Matthieu Piel
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Our team studies different processes happening in the cell: cell migration, cell volume/mass regulation, cell division. We are interested by processes involving the cytoskeleton, organelles and their relation with mechanosensitivity. We develop and use innovative tools based on nano and micro-fabrication techniques, to control and modulate the main physical and chemical parameters of the cell micro-environment.

These tools are coupled with high quality quantitative microscopy, and used alongside molecular and cell biology techniques, to obtain a quantitative description of the cell behavior. As well as highlighting new basic concepts about cell behavior, our multidisciplinary approach leads to the development of novel tools with potential applications in biomedical research.

The focus of our current research is how cells proliferate and migrate when space is limited. We want to understand how cells (immune cells and cancer cells) can produce efficient motion under confinement and squeeze through small holes. We also want to understand how physical constrains affect dividing cells.

Our current project on cell proliferation under external constrains has been awarded an **ERC Consolidator grant** in 2012.

M. Piel is author of more than 100 publications (H index 50) with more than 9300 citations. He holds three patents, and is a co-founder of the CYTOO Company. He is teaching at the Center for Interdisciplinary Research. He also teaches cell biology and biophysics in several master courses in Paris. He is one of the founder of Institut Pierre-Gilles de Gennes for Microfluidics. He has been invited to over 60 international meetings and gave over 40 seminars in the last 5 years. He was awarded the Bronze medal of CNRS in 2012.

Here is a video that we produced for the ASCB about the life of a dendritic cell:

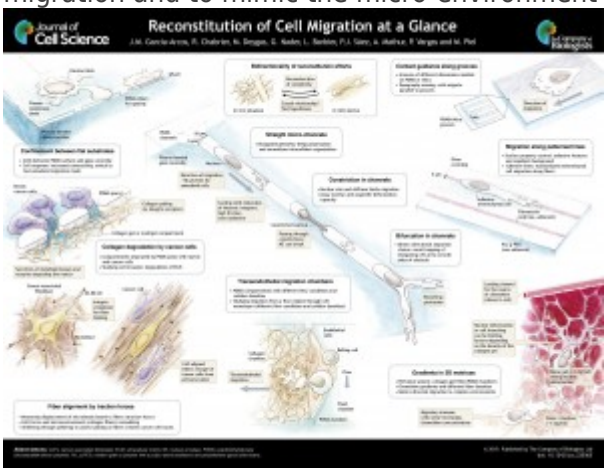
ASCB Celldance 2016 – Piel from ASCB on Vimeo.

Techniques and tools we created and use:

- **Micropatterning:** We have demonstrated that micro-patterns of extra-cellular matrix molecules are able to determine the polarity and division axis of cultured cells (see publication). This discovery was patented and licensed to a start-up company (CYTOO, created

in 2008) and we have kept developing this technology.

- **Microchannels:** We use microfabricated channels (see method publication) to study cell migration and to mimic the micro-environment of the cell in the body. See poster below.



- **Confinement devices:** We developed tools to confine the cell to very low height and we have exploited them to understand how mechanical constrains affect cell division and migration.
- **Cell volume measurement:** We published a technique to measure precisely the cell volume with exclusion fluorescence (see publication) and showed that mammalian cells swell during mitosis (see publication).

Members of the team:

-  **Aastha Mathur** (postdoctoral researcher): Mechanics of 3D cell motility using reduced system.
-  **Larisa Venkova** (PhD student): Cell volume regulation in response to deformations.
-  **Nishit Srivastava** (postdoctoral researcher): Cell growth and size homeostatis with single-cell mass and volume measurements.
-  **Guilherme Nader** (postdoctoral researcher): Probing the consequences of the loss

of nuclear envelope integrity caused by nuclear deformation in confined microenvironments.

-  **Juan Manuel García Arcos** (PhD student): Bleb morphogenesis and bleb stabilization in confined cancer cells.

Subgroup: MOTILE (Mechanobiology Of Trans-Migration in Leukocytes) team headed by Pablo Vargas

Since 2016, **Pablo Vargas** is part of the team as a permanent researcher (CR1 INSERM). His main interests are in understanding the mechanics behind the efficient migration of cells between distant organs. To do that, his group is using leukocytes specialized for migration in complex microenvironments.

-  **Lucie Barbier** (PhD student): Mechanosensing via intracellular membranes.
-  **Pablo Saez** (postdoctoral researcher): Integration of physical and mechanical cues during chemotaxis.
-  **Mathieu Deygas** (postdoctoral researcher): Integration of biochemical signals during migration in 3D microenvironments.
-  **Bianca Calí** (postdoctoral researcher): Nuclear dynamics during leukocyte migration.

Students both in our team and in another team:

-  **Ido Lavi** (PhD student): Theoritical analysis of cell migration, with the team of Raphaël Voituriez (UMR 7600 Sorbonne Université).
-  **Valentin Laplaud** (PhD student): Probing the cortex of the cell with magnetic tools, with the team of Olivia Du Roure (ESPCI).
-  **Zahraa Al Raies** (PhD student): The role of nuclear envelope integrity in aging, with the team of Ana-Maria Lennon-Duménil (U932/INSERM/Institut Curie).
-  **Kostiantyn Breiev** (PhD student): Creating production ready cell confinement devices. In collaboration with the 4DCell company.
-  **Alice Williart** (master student): Impact of mechanical state of nuclear envelope on HIV infection. In collaboration with the team of Nicolas Manel (U932/INSERM/Institut Curie).

Key publications

Year of publication 2018

Clotilde Cadart, Sylvain Monnier, Jacopo Grilli, Pablo J Sáez, Nishit Srivastava, Rafaele Attia, Emmanuel Terriac, Buzz Baum, Marco Cosentino-Lagomarsino, Matthieu Piel (2018 Aug 18)
Size control in mammalian cells involves modulation of both growth rate and cell cycle duration.
Nature communications : 3275 : DOI : 10.1038/s41467-018-05393-0

Year of publication 2016

M Raab, M Gentili, H de Belly, H R Thiam, P Vargas, A J Jimenez, F Lautenschlaeger, Raphaël Voituriez, A M Lennon-Duménil, N Manel, M Piel (2016 Apr 15)

ESCRT III repairs nuclear envelope ruptures during cell migration to limit DNA damage and cell death
Science (New York, N.Y.) : DOI : 10.1126/science.aad7611

Hawa-Racine Thiam, Pablo Vargas, Nicolas Carpi, Carolina Lage Crespo, Matthew Raab, Emmanuel Terriac, Megan C King, Jordan Jacobelli, Arthur S Alberts, Theresia Stradal, Ana-Maria Lennon-Dumenil, Matthieu Piel (2016 Mar 16)
Perinuclear Arp2/3-driven actin polymerization enables nuclear deformation to facilitate cell migration through complex environments.
Nature communications : 10997 : DOI : 10.1038/ncomms10997

Pablo Vargas, Paolo Maiuri, Marine Bretou, Pablo J Sáez, Paolo Pierobon, Mathieu Maurin, Mélanie Chabaud, Danielle Lankar, Dorian Obino, Emmanuel Terriac, Matthew Raab, Hawa-Racine Thiam, Thomas Brocker, Susan M Kitchen-Goosen, Arthur S Alberts, Praveen Sunareni, Sheng Xia, Rong Li, Raphael Voituriez, Matthieu Piel, Ana-Maria Lennon-Duménil (2016 Jan 8)
Innate control of actin nucleation determines two distinct migration behaviours in dendritic cells.
Nature cell biology : 43-53 : DOI : 10.1038/ncb3284

Year of publication 2015

Paolo Maiuri, Jean-François Rupprecht, Stefan Wieser, Verena Ruprecht, Olivier Bénichou, Nicolas Carpi, Mathieu Coppey, Simon De Beco, Nir Gov, Carl-Philipp Heisenberg, Carolina Lage Crespo, Franziska Lautenschlaeger, Maël Le Berre, Ana-Maria Lennon-Dumenil, Matthew Raab, Hawa-Racine Thiam, Matthieu Piel, Michael Sixt, Raphaël Voituriez (2015 Apr 9)
Actin flows mediate a universal coupling between cell speed and cell persistence.
Cell : 374-86 : DOI : 10.1016/j.cell.2015.01.056

Yan-Jun Liu, Maël Le Berre, Franziska Lautenschlaeger, Paolo Maiuri, Andrew Callan-Jones, Mélina Heuzé, Tohru Takaki, Raphaël Voituriez, Matthieu Piel (2015 Feb 12)
Confinement and low adhesion induce fast amoeboid migration of slow mesenchymal cells.
Cell : 659-72 : DOI : 10.1016/j.cell.2015.01.007