droplets formed using a microcapillary device. [Part (a) reproduced with permission from[26]. © 2007 Materials Research Society; parts (b) and (c) reprinted with permission from[27]. © 2007 American Physical Society.]

Table-top experiment:





Schematics of wetting of four different surfaces. The largest contact area between the droplet and the surface is given in flat and micro-structured surfaces, is reduced in nano-structured surfaces, and is minimized in hierarchical (nano-micro) structured surfaces. This contains the principle of the so-called self-cleaning Lotus leaf effect, depicted to the left.

Natural and biomimetic artificial surfaces for super-hydrophobicity, self-cleaning, low adhesion, and drag reduction, B. Bhushan, Y. C. Jung, Progress in Materials Science 56, 1-108 (2011)

Peacock feathers: Brown pigment + nanostructures