Bio-Inspired Design

Wb2436-05 (3 EC)


Paul Breedveld


Just Herder


Tetsuo Tomiyama


Martijn Wisse


Dimitra Dodou

Faculty Mechanical, Maritime, and Materials Engineering
Department BioMechanical Engineering

Delft University of Technology

Some organisms are very handy…

http://monsterfinance.wordpress.com/2008/08/18/16/

- Biology knows very flexible solutions where engineers tend to come up with “grossly overweight and highly inept animals” [1]

1) EI Rivin, Mechanical Design of Robots, McGraw-Hill, 1988

General Objective

Goal

- Overview of non-conventional mechanical approaches in biology.
- More creativity in mechanical design.
- Better (simpler, smaller, more robust, etc) technical solutions.

Focus

- Concentrate on *physical* part (structure, mechanisms) of organisms, in contrast with course Wb5435-05 “Machine Intelligence” that focuses on *psychological* part (brains, behaviour) of organisms.

Learing Objectives

After completion of this course students will be able to:

1 Describe methods for creative design.

2 Identify mechanical working principles and phenomena of biological creatures:
- Explain their construction, motion, and/or processing.
- Formalize the essence of these mechanisms in models.
- Derive non-conventional principles from these models.

3 Implement these principles in innovative mechanical devices:
- Summarize transition from the biological to mechanical.
- Present their design in drawings or in working models.

Bio-Inspired Design vs Biomimetics

Biomimetics = Imitating Nature

TU Delft

Bio-Inspired Design vs Biomimetics

Biomimetics = Imitating Nature

Bio-Inspired Design vs Biomimetics

Biomimetics = Imitating Nature

Bio-Inspired Design =

- Not imitating nature, but using nature as source of inspiration (as well as man-made technical devices).
- Nature is not perfect, mankind either.
- But nature uses different, sometimes very ingenious approaches that can make us more creative in finding better solutions.

Main Topics

I Bioconstruction

(how are creatures constructed, how do they deal with energy)

- Biostructure
- Bioenergy (muscle configurations & biological springs)
- Bioreproduction & regeneration
- Biomaintenance & repair

II Biomotion (how do creatures move)

- Bioclamping (hands & other clamping methods)
- Biopropulsion (macroscale & microscale)

III Bioprocessing (how do creatures behave & coordinate)

- Biobehaviours & group intelligence

Lecture 1: Introduction: Lift off!!

- **Jan 31, 8:45-10:30, room TN-F, Paul & Tetsuo**
- Contents 1st hour (Paul): Background, goal, focus, themes and overview of lectures.
- Contents 2nd hour (Just): Creating student groups & handing out assignments.

Lecture 2: The Bio-Inspired Design Approach

- **Feb 2, 8:45-10:30, room B, Paul & Tetsuo**
- Contents: essence of creative design & what you didn't know about friction.

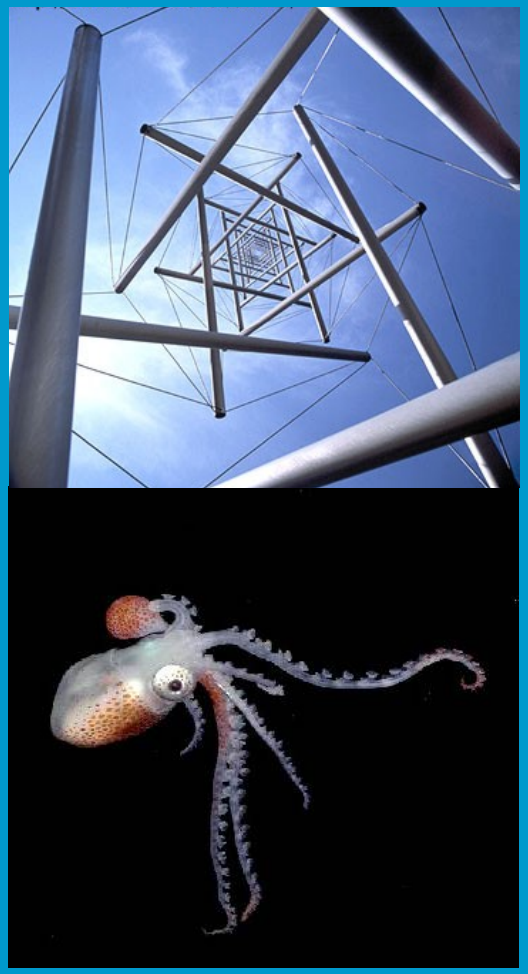
http://www.photosof.org/view/fly_robot_insect-other.html

http://www.worth1000.com/entries/67700/battle-snail

Lecture 3: Bioconstruction

Biostructure & bioenergy (muscle configurations)

- **Feb 7, 8:45-10:30, room TN-F, Paul & Just**
- Contents 1st hour (Just): mechanical stiffness & motion: strength at low weight, redundant structures, etc.
- Contents 2nd hour (Paul): hydrostatic stiffness & motion: energetically efficient muscle configurations, stiffness with soft structures.



TU Delft

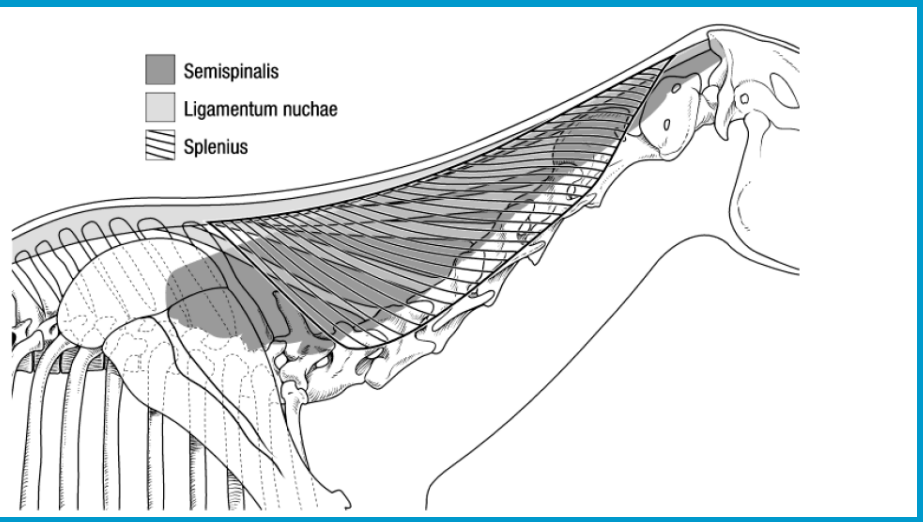
Lecture 4: Student presentations

Presentation 1: Problem analysis

- **Feb 9, 8:45-10:30, room B, Just, Paul & Tetsuo**

Lecture 5: Bioconstruction
Bioenergy (biological springs)

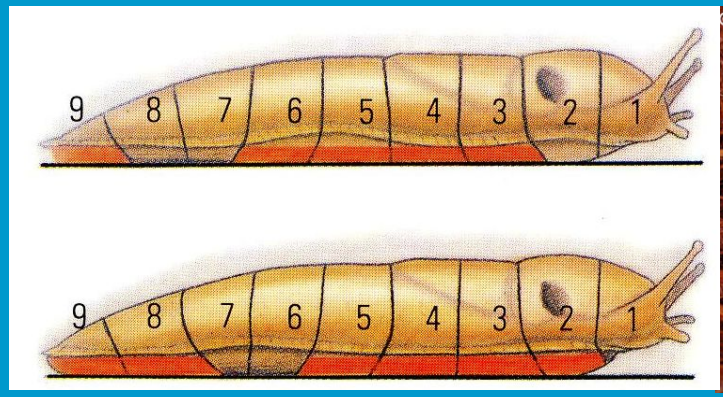
- **Feb 14, 8:45-10:30, room TN-F, Just**
- Contents: bioenergy: storing energy in springs (neck of giraffe, chameleon, grasshopper, tendons in human ankles), vibration (birds, flying insects), etc.



TUDelft

Lecture 6: Biomotion
Biopropulsion (macroscale)

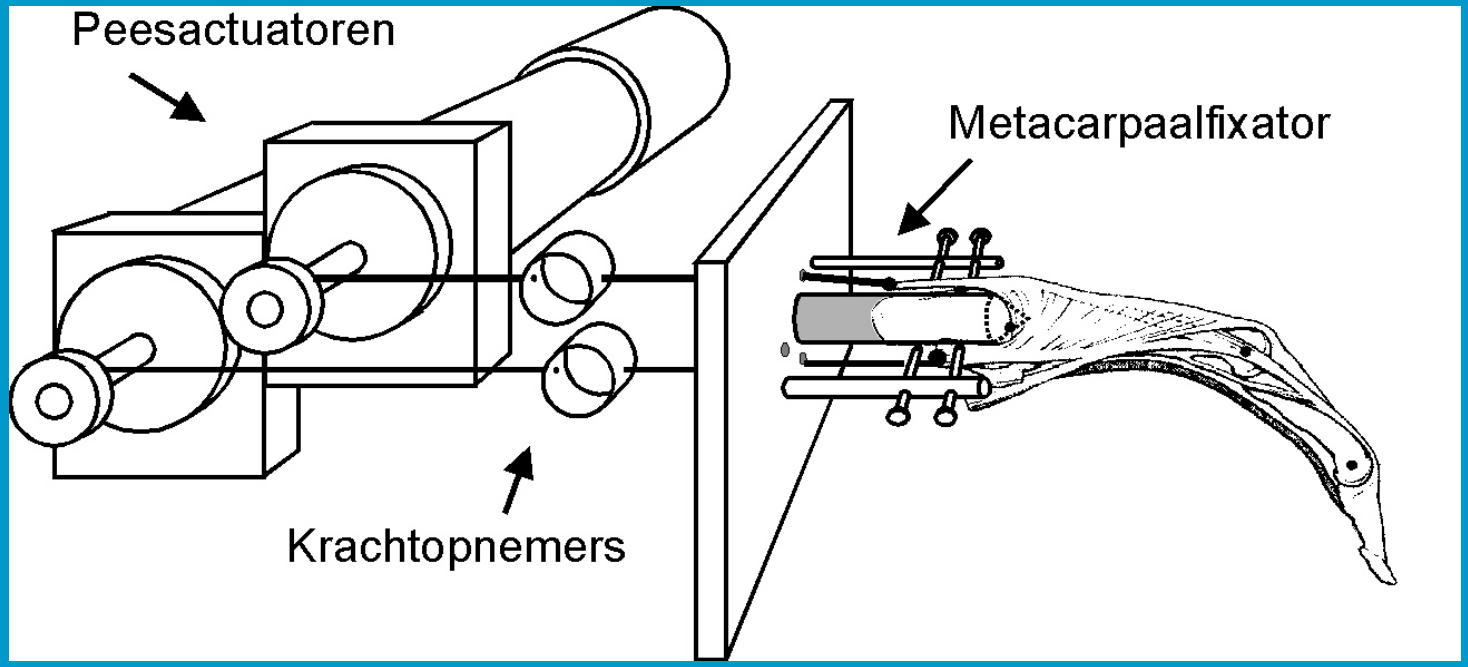
- **Feb 16, 8:45-10:30, room B, Martijn & Paul**
- Contents 1st hour (Martijn): bi-articular muscles, walking, walking robots.
- Contents 2nd hour (Paul): floating & crawling.



TU Delft

Lecture 7: Biomotion
Bioclamping (hands)

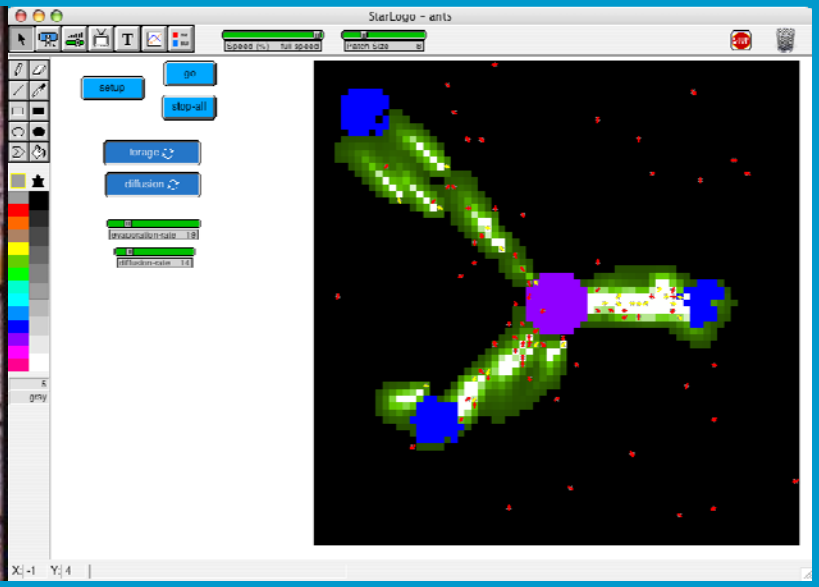
- **Feb 28, 8:45-10:30, room TN-F, Just**
- Contents: biomechanisms of hands.



TU Delft

Lecture 8: Bioprocessing
Biobehaviours & group intelligence

- **March 2, 8:45-10:30, room B, Tetsuo**
- Contents: simple laws for complex behaviour (cells, ants, spider), etc.



TU Delft

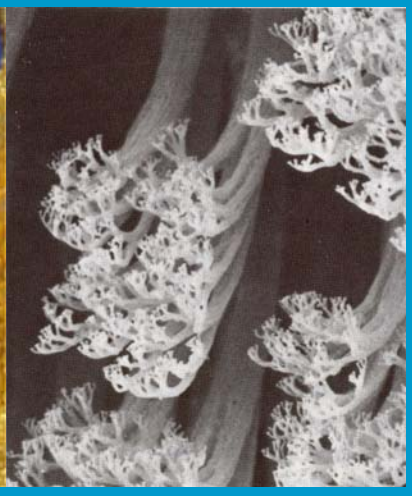
Lecture 9: Student presentations

Presentation 2: Biological examples

- **March 7, 8:45-10:30, room TN-F, Just, Paul & Tetsuo**

Lecture 10: Biomotion
Bioclamping (others)

- **March 9, 8:45-10:30, room B, Paul & Dimitra**
- Contents 1st hour (Paul): bioclamping.
- Contents 2nd hour (Dimitra): biosticking part 1.

TU Delft

Lecture 11: Biomotion

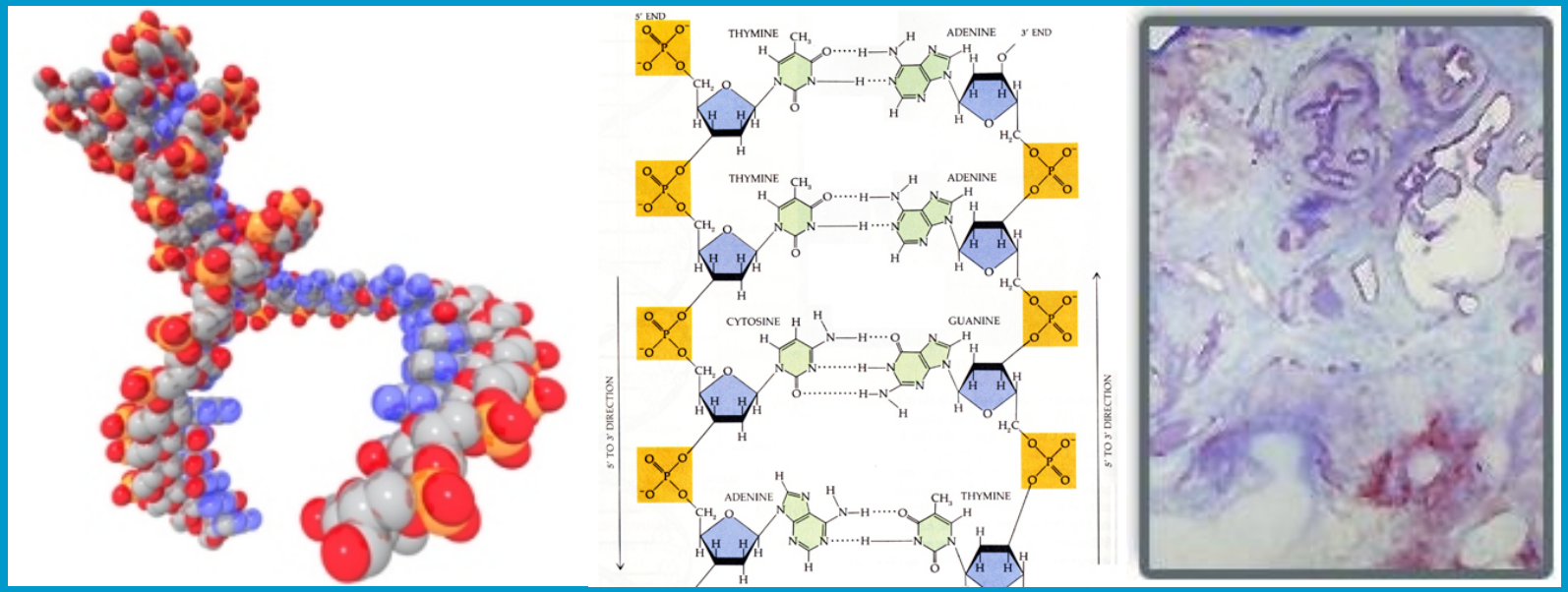
Bioclamping (others) & biopropulsion (microscale)

- **March 14, 8:45-10:30, room TN-F, Dimitra & Paul**
- Contents 1st hour (Dimitra): biosticking part 2
- Contents 1st hour (Paul): propulsion of micro organisms & single-celled organisms.

TU Delft

Lecture 12: Bioconstruction
Bioreproduction & regeneration

- **March 16, 8:45-10:30, room B, Tetsuo**
- Contents: (re-)production & (re-)generation in biology.



TU Delft

Lecture 13: Bioconstruction
Biomaintenance & repair

- **March 21, 8:45-10:30, room TN-F, Tetsuo**
- Contents: maintenance & repair in biology.

TU Delft

Lecture 14: Student presentations

Presentation 3: Concept solution

- March 23, 8:45-10:30, room B, Just, Paul & Tetsuo