# Chapter 9

# Appendix: Movie Captions

**Supplementary Movie 1**

The stroke cycle in a free-swimming juvenile moon jellyfish (Aurelia aurita) consists of a muscle-powered contraction phase (power stroke) followed by elastic recoil (recovery stroke).

#### 9.0.6.1 Supplementary Movie 2

Failure of biomimetically designed medusoid to contract and propel itself. The medusoid was stimulated at 1 Hz through an externally applied monophasic voltage square pulse (2.5 V/cm, 10 ms duration). Due to mismatch of muscle stresses and substrate compliance, muscle contraction does not result in sufficient bell deformation, and no thrust is generated.

**Supplementary Movie 3**

Optimally designed medusoid constructs exhibit jellyfish-like body contraction and propulsion. Medusoids were paced at 1 Hz through an externally applied monophasic voltage square pulse (2.5 V/cm, 10 ms duration). The first scene shows a mature construct still attached at its center to its acrylic template, just prior to release. Note that the striated appearance of the template is caused by its fabrication process; this striation does not reflect the alignment of the muscle tissue on top of the silicone membrane covering the template. Subsequent scenes show exemplary propulsion of free-swimming medusoids.

**Supplementary Movie 4**

Jellyfish and optimal medusoids achieve comparable propulsion efficacy (distance traveled per stroke), whereas suboptimal medusoids ("sieve design") exhibit inferior performance. While medusoids were paced at 1 Hz through an externally applied electric field (2.5 V/cm, 10 ms duration), in this particular scene the jellyfish contracts at a frequency of ca. 2 Hz. In order to facilitate comparison, the frame rate of the jellyfish recording was halved to synchronize stroke phases.

**Supplementary Movie 5**

Sequence of raw DPIV data of jellyfish, medusoid and suboptimally (= sieve-) designed medusoids. Here, fluid flow around the jellyfish/Medusoid bell is visualized by the displacement of neutrally buoyant particles suspended within the fluid and illuminated within a single plane using laser light. The relative motion of the particles allows quantifying 2-D fluid flow within the plane.

**Supplementary Movie 6**

Fluid flow field and vorticity field of a juvenile jellyfish during the stroke cycle. The movie was generated from DPIV data. The power stroke is characterized by maximal fluid velocities and formation of a starting vortex, generating thrust. The recovery stroke is characterized by reduced fluid velocities and the formation of a stopping vortex, generating feeding currents towards the subumbrellar side.

**Supplementary Movie 7**

Fluid flow field and vorticity field of an optimally designed medusoid during the stroke cycle. The movie was generated from DPIV data. As in the jellyfish, the power stroke generates maximal fluid velocities and a starting vortex ring, resulting in thrust. The recovery stroke generates a stopping vortex ring that draws feeding currents towards the subumbrella.

**Supplementary Movie 8**

Fluid flow field and vorticity field of a suboptimal medusoid design. The movie was generated from DPIV data. In contrast to jellyfish and optimal medusoids, suboptimal medusoids with "sieve design" fail to sufficiently accelerate fluid during the power stroke, resulting in poor thrust generation. Vorticity patterns are more diffuse compared to those observed in jellyfish and optimal designs, and further flow analysis revealed that generation of feeding currents was inferior as well.

**Supplementary Movie 9**

Spontaneous lappet contractions of medusoid construct are unsynchronized; external field stimulation (monophasic voltage square pulse, 2.5 V/cm, 10 ms duration) synchronizes muscle activation.

**Supplementary Movie 10**

Finite element simulation of cardiomyocyte-powered thin film contraction, adapted from original movie courteously provided by Jongmin Shim (c.f. Shim et al., 2012).

**Supplementary Movie 11**

Lobed medusoid design exhibits pronounced contraction but no propulsion.

**Supplementary Movie 12**

Tracking of angular speed of jellyfish lappets during stroke cycle. Displacement of labeled lappet tip relative to central reference pint is plotted as a function of time.

**Supplementary Movie 13**

Efficient propulsion: Ephyra reared at 13°C, swimming at 13°C water temperature, propels itself efficiently. The lobed geometry is suitable for propulsion due to boundary layer overlap that resists leakage through gap space and effectively extends paddle surface.

**Supplementary Movie 14**

Treading the water: Ephyra reared at 13°C, swimming at 21°C water temperature, fails to propel itself. The lobed geometry sieves through the fluid and is not suitable for propulsion at the lower viscosity of water at this temperature.