Preface

From a physical perspective, self-propulsion is a fundamental characteristic of living matter. The term "active matter" refers to entities that utilize energy for locomotion, and it has rapidly evolved into a significant subfield within non-equilibrium physics. Swimming and flying in fluids have long been classical subjects in the field of biofluid dynamics. However, owing to the advancements in active matter physics, these disciplines within biofluid research have become fresh frontiers in the realm of nonlinear and non-equilibrium physics, both in terms of theoretical and experimental investigations. In Japan, workshops at the Research Institute for Mathematical Sciences (RIMS) at Kyoto University have focused on the physics of biofluid locomotion since 2012. The criticality of integrating conventional biofluid problems with biological responses to environmental stimuli such as chemicals and light, and their algorithms dominating their responses have been acknowledged. The significance of this research is highlighted by the success of the RIMS visiting research project "Mathematical Biofluid Mechanics" and activities in a JSPS KAKENHI project "Ethological Dynamics in Diorama Environments" in grant-in-aid for transformative research areas (A).

In this special topics compilation, we present comprehensive reviews by leading researchers, which provide in-depth insights into recent advances for understanding the physics underlying the locomotion, control, and maneuvering of entities that swim and fly. These areas, along with their underlying algorithms, have received limited coverage within the JPSJ. The articles in this special topics compilation encompass various aspects of the field and employ diverse methodologies, including theoretical analyses, numerical simulations, laboratory experiments, and field studies. Special emphasis is placed on advancements in "mechanisms of flying and swimming" in fluids such as air and water, "navigation" to reach destinations in different environments, "collective behaviors" of individual active agents as they interact, "adaptive locomotion" to adapt to environmental changes, and "control and maneuvering" of locomotion for purposes such as feeding and predation.

The topics explored in this special topics collection span a wide spectrum of length scales, from the microscale realm of cellular swimming in experimental (Nishiguchi), theoretical (Yasuda, Hosaka, and Komura) and computational (Omori and Ishikawa) explorations, up to the realm of flying insects (Nakata; Kolomenskiy), flying bats (Teshima, Fujioka, and Hiryu), and avian movement at ecological scales (Goto and Yoda). Furthermore, various approaches are highlighted, which range from the nonlinear dynamics of elastic filaments (Radisson and Kanso), control theory and its application in biofluid locomotion (Moreau), to the ethological dynamics of amoeba and microalgae (Nishigami, Kunita, Sato, and Nakagaki).

These diverse research domains emphasize the intriguing aspects of biofluid locomotion and simultaneously demonstrate the potential to unveil the universal physical principles that govern locomotion mechanisms and survival strategies. Through this special topics collection, we aim to provide guidelines for further advancement, evoke interest both within and beyond the physics community, and contribute significantly to the broader development of physics.

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