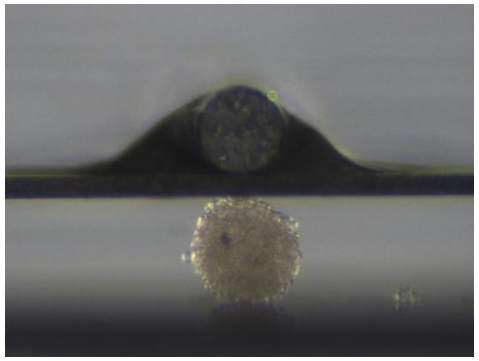
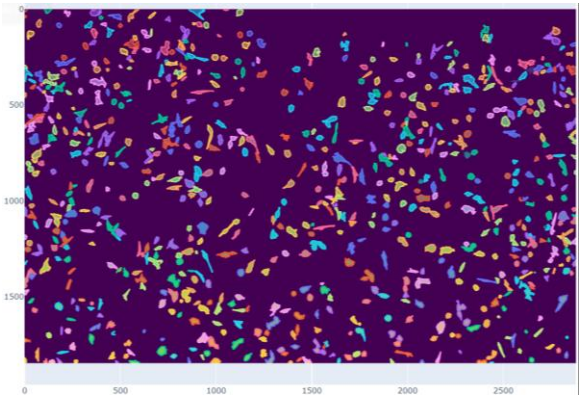
437

On biomechanics and its relevance to udder research



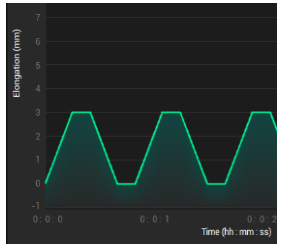


הכנס ה - 34
למדעי הבקר והצאן

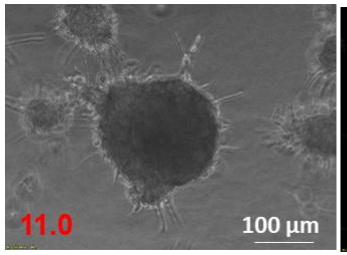
Yifat Brill-Karniely, PhD
Institute of Animal Science
Volcani Center

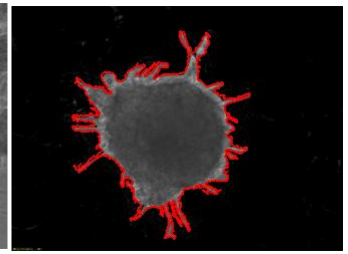
Outline

- Why are biomechanical aspects important in the study of bovine mammary glands?



- Applicative biomechanical research





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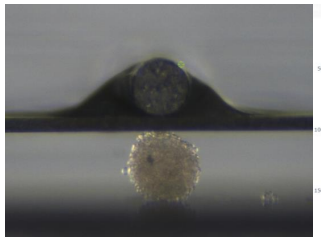

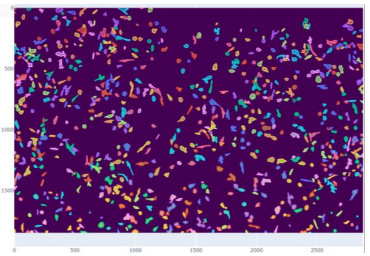

Holistic approach: biology, mechanics, structure, environment

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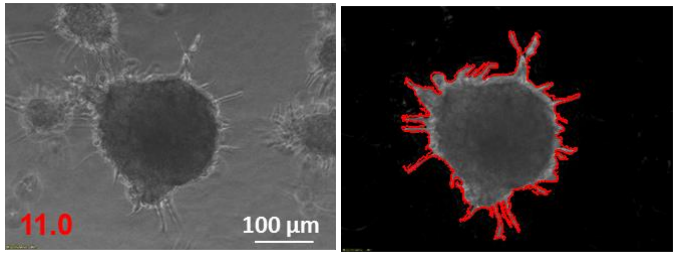
Aggregates and tissues morphology



Brill-Karniely* et al., *Science Advances* 2020

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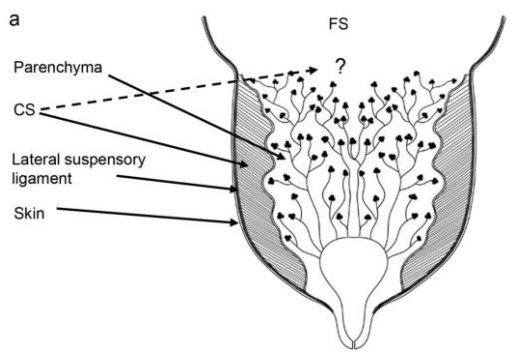

Kosenko A., .. Barash I, *Cell and Tissue Research* (2022)

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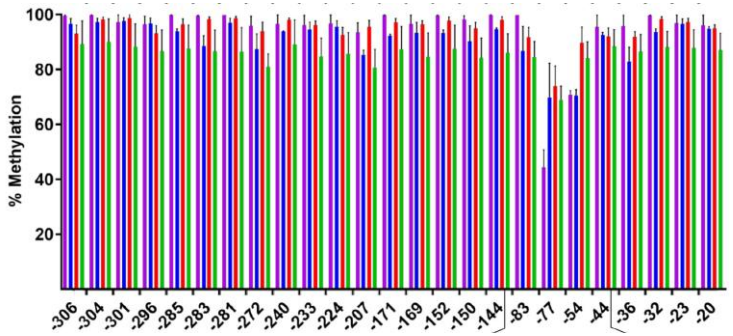
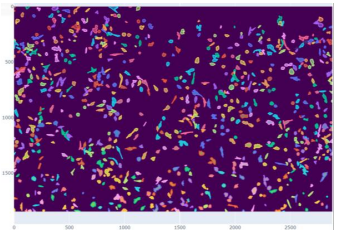
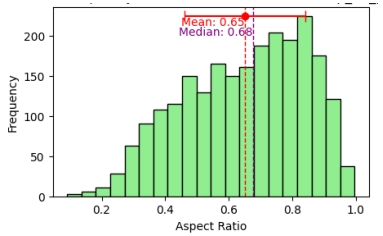


Havusha-Laufer S., .. Barash I, *Journal of Mammary Gland Biology and Neoplasia* (2020)

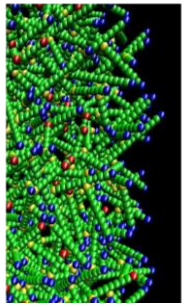
Cell morphology

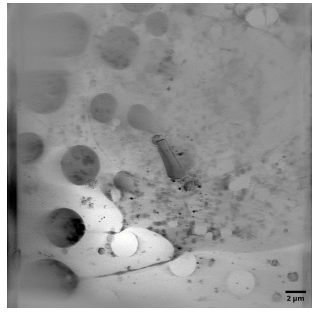




YBK lab, unpiblished

Intracellular dynamics





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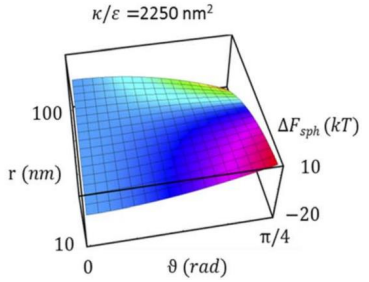
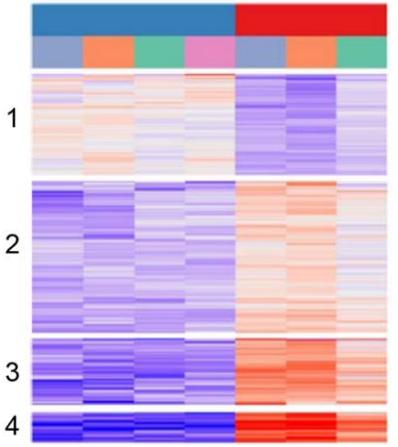
$$\frac{d\Delta F_{cyl}}{d\theta} = 2l\left(\frac{\kappa}{r} - \varepsilon r\right)$$



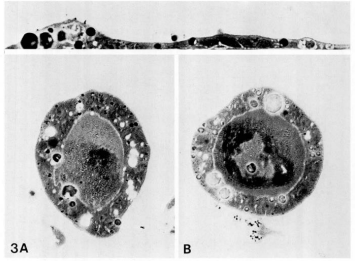
Brill-Karniely* et al., *Nanoscale Adv.* 2022

Genetics

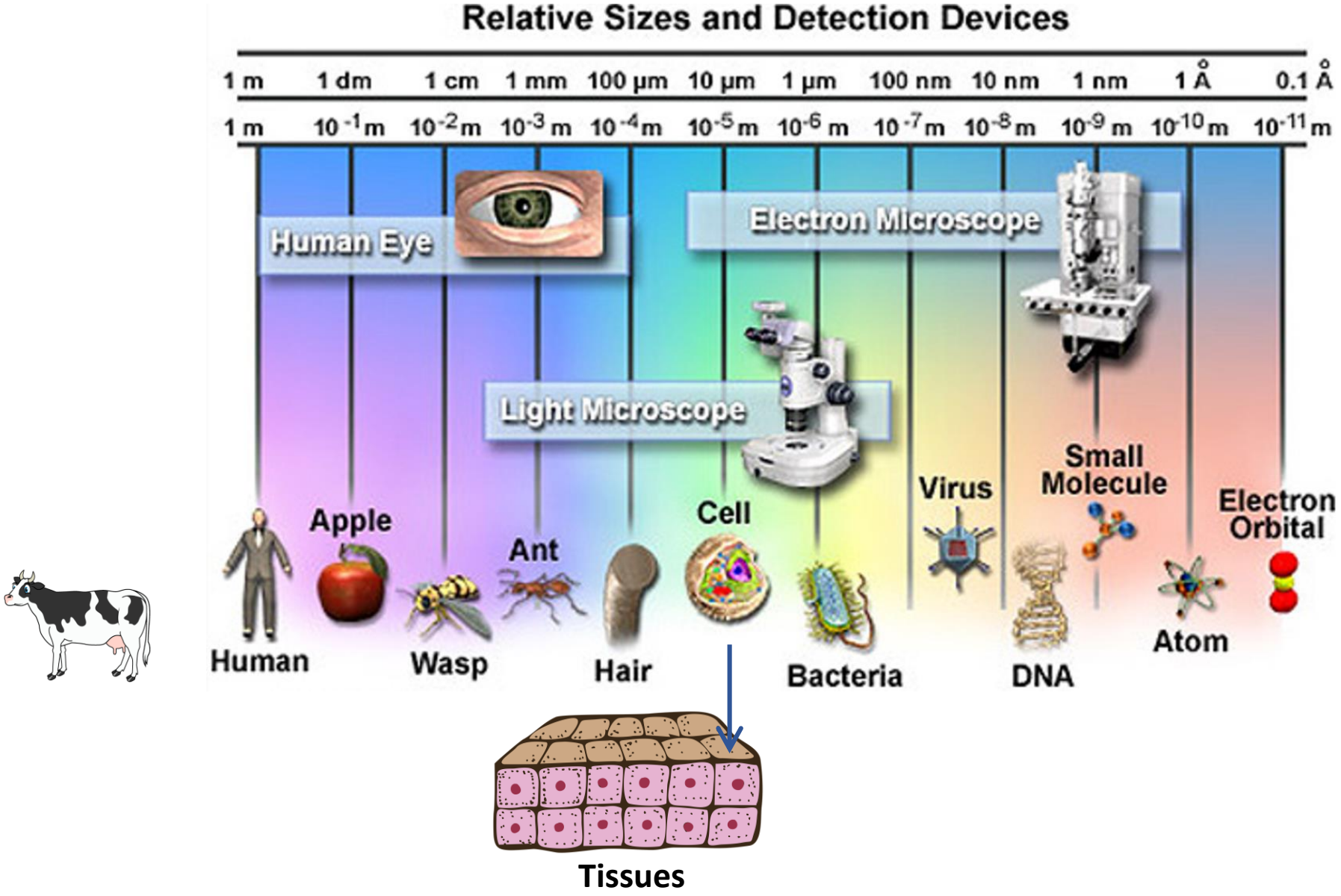


Kosenko A., .. Barash I, *Cell and Tissue Research* (2022)

Micro-environment

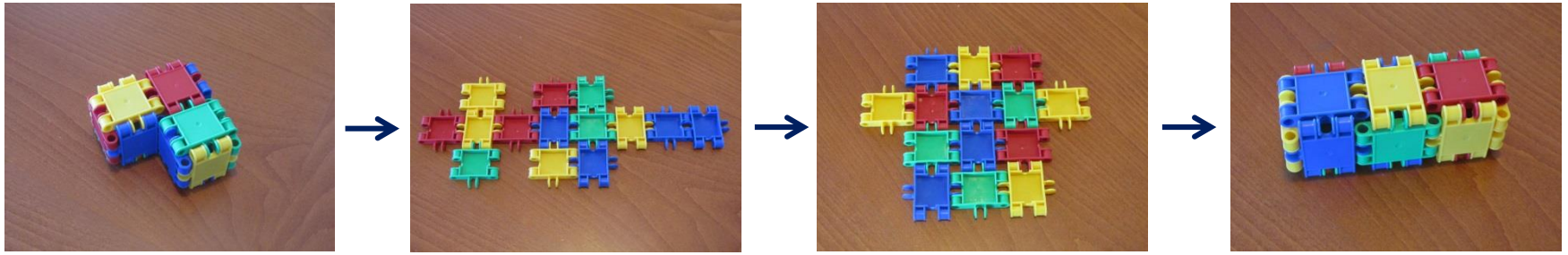


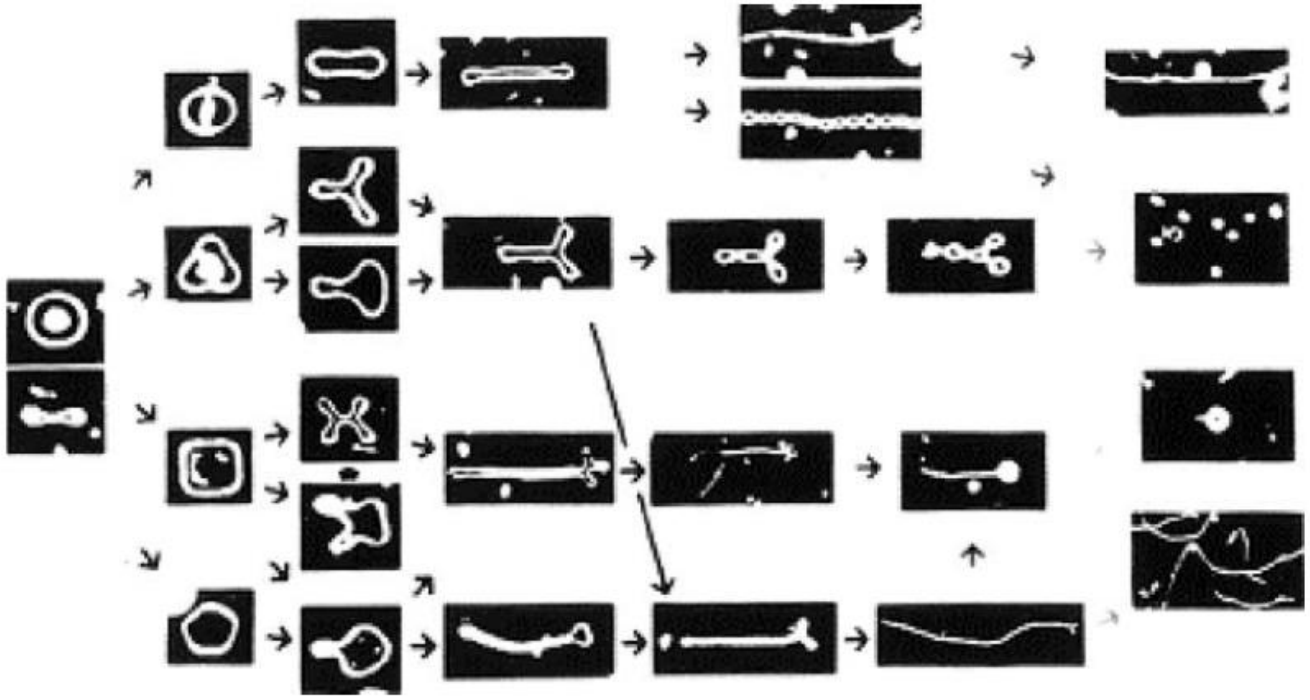
Bissell & Barcellos-Hoff, *J. Cell Sci. Suppl.* 1987



http://micro.magnet.fsu.edu/cells/

Same composition – different structure and function

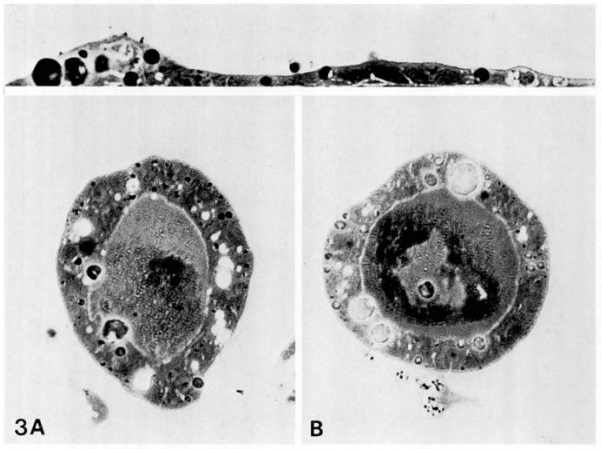




H. Hotani J. Mol. Biol. (1984)

Form ⟺ Function

Mina J. Bissell, Berkeley U.

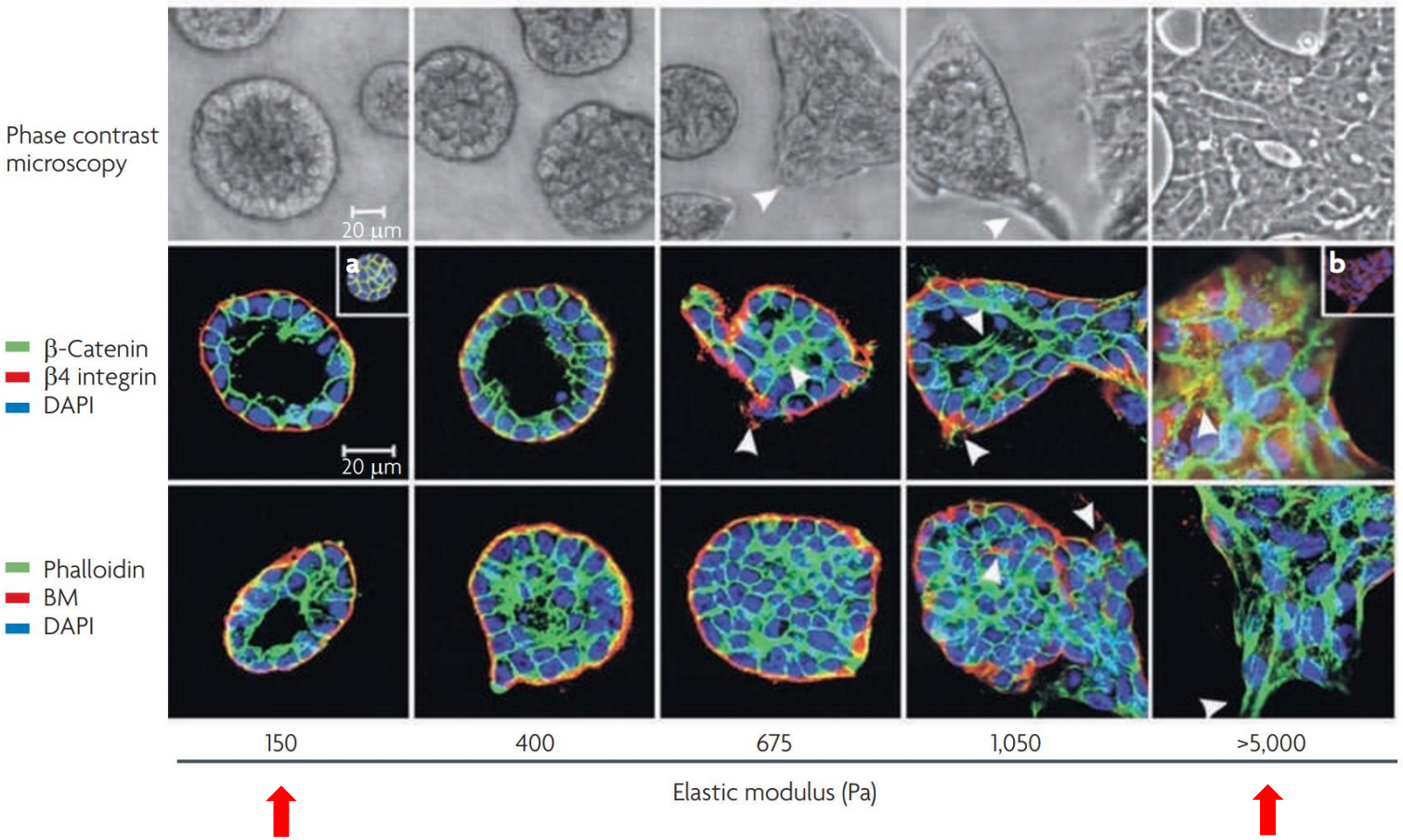


Bissell & Barcellos-Hoff, *J. Cell Sci. Suppl.* 1987

The basic functional unit for expression of milk proteins:

Mammary epithelial cells + ECM scaffold.

Importance of mechanical environment

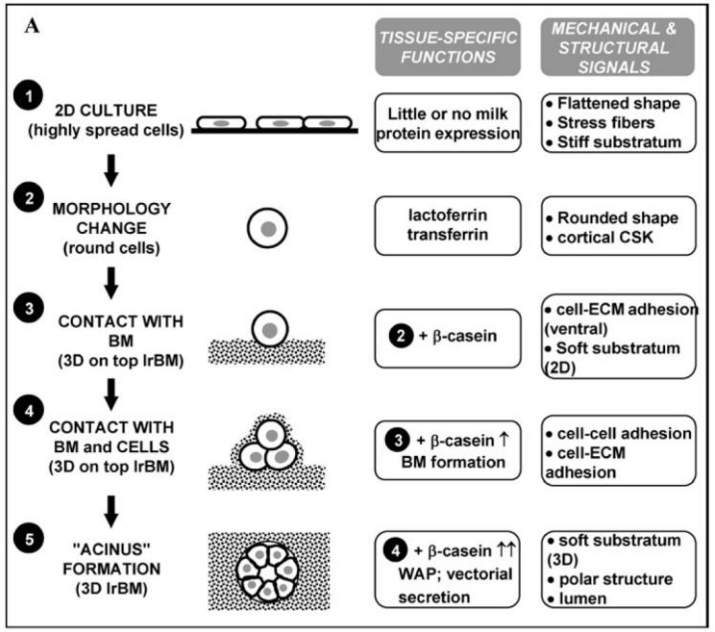


Physiological rigidity: Alveoli

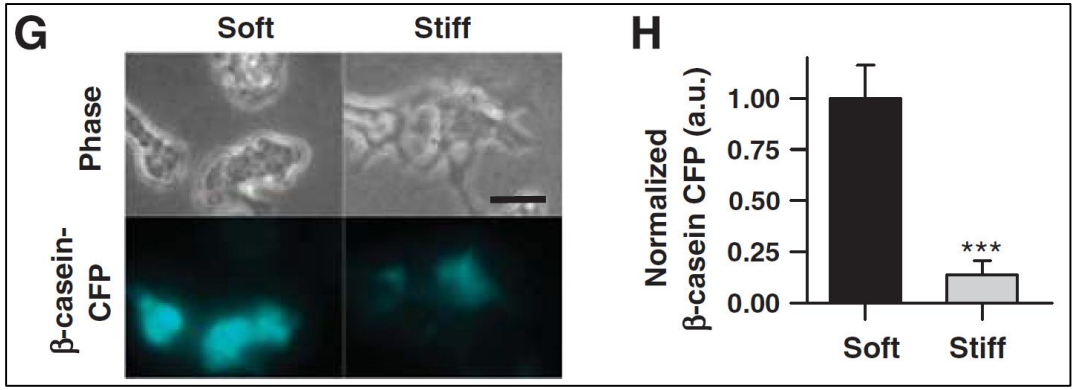
Stiff: Cancer

Paszek, Matthew J. et al. *Cancer Cell* 2005

Importance of mechanical environment

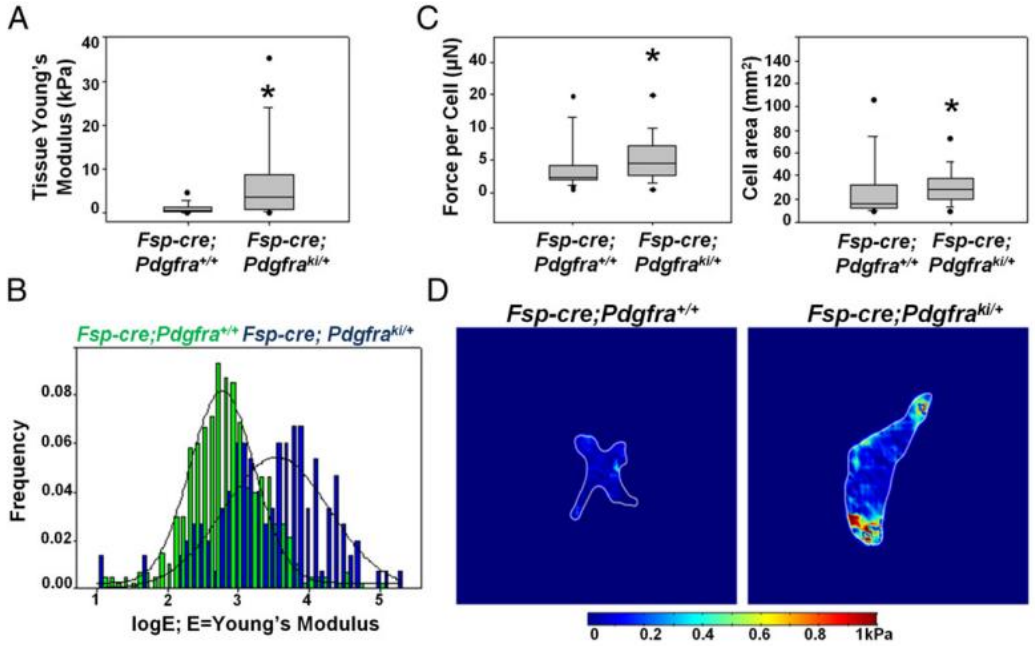


Alcaraz et al., *Journal of Mammary Gland Biology and Neoplasia* 2004



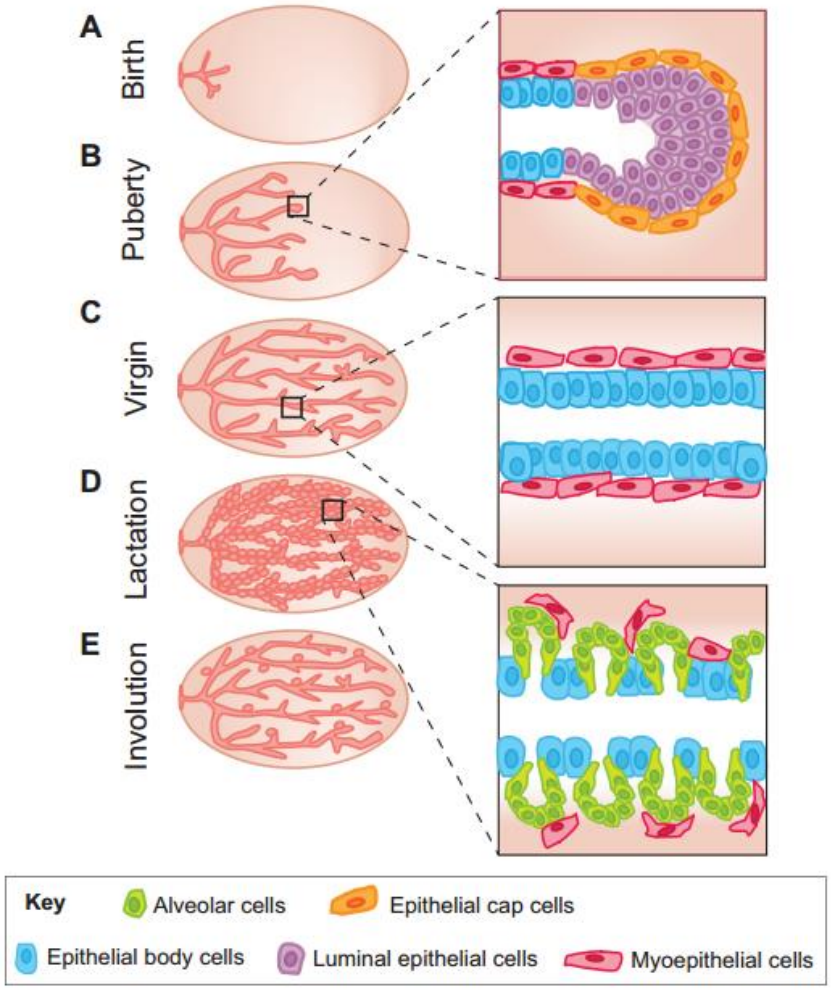
Alcaraz et al., *The EMBO Journal* 2008

Mammary gland function is correlated with cell and tissue rigidity

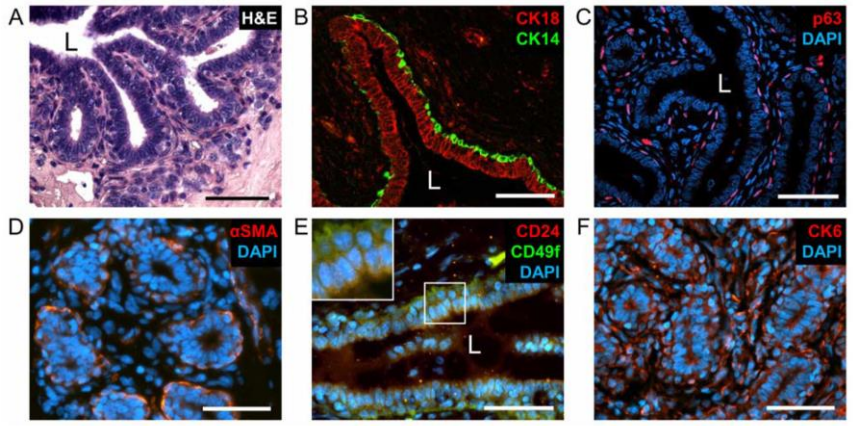


Hammer et al., *Neoplasia* 2017

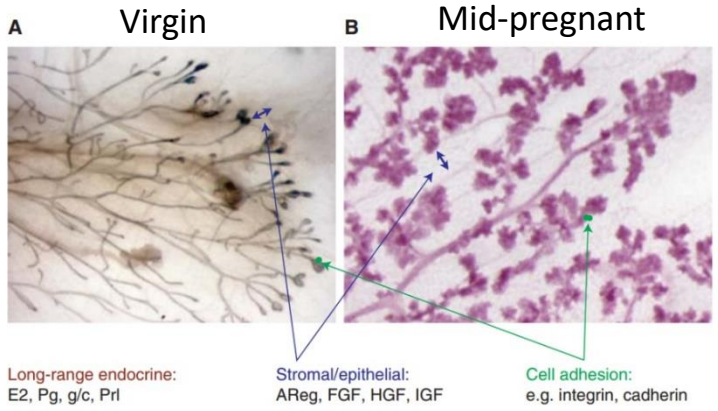
Massive physical alterations of mammary glands during development



Inman, .., Bissell, *Development* 2015



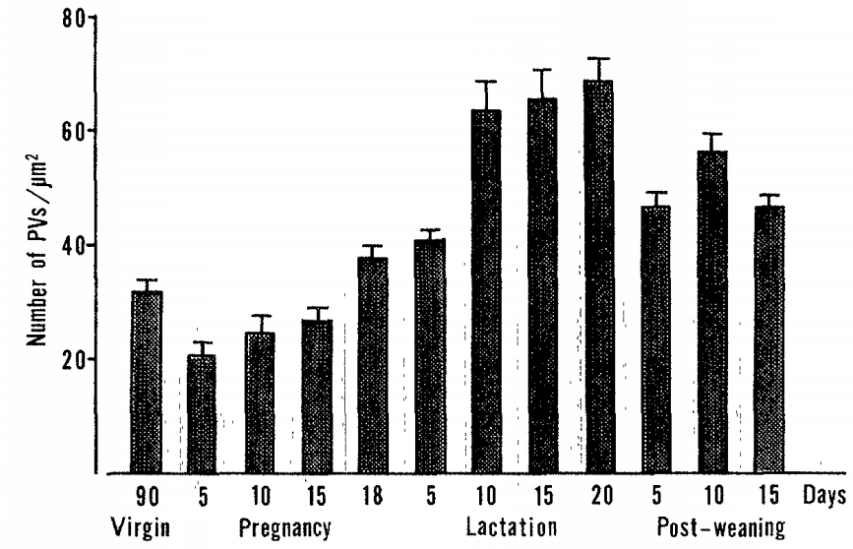
Rauner & Barash, *PLoS ONE* 2012



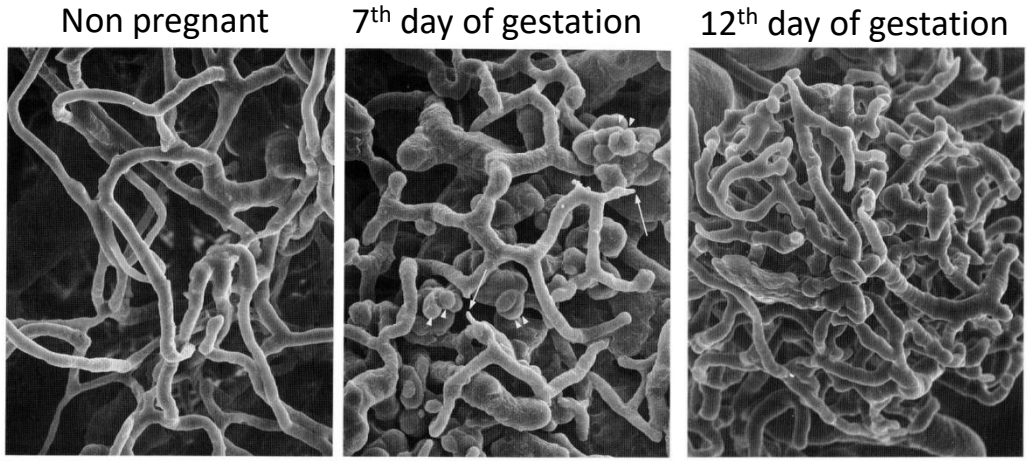
Muschler & Streuli, *CSH Perspect Biol* 2010

Massive physical alterations of mammary glands during development

Change in vascular density: more than 3 fold



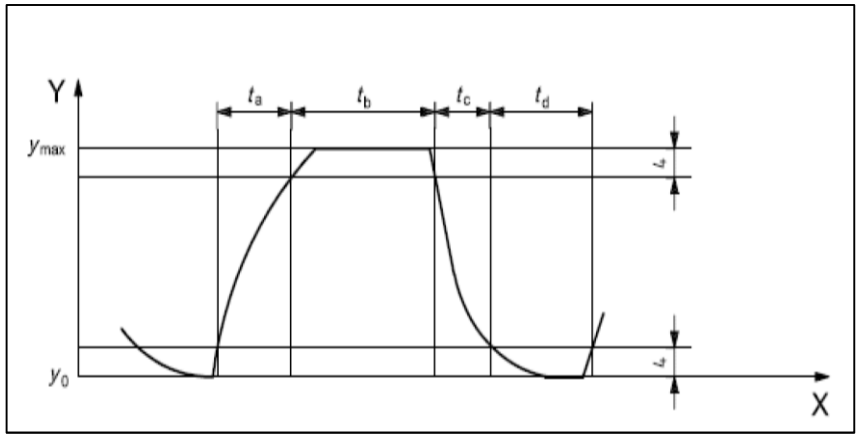
Matsumoto et al., *J. of Vet. Med. Sci.* 1992



Yasugi et al., *Arch. Histol. Cytol.* 1989

Vacuum forces during milking

From a tour guided by Prof. Uzi Moallem (Volcani Inst.)



Israel recommendation for milking apparatus,
Israel Dairy Board 2007

Outline

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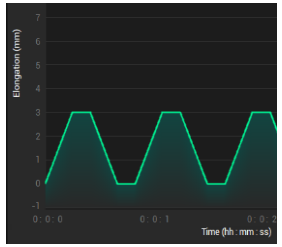
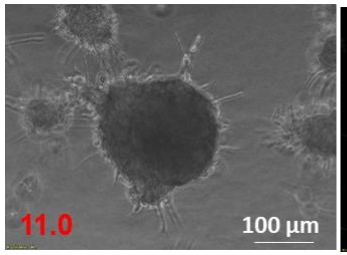
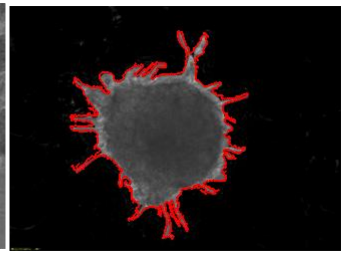
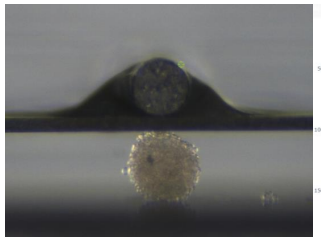


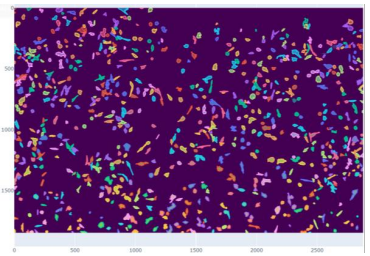
- Applicative biomechanical research





- Present research and perspectives





Holistic approach: biology, mechanics, structure, environment

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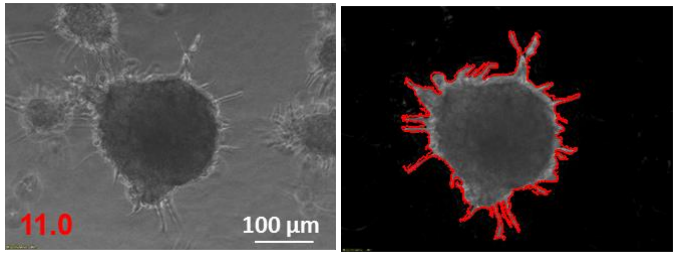
Aggregates and tissues morphology



Brill-Karniely* et al., *Science Advances* 2020

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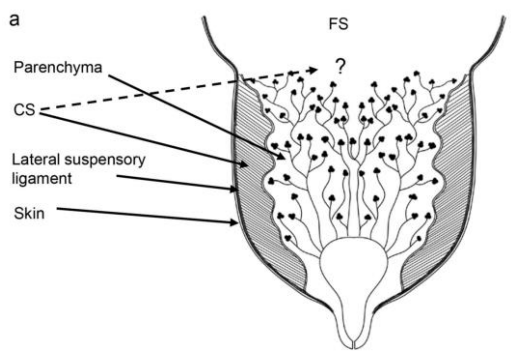

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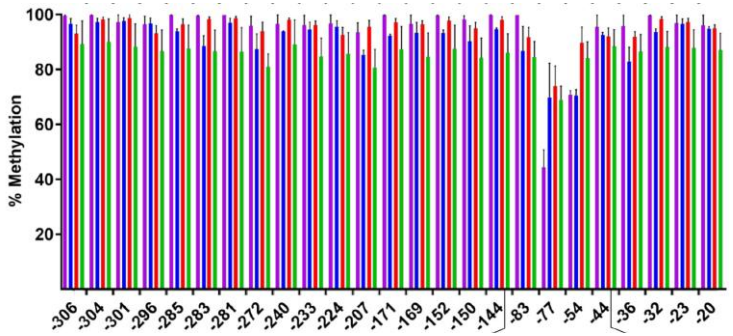

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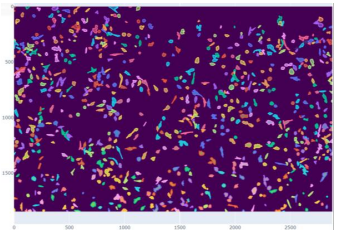
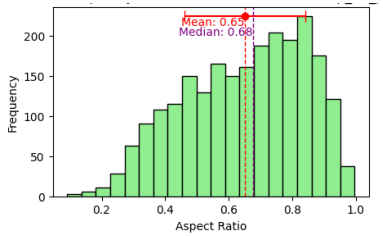
Cell morphology





YBK lab, unpiblished

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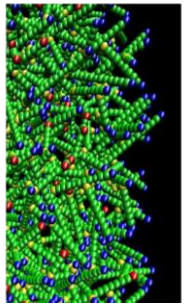

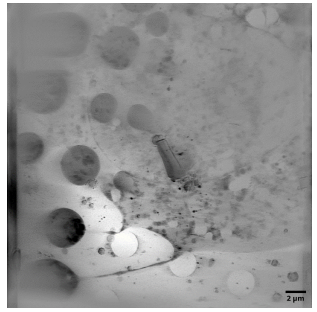

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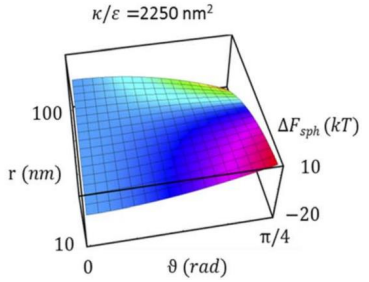

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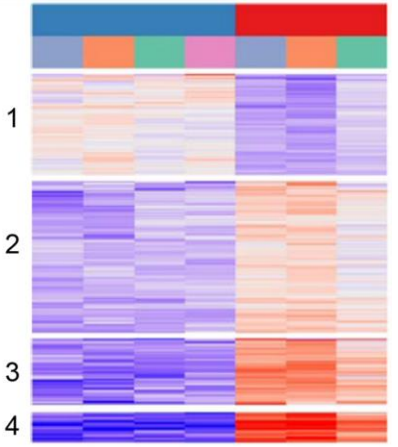

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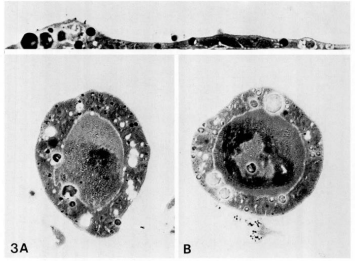
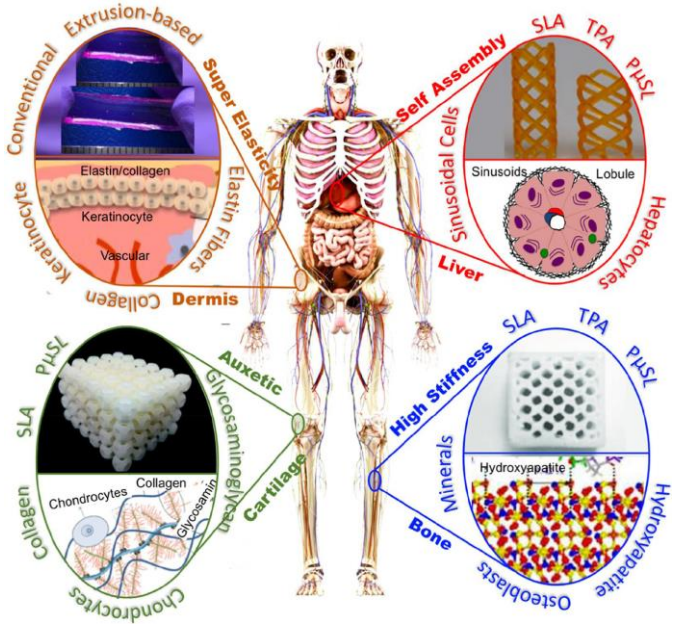
Micro-environment



Bissell & Barcellos-Hoff, *J. Cell Sci. Suppl.* 1987

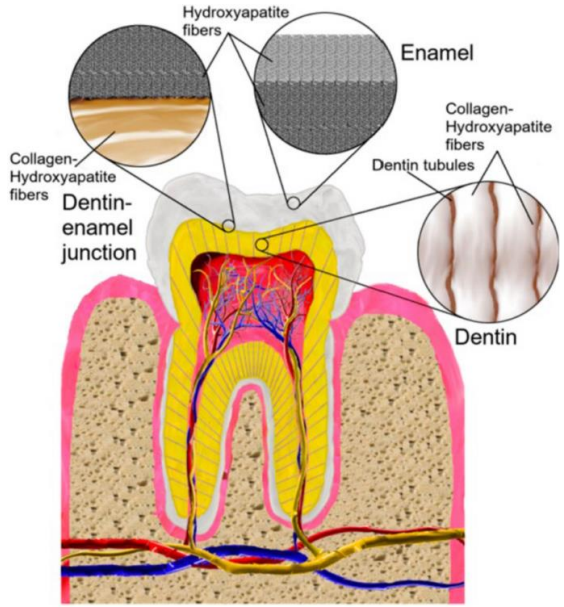
Applicative biomechanical research: tissue engineering and transplants

Tissue engineering



Dogan et al., *Applied Materials Today* 2020

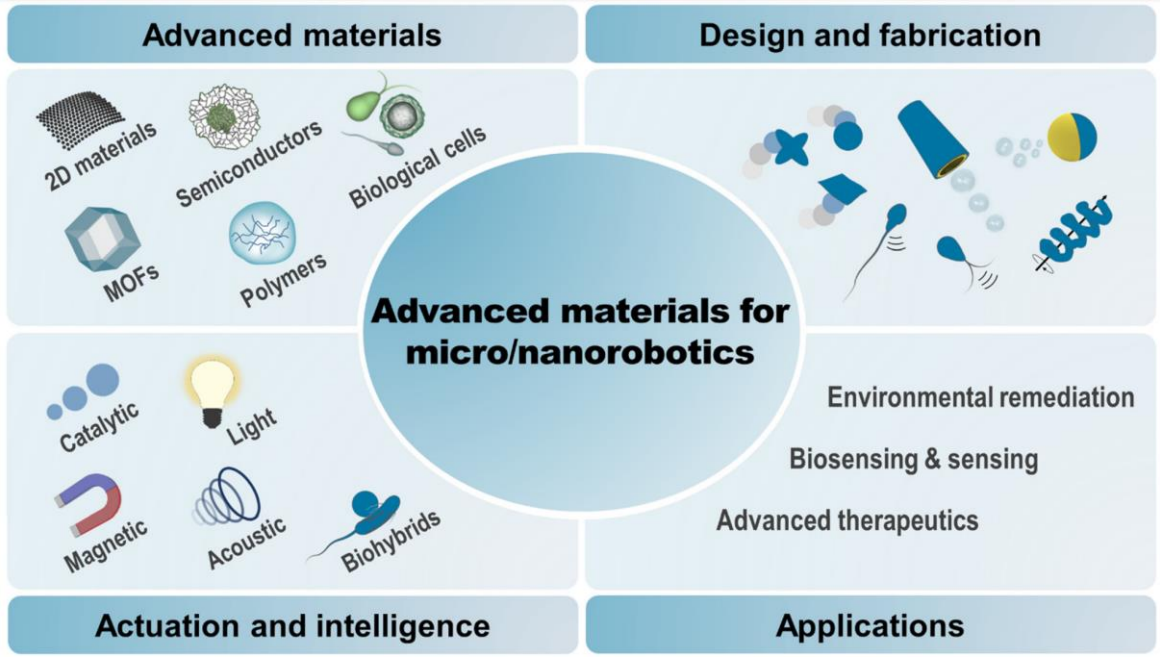
Dental medicine



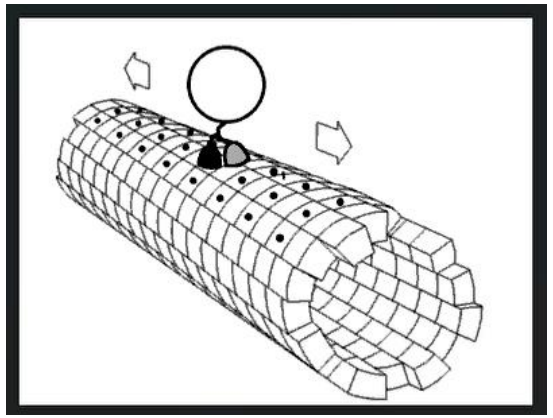
Alsuraif et al. *Beni-Suef Univ J Basic Appl Sci* 2024

Applicative biomechanical research: nano / micro robotics

Nano / micro robotics



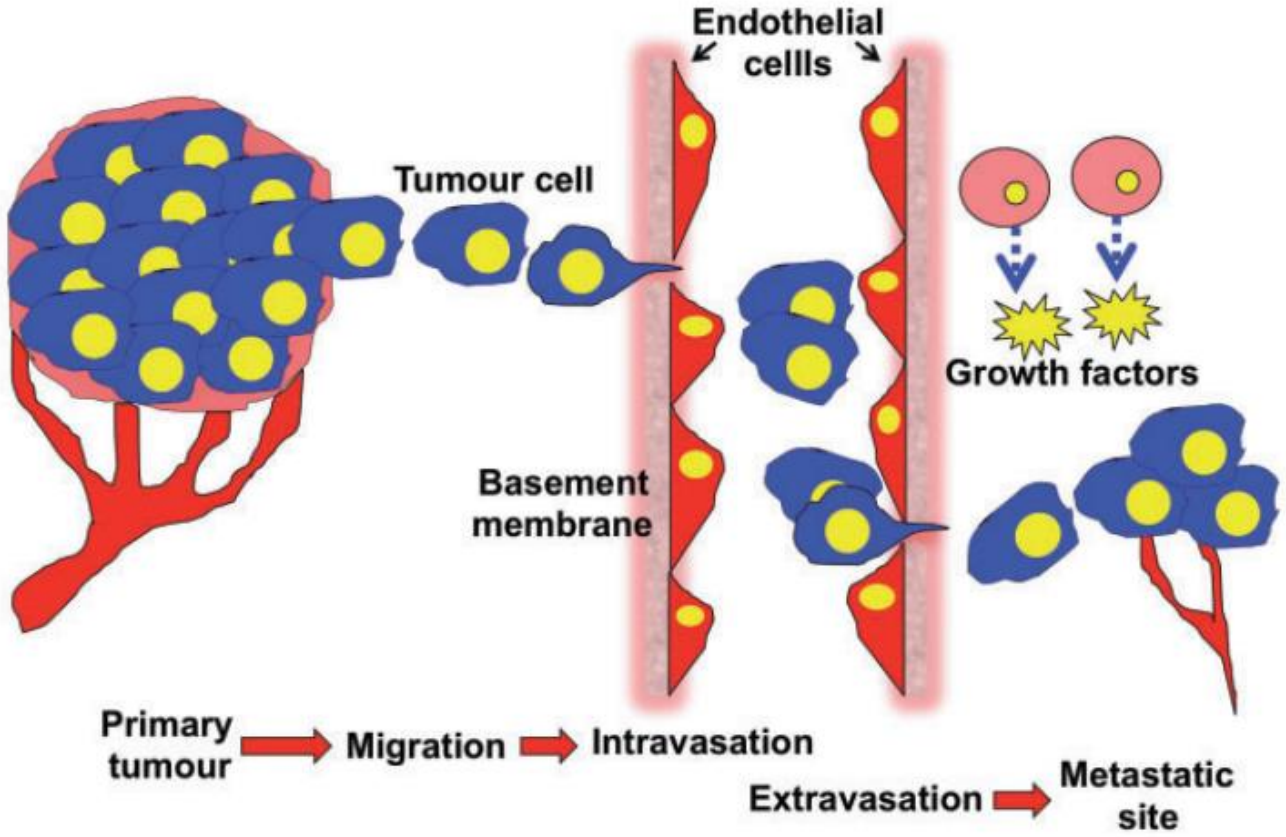
Kim et al., *Chem. Soc. Rev.* 2024



Wikipedia

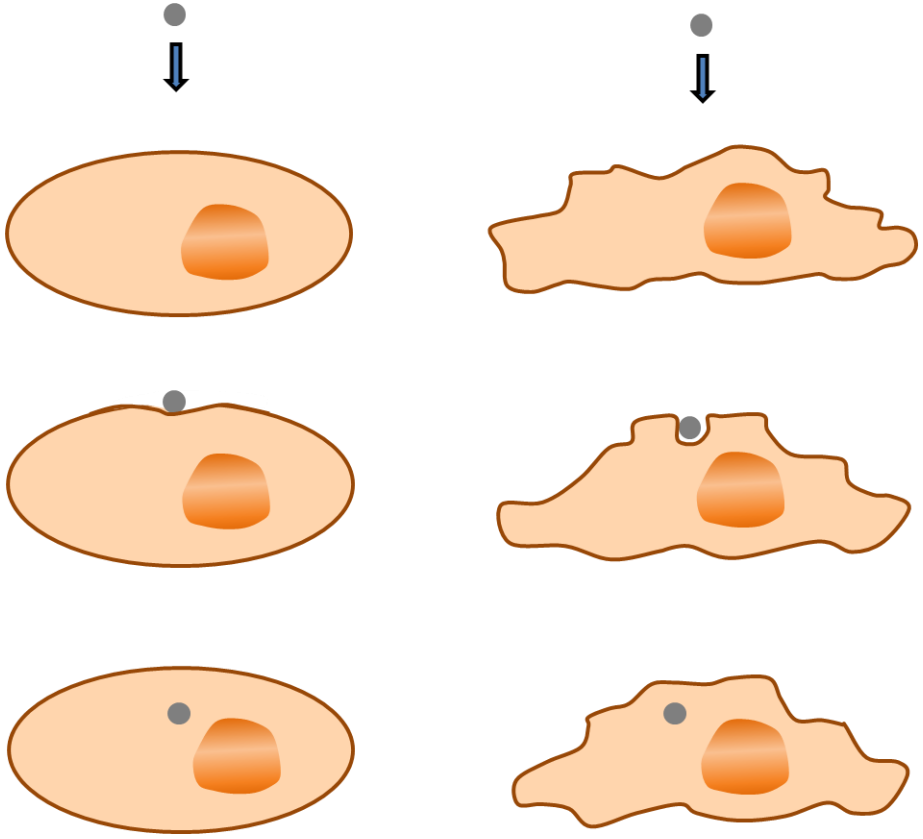
Applicative biomechanical research: cancer research

Cancer cells are more deformable than normal cells



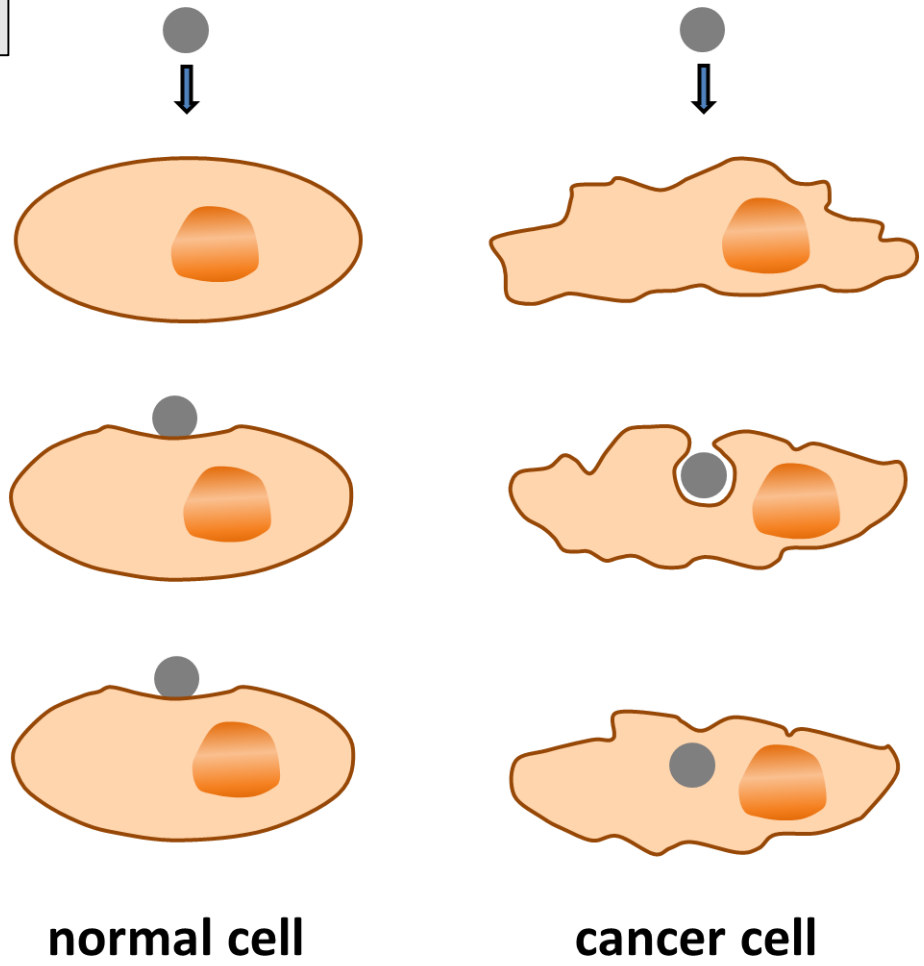
Fife CM et al., *British Journal of Pharmacology* 2014

Mechanical targeting in cancer therapy



Mechanical targeting in cancer therapy

Larger particles

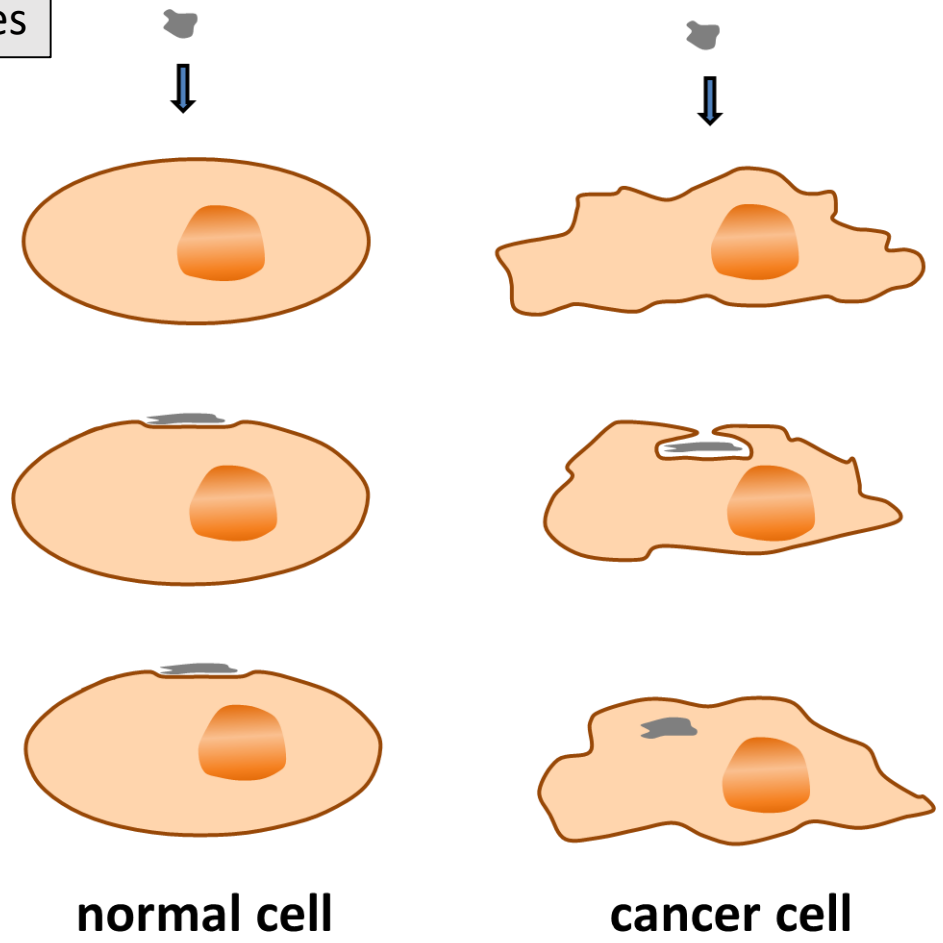


normal cell

cancer cell

Mechanical targeting in cancer therapy

Flexible particles



normal cell

cancer cell

Mechanical targeting in cancer therapy

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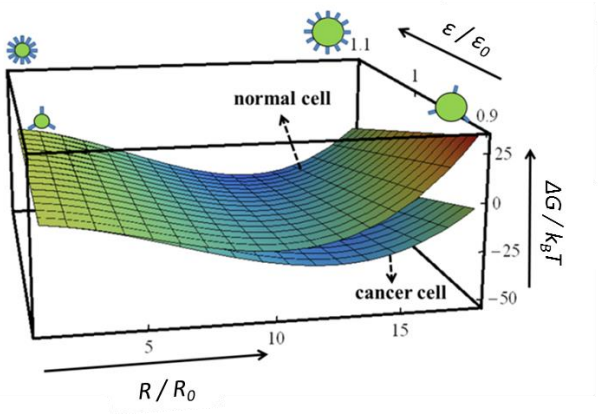
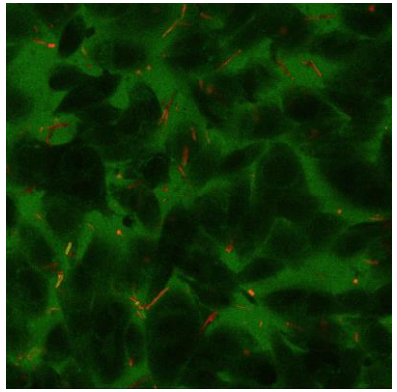
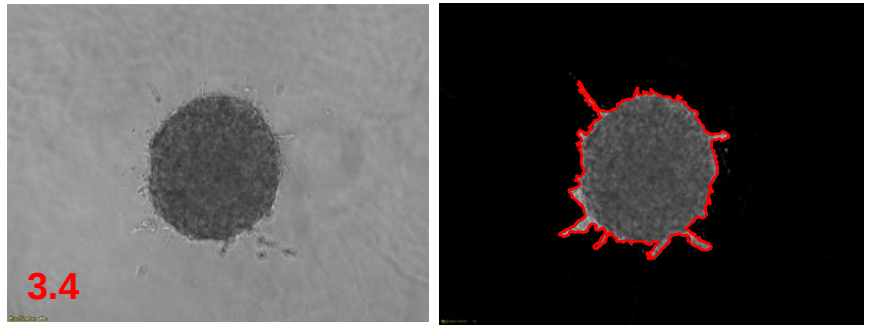
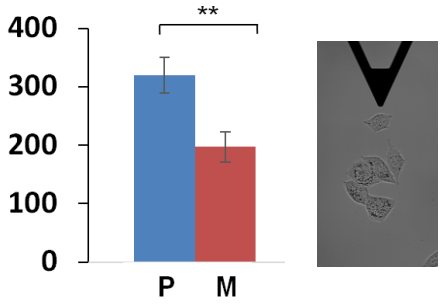


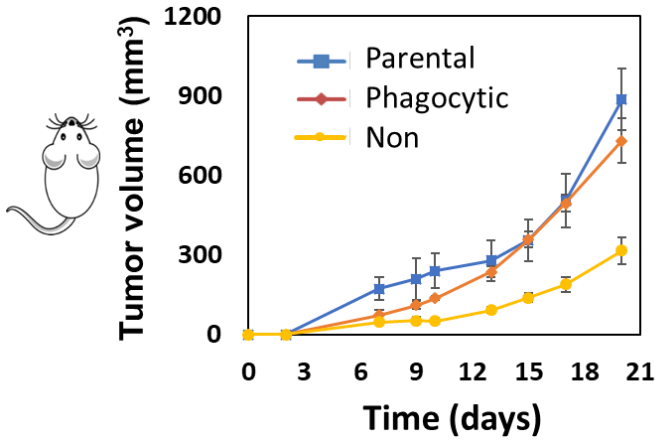


Primary

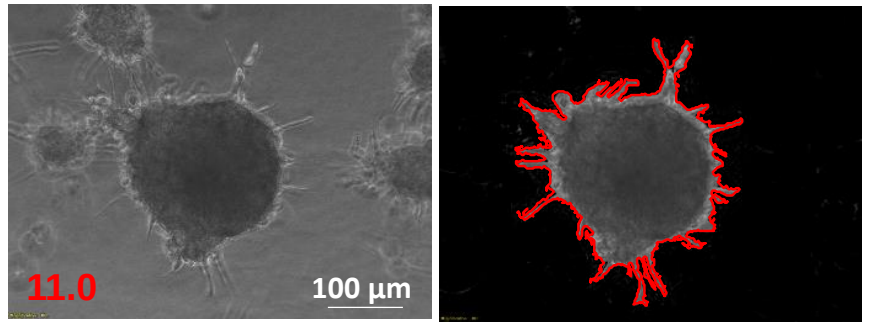


Young's modulus / Pa





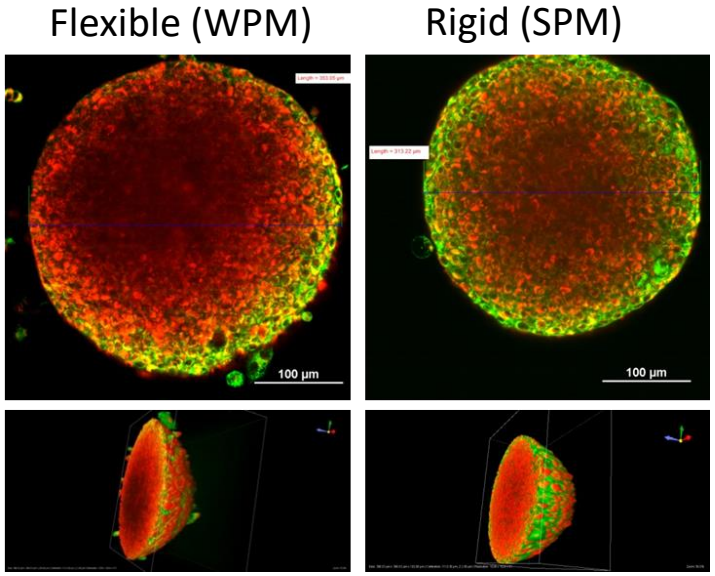
Metastatic

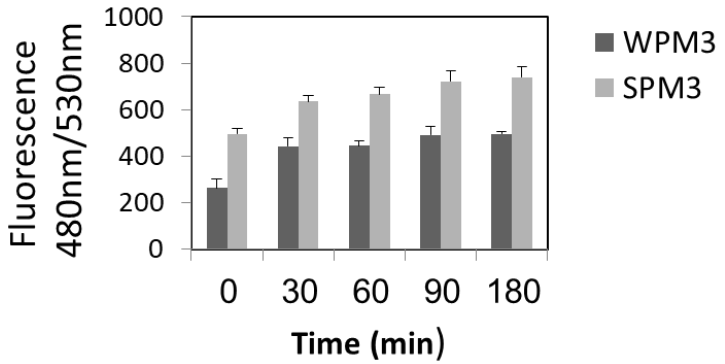


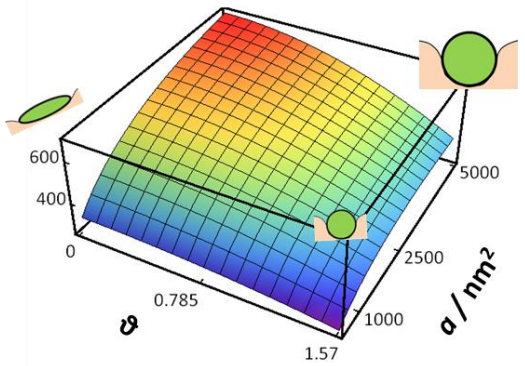
Brill-Karniely* et al., *Science Advances* 2020

Patented Technology-
Predictive diagnostics

Mechanical targeting in cancer therapy





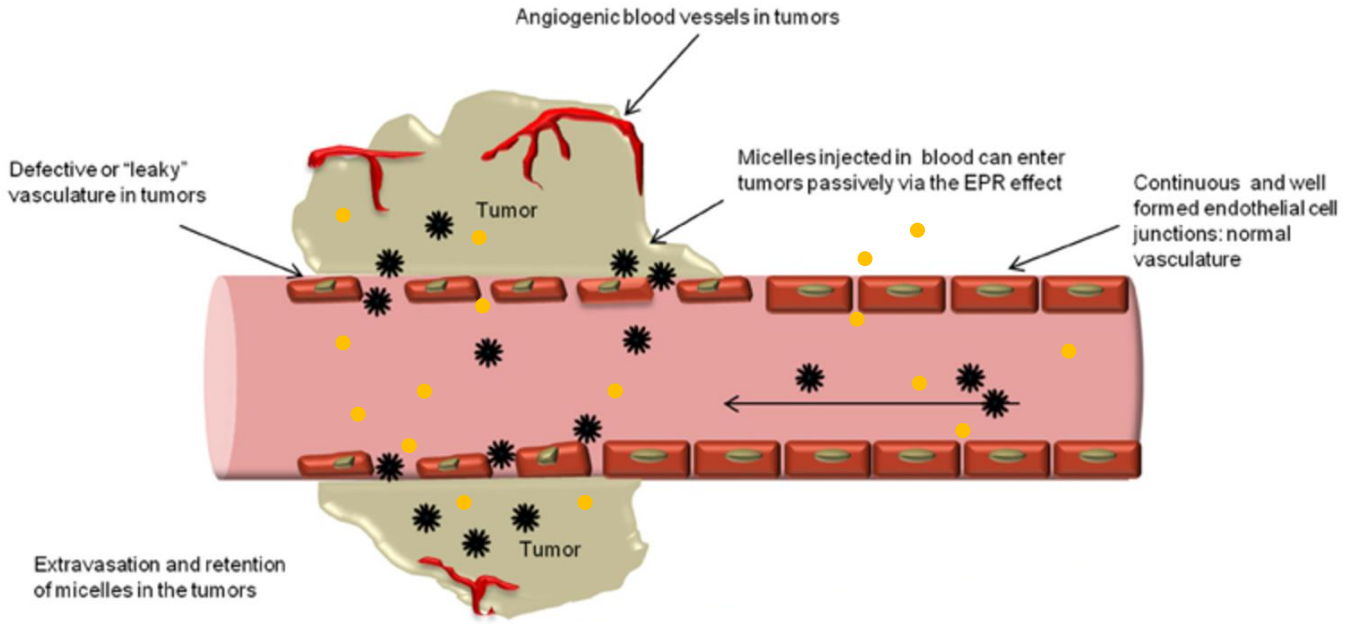


$$\Delta F = -\varepsilon \cdot a + 2\kappa_c(1 - cos\theta) + \kappa_r\sqrt{\frac{2a}{\pi(1-cos\theta)}} \cdot sin\vartheta$$

Stern T et al., *J Control Release* 2016

Patented Technology-
Predictive diagnostics

The Enhanced Permeability and Retention effect



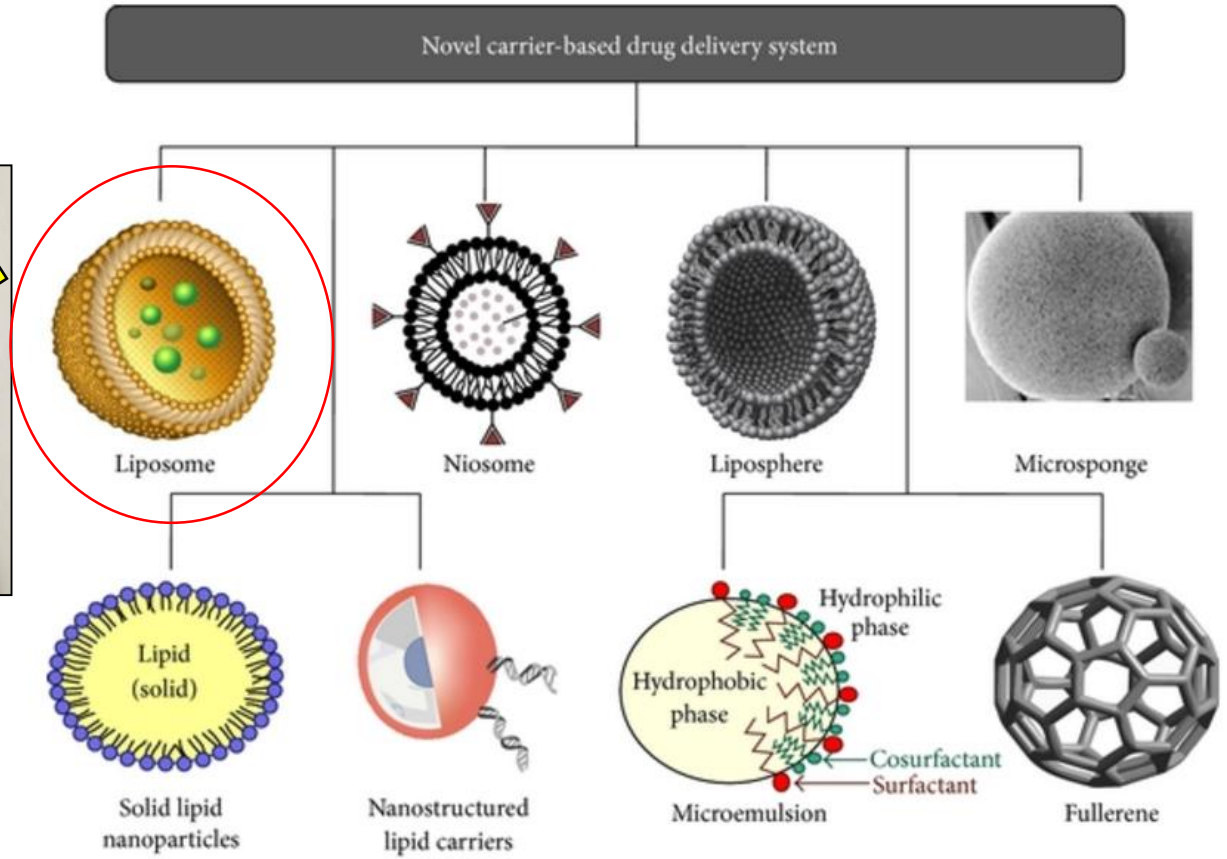
Jhaveri & Torchilin *Frontiers in Pharmacology* 2014

Enhanced **P**ermeability and **R**etention effect

Matsumura Y, Maeda H, 1986

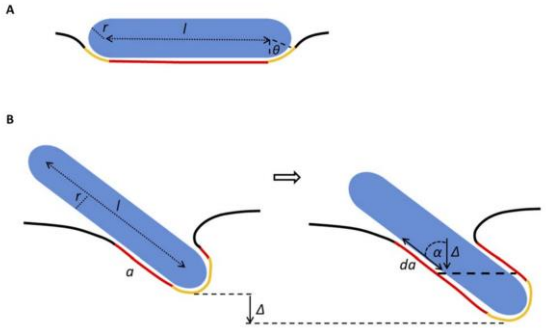
Drug delivery systems

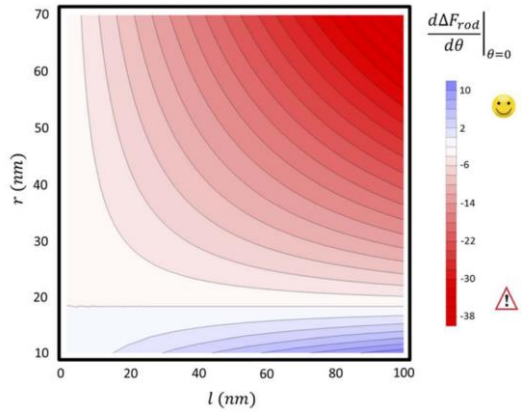
פרופ' יחזקאל ברנהולץ
פרופ' אלברטו גביזון

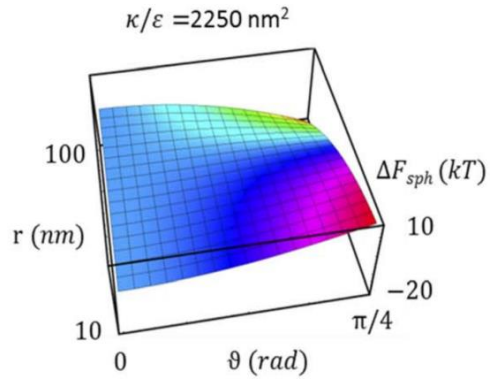


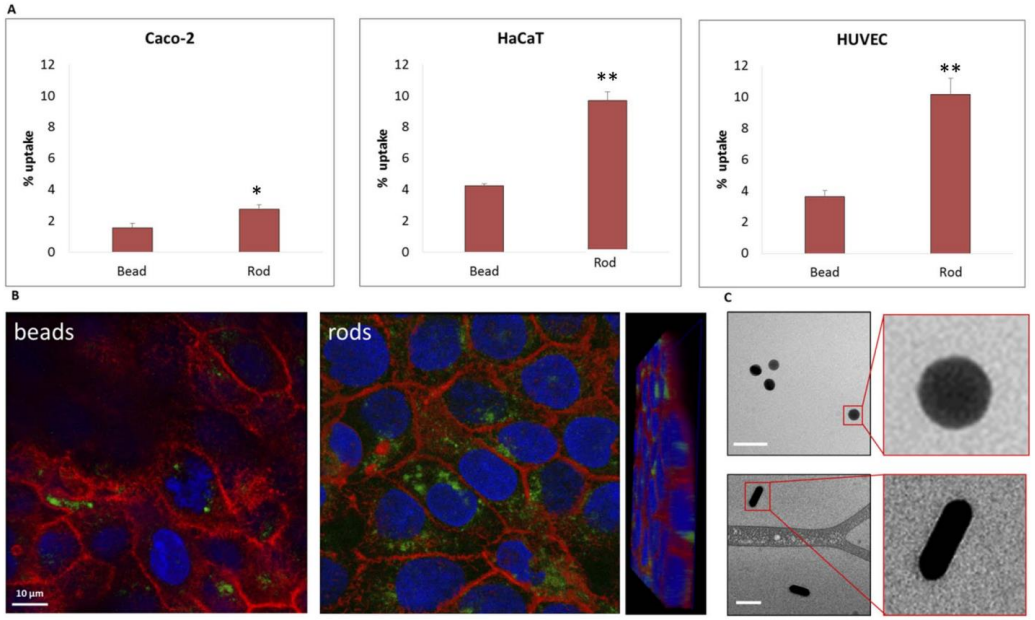
Vyas et al. *The Scientific World Journal* 2014

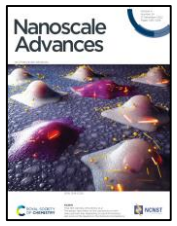
Cytotoxicity







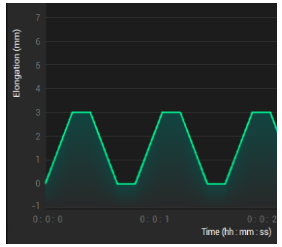




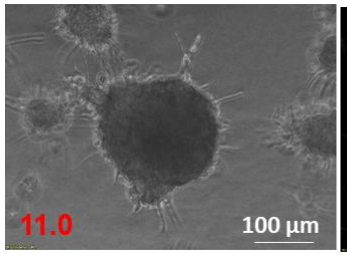
Brill-Karniely* et al., *Nanoscale Adv.* 2022

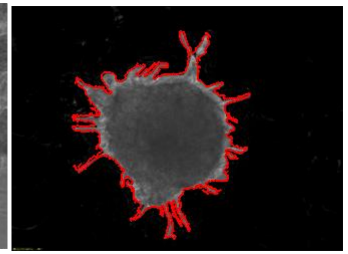
Outline

- Why are biomechanical aspects important in the study of bovine mammary glands?

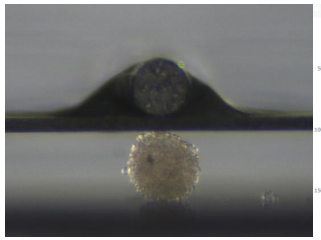


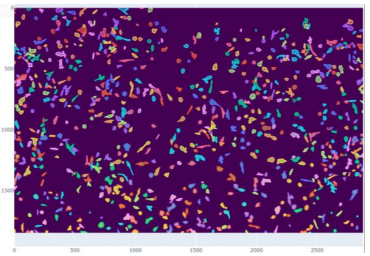
- Applicative biomechanical research





- Present research and perspectives





Vacuum forces during milking

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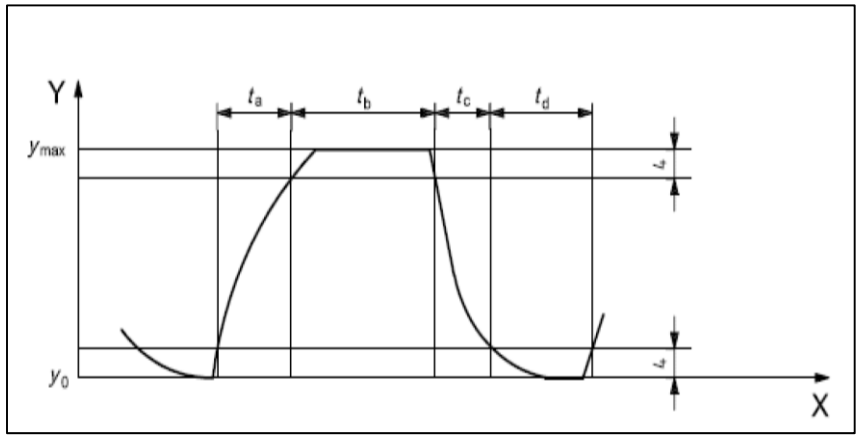
From a tour guided by Prof. Uzi Moallem (Volcani Inst.)



Israel recommendation for milking apparatus, Israel Dairy Board 2007

8.7 **ואקום ביחידת החליבה:**

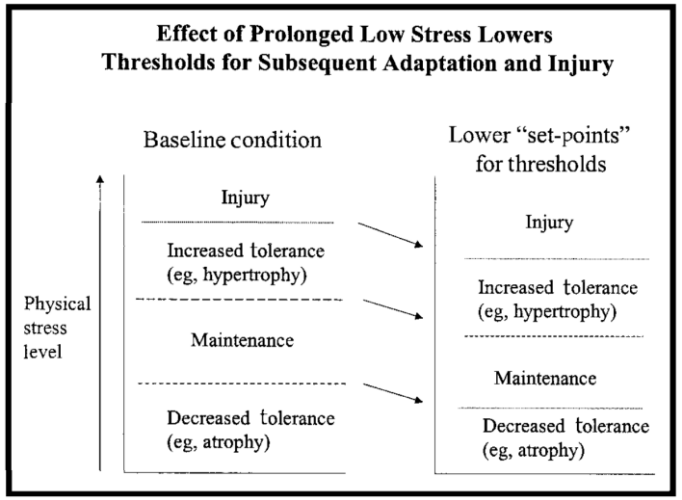
ההוראות למשתמש לחליבה יציינו, לקצב זרימה מוגדר (כאשר לפחות אחד מהנתונים בטבלה מס. 1 נבחר):

א. רמת הוואקום הממוצעת בבטנה ו \ או רמת הוואקום הממוצעת הרצויה בבטנה במשך שלב **B** ושלב **D** של הפעימה.

ב. רמת הוואקום הנומינלית המקבילה בקו החלב. רמת ואקום הנומינלית תהיה מבוססת על מפל הוואקום הממוצע כפי שנמדד בסעיף 8.6 בפרק ג'.

הערה: הן המחקר והן הנסיון בשדה מראים שרמת ואקום ממוצעת בבטנה בתחום שבין **42 kPa -ל 32 kPa** במשך שיא זרימת החלב בחליבה של פרות מבטיח כי רוב הפרות יחלבו במהירות, בעדינות והיטב. במקביל רמת

ההמלצות הישראליות למתקני חליבה, מאל"ה – מועצת החלב 2007



Mueller et al., Physical Therapy . Volume 82 . Number 4 . April 2002

In vivo: Effects of pulsation ratio and rate

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Effects of Pulsation Ratio, Pulsation Rate, and Teatcup Liner Design on Milking Rate and Milk Production

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Fresno 93702

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Department of Animal Science
California State University
Fresno 93740

SUZANNE STRASSER
Animal Science Extension
University of California
Davis 95616

TABLE 4. Least squares means by pulsation ratio.

Pulsation ratio	Fat %	Protein %	SCC (× 1000)	Total yield per milking	Machine-on time per milking
				(kg)	(min)
50:50	3.96	3.43	108	12.1[a]	8.44[a]
60:40	3.97	3.39	112	12.6[ab]	8.00[b]
70:30	4.09	3.44	105	12.6[b]	7.47[c]

	Average flow rate	Yield at 2 min		Fat yield	3.5% FCM per milking
	(kg/min)	(kg)	(%)		(kg)
50:50	1.5[a]	4.5[a]	38.7[a]	.48[a]	13.0[a]
60:40	1.6[b]	5.2[b]	42.2[b]	.49[ab]	13.4[ab]
70:30	1.7[c]	5.6[c]	45.5[c]	.52[b]	13.8[b]

[a,b,c]Means with different superscripts differ ($P < .05$).

Journal of Dairy Research (2009) **76** 272–277. © *Proprietors of Journal of Dairy Research 2009*
doi:10.1017/S0022029909003963 *Printed in the United Kingdom*

Milk flow-controlled changes of pulsation ratio and pulsation rate affect milking characteristics in dairy cows

Sarah Ambord and Rupert M Bruckmaier*

Veterinary Physiology, Vetsuisse Faculty, University of Bern, 3001 Bern, Switzerland

Received 24 September 2008; accepted for publication 12 January 2009; first published online 2 March 2009

Table 1. The milking machine settings and their changes when milked with milk flow-controlled b-phase

Milk flow rate, kg/min	Pulsation ratio	Pulsation rate, cycles/min	a-+b-phase, ms
0–2·0	60/40	55	655
2·0–2·5	63/37	53	713
2·5–3·0	65/35	51	765
3·0–3·5	68/32	48	850
3·5–4·0	70/30	45	933
4·0–4·5	73/27	43	1019
4·5–5·0	74/26	42	1057
5·0+	75/25	42	1071

Journal of Dairy Research (2015) **82** 453–459. © *Proprietors of Journal of Dairy Research 2015*
doi:10.1017/S0022029915000515

The effect of pulsation ratio on teat condition, milk somatic cell count and productivity in dairy cows in automatic milking

Sabine Ferneborg* and Kerstin Svennersten-Sjaunja

Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Sweden

Table 4. Milk yield, strip milk fat content and strip milk somatic cell count (SCC) in control (C) and treated (T) quarters after pulsation ratio treatments were applied, and p-values for the differences between pre- and post-treatment values. Values presented are mean ± SE, $n = 320$

	Milk yield (kg per udder half)		Fat content (% per udder half)		SCC† (×1000 cells/ml per quarter)		*P* values‡		
	C	T	C	T	C	T	Milk yield	Fat content	SCC
60:40	5·3 ± 0·1	5·3 ± 0·1	9·4 ± 0·3	8·9 ± 0·3	4·90 ± 0·05 (79)	4·95 ± 0·05 (89)	0·21	0·17	0·13
70:30	5·3 ± 0·1	5·3 ± 0·1	9·1 ± 0·3	9·0 ± 0·3	5·04 ± 0·05 (110)	4·96 ± 0·05 (91)	0·54	0·86	0·69
75:25	5·6 ± 0·1	5·8 ± 0·1	8·7 ± 0·2	9·0 ± 0·2	5·12 ± 0·05 (132)	5·16 ± 0·05 (144)	0·54	0·40	0·54

†Somatic cell count, Log_{10} values with antilog values within brackets
‡Statistical significance of the difference between quarters compared with pre-treatment

Relationship of Pulsation Rate, Pulsation Ratio, and Vacuum Decrease Time to Milking Performance[1]

M. B. ROSEN, E. V. CARUOLO, and R. D. MOCHRIE
Department of Animal Science

D. A. DICKEY
Department of Statistics
North Carolina State University
Raleigh 27650

TABLE 2. Effect of static pulsation ratio on milking.

Variable	n[1]	Ratio 40:60	50:50	60:40	70:30	SE
Time to reach peak rate, min	48	2.03[a]	1.79[ab]	1.60[ab]	1.26[b]	.146
Peak rate, kg/min	48	.61[a]	.69[b]	.78[c]	.85[d]	.015
Average rate, kg/min	48	.48[a]	.55[b]	.61[c]	.66[d]	.011
Machine time, min	48	5.08[a]	4.41[b]	4.02[c]	3.64[d]	.084
Machine yield, kg	48	2.28	2.28	2.26	2.24	.011
Stripping yield, kg	48	.04[a]	.05[a]	.05[a]	.07[b]	.004
Total yield, kg	48	2.31	2.32	2.31	2.31	.011
Fat percent of total yield	48	4.10	4.15	4.12	4.13	.017

[a,b,c,d]Means with different superscripts differ by Honestly Significant Difference ($P<.05$).
[1] Number of observations in each mean.

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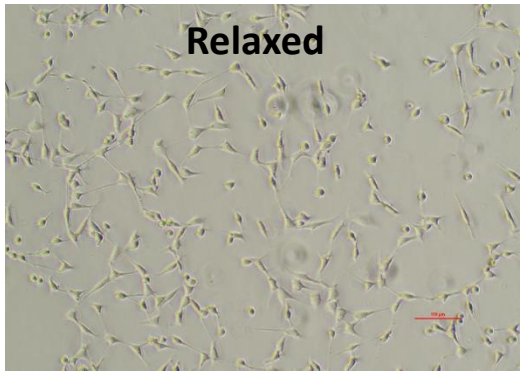
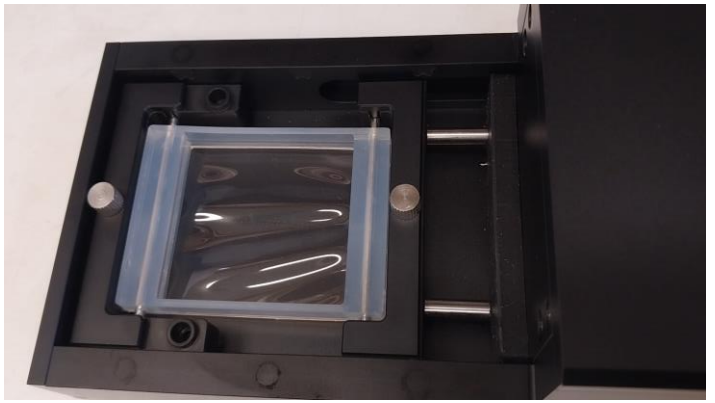
An *in vitro* model of stretching pulses during milking

Guy Dabby





CytoStretcher (CuriBio)

ISRAEL DAIRY BOARD

L1 bovine mammary epithelial cells generously provided by Prof. Itamar Barash (Volcani Inst.):
German and Barash, *In Vitro Cell Dev Biol – Animal* 2002

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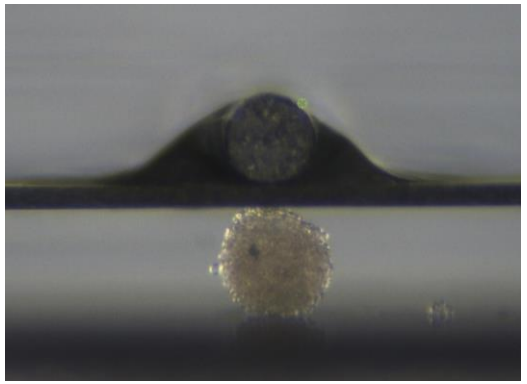
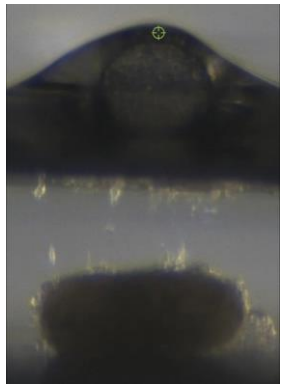
Acute compression of bovine MEC spheres

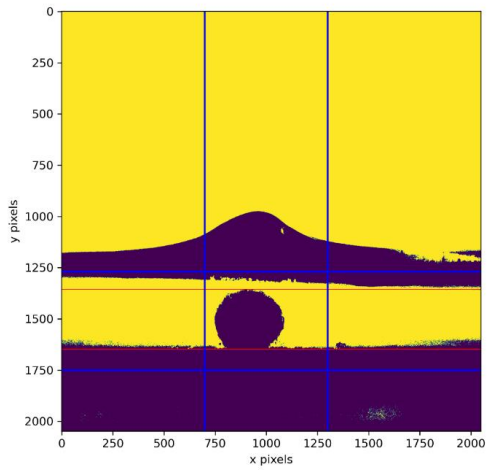
Nir Zaharoni

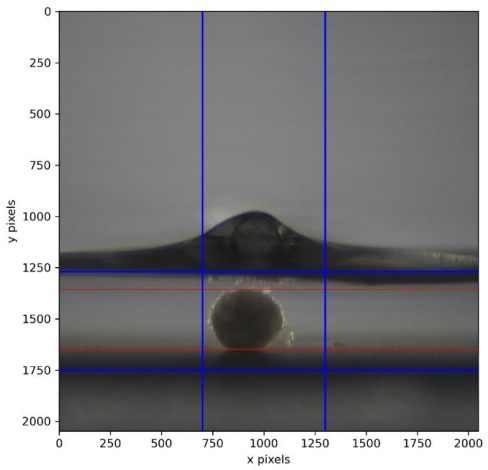
Acute compression

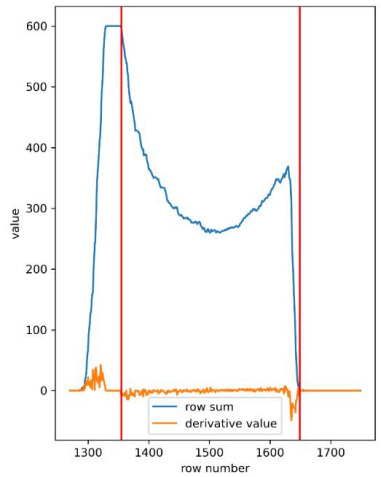


Partial recovery

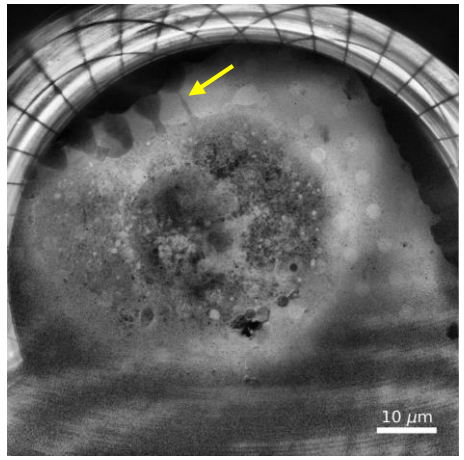


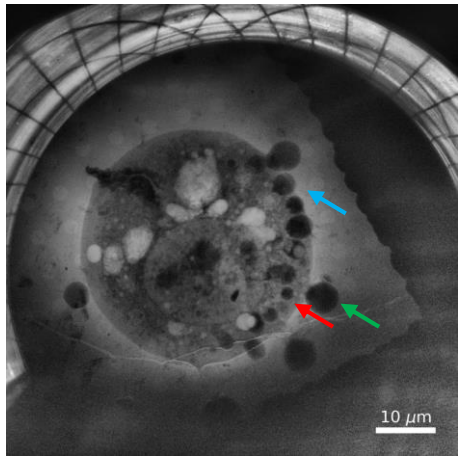


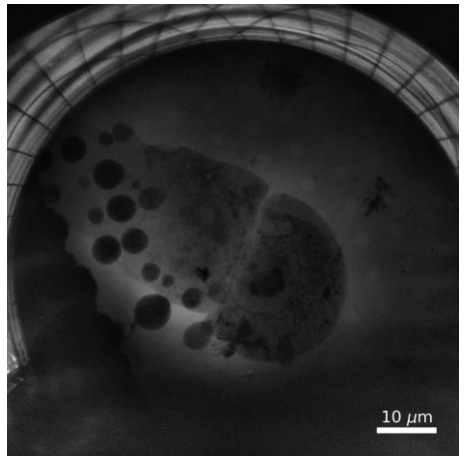


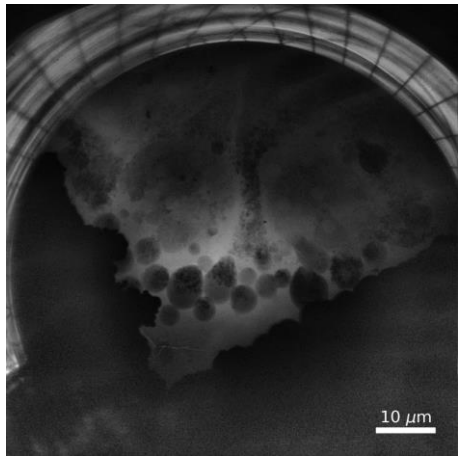


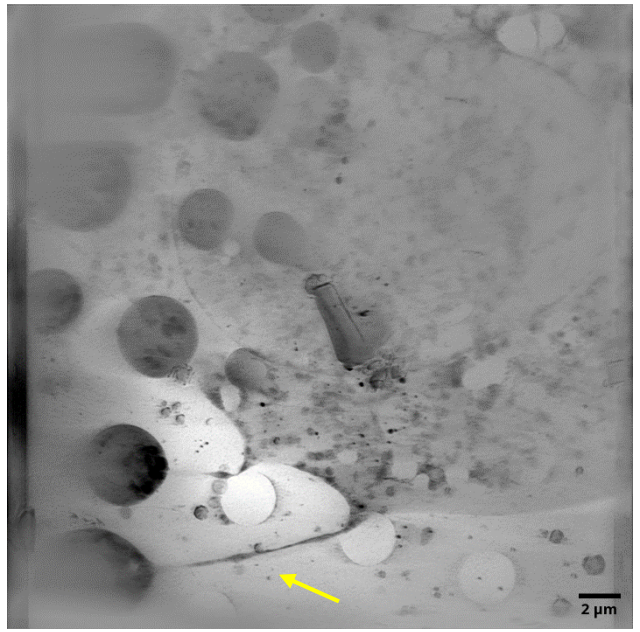
Milk fat globules secreted by bovine MECs: cryo soft X-ray tomography











Prof. Michael Elbaum
Weizmann Institute of Science

Dr. Sergey Kapishnikov
SiriusXT Ltd., Dublin

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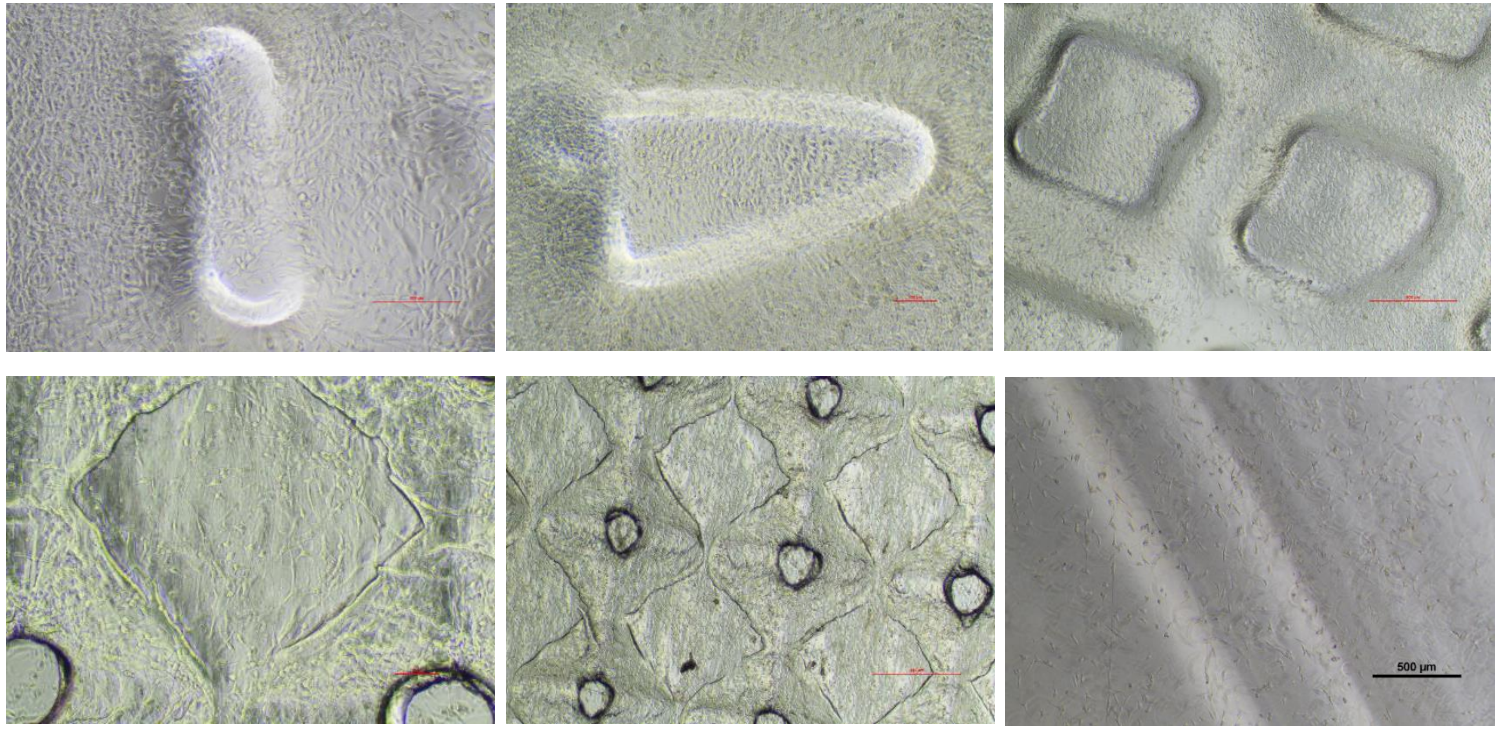
Culture topography



State of Israel
Ministry of Agriculture
Food Security &
Chief Scientist Office

משרד החקלאות וביטחון המזון

מדינת ישראל
משרד החקלאות
וביטחון המזון
לשכת המדען הראשי

Summary

- Holistic approach that involves mechanical aspects can make significant contribution to udder research.
- In other fields such research is at the forefront of various application developments.

Thanks you