



# Editorial: Quantitative Phase Imaging and Its Applications to Biophysics, Biology, and Medicine

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## Editorial on the Research Topic

### Quantitative Phase Imaging and Its Applications to Biophysics, Biology, and Medicine

Label-free imaging capability has played an important role throughout the history of microscopy, and it is also crucial for many research fields, including neuroscience and stem cell studies. From the invention of phase-contrast microscopy by Zernike [1], the refractive index has been exploited for label-free high-contrast imaging of unlabeled live biological cells and tissues. The development of a series of label-free imaging techniques, including differential interference microscopy [2] and reflection interference contrast microscopy [3], has dramatically expanded the applicability of microscopy for the precise investigation of the morphology of cells and subcellular organelles.

Recent developments in quantitative phase imaging (QPI) [4] have highly expanded the applicability of the refractive index as a reporter for advanced biological studies [5]. By directly and quantitatively measuring refractive index distributions or optical phase delay information, QPI provides various pieces of morphological and biophysical information about live cells and tissues, generating a series of new methods for cell biology [6, 7], biophysics [8], reproductive science [9–11], infectious diseases [12], hematology [10, 13], and neuroscience [14, 15].

This Special Research Topic includes a collection of research results that push the frontiers of QPI to new areas and applications. The articles collected in this Research Topic can be categorized into three classes. The first sub-topic introduces new optical developments in QPI (Linarès-Loyez et al.; Lu et al.). The second sub-topic presents novel experimental methodology exploiting refractive index information (Bélanger et al.; Cohoe et al.). The third sub-topic features applications in biology and medicine (Hu et al.; Murray et al., Memmolo et al.; Yaikova et al.).

The first sub-topic starts with a study that presents a method for live super-resolution imaging and single-particle tracking in 3D. Linarès-Loyez et al. present a method that utilizes quantitative intensity and phase imaging in the formation of fluorescent self-interference. Lu et al. demonstrate a simple but powerful QPI method using an optical diffuser. By exploiting optical memory effects, the quantitative phase information is retrieved from a measurement of speckle patterns.

The papers in the second sub-topic present new approaches that utilize QPI. Bélanger et al. report an experimental method for measuring cell volumes using QPI and a low-cost, open-source, and 3D-printed flow chamber. Cohoe et al. demonstrate a label-free imaging approach for the study of protozoa. The optical phase delay images were measured at multiple wavelengths, which were utilized for effectively addressing a phase unwrapping issue in QPI.

The third sub-topic features new research results in the study of biology and medicine. Memmolo et al. present biophysical studies of red blood cells (RBCs) using QPI and a microfluidic

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device. RBCs demonstrate remarkable deformability, which is crucial for them to pass through small capillaries in physiological conditions. The deformability of RBCs is strongly correlated with the pathophysiology of various diseases, but access to it requires complicated and low-throughput conventional methods. In this work, the shapes of RBCs and their responses to flow conditions were quantitatively measured and analyzed. Hu et al. report measurements of collagen fiber organization in tissue using spatial light interference microscopy. They compared the collagen fiber organization in tissue affected by pelvic organ prolapse to asymptomatic controls (Hu et al.). Murray et al. address an important problem in cancer diagnosis and treatment using QPI. They present a QPI-based *in vitro* drug screening method for identifying evolving resistance at an early stage in order to help make better clinical decisions for cancer therapies. Yaikova et al. present an algorithm to analyze bone tissue images by automatically differentiating

objects based on their image signals and recovering their morphological topology.

In sum, this Research Topic features eight excellent research reports encompassing the methodology of QPI and its applications in biology and medicine. The editors appreciate the contributions of all of the authors. Every year, an increasing number of interesting research papers in QPI have been reported, ranging from new optical methodologies and biological applications to the potential for clinical diagnosis. It is our hope that this special topic will further accelerate the scientific advancements in QPI and its practical applications in biology and medicine.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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