

Cell Mechanobiology Research for Health Development in Africa

Kayode A. DADA*; Fatai A. BALOGUN

(*kayodeayodejidada@yahoo.com)

Centre for Energy Research and Development, Obafemi Awolowo
University, Ile-Ife, Nigeria





Motivation



- ▶ The intrinsic properties of a cell is guided by how it interacts with its neighbours and environment.
- ▶ The effect of the interaction is felt at the tissue and organism level.
- ▶ The interaction involve generation, sensing and transmission of mechanical forces.
- ▶ Conventional methods of diseases/illness diagnosis and progression are conventionally through biochemical principles.



Basic principles in mechanobiology

- ▶ Cell mechanobiology is a field of study that combines efforts from materials science, mechanics, cell and molecular biology.
- ▶ Mechanobiology can be described as an interdisciplinary field that involve the study of physical forces and how they affect cell mechanics.
- ▶ It helps in understanding the role of mechanical forces in the well-being of a cell as it interacts with its neighbours and environment

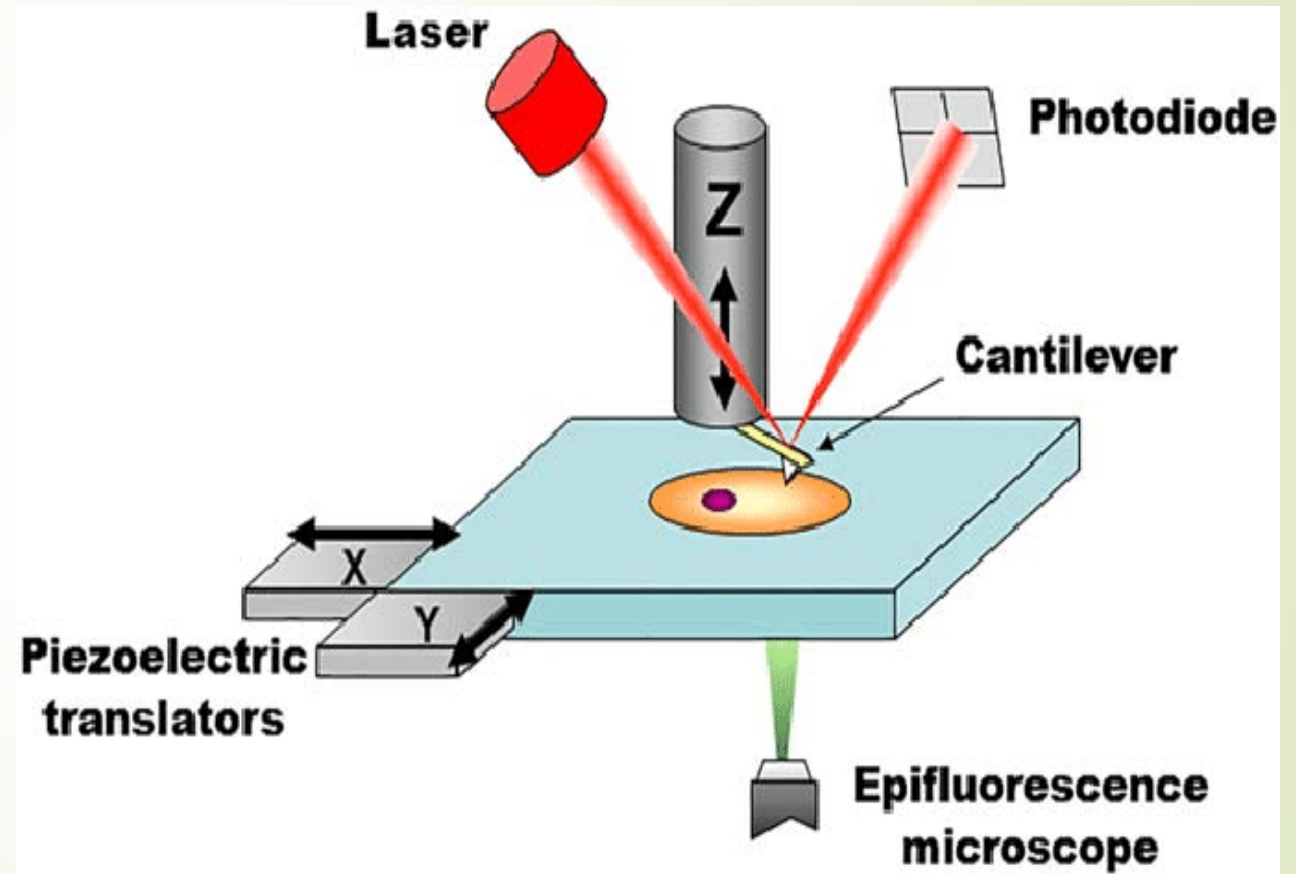
Facilities

TECHNIQUE	FORCES	MAIN APPLICATIONS	MERITS	DEMERITS
Atomic force microscopy	Compressive and tensile forces (pN and mN range)	Molecular, cellular and tissue stiffness measurements, protein unfolding, cell adhesion measurements, stress application to biological samples, surface scanning	High spatial and temporal resolution, combination with other techniques, working range over several scales	Restricted to surfaces, not high throughput
Optical stretcher	Tensile forces (pN range)	Cell deformation assays	High throughput, contact-free	Limited spatial resolution and force, heating of samples
Optical tweezers	Tensile, compressive, shear forces (pN range)	Stress application to cells and molecules	High temporal and spatial resolution	Limited force, often μm -sized beads have to be attached to the sample, heating of samples

TECHNIQUE	FORCES	MAIN APPLICATIONS	MERITS	DEMERITS
Cell poking	Compressive forces (nN- μN range)	Cell stiffness measurements	Easy to set up	Restricted to surfaces, limited force and spatial resolution
Magnetic bead twisting	Shear forces (pN- nN range)	Cell rheology, stress application to cell surface receptors	High throughput, good force resolution	Restricted to surfaces, binding may cause secondary effects
Magnetic tweezers	Tensile forces (pN- nN range)	Cell stiffness measurements	Easy to set up	Requires magnetic beads to be taken up by or bound to cells
Micropipette aspiration	Tensile forces (tens of pN-μN range)	Cell stiffness, membrane tension measurements	Easy to set up	Limited spatial and force resolution
Microrheology	Passive method (no forces actively applied)	Cell rheology	Easy to set up, high throughput, in vivo measurements possible	Position of the particles difficult to control

Atomic force microscope

- Easy to use
- Simple or no sample preparation
- Can be operated in any medium.
- Require lesser time when compared to conventional biochemical techniques.
- Cost: \$150 – 200 k



Institutions with Mechanobiology +++

- ▶ University of Cape Town: <http://www.mechanobiology.uct.ac.za/>
- ▶ Department of Biomedical Engineering, University of Medical Sciences and Technology (UMST)
- ▶ University of Pretoria (Department of Physiology; Microscopy and microanalysis laboratory; Physics#)
- ▶ iThemba Labs (Materials Science division#)
- ▶ University of Witwatersrand (Microscopy and Microanalysis Unit#)
- ▶ Stellenbosch University: Chemistry#

Major health issues of interest

- Malaria
- Wound healing
- Cancer
- Sickle cell
- Diabetes
- UD = undetected
- International diabetes federation

Case	World Stat WS (X10 ⁶)		Africa (% of WS)		Year	Source
	Incidents	Fatality	Incidents	Fatality		
Malaria	241	0.627	95	96	2020	W.H.O
Cancer	~ 19.292	~9.958	5.75	7.144	2020	GLOBOCAN
Diabetes	537	6.7	4.47 (54% UD)	6.21	2021	IDF

Present obstacles facing Mechanobiology in Africa

- ▶ Inadequate research facilities for exploration of the field of study.
- ▶ Very minimal research scientists within Africa venture into mechanobiology.
- ▶ Funding for the available scientist to carryout novel study in mechanobiology is very low in many African countries and in others, funding is not available.
- ▶ A handful of postgraduate education is geared towards mechanobiology.
- ▶ Clinical obstacles usually arise during clinical research in mechanobiology in many parts of Africa.

Support for Cell Mechanobiology in Africa ...


- ▶ Governments are encouraged to make adequate funding available for procurements of facilities that can be used to carry out novel studies in mechanobiology. Funding should also be provided for the researchers as incentives. Such facilities can also be used to carried out clinical trials for such novel studies.
- ▶ Mechanobiology should be incorporated into present basic medical graduate studies. Government should support the collaboration with research scientists outside Africa. Such collaboration should be geared towards encouraging students and indigenous scientists to take up researches in mechanobiology for application in the health sector.

... support for Cell Mechanobiology in Africa

- ▶ The barriers in clinical research should be reduced. Government should make policies that will make it easy for scientist in mechanobiology to have access to clinical specimens that will help in improving the transfer of scientific results into clinical applications.
- ▶ Adequate support for mechanobiology field of study will help to provide basic information on the (a) efficacy of locally produced sickle cell anaemia drugs; (b) metastatic nature of common cancers types in Africa; (c) procedures for fast wound healing; (d) nature of the erythrocyte of HIV/AIDS, diabetic and malaria patients.
- ▶ Active collaborations should be in place among various institutions and/or research centres.

References

- Jansen K.A., Donato D.M., *et al.* (2015). *doi: 10.1016/j.bbamcr.2015.05.007.*
- Ladoux B. and Mege R-C. (2017). *doi:10.1038/nrm.2017.98*
- Mohammed D., Versaevel M., *et al.* (2019). *doi: 10.3389/fbioe.2019.00162*
- Wang J.H.-C and Thampatty B.P. (2006). *doi: 10.1007/s10237-005-0012-z*
- <https://gco.iarc.fr/today/data/factsheets/populations/900-world-fact-sheets.pdf>
- <https://gco.iarc.fr/today/data/factsheets/populations/903-africa-fact-sheets.pdf>
- <https://www.idf.org/our-network/regions-members/africa/diabetes-in-africa.html>
- <https://diabetesatlas.org/>



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