

## Description of Additional Supplementary Files

**File name:** Supplementary Movie 1

**Description:** Swimming of *T. thermophila* recorded by only one focal plane observation using normal optical microscope. This movie shows the trajectory of the swimming cell, which appears to different observers to be following either a right- or left-handed helical path due to an optical illusion, for ~7.8 seconds (22 ms intervals,  $\times 0.5$  actual speed). The image is 234  $\mu\text{m}$  high and 277  $\mu\text{m}$  wide.

**File name:** Supplementary Movie 2

**Description:** Swimming of *T. thermophila* which intakes the fluorescent bead recorded by tPOT microscope. This movie shows both sides of the field of view split by the prism of tPOT microscope for ~1.3 seconds (11 ms intervals,  $\times 1$  actual speed). The image is 362  $\mu\text{m}$  high and 439  $\mu\text{m}$  wide.

**File name:** Supplementary Movie 3

**Description:** Swimming of *P. multimicronucleatum* recorded by only one focal plane observation using normal optical microscope. This movie shows the trajectory of the swimming cell, which appears to different observers to be following either a right- or left-handed helical path due to an optical illusion, for ~5.5 seconds (5.5 ms intervals,  $\times 1$  actual speed). The image is 668  $\mu\text{m}$  high and 446  $\mu\text{m}$  wide.

**File name:** Supplementary Movie 4

**Description:**  $\text{Ca}^{2+}$  stimulated backward swimming of *T. thermophila*. The cell (indicated by the red circle in the movie) swam backward along right-handed helical path and then forward along right-handed path. This movie shows only one side of the field of view imaged by tPOT microscope for ~12 seconds (11 ms intervals,  $\times 1$  actual speed). The image is 689  $\mu\text{m}$  high and 466  $\mu\text{m}$  wide.

**File name:** Supplementary Movie 5

**Description:**  $\text{Ca}^{2+}$  stimulated swimming pattern switching of *T. thermophila*. The cell (indicated by the red circle in the movie) swam backward along right-handed helical path, forward along left-handed path, backward again along right-handed helical path, and forward again along left-handed path. This movie shows only one side of the field of view imaged by tPOT microscope for ~13 seconds (11 ms intervals,  $\times 1$  actual speed). The image is 769  $\mu\text{m}$  high and 364  $\mu\text{m}$  wide.

**File name:** Supplementary Data 1

**Description:** Data used to generate the charts and graphs in the main figures.