

Okrugli stol: Trendovi razvoja biomedicinskog inženjerstva

Izazovi biomedicinskog inženjerstva početkom 21. stoljeća

*Challenges of biomedical engineering at the beginning
of the 21st century*

Ratko Magjarević



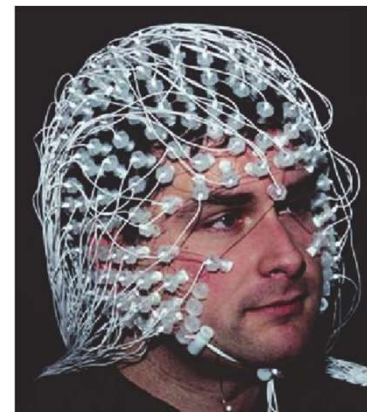
International Federation for Medical and Biological
Engineering



University of Zagreb
Faculty of Electrical Engineering and Computing

Outlines

- Biomedical engineering – past, present, future
- Engineering professions related to engineering in medicine and biology
- BMEs on labour market
- Innovations in biomedical devices and technology
- Discussion



Biomedical engineering

- Biomedical engineers are working at the interface of engineering, life sciences and healthcare.
- Biomedical engineers use principles of:
 - applied sciences (including engineering, electronics, chemical and computer engineering) and
 - basic sciences (physics, chemistry and mathematics) for applications in biology and medicine

<http://www.embs.org/about-biomedical-engineering>

Bioengineering

The profession named Bioengineering and/or Biological Engineering is younger than biomedical engineering and emerged with the realization of the possibility of manipulation of living cells

Biological engineering is based on

- molecular biology and on
- engineering principles used in the design, synthesis and analysis
- at the cellular and molecular level

as opposed to biomedical engineering, which uses traditional engineering principles in order to analyze and solve problems in medicine and that solutions need not be based the use of living cells

http://web.mit.edu/be/programs/be_faq.shtml

Clinical engineering

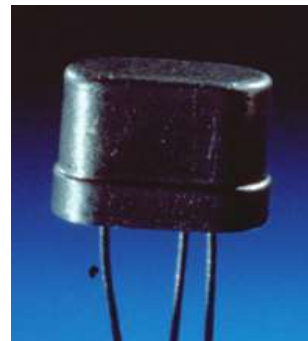
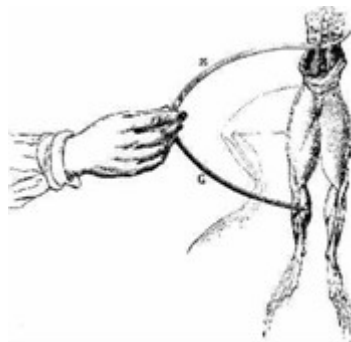
Clinical engineers are professionals who support and enhance patient care by applying engineering and managerial skills to healthcare technology

- trained to solve problems when working with complex human and technological systems of the kind found in health care facilities
- function of technological systems manager for medical equipment including very often, and information systems in health care facilities
- provide valuable feedback on the operation of medical equipment and
- contribute to the research and development from their direct experience

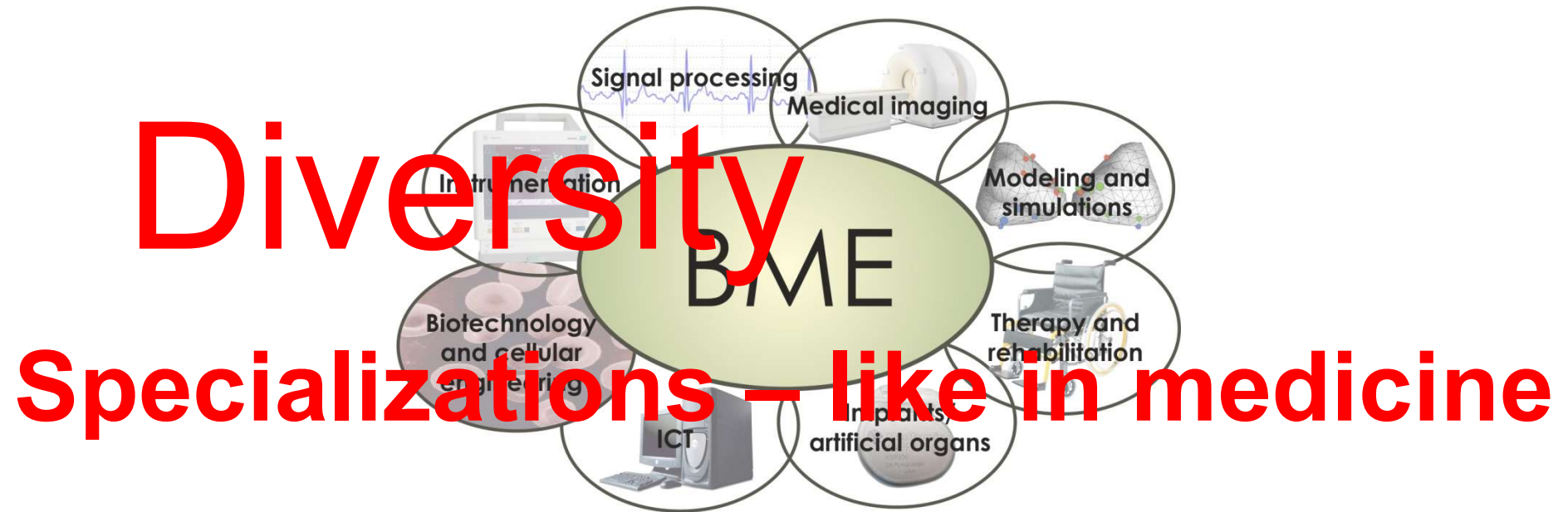
<http://www.accenet.org/default.asp?page=about§ion=definition>

How old is Biomedical Engineering?

- Leonardo da Vinci researched the anatomy and mechanics of human body
- Luigi Galvani and Alessandro Volta (18th century), discovered **biopotentials** and **bioelectricity**
- The development of **biomedical electronics**, today called **biomedical engineering** starts intensively after the invention of the silicon transistor, 1947
- Institutionally, at international level, in 1959, the **Int'l Society for Biomedical Electronics** (today IFMBE) was founded in Paris
- Peer reviewed journals – 50th anniversary of ***Medical and Biological Engineering and Computing*** celebrated in May 2012



Biomedical Engineering



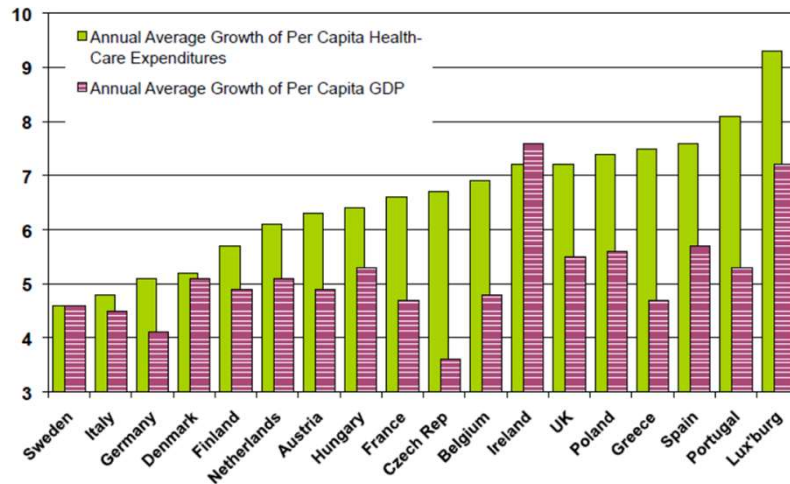
Biomedical engineering is an engineering discipline that:

- advances **knowledge** in engineering, biology and medicine, and in basic sciences,
- improves human health by **design and problem solving skills** of **engineering science** applied to diagnosis, monitoring, therapy and rehabilitation, but also to prevention and prediction
- integrates engineering sciences with biomedical sciences and **clinical practice**

http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=106041

Healthcare Expenditures in Europe

FIGURE 2: ANNUAL AVERAGE GROWTH OF PER CAPITA HEALTH EXPENDITURE.

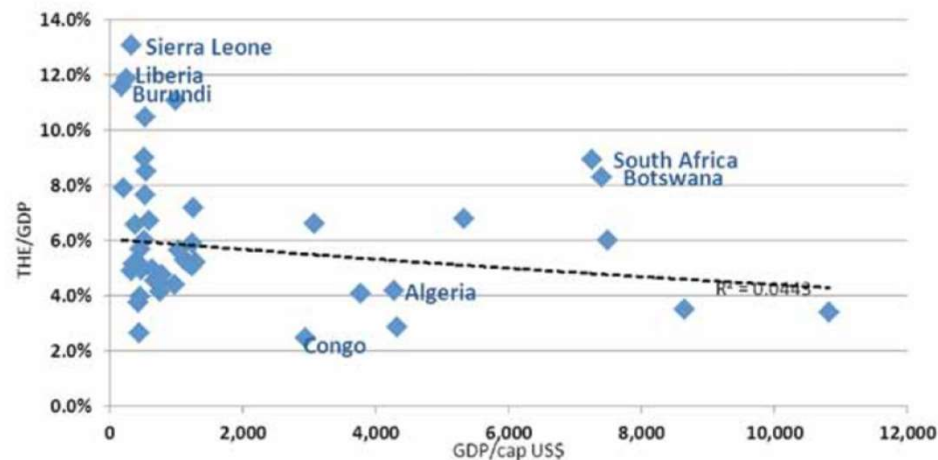


Source: OECD Health Data; own calculations.

- Increase of Healthcare Insurance/National Healthcare system expenditures
- Increase of medical staff workload

Healthcare Expenditures in Africa

Figure 2.1: Total health expenditure as a share of GDP and GDP



From: State of Health Financing in the African Region, WHO Regional Office for Africa, 2013

Grand Challenges in 21st Century

Reverse-engineer the brain



- The intersection of engineering and neuroscience promises great advances in health care, manufacturing, and communication.
 - Understanding how and why brain works and fails
 - Simulations leading to more sophisticated methods for testing new technologies like drugs and neural implants
 - Artificial retina
 - Cochlear implants
 - Movement and prosthesis control
 - Fighting dementia, Parkinson disease....
 - Building smarter computers
- <http://www.engineeringchallenges.org/cms/8996/9109.aspx>

Potential for Providing Medical Care



PM new generation

New trends in their research and development - miniaturization

93% smaller than conventional pacemakers

Ultra low-power circuit design delivers an estimated average 12-year battery longevity.

Physical characteristics

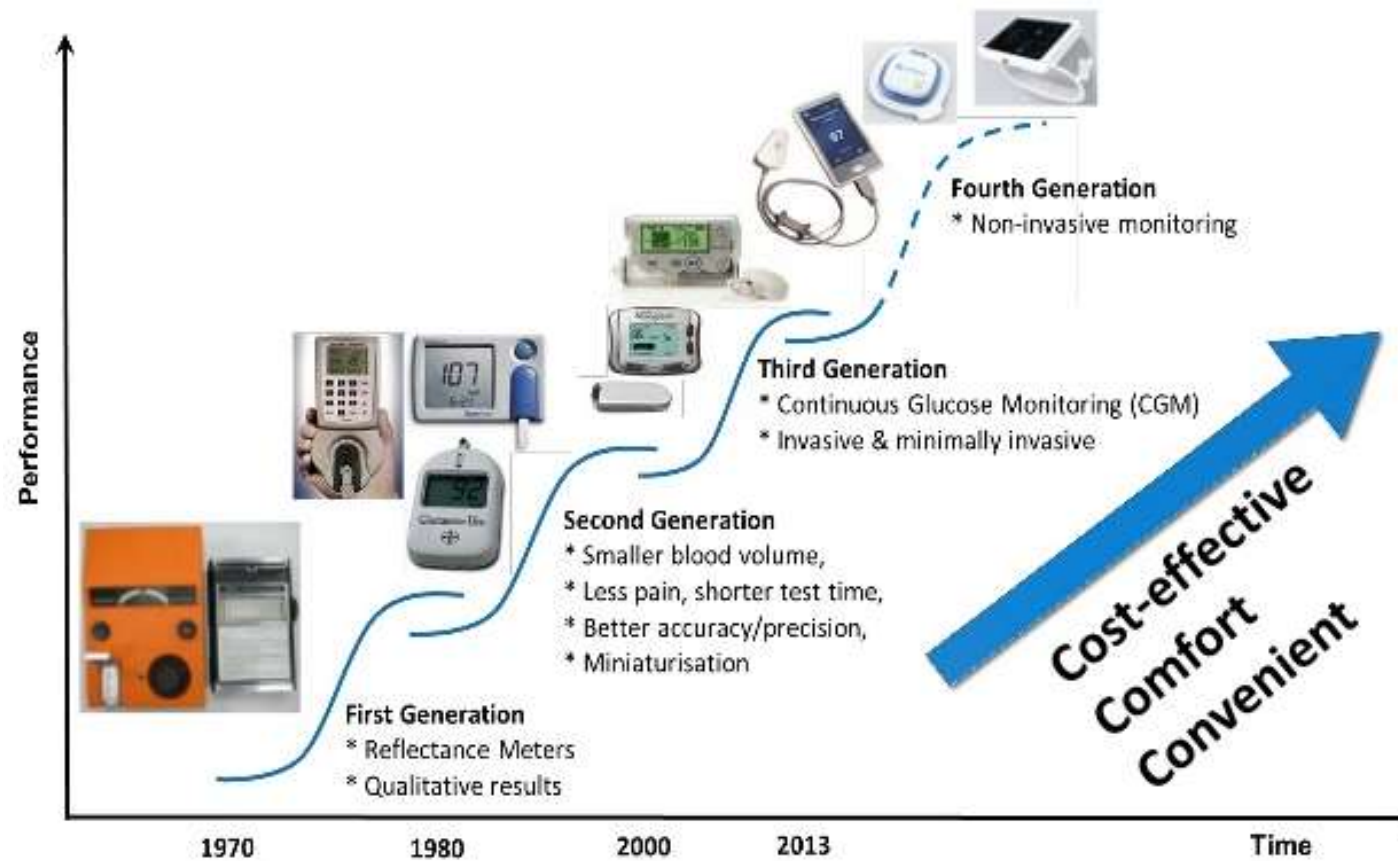
Volume 0.8 cc

Length 25.9 mm

Outer diameter 6.7 mm (20.1 Fr)

Mass 1.75 g

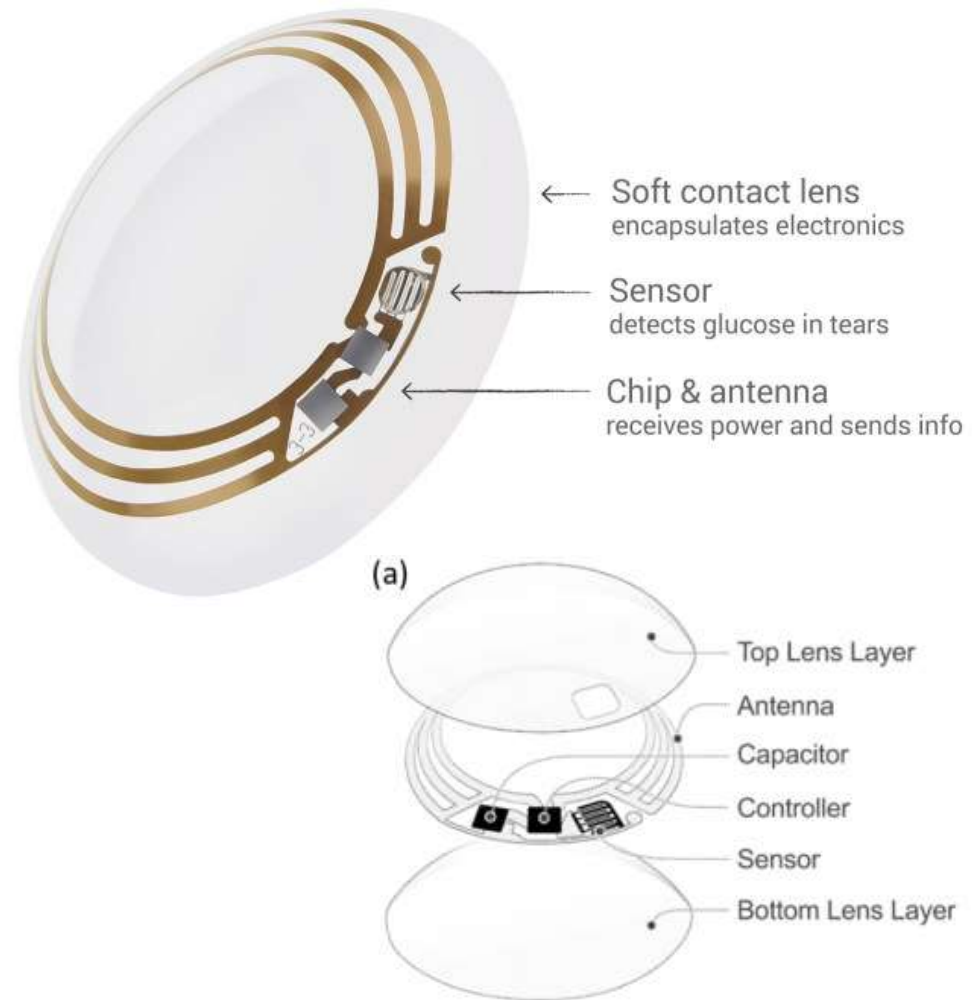
Evolution of blood glucose monitoring



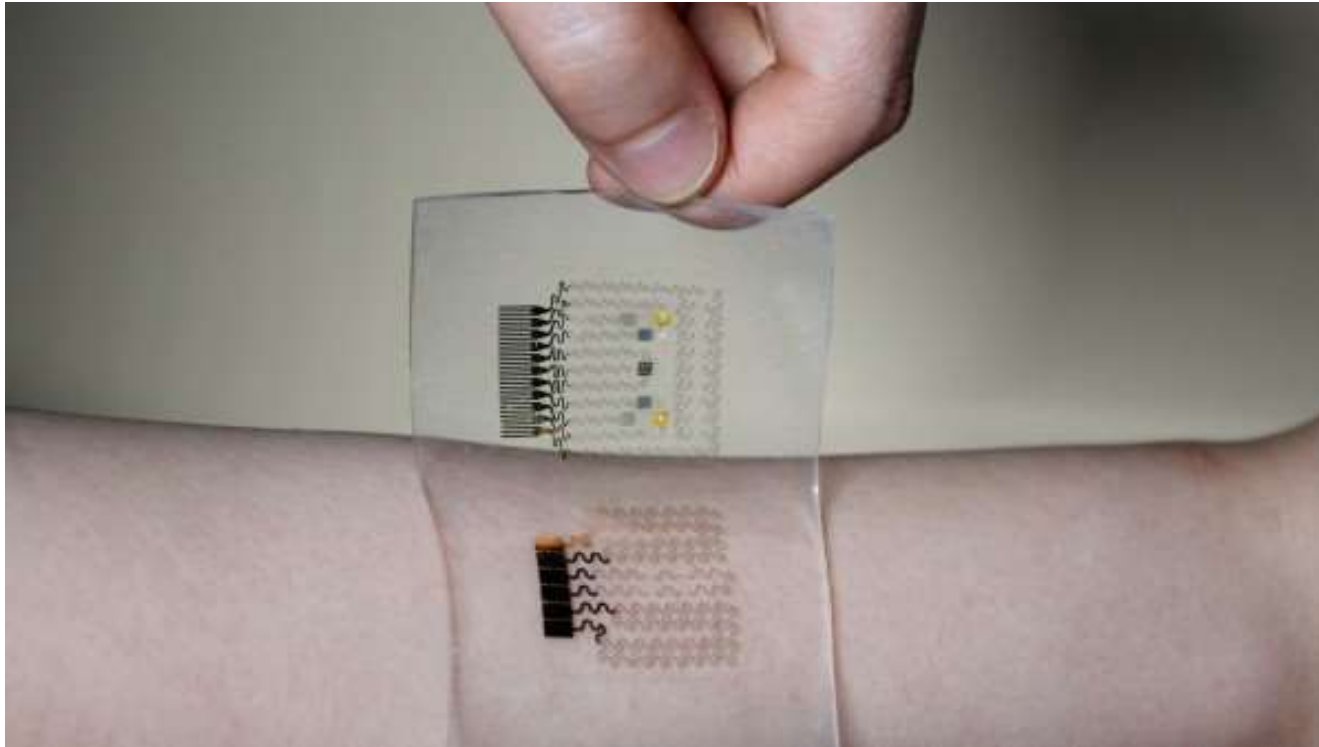
Non-invasive measuring of blood glucose

Research for easy and less-invasive way to measure glucose daily:

- tears,
- airway mucus,
- sweat,
- saliva or
- the interstitial fluid of subcutaneous tissue



Non-invasive measuring of blood glucose



An electronic skin patch that senses excess glucose in sweat and automatically administers drugs by heating up microneedles that penetrate the skin.

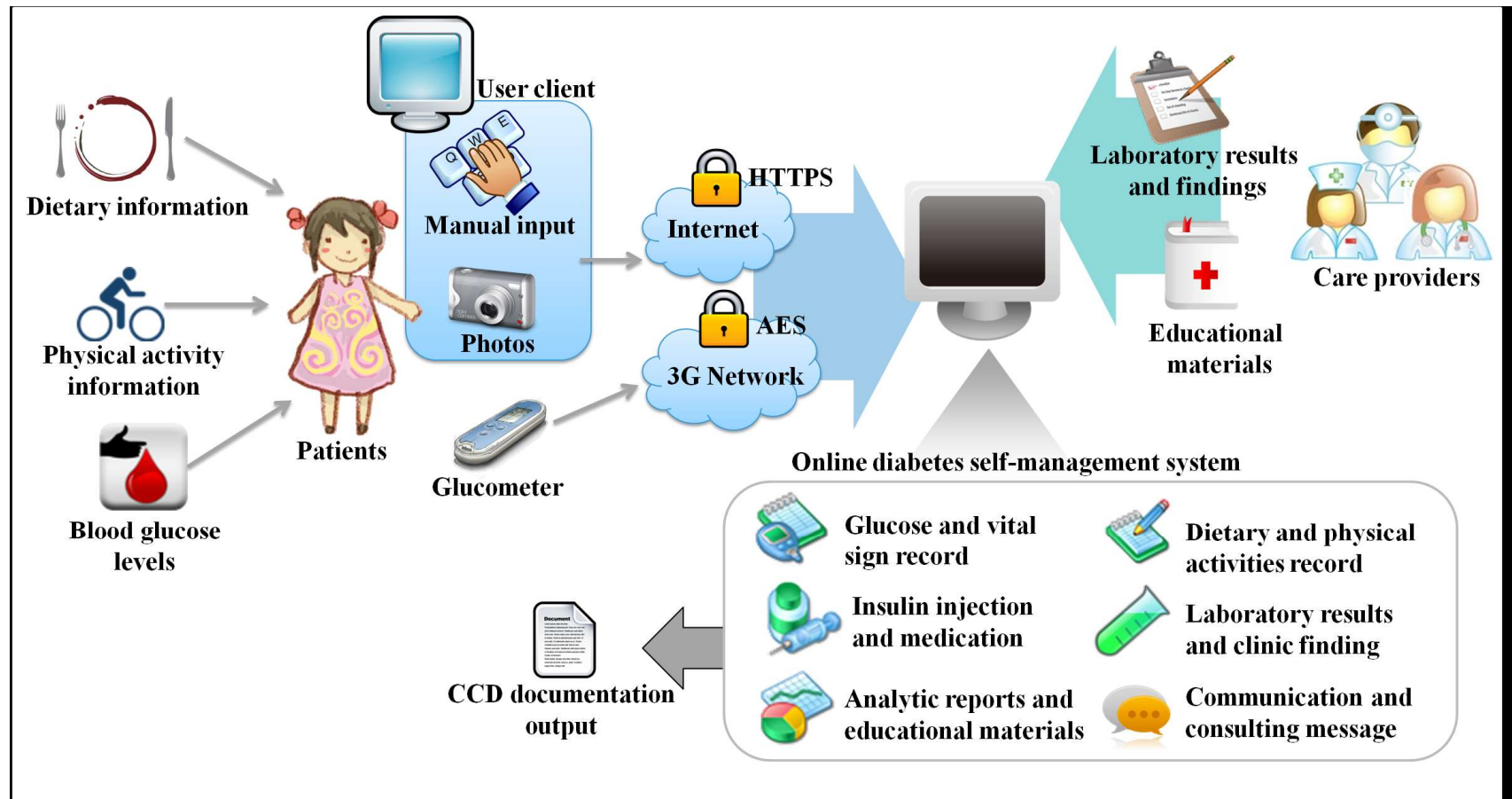
See also: Hyunjae Lee et al., A graphene-based electrochemical device with thermoresponsive microneedles for diabetes monitoring and therapy, *Nature Nanotechnology*, 2016

ICT in Healthcare



- Accessibility to information and communication technologies (ICT) provides an opportunity to facilitate acquisition of health data from wide populations, their use in research, analytics and finally in improving the outcomes of health care.

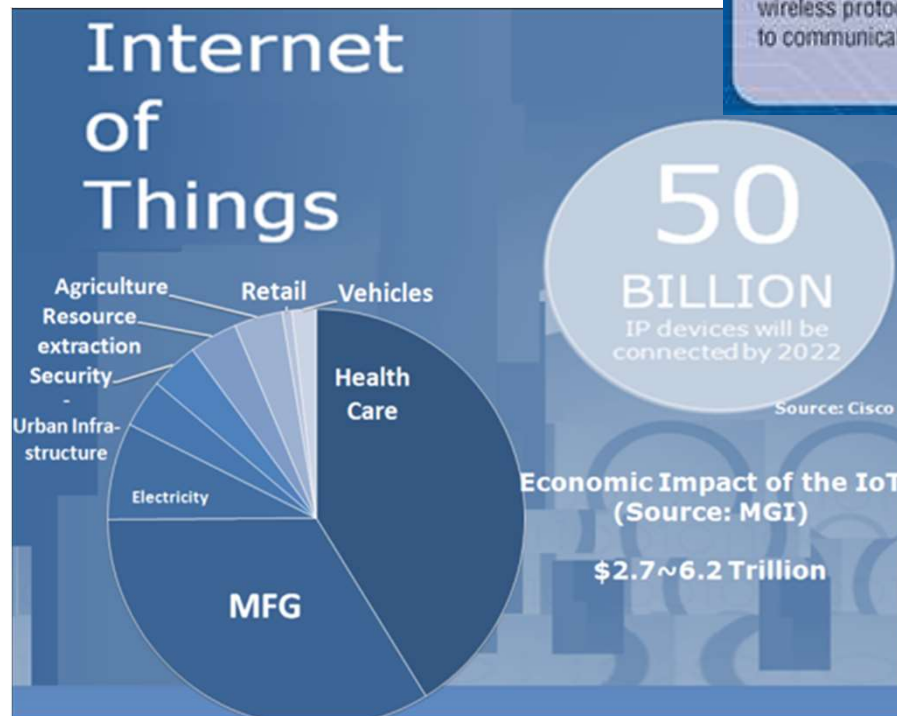
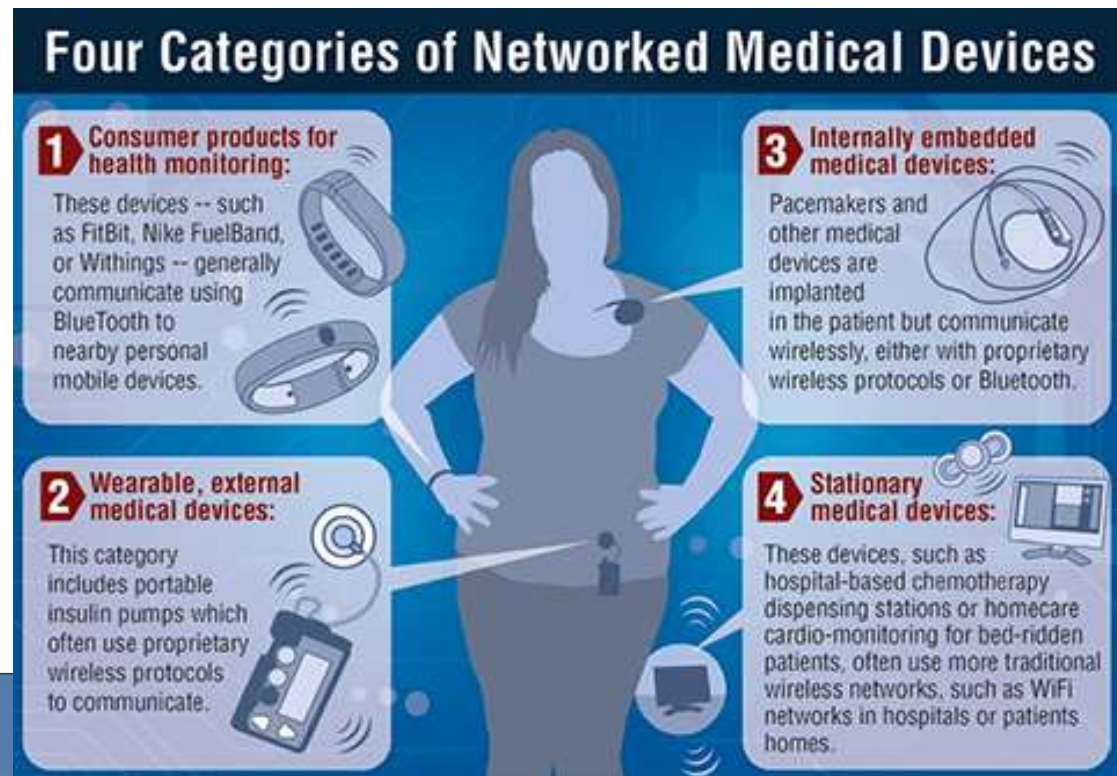
Self-Management and Telecare



From: Chen L, et al. Evaluating Self-Management Behaviors of Diabetic Patients in a Telehealthcare Program: Longitudinal Study Over 18 Months
J Med Internet Res 2013;15(12):e266, DOI: [10.2196/jmir.2699](https://doi.org/10.2196/jmir.2699)

IoT in Health Care

- Global connectivity
- Personal mobile devices
- Digital society



Source: NetSecurity.org

BME innovation in Europe

Patent applications in medical technology
field filled with EPO in 2014



In 2014, more than 11,000 patent applications were filed with the European Patent Office (EPO) in the field of medical technology – 7% of the total number of applications – still more than any other sector in Europe. 51% of these patent applications were filed from European countries (EU28, Norway and Switzerland) and 49% from other countries, with the majority of applications filed from US (39%).

Job Opportunities - Labor Market

“Biomedical engineers are projected to be the fastest growing occupation in the economy.”

Source: 2008-2018 prediction by the US Department of Labor

The Jobs of the Future – extected growth

Biomedical engineers 72%

Network systems analysts 53%

Home health aides 50%

Personal and home-care aides 46%

Financial examiners 41%

Medical scientists 40%

Physician assistants 39%

Skin-care specialists 38%

Biochemists and biophysicists 37%

Athletic trainers 37%

Source: Wall Street Journal, 26 May 2010

Best Jobs in America
CNNMoney/PayScale's top 100 careers with big growth, great pay and satisfaction

2013

See the top 100

2015

Biomedical Engineers

Rank 1 Job title Biomedical Engineer Median pay \$85,620 per year \$41.16 per hour

Rank 2 Job title Clinical Nurse Specialist Median pay \$85,620 per year \$41.16 per hour

Summary

Quick Facts: Biomedical Engineers	
2016 Median Pay	\$85,620 per year \$41.16 per hour
Typical Entry-Level Education	Bachelor's degree
Work Experience in a Related Occupation	None
On-the-job Training	None
Number of Jobs, 2014	22,100
Job Outlook, 2014-24	23% (Much faster than average)
Employment Change, 2014-24	5,100

<https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm>



On IFMBE

International Federation for Medical and
Biological Engineering



Mission

The objectives of the International Federation for Medical and Biological Engineering are **scientific, technological, literary, and educational**.

The mission of the IFMBE is **to encourage, support, represent and unify the world-wide Medical and Biological Engineering Community** in order to promote health and quality of life through the advancement of research, development, application and management of technology.

Within the field of medical, clinical and biological engineering its aims are to **encourage research and the application of knowledge, to disseminate information and promote collaboration**.



To function as the **leader** in representing the international community of medical and biological engineering.

To foster the **creation**, and **application** of medical and biological engineering knowledge and the management of technology for improved health and quality of life.

To promote the **development** of the medical and biological engineering profession, and the recognition and awareness of the profession by the public.

To advance **collaboration** between national and transnational societies, industry, government and non-government organizations engaged in health care and in biomedical research and its applications.

To recommend policies and provide guidelines in appropriate professional, educational and ethical areas.

To enable IFMBE to achieve its goals effectively, optimize the organizational structure and communication and enhance its finances.



Since 1959

Affiliated Members of IFMBE

INTERNATIONAL FEDERATION FOR
MEDICAL AND BIOLOGICAL ENGINEERING

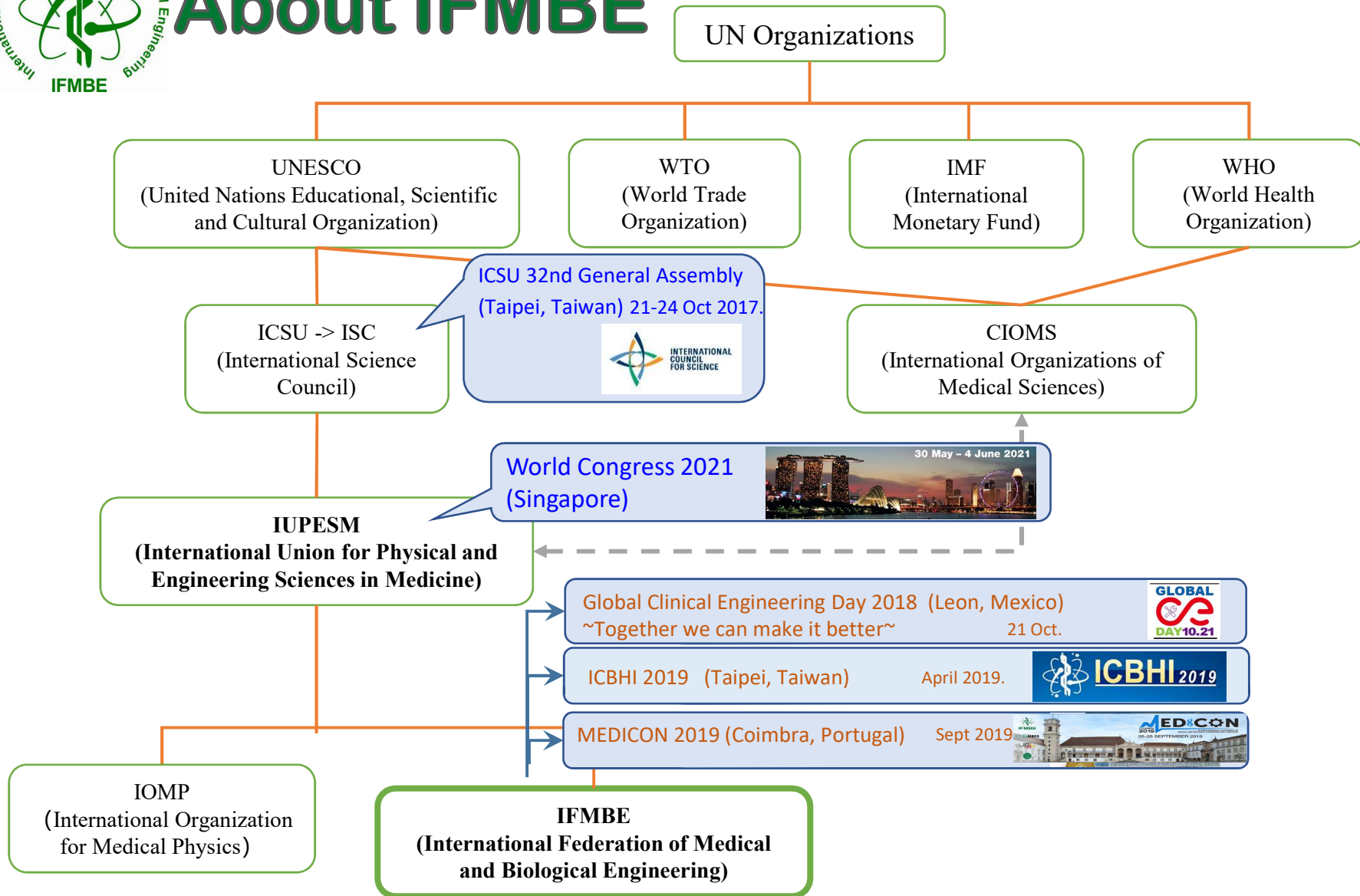
Affiliated with the International Union for Physical and Engineering Sciences in Medicine (IUPESM)

www.ifmbe.org





About IFMBE

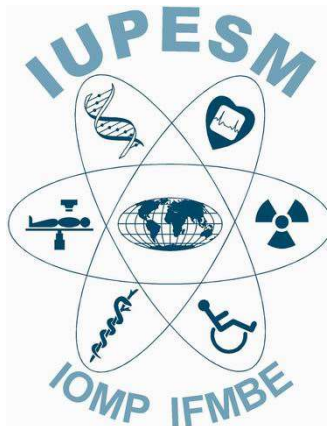




IFMBE's Liaisons



- Close association with the **International Organization of Medical Physics**



- The two international bodies have established the umbrella organization **International Union for Physical and Engineering Sciences in Medicine**

“The principal objective of IUPESM is to contribute to the advancement of physical and engineering sciences in medicine for the benefit and well being of humanity.”



IFMBE's Liaisons



**International
Science Council**

ISC

International Science Council



IUPESM

International Union for
Physical and Engineering Sciences
in Medicine

Scientific Unions (39)

Scientific Members

(mainly Academies of Science, 141)

IFMBE

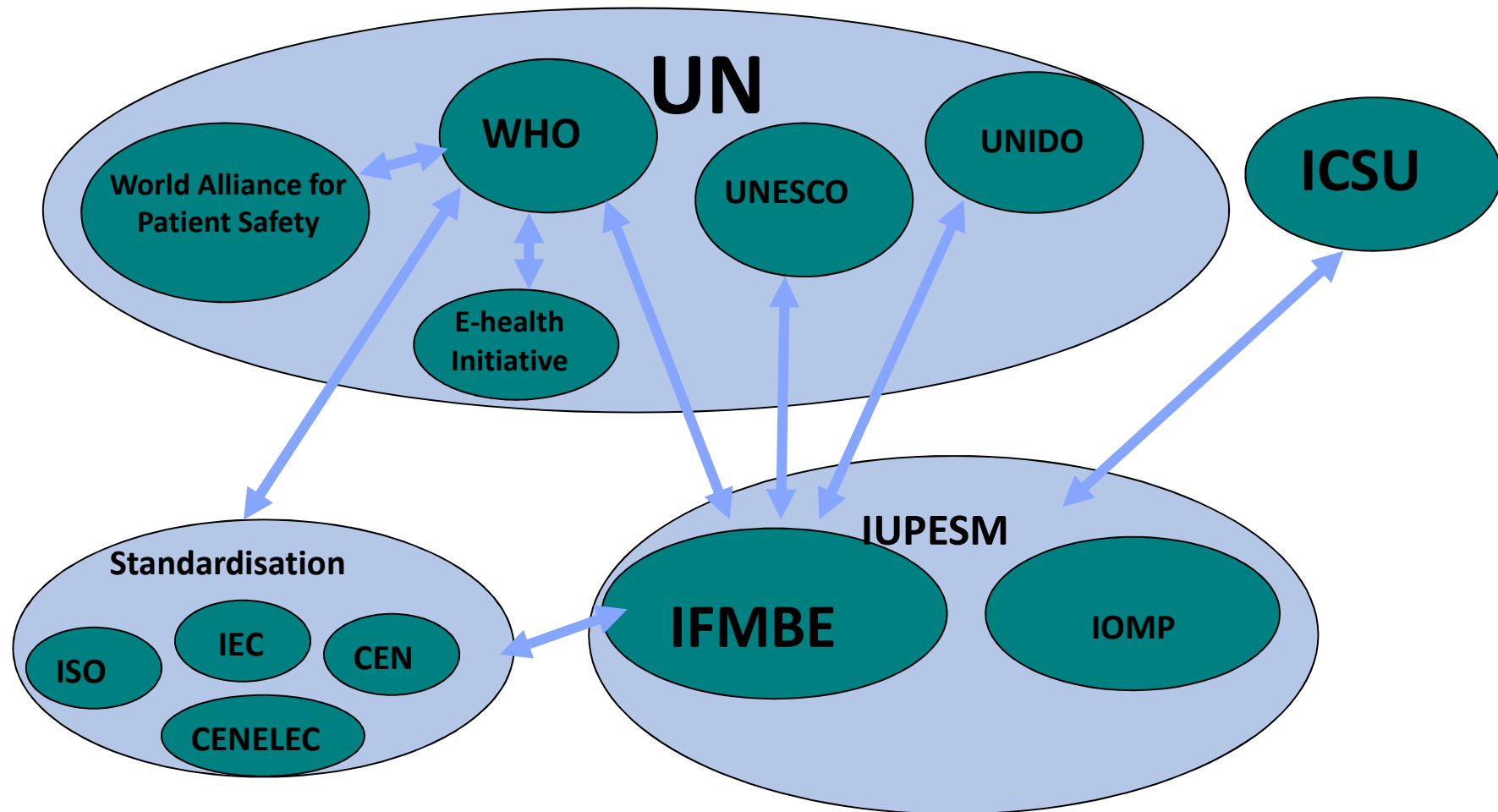
**International
Federation for
MBE**

IOMP

**International
Organization for
Medical Physics**



IFMBE's Liaisons to UN & WHO





World Health Organisation

IFMBE is a non-governmental organisation affiliated to WHO and has major interests in:

- patient safety issues
- human resources program
 - strengthen the position of clinical engineers and biomedical engineers whose workplace is within the healthcare system
- e-health programs
- health technology assessment and management
- evidence based medicine

IFMBE is representing the WHO in international standardisation bodies



Access to medical devices for Universal Health Coverage and achievement of SDGs



WHA60.29 Health technologies¹

The Sixtieth World Health Assembly,

Having considered the report on health technologies;²

Recognizing that health technologies equip health-care providers with tools that are indispensable for effective and efficient prevention, diagnosis, treatment and rehabilitation and attainment of internationally agreed health-related development goals, including those contained in the Millennium Declaration;



WHO list of priority medical devices for cancer management

WHO Medical device technical series

European Parliament Interest Group

EPIG

ON BIOMEDICAL ENGINEERING

11 OCTOBER 2018, 10:30-13:00



MEDICAL DEVICES & MODERN MEDICINE

from HORIZON2020 to HORIZON EUROPE: GAPS & OPPORTUNITIES

Nicola Caputo, MEP

Lara Comi, MEP

11 October 2018, 10:30-13:00, A3H1, EUROPEAN PARLIAMENT, BRUSSELS



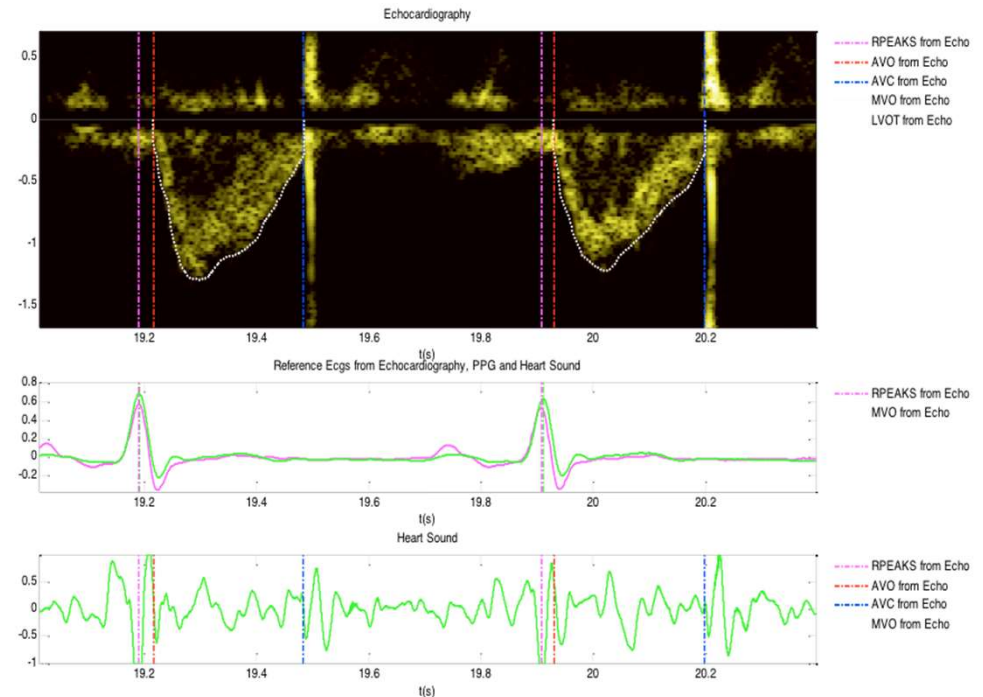
ICBHI 2019

International Conference on Biomedical and Health Information
Taipei, Taiwan, 17-20 April 2019

**Future Trends of Biomedical and Health Informatics,
& Cybersecurity in Medical Devices**

- **Scientific Challenge on Cardiac Signal Processing Best Paper Award**

ICBHI 2019 will award **TWO** Best Paper Awards to participants in the Scientific Challenge Competition.



Conclusions

- Engineering jobs are present in medicine and health care, primarily through research, development and manufacturing of medical products, devices and systems, but is increasingly encountered in clinical settings.
- Thanks to the safe production and maintenance, unintended consequences of medical devices are rare, but concern about the immediate security and safety of the device is necessary and appropriate to the care of biomedical, biological or clinical engineering profession.
- Early introduction of research methods and encouraging innovativeness in students through problem based learning and design competitions is promising.

Thank you for your attention!