Measuring cell dry mass with Quantitative Phase Imaging

Application note

Obtaining quantitative data on cell morphology and dynamics is critical in live-cell imaging. Many of the cell reactions are reflected in the change of cell dry mass (content of proteins, nucleic acids, lipids, ...). Cell dry mass is therefore a sensitive parameter for the evaluation of cell condition. Changes in cell dry mass can signal changes in cell metabolism, viability, unique cell behavior and rare cell event that would otherwise require the employment of fluorescent imaging or remain unspotted. QPI enables direct measurement of cell dry mass in pg/µm² and thus allows reliable analysis of sensitive cellular parameters completely non-invasively. With QPI, previously unseen dynamic changes in the cell's life can be explored.

Cell dry mass

Apart from water, which represents approximately 70% of the cell mass, live cells are made of many essential biomolecules. All non-water cell content is called the **cell dry mass**. It includes mostly proteins and lipids, but other components also contribute (see Fig. 1) [1].

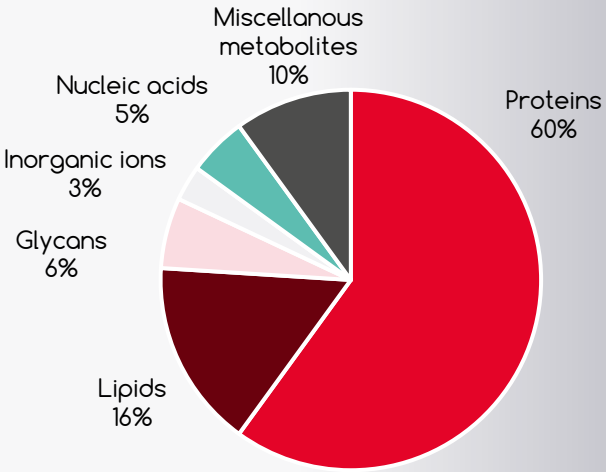


Fig. 1: Cell dry mass composition.

Sensitive indicator of cell status

The sum of biomolecules directly reflects cell status. It is closely linked to **cell metabolism, cell cycle, cell growth** and crucial cell events like **division** or **death**.

Moreover, the transfer of mass plays a crucial role during **cell movement** because it enables the cell to migrate and for example to metastasize.

Cell dry mass as a new label-free testing parameter

Cell dry mass is also a precise tool for monitoring cell reactions to experimental conditions like drug testing etc. It is highly relevant for example in cancer research where cell cycle aberrations or cell death induction are targeted.

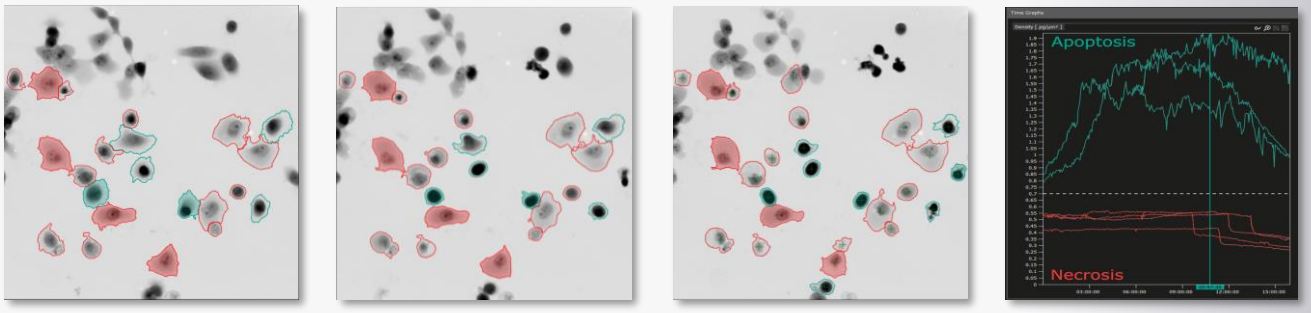


Fig. 2: Cell grouping based on the cell dry mass density [pg/µm²] changes: Two cell categories can be distinguished without fluorescent staying: cells dying via apoptosis (turquoise) with increased cell density and cells dying via necrosis (red) with stable cell density followed by a sudden decrease corresponding to the membrane rupture.

Application note

Cell dry mass monitoring

Progression through the cell cycle is one of the most fundamental features of cells. Q-Phase is a label-free quantitative tool for precise detection of the different effects elicited by drugs, chemical agents, growth factors and media on cellular growth along the cell cycle. A single experiment using Q-Phase provides information-rich data about the cell cycle on both individual cell and cell population levels which helps to identify symmetrical and asymmetrical cell division, cell cycle inhibition, doubling time or to detect a subpopulation that can escape the chemotherapeutic cytotoxic effect.

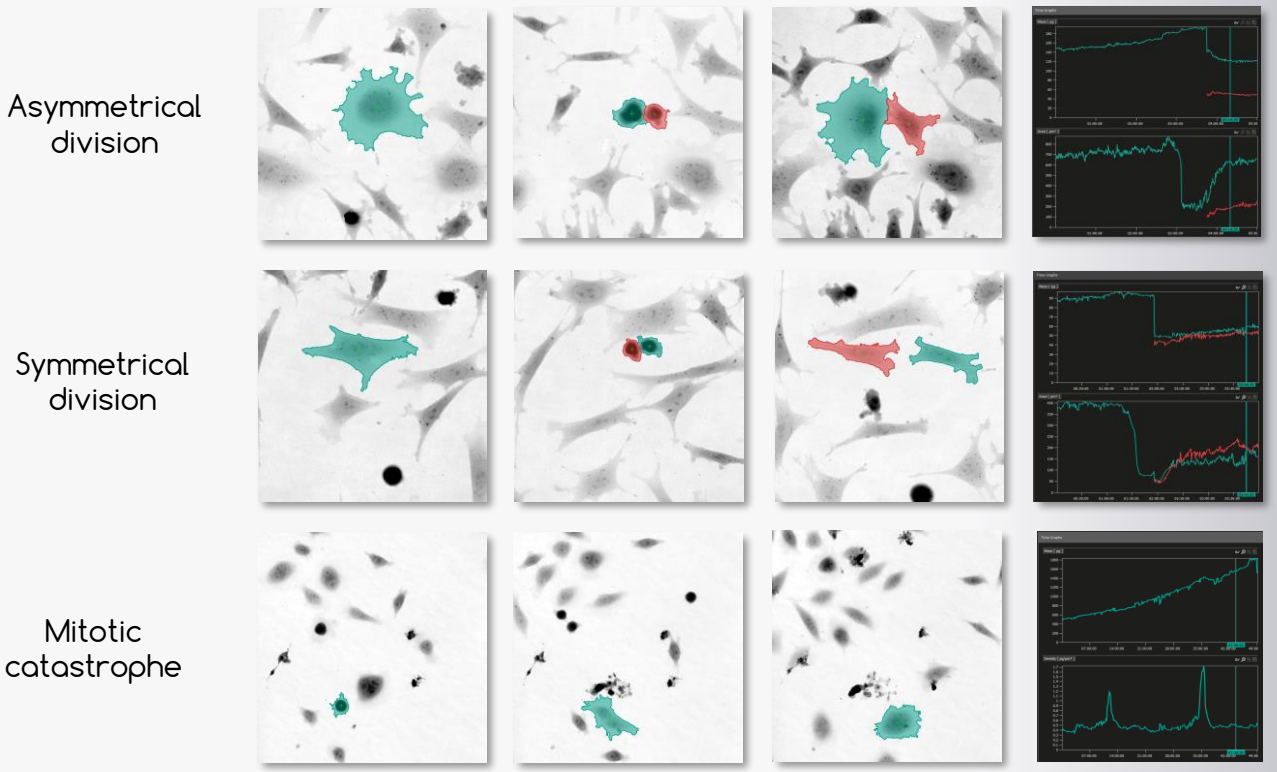
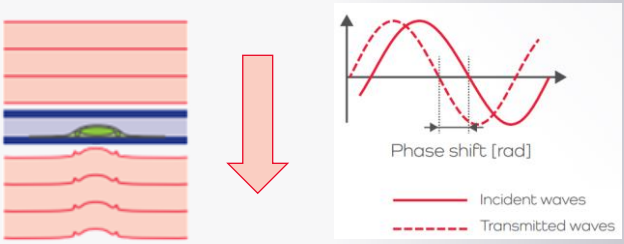


Fig. 3: Quantitative monitoring of cell cycle events.
Time graphs display changes in cell dry mass (upper graphs) and corresponding cell density (lower graphs) during key cellular processes.

Principle behind Q-Phase

Telight Q-Phase is an inverted transmission light microscope based on the technology called **Quantitative Phase Imaging**. In every pixel of acquired images, the system allows real-time quantification of the phase shift of the light waves transmitted through studied objects.

From the detected phase shift values, cell dry mass can be calculated according to the equation on the right [2]. **Q-Phase thus enables real-time measurement of cell dry mass – a unique cellular parameter.**



$$m = \frac{\varphi\lambda}{2\pi\alpha}$$

φ ... detected phase value [rad]
λ ... wavelength [µm] (λ = 660 nm in Q-Phase)
$\mathbf{m}$ = cell dry mass density [pg/µm^2]
α = specific refraction increment [0.18 µm^3/pg]

Q-Phase is a valuable tool for live cell imaging, designed for direct and precise cell dry mass quantification. Together with its segmentation software, it alllows automated analysis of the hidden life of cells.

References

[1] Prescher, J. A., & Bertozzi, C. R. (2005). Chemistry in living systems. *Nature chemical biology*, 1(1), 13-21. http://doi.org/10.1038/nchembio0605-13

[2] Wayne, R. O. (2014). *Light and video microscopy*, 2nd ed. Academic Press. Chapter 6 – Methods of Generating Contrast. http://doi.org/10.1016/B978-0-12-411484-5.00006-8.

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