



清華大學  
Tsinghua University

# WAY FORWARD 2023

งานประชุมวิชาการ นักเรียนไทยในจีน ครั้งที่ 1

กาญจน์บัณฑิต เกษาคุปต์

MECHANICAL ENGINEERING, TSINGHUA UNIVERSITY

5 JUNE 2023

# SELF-INTRODUCTION



- กาญจน์บัณฑิต เกชาคุปต์ (Kechacoop Kanbodin)
- ประวัติการศึกษาโดยสังเขป
  - มัธยม : โรงเรียนสวนกุหลาบวิทยาลัย ประเทศไทย
  - ปริญญาตรี : Tohoku university, Sendai, Japan
- ปัจจุบัน : Tsinghua university, Beijing, China
  - Master degree
  - คณะ Mechanical Engineering

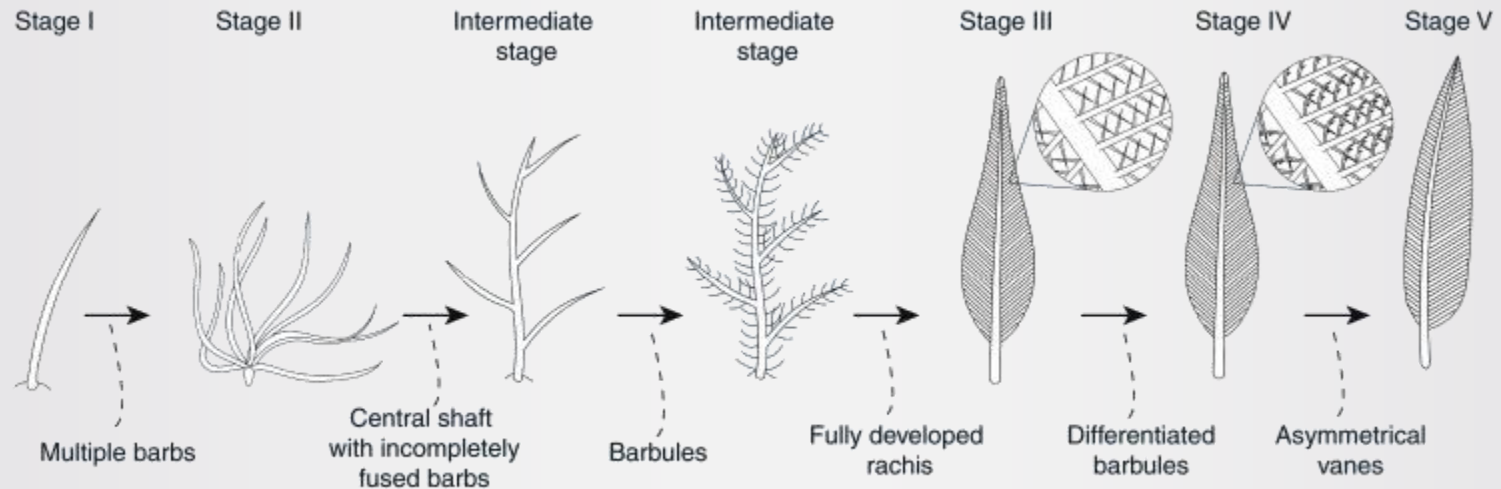


# RESEARCH DIRECTION

AERODYNAMIC EFFECT ON MICRO-STRUCTURES OF AVIAN FEATHER



# BACKGROUND



Current Biology

**Figure 1.** Stages of feather evolution

retrieved from Daniel T. Ksepka, Feathered dinosaurs, *Current Biology*, Volume 30, Issue 22, 2020, Pages R1347-R1353, ISSN 0960-9822, <https://doi.org/10.1016/j.cub.2020.10.007>.

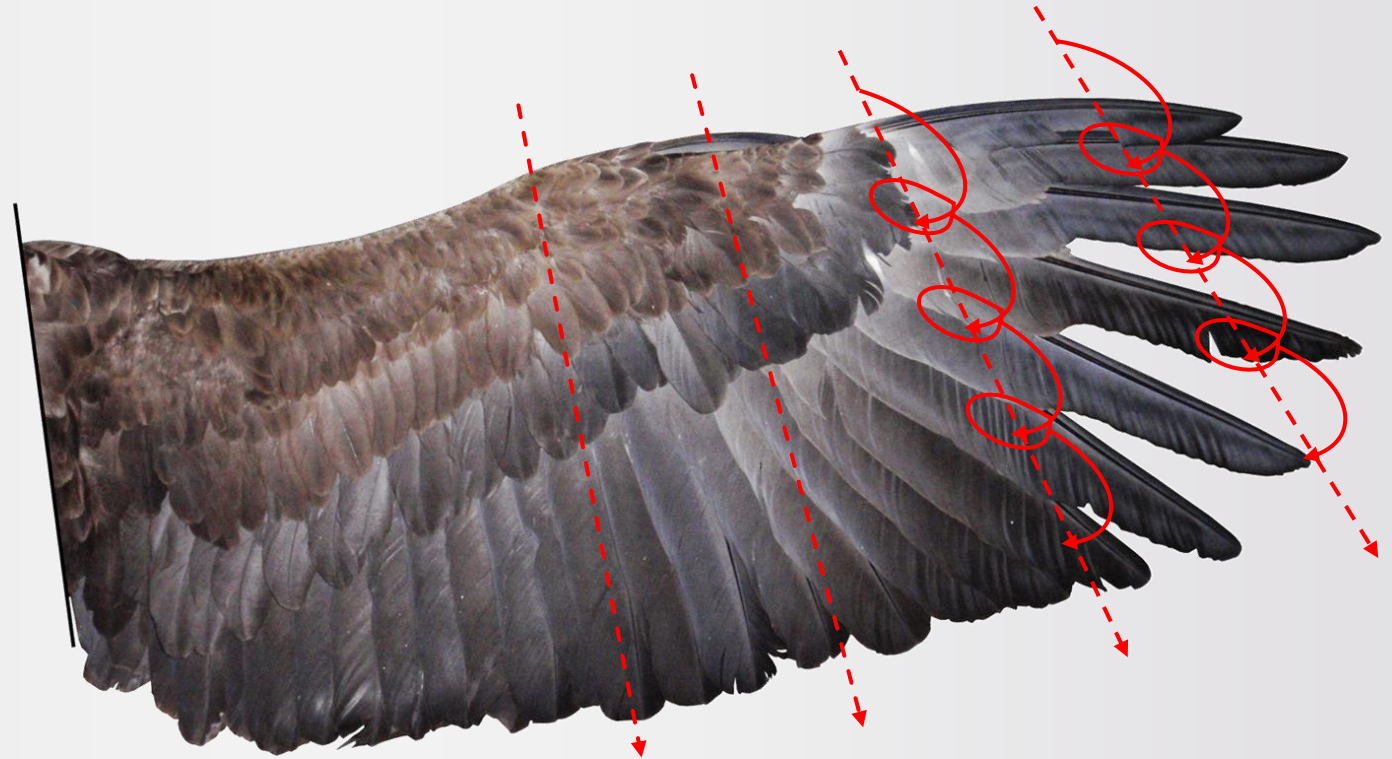
Feather, believed to first emerge during the late Jurassic to the early Cretaceous period [1,2], has been continuously evolving ever since and the current-day avian feather has been considered one of the most complex biological structures.

[1] Julia Clarke, Feathers Before Flight. *Science* **340**, 690-692(2013). DOI:[10.1126/science.1235463](https://doi.org/10.1126/science.1235463)

[2] Xu, X. Scales, feathers and dinosaurs. *Nature* **440**, 287-288 (2006). <https://doi.org/10.1038/440287a>



## BACKGROUND



**Fig 2.** | Wing of white-tailed eagle (*Haliaeetus albicilla*), showing the arrangement of feathers. Wing from a stuffed specimen at Bohusläns Museum in Uddevalla, Sweden. (2010, August 5). [https://en.wikipedia.org/wiki/Bird\\_wing#/media/File:H.\\_albicilla\\_wing.png](https://en.wikipedia.org/wiki/Bird_wing#/media/File:H._albicilla_wing.png)

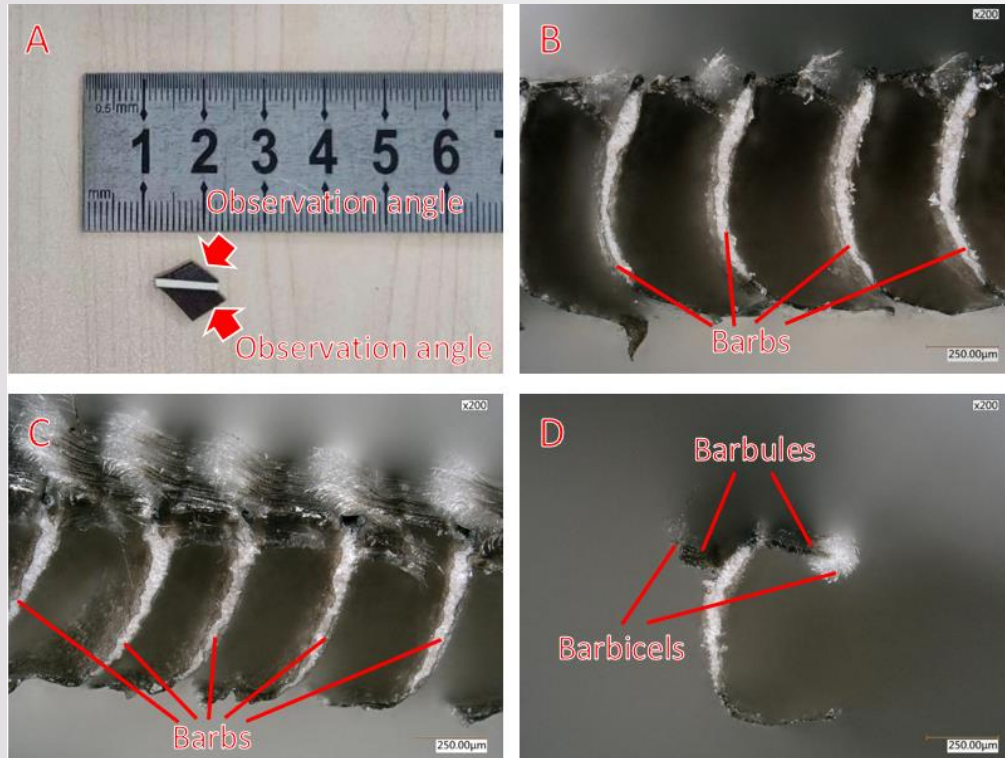
# MICRO-STRUCTURE OF AVIAN FEATHERS



- KEYENCE VHX-S650E
  - Free-angle observation system
- KEYENCE VH-ZST
  - Dual-objective zoom lens
  - Up to 2000x magnification power
- KEYENCE VHX-6000
  - Digital microscope controller
  - 1/1.8inch CMOS image sensor
  - Up to 50 fps



Figure 4 | Optical microscope system



**Figure 5** | Cross-sectional view of feather micro-structure

A) Sample used in cross-section microscopic observation B) Microscopic observation of cross-section view of barbs and barbules structure from leading vane C) Microscopic observation of cross-section view of barbs and barbules structure from trailing vane D) Microscopic observation of cross-section view of a single barb



**Figure 6** | Interaction of feather micro-structure when under the pressure from fluid flow

## MICRO-STRUCTURE OF AVIAN FEATHERS



# MICRO-STRUCTURE OF AVIAN FEATHERS

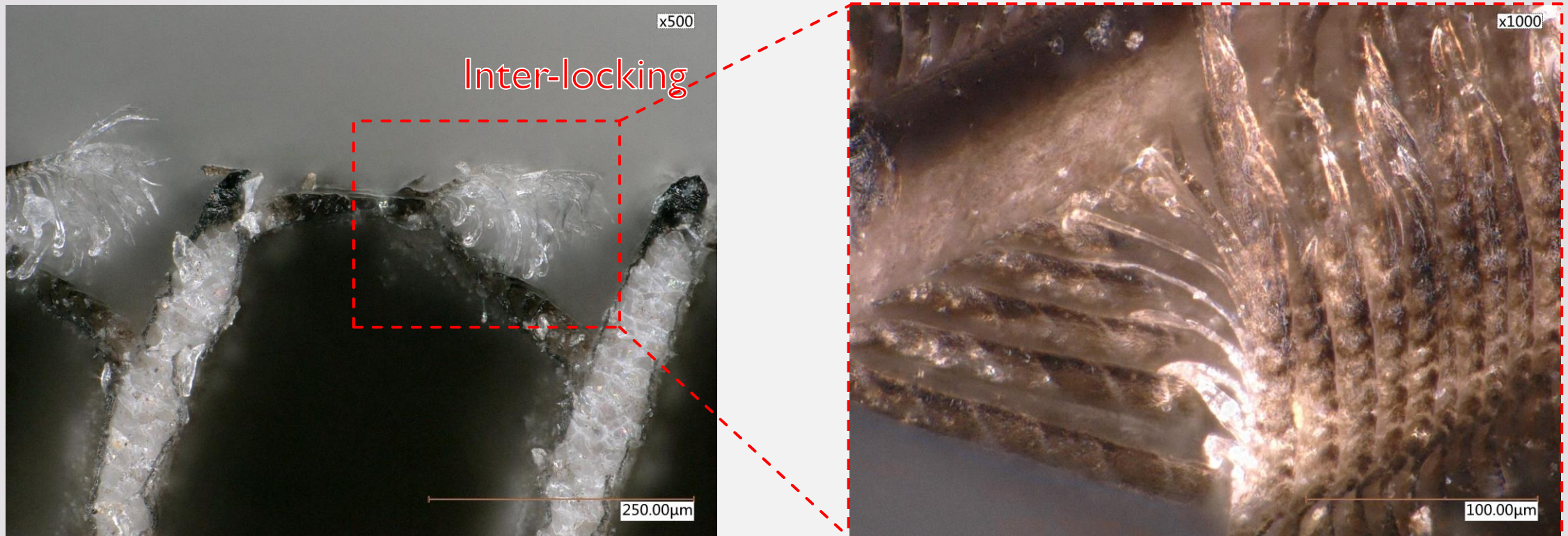


Figure 7. Interlocking motion of feather micro-structure



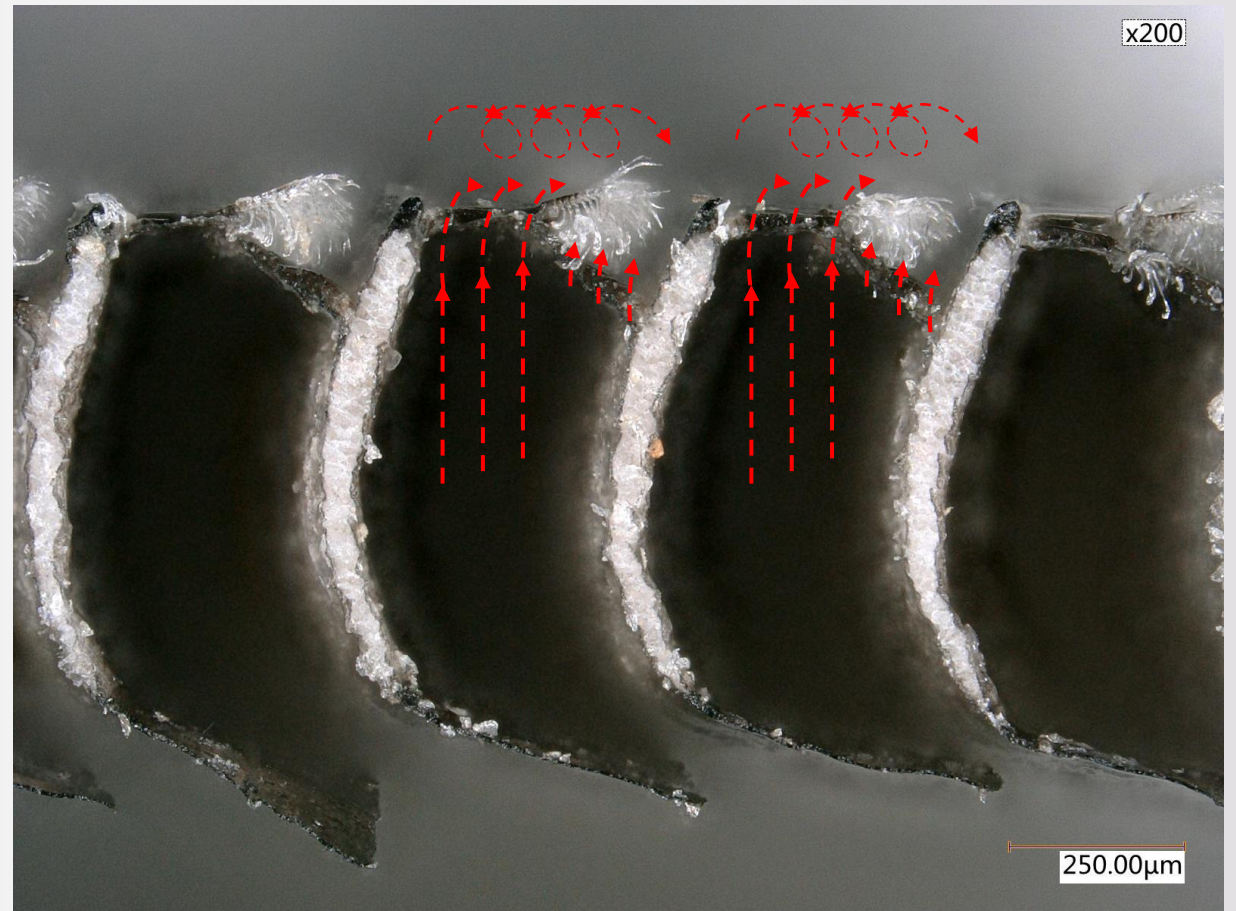
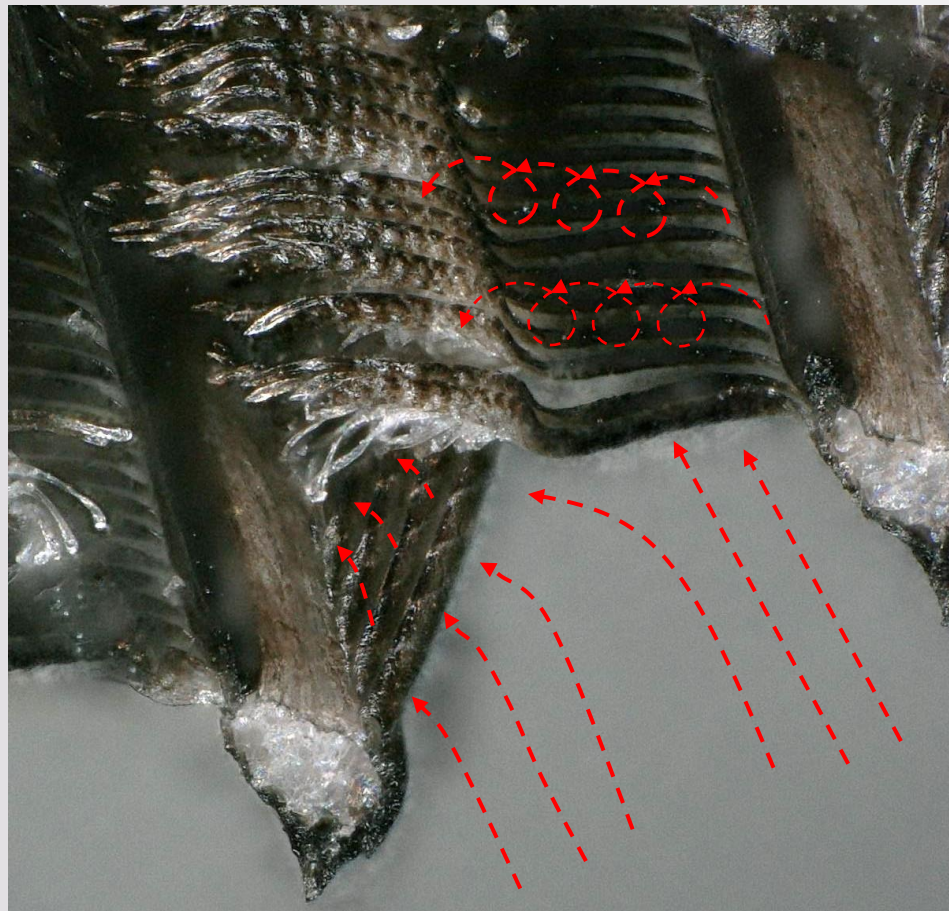
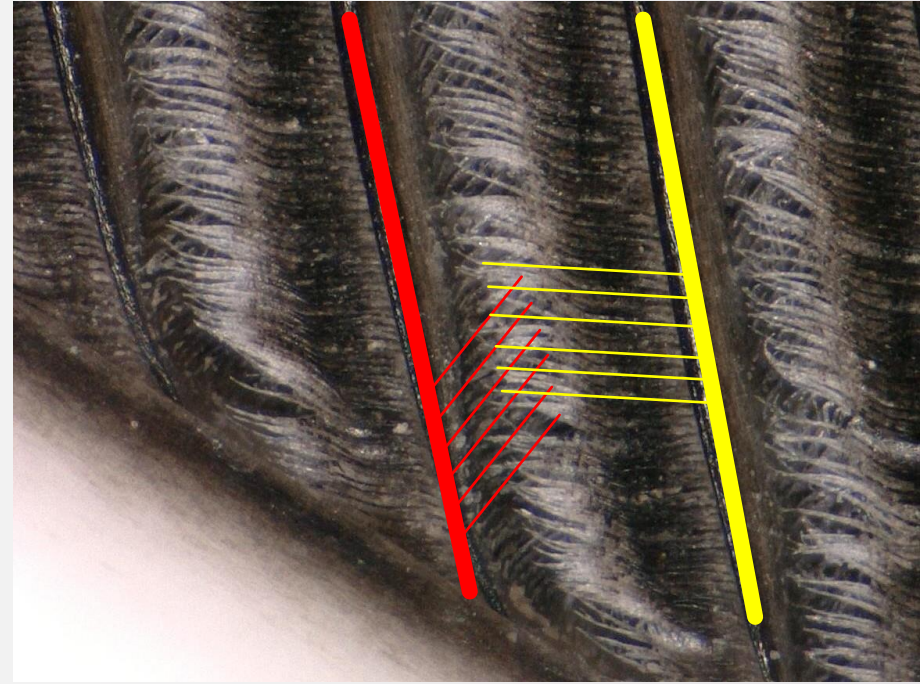
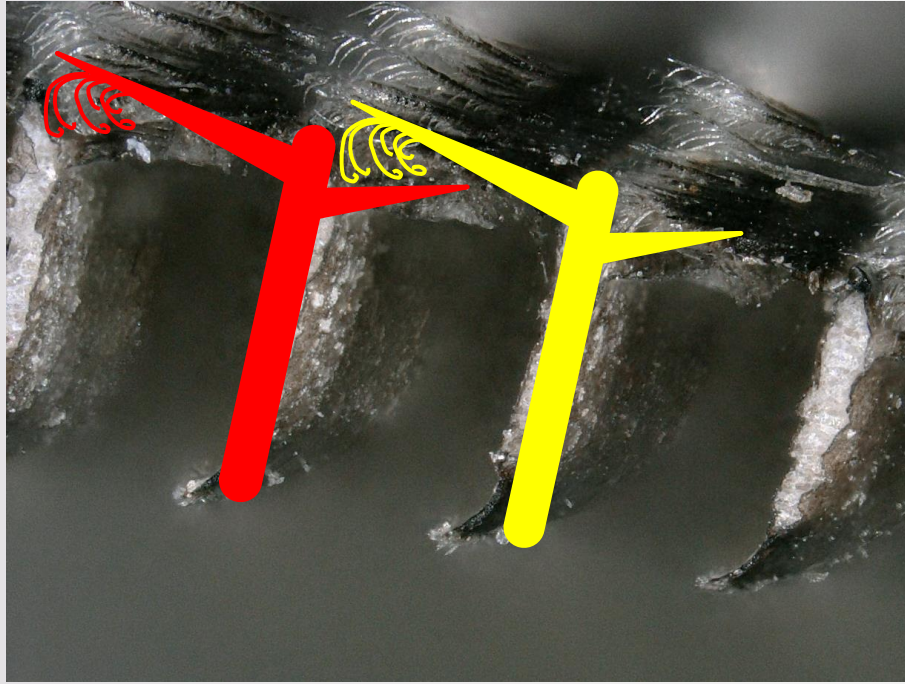


Figure 8. Hypothesis on expected airflow around feather micro-structure

## MICRO-STRUCTURE OF AVIAN FEATHERS





*Figure 13 | Important aspect in consideration for future simplified micro-structure model*

NUMERICAL MODEL



# MICRO-FLOW EXPERIMENT

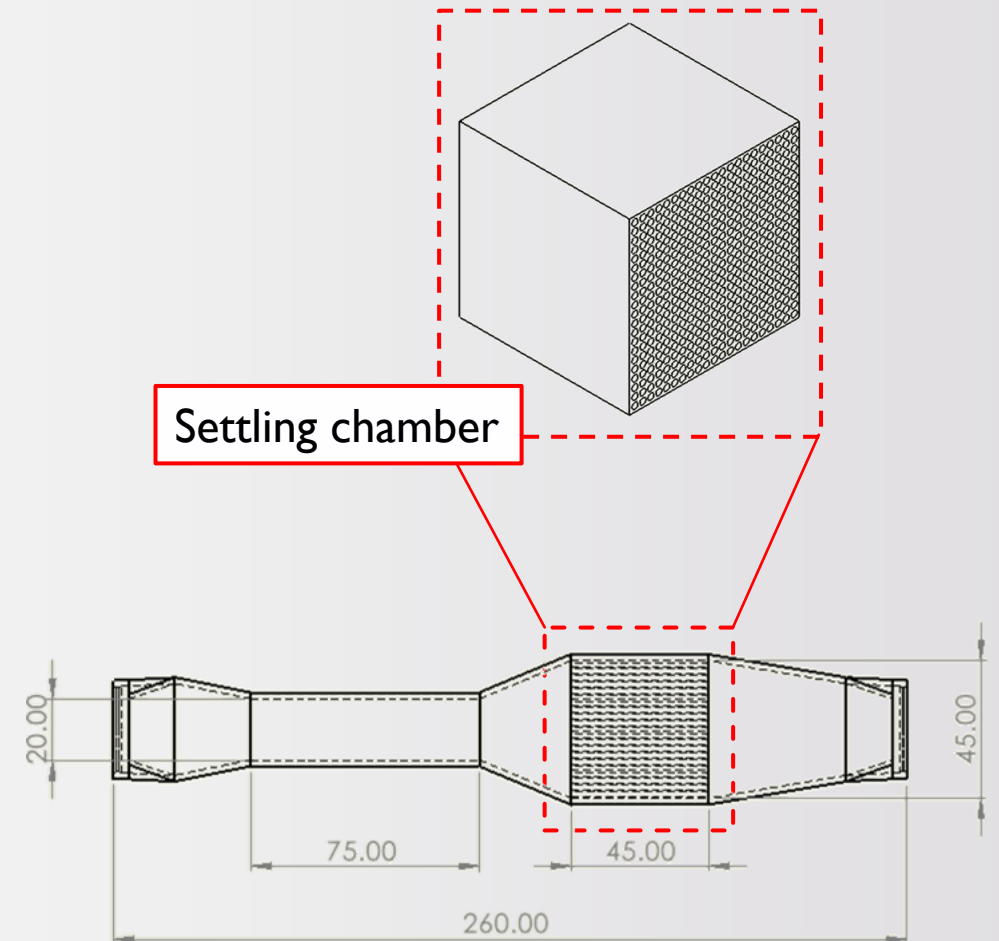
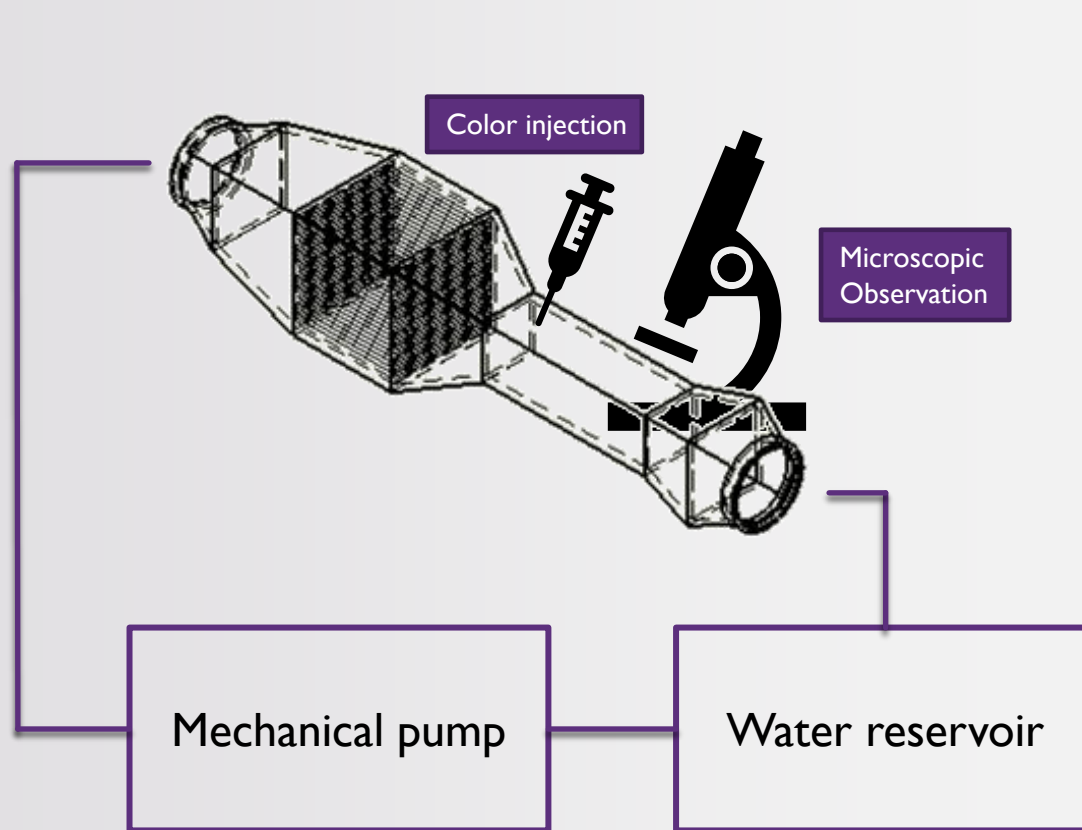
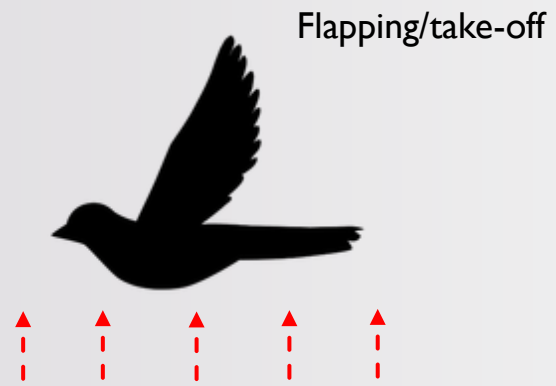


Figure 14 | Preliminary Design of water tunnel for micro-flow experiment



**Fig. 15** | Bird flight in motion, retrieved from Rovatti, M. (2023). An unnecessarily drawn-out analysis of bird flight for animation — Animator Notebook. Animator Notebook. <https://www.animatornotebook.com/learn/bird-flight>

FUTURE RESEARCH – MICRO-FLOW EXPERIMENT





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ขอบคุณครับ

谢谢你!

THANK YOU VERY MUCH FOR YOUR ATTENTION!

FEEL FREE TO ASK QUESTIONS OR COMMENTS!