Bionik: Building on Biological Evolution

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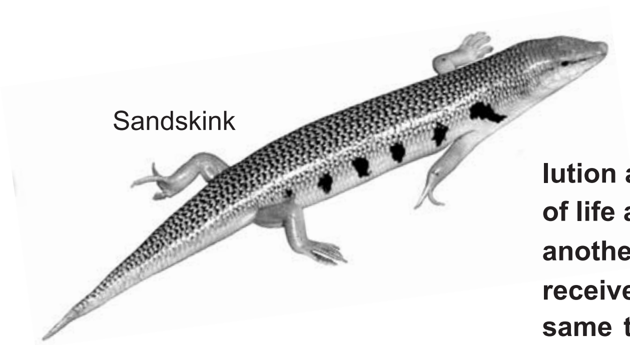
Bionik & Evolution

Bionik rests on the foundations of biological evolution. Disciples of Evolutionary Algorithms are convinced of the performance of the biological optimization-method. Of this follows:

What is Bionik?

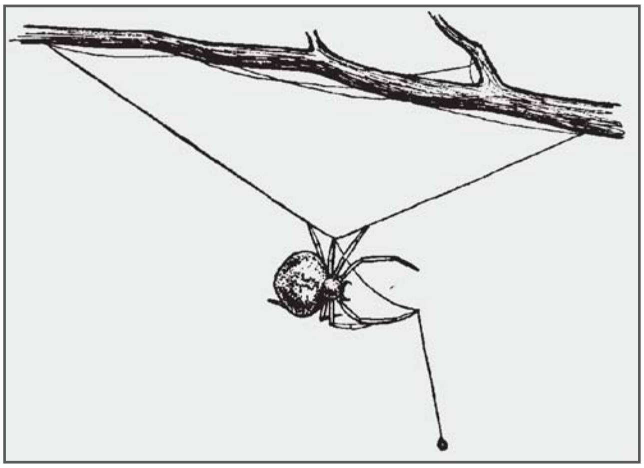
Science for the modeling and utilization of results of biological evolution



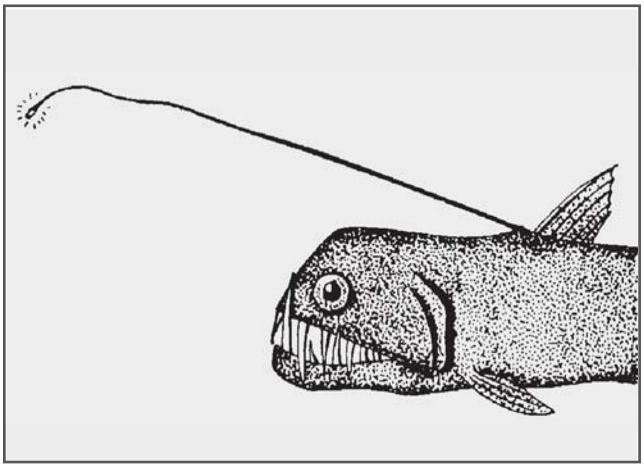
The task of Bionik is the analysis of biological processes and structures and their synthesis for the designs of tomorrow. The idea of Bionik is based on the fact of evolution and coevolution in nature. Technologies of life are optimized and in harmony with one another. It is a chance if imitating the biology to receive an efficient solution which fits at the same time in the environment. Because who speaks today about gentle technology does it mostly with a look to biology.

Prepared for GECCO 2004

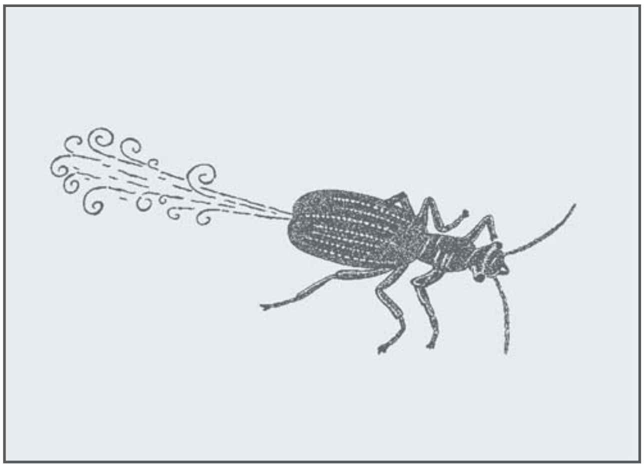
Wondrous Technologies in Nature



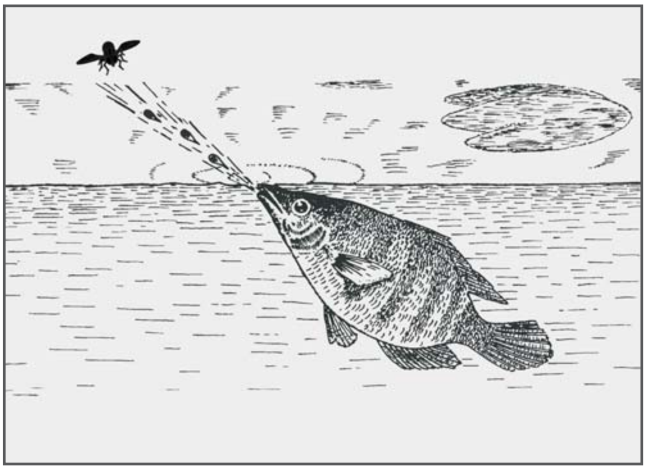
Lasso spider waiting for a chance



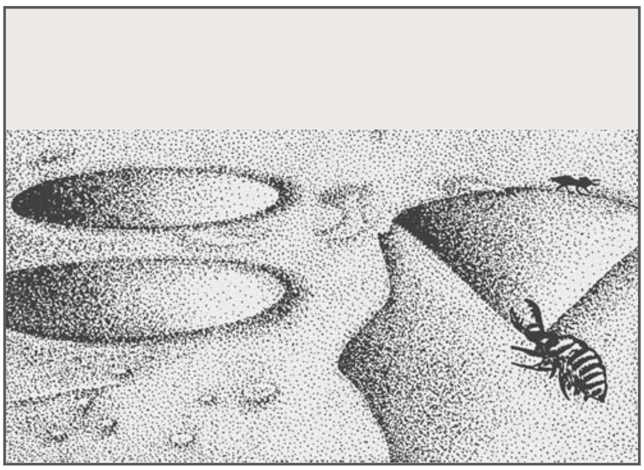
Angler-fish with an illuminated lure



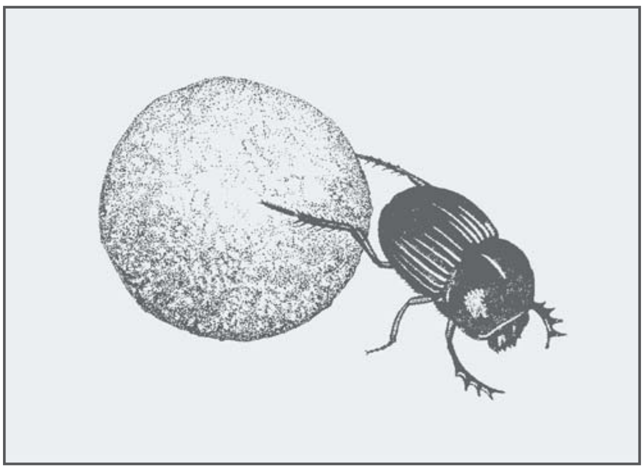
Bombardier beetle in shooting position



The archer-fish aims at an insect

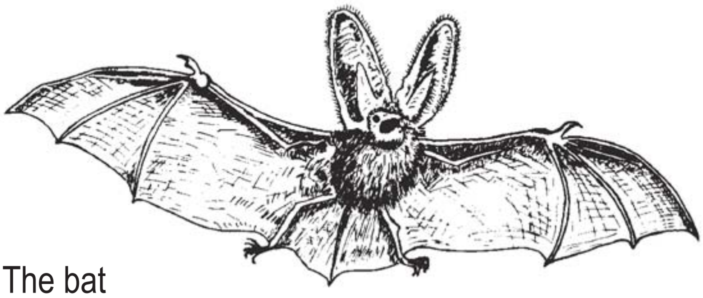


Ant-lion lurking in the pitfall

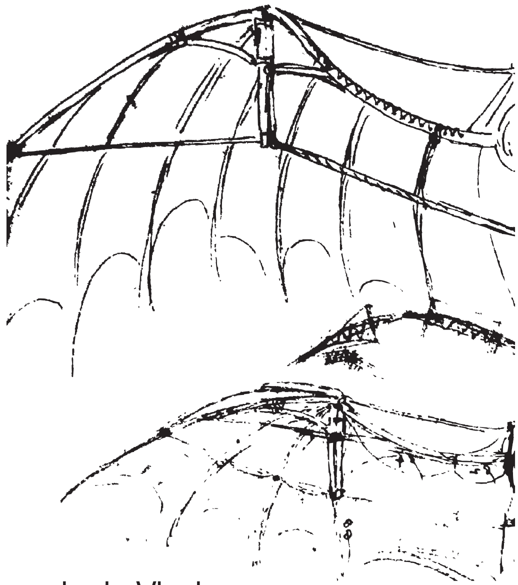


Scarab rolling the gathered food away

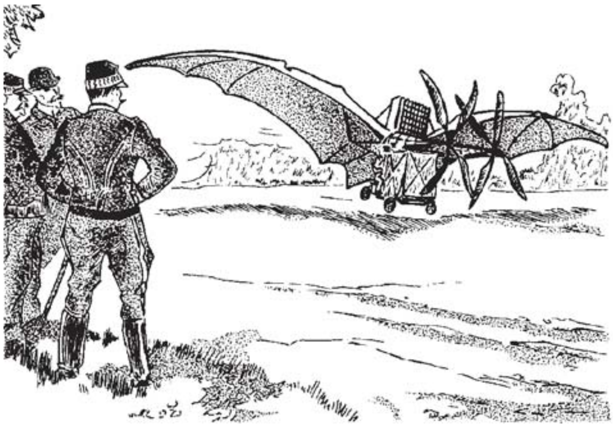
Flight history and Bionik



The bat
Biological model simply to be mimicked

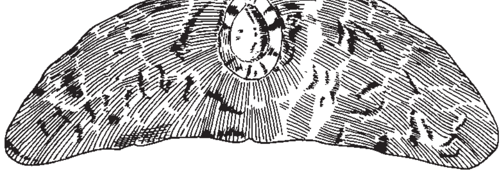


Leonardo da Vinci
Part of the outline for a flying machine

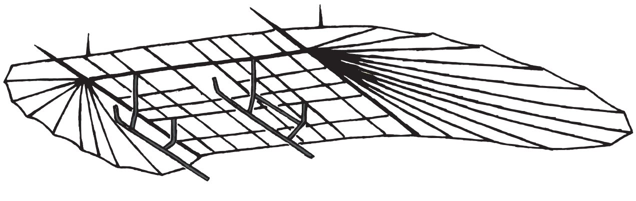


Before the examining board
The Avion III makes only small jumps

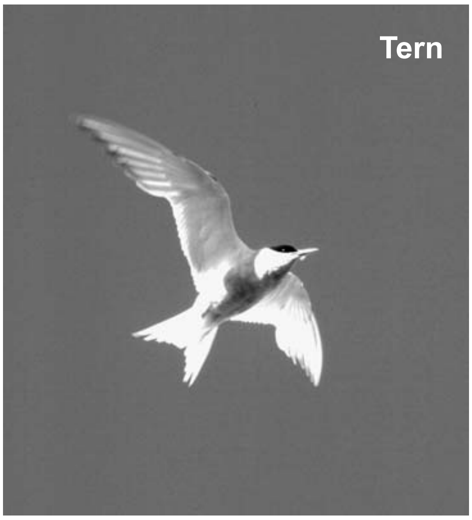
Otto Lilienthal on August 16th, 1894
The glider mimics a bird with spread wing tips



The seed of *Macrozanonia macrocarpa*



as a model for the tailless airplane of Igo Etrich



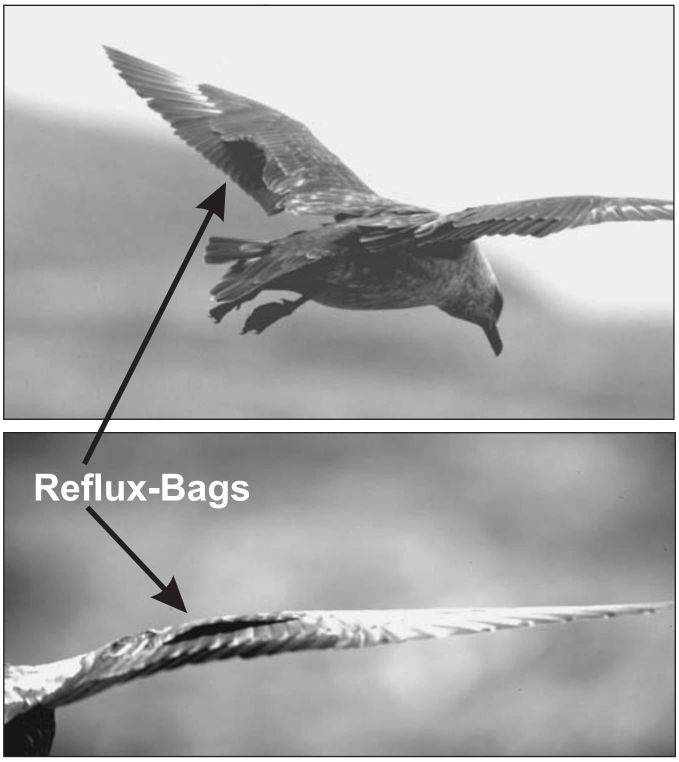
Spindle body!
Wing in front!
Elevator behind!

Solution of the biological evolution and the

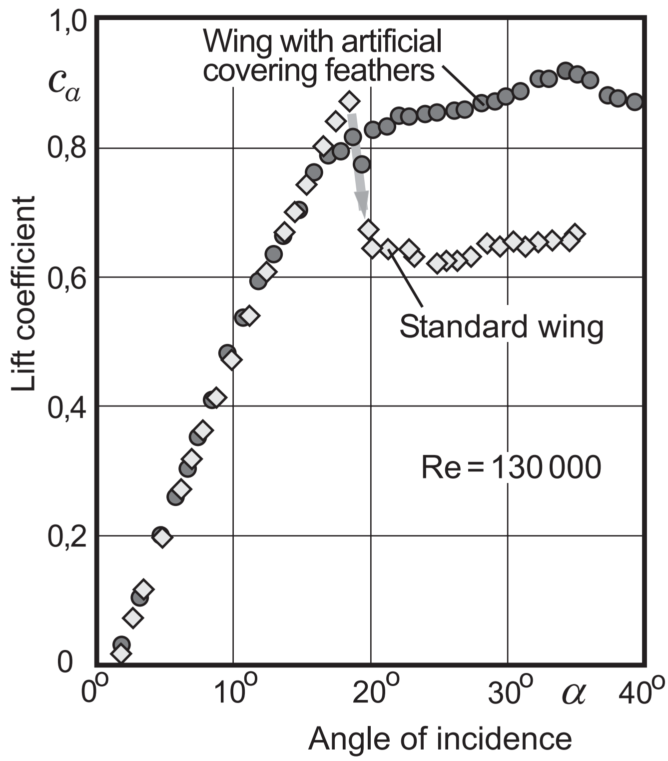
Bionik development in the past

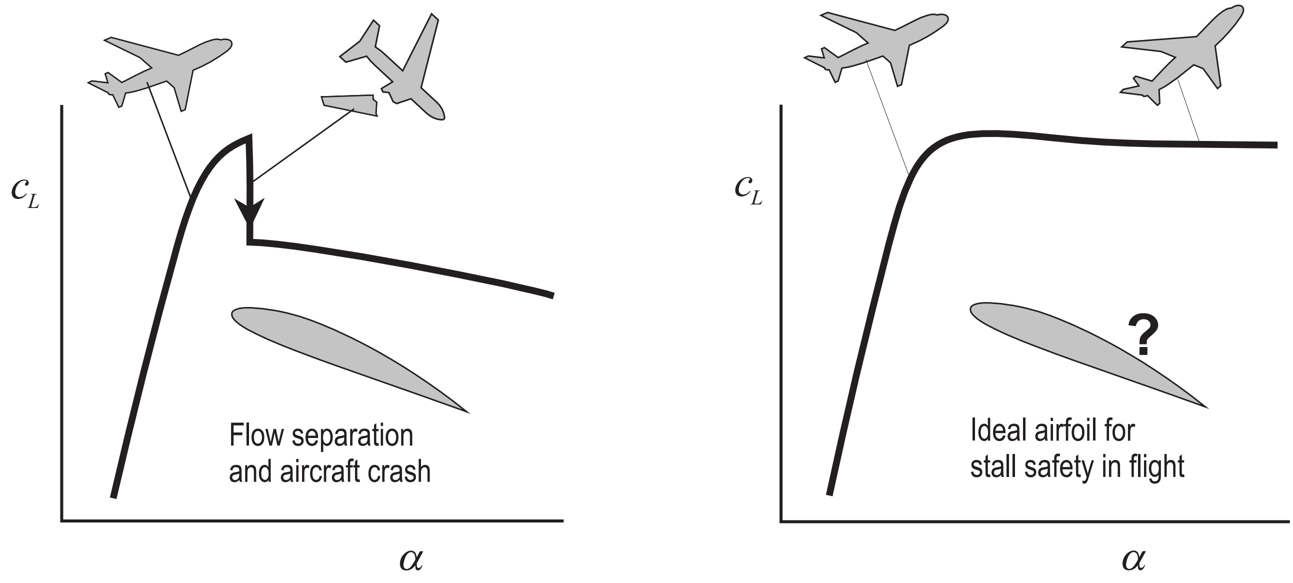
engineering solution after 100 years development

Bionik development today (covering-feather-effect)

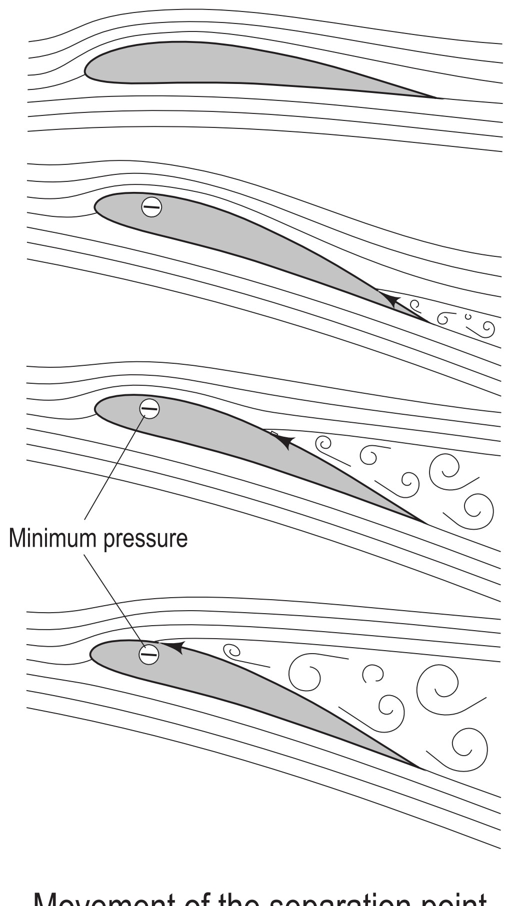


Brown Skua: Aeroflexible covert feathers act as a non-return valve. The reverse flow opens - just before stall - the Reflux-Bags.

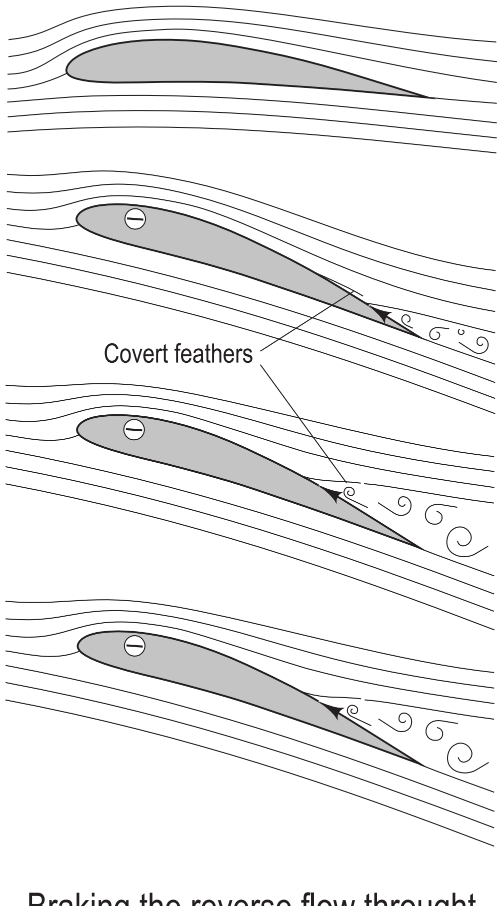




Research goal for aircraft safety

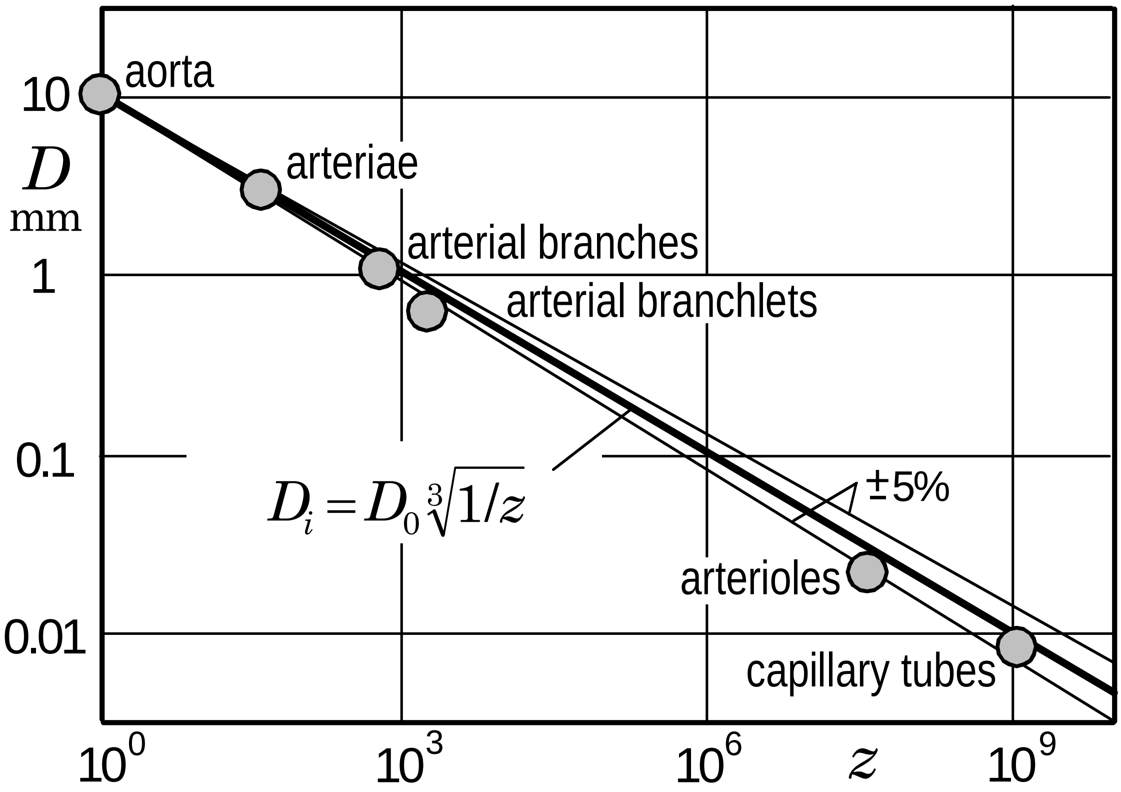


Movement of the separation point
to the region of minimum pressure



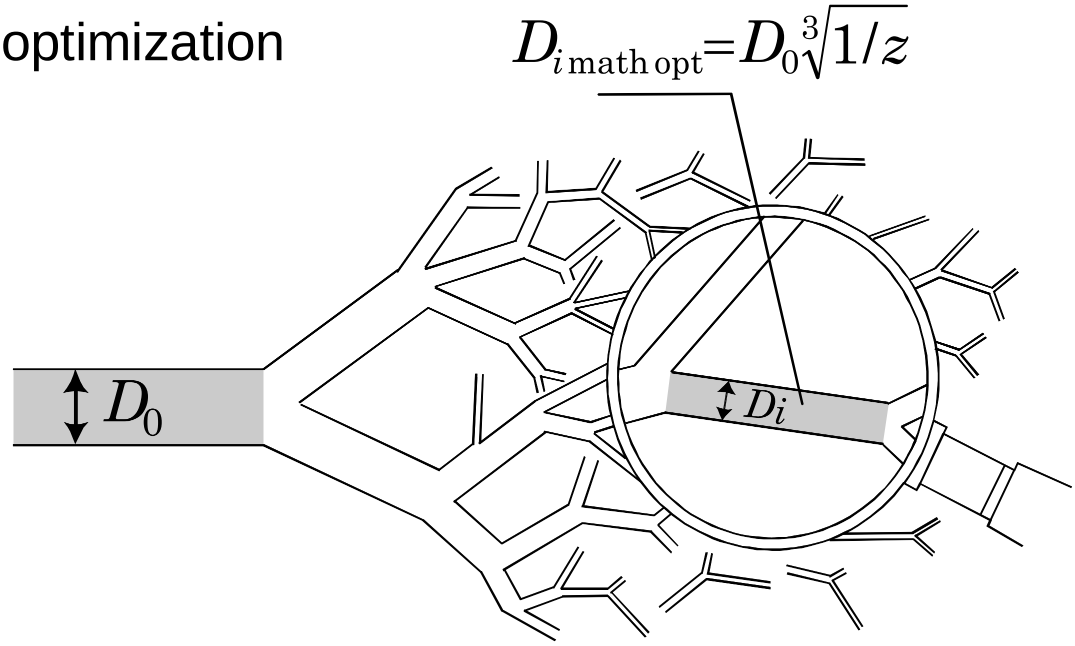
Braking the reverse flow throught
the covert feathers

Evolution and



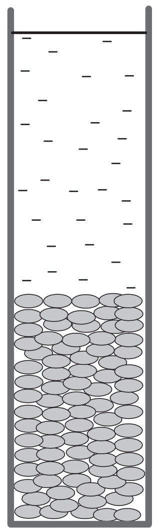
mathematical

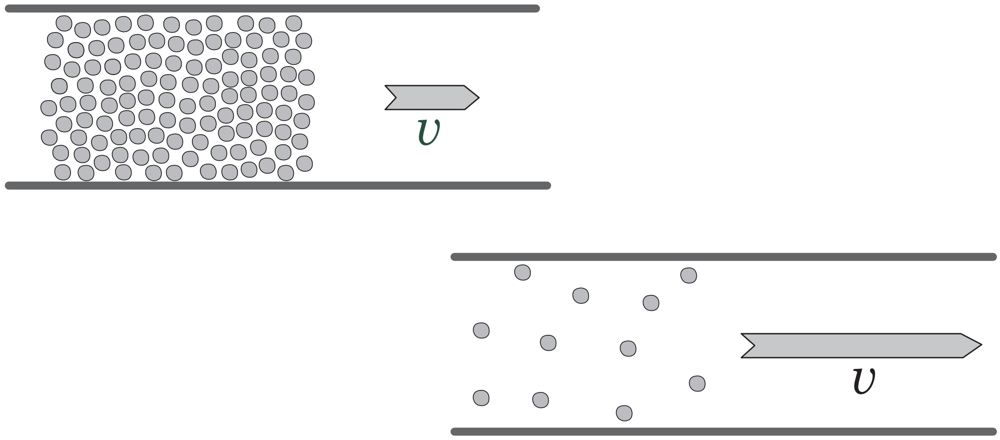
optimization

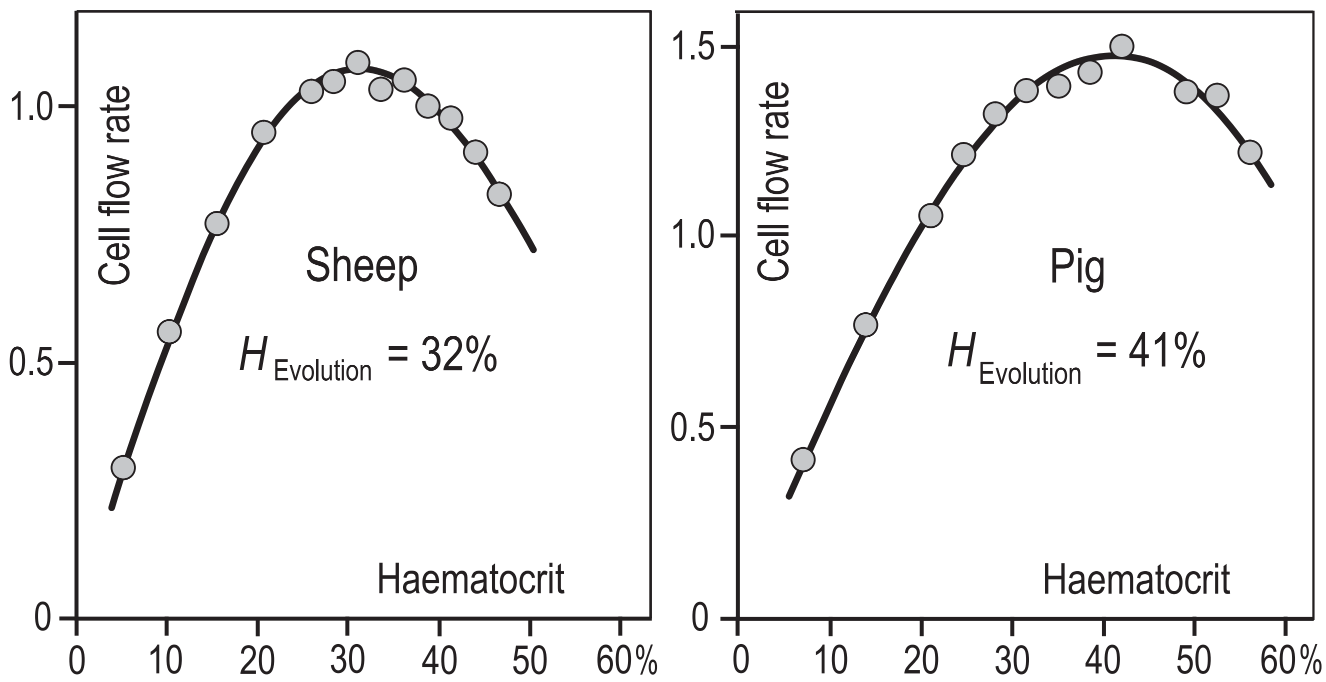


Optimized biological solution: Proof 1

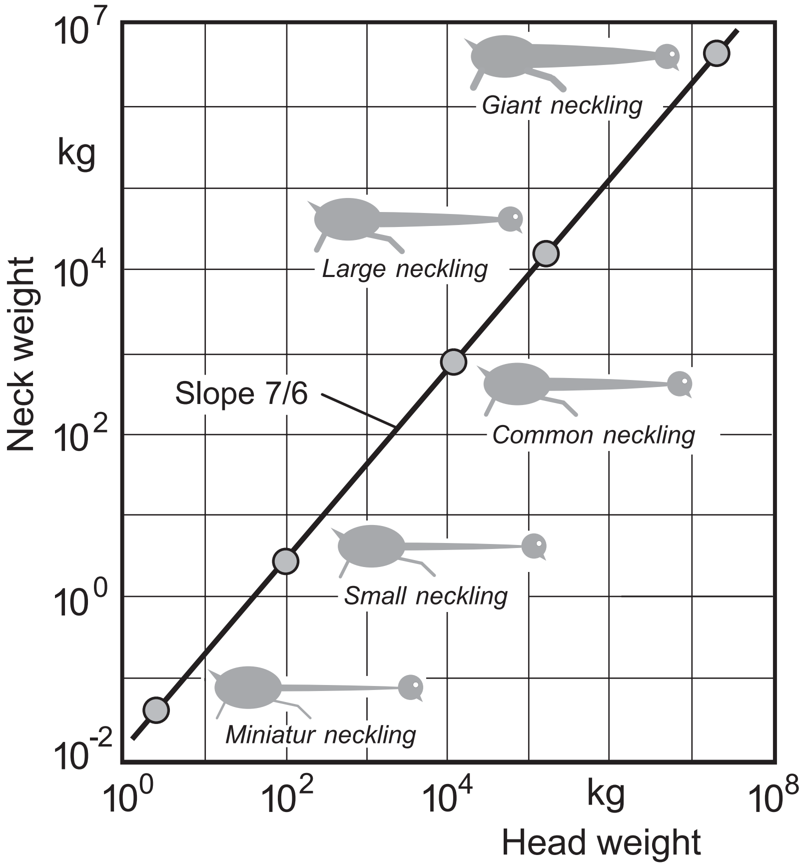
$$\text{Haematocrit } H = \frac{\text{Volume blood cells}}{\text{Total volume}}$$





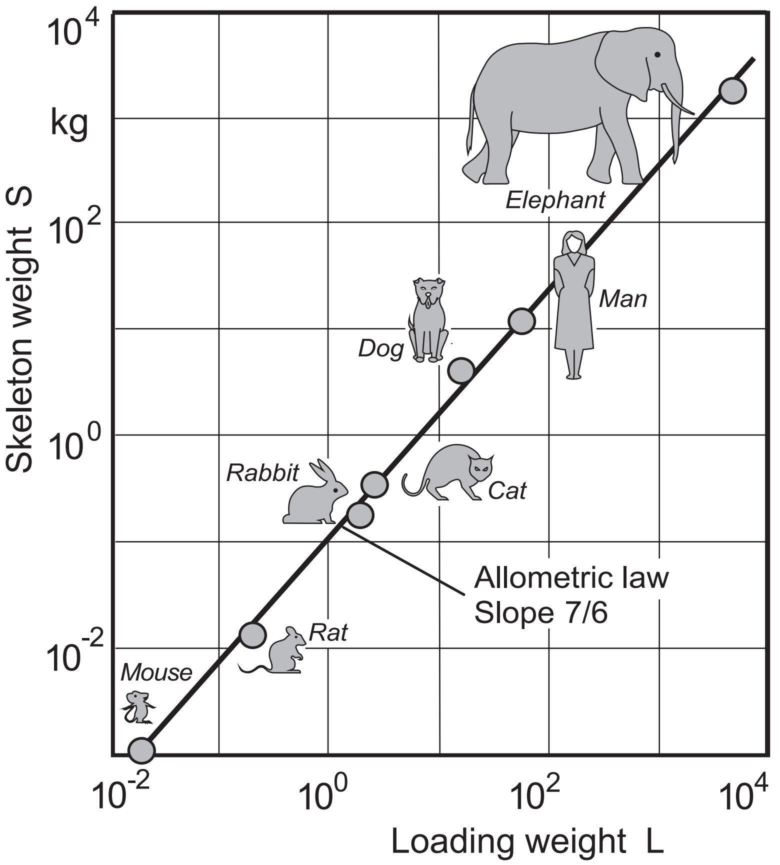


Optimized biological solution: Proof 2



The allometric law
of the necklings

The species of necklings are
living on an extrasolar planet

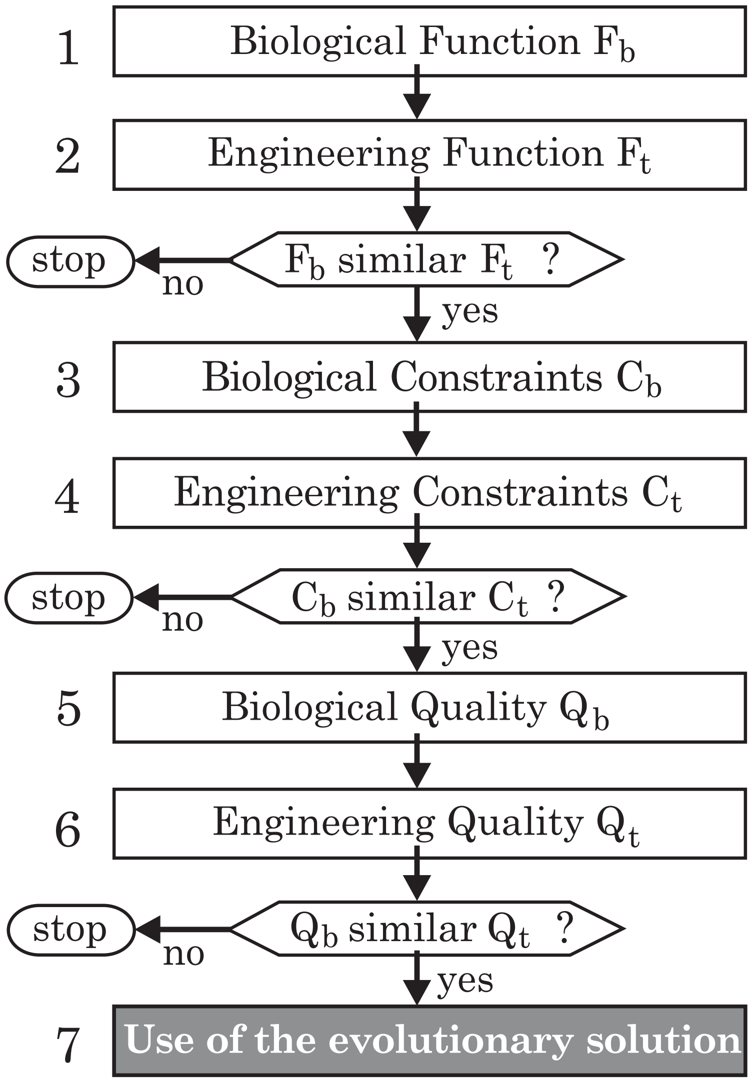


The allometric law
of the earth-mammals

Theory for
minimum weight

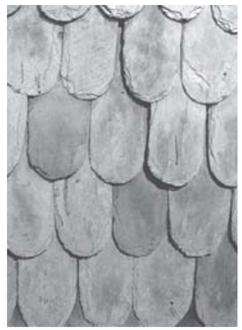
$$S = L^{7/6}$$

Optimized biological solution: Proof 3



Seven steps to design Bionik Solutions

F_b

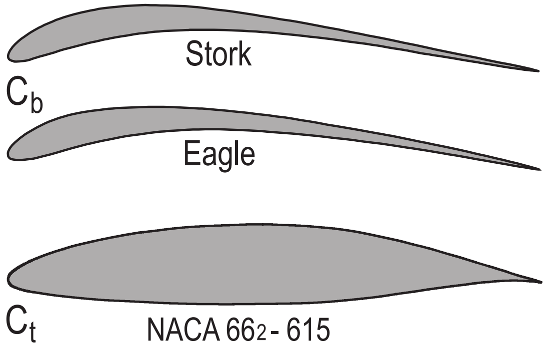


F_t

F_b = Butterfly scales

F_t = Roofing tiles

$F_b \neq F_t$



C_b = Bird wing profile

C_t = Airfoil section

$C_b \neq C_t$

Q_b

Q_t

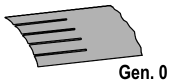
Q_b = Poppy capsule

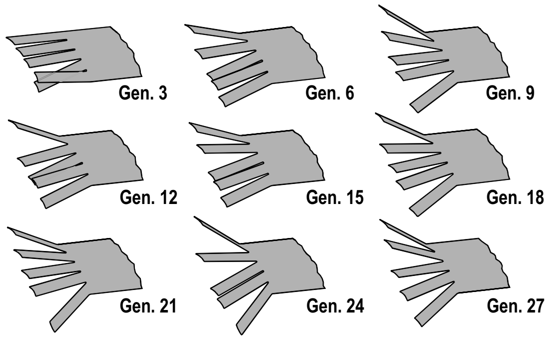
Q_t = Salt shaker

$Q_b \neq Q_t$

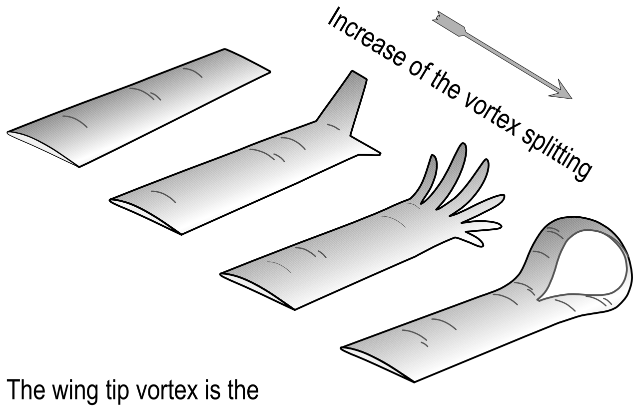
Evolution in nature ...

and in a wind-tunnel



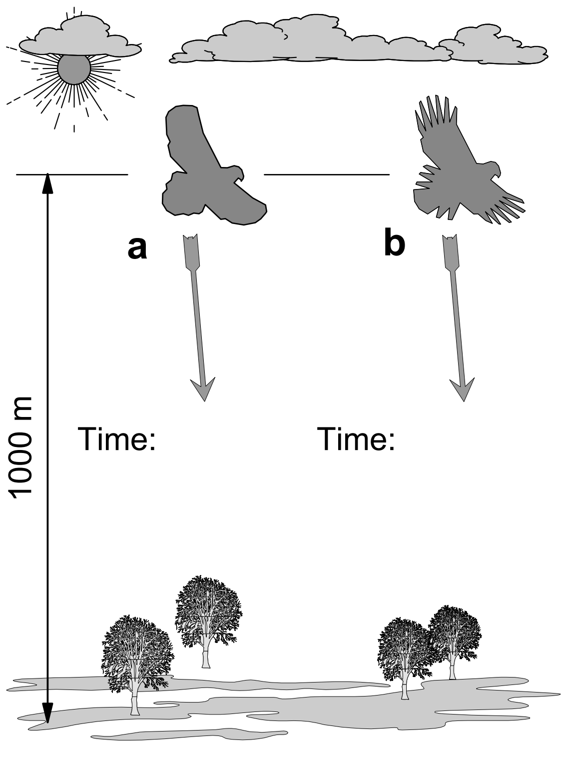


Concept of Neo-Bionik:
Continued evolution under engineering restrictions



The wing tip vortex is the lateral continuation of the circulation round the air-foil which produces the lift. Therefore a reduce of the vortex intensity will decrease the lift. However, if the vortex is split, the vortex energy can be reduced without a loss of the lift.

From the standard-wing to the wing-tip-loop (spiroid-wing)



Note down the time up to the ground touch

a: For a bird without winglets
b: For a bird with multi-winglets

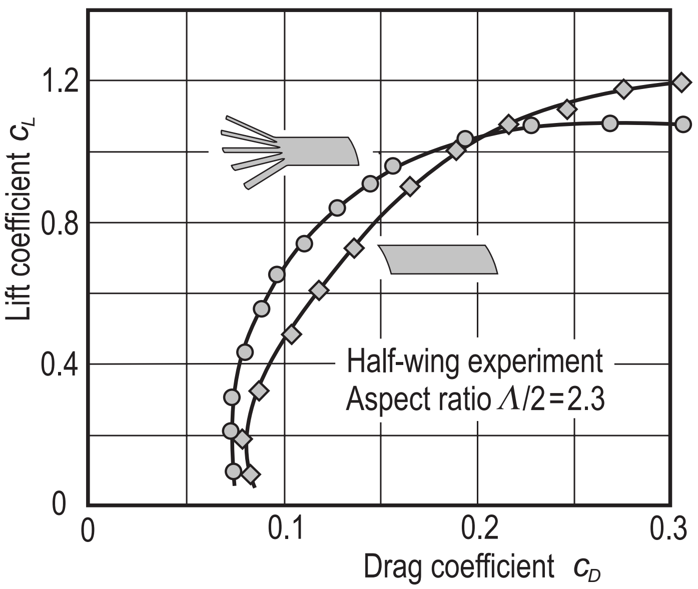
$$v_{descent} = \sqrt{\frac{2g}{\rho}\frac{W}{A}\frac{c_D^2}{c_L^3}} \qquad W = 0.8\ \text{kg} \quad A = 0.2\ \text{m}^2 \quad g = 9.81\ \text{m/s}^2 \quad \rho = 1.12\ \text{kg/m}^3$$

$$\left(\frac{c_D^2}{c_L^3}\right)_a =$$

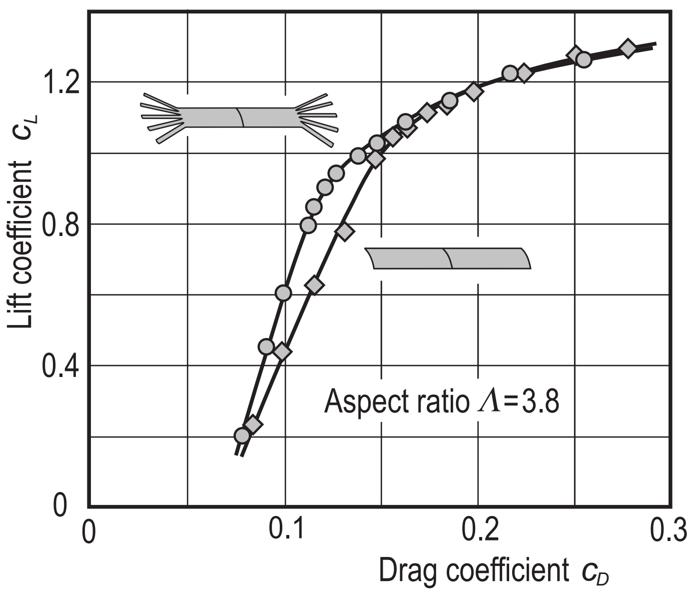
$$\left(\frac{c_D^2}{c_L^3}\right)_b =$$

$$\left(v_{descent}\right)_a =$$

$$\left(v_{descent}\right)_b =$$



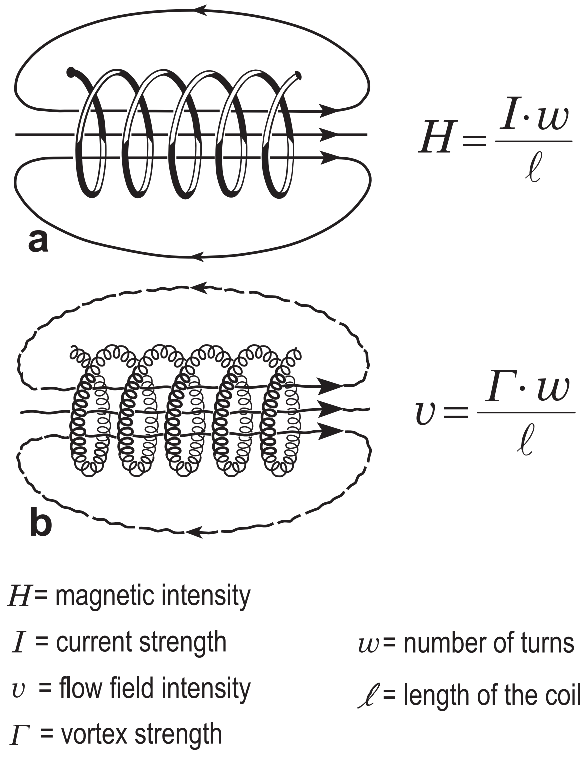
Spread wing versus normal wing
(Diploma thesis Gerhard Peintinger 1984)



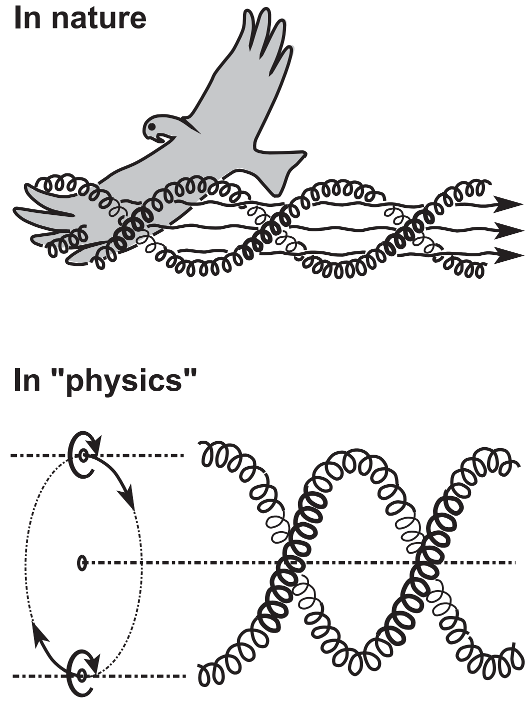
Spread wing versus normal wing
(Diploma thesis Michael Stache 1992)

Winglets at an airplane: Pre-stage of the spread primary feathers of the bird

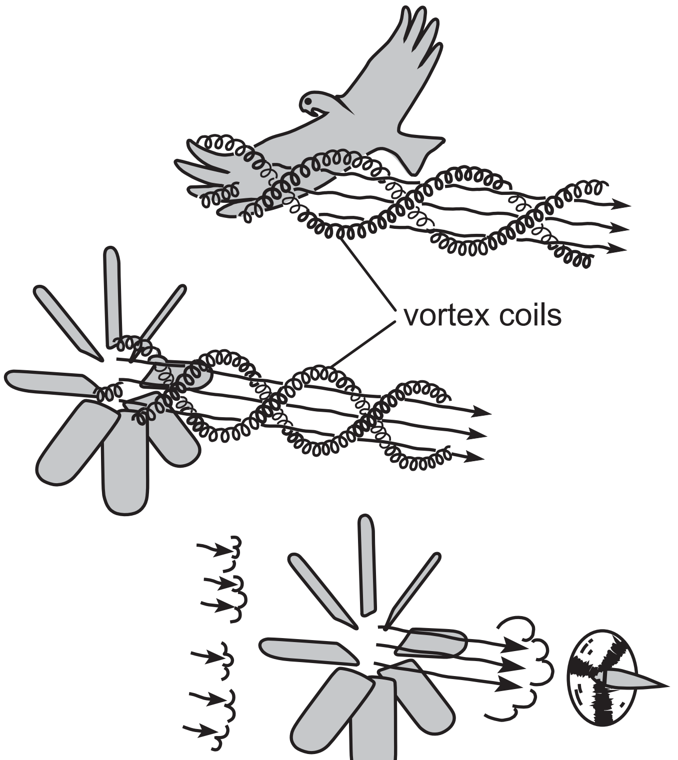
Multiwinglets at a glider designed with the Evolution Strategy



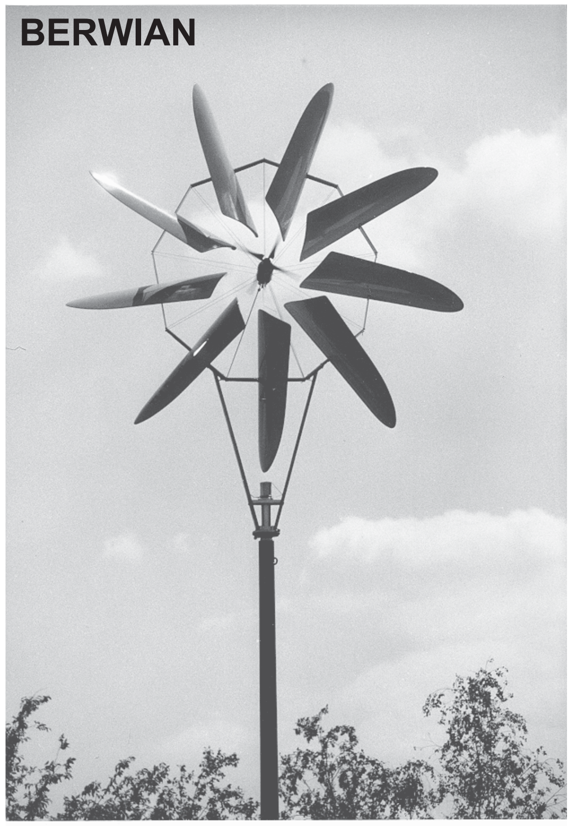
Magnet coil (a) and vortex coil (b)



Self-winding of a vortex coil

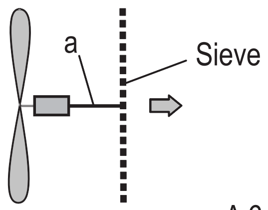


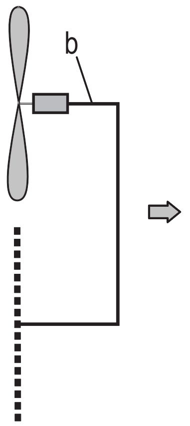
From the bird wing
to the concentrator wind turbine



Berlin-**Wi**nd-**An**emone

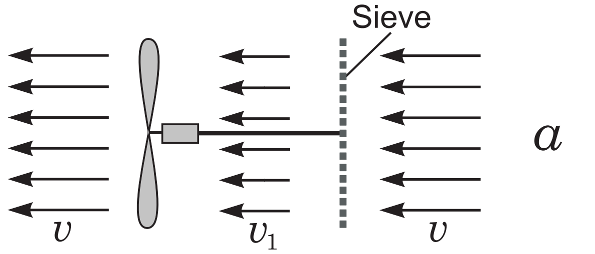
The propeller-sieve-model of Heinrich Hertel



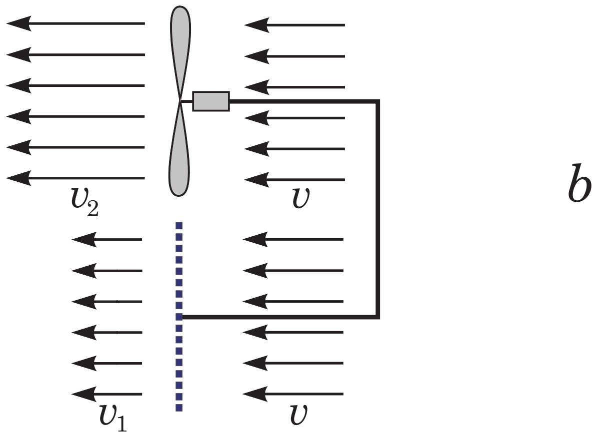


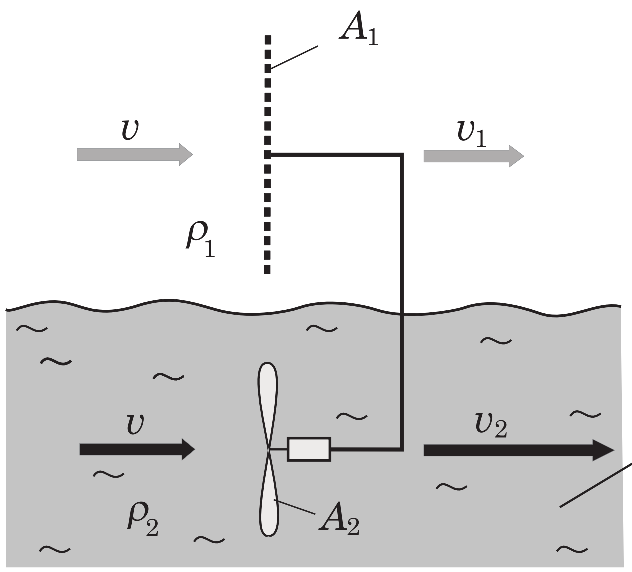
A 64000-dollar question:
A sieve shall be driven through the air.

Is from the energetic point of view:
"a" better than "b"
"b" better than "a"
"a" as good as "b"
?



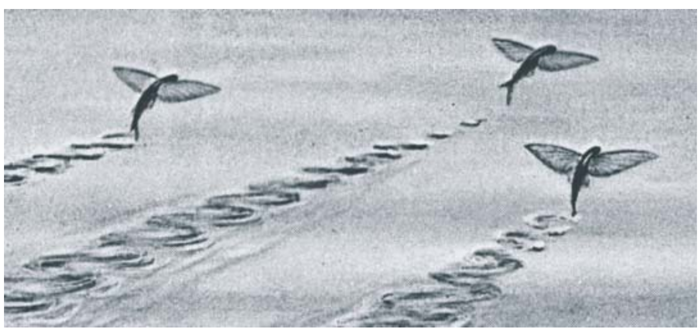
$$\frac{P_b}{P_a} = \frac{1+\sqrt{2-\left(\frac{v_1}{v}\right)^2}}{1+\frac{v_1}{v}}$$



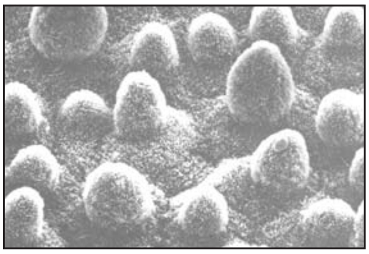


$$P = \frac{T\cdot v}{2}\left[1+\sqrt{1+\frac{\rho_1 A_1}{\rho_2 A_2}\left(1-\frac{v_1^2}{v^2}\right)}\right]$$

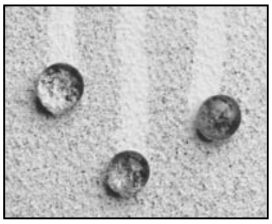
The flying fish and the propeller sieve model



Lotus flower



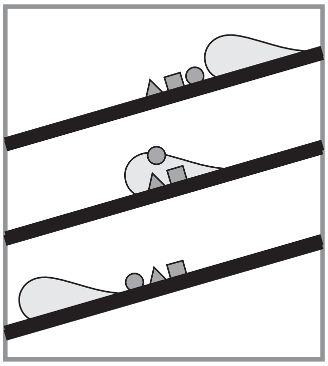
Microrelief of the leave



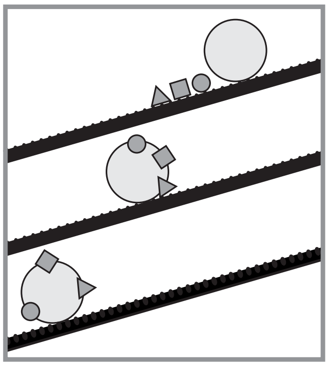
Self-cleaning ability

Bionik product "Lotusan"

Development of the Lotus color



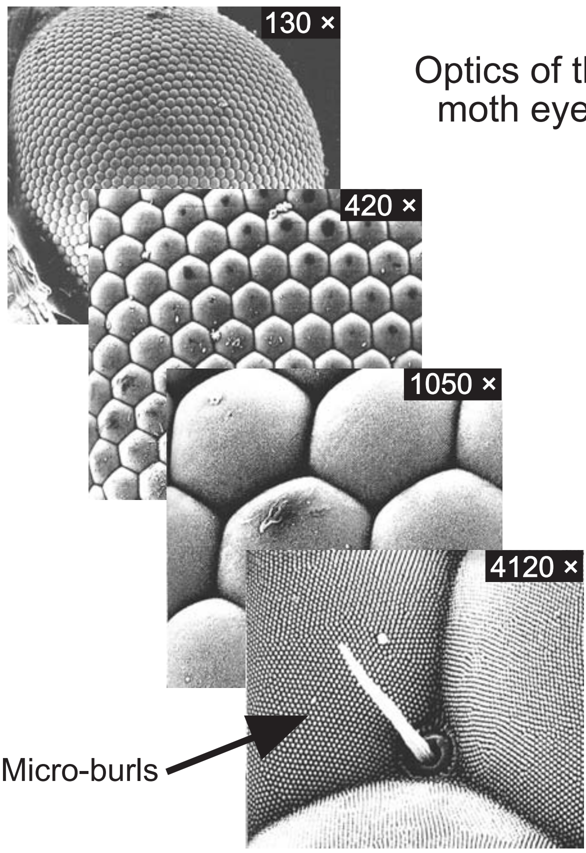
Smooth surface: The dirt particles are predominantly owerflowed by the water-droplet.



Micro-burled waxen surface: The rolling droplet washes the dirt particles away.

Mechanism of the Lotus-Effect®

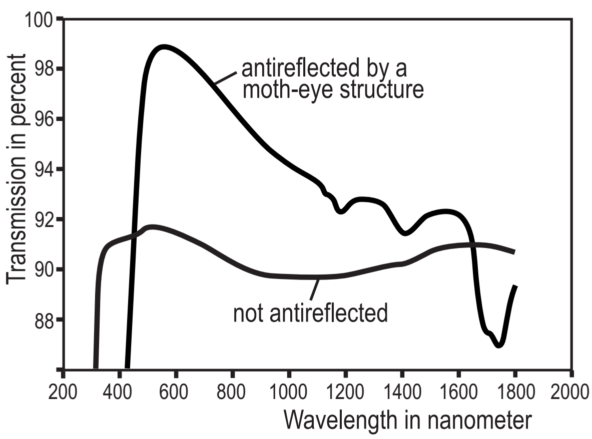
Optics of the moth eye



Micro-burls

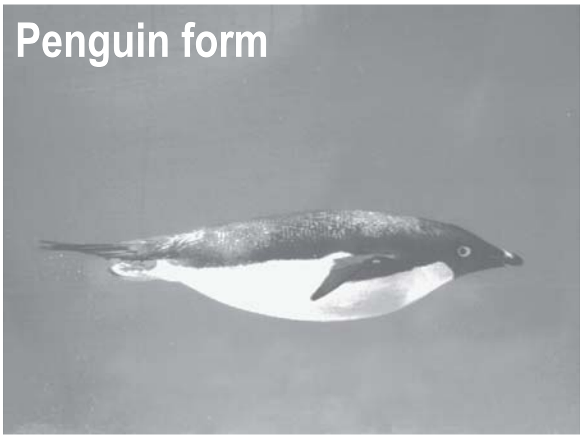
Light-reflection is avoided by a steadily increasing refractive index

The burls work as a gentle amendment of the refractive index

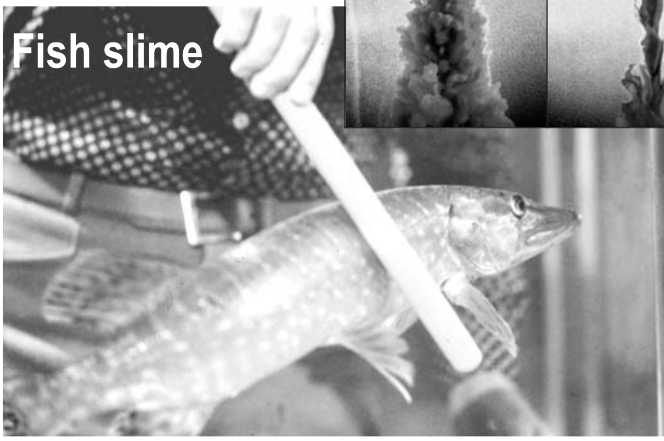


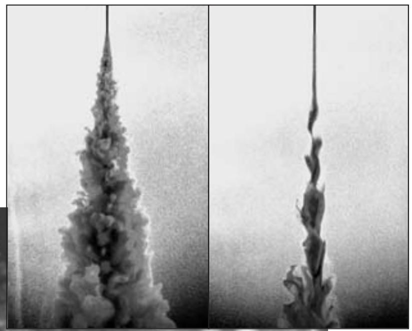
Biologically inspired micro-structures

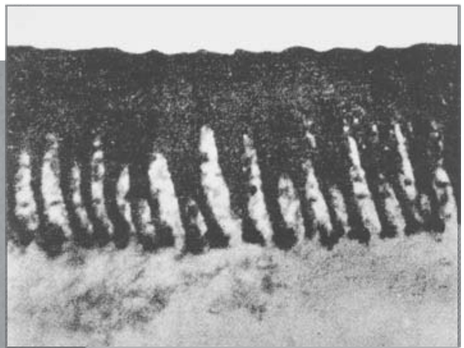
Five cunning techniques which reduce the flow resistance in nature



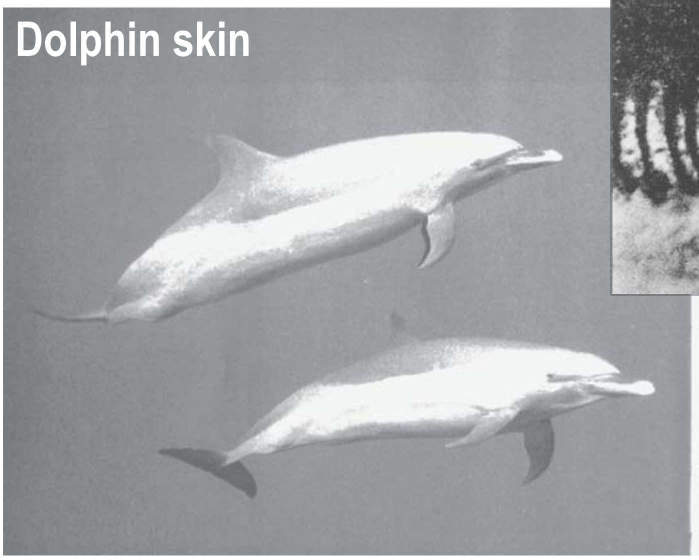
Drag minimization in nature 1



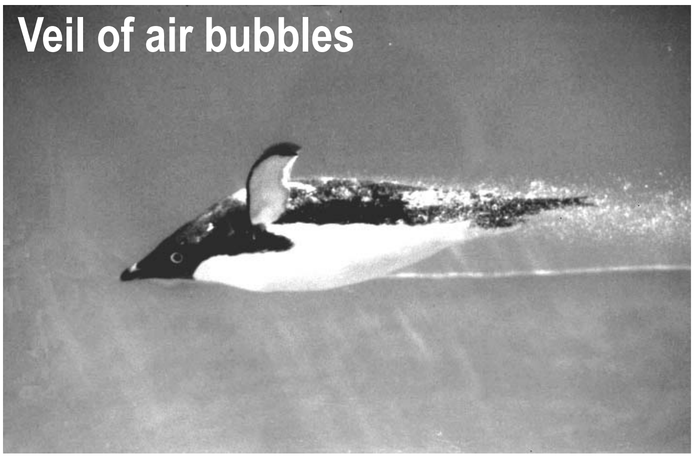




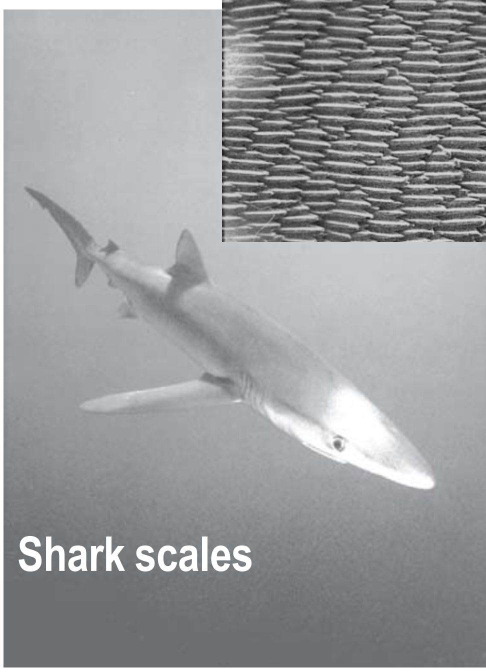
Drag minimization in nature 3

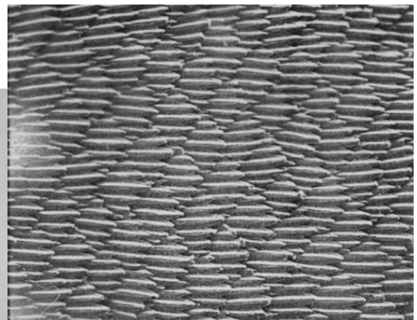


Drag minimization in nature 2



Drag minimization in nature 5





Drag minimization in nature 4

1.

The streamlined body of fish, sharks, wales, dolphins and penguins, which avoids vortex formation.

2.

The compliant dolphin skin, which absorbs oscillations so that the transition to turbulence is delayed.

3.

The threadlike molecules of the fish slime, which smooth small eddies in the turbulent boundary flow.

4.

The longitudinal grooves in the shark skin, which slow down the flicker of the flow in the laminar sublayer.

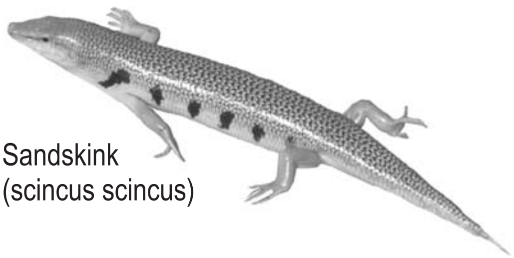
5.

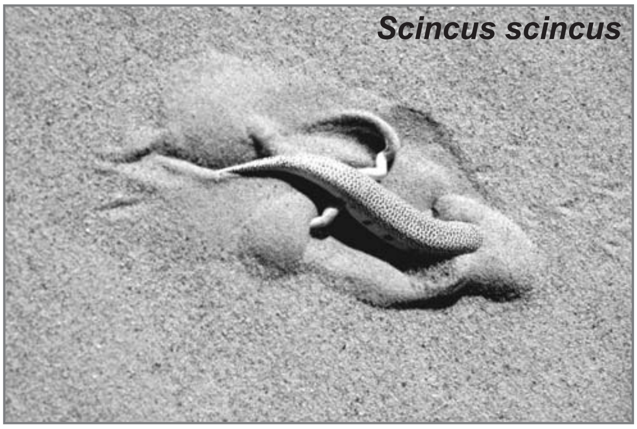
Air bubbles, which leave the plumage of the penguin at high speeds and reduce the viscosity of the water.

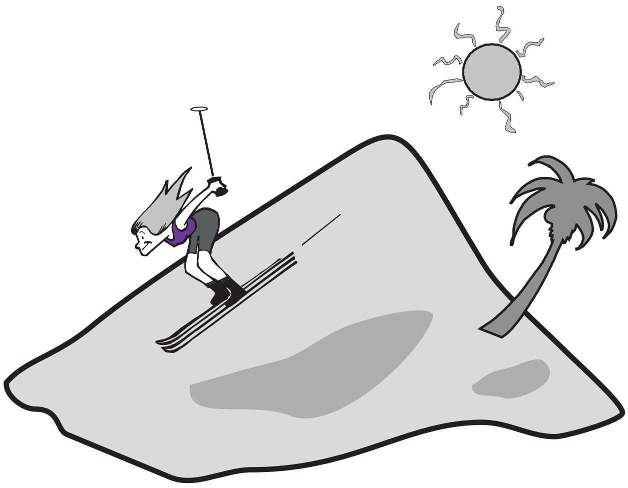
Cunning techniques which reduce flow resistance of fast swimming animals

6.

Solid friction



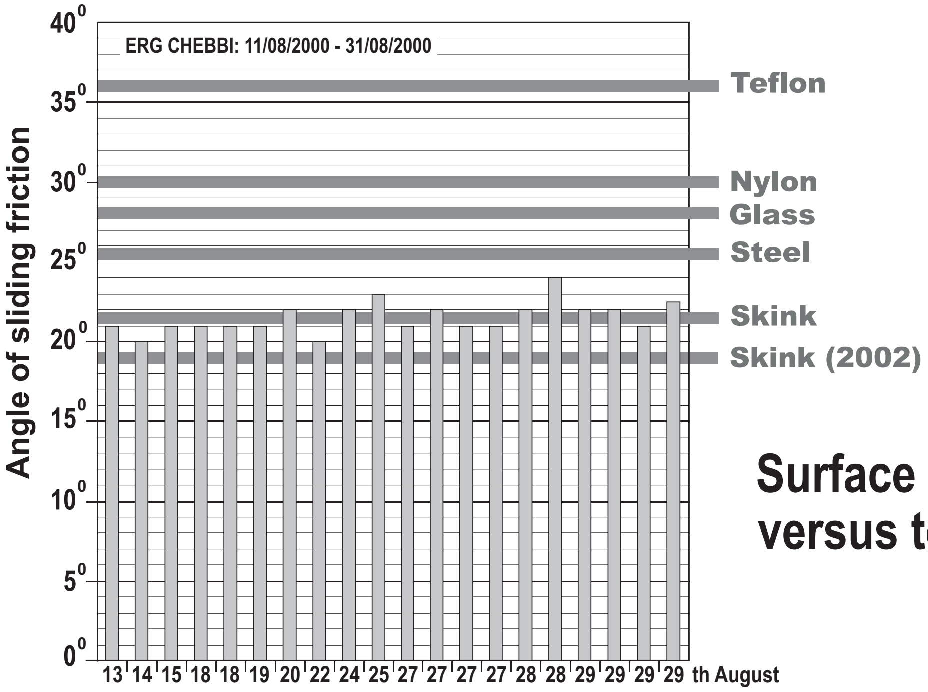


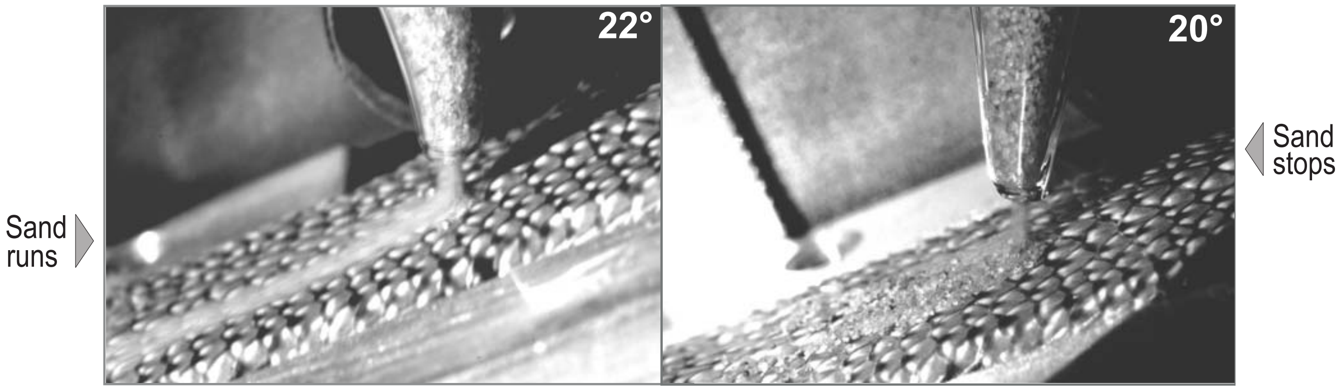


The sandfish of the Sahara may reduce the solid friction coefficient

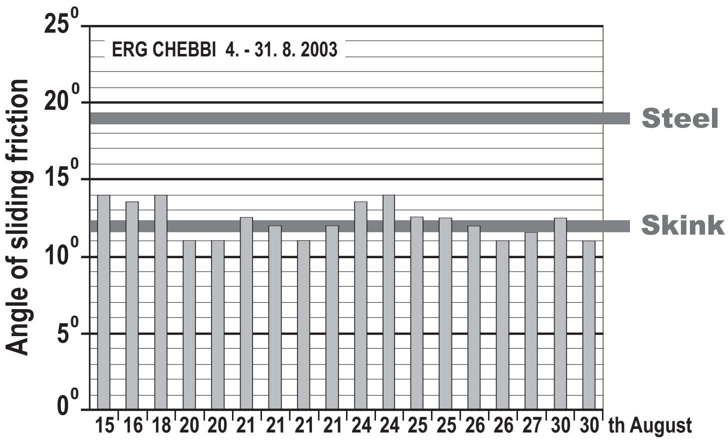
Ingo Rechenberg and
Abdullah Regaby El Khyari

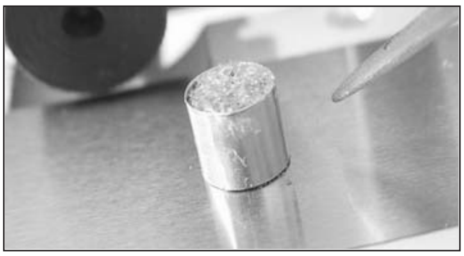
Surface friction: Sandskink versus technical materials



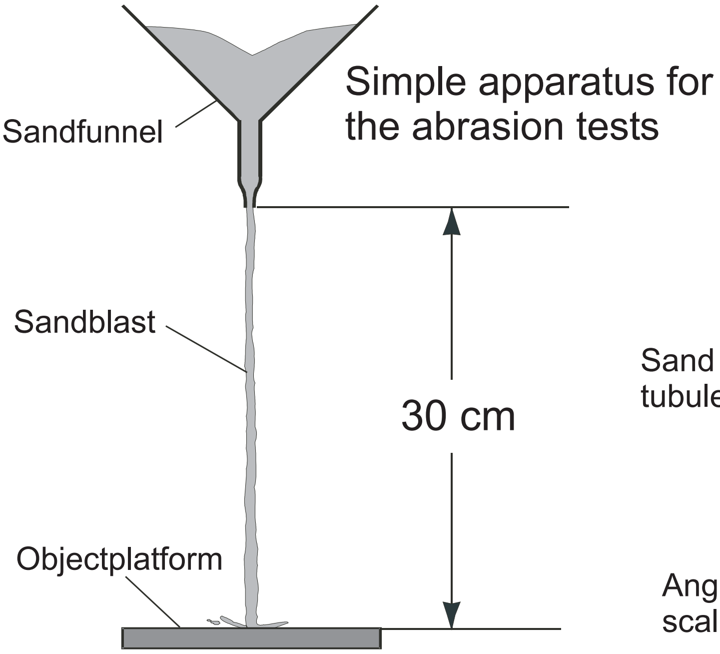


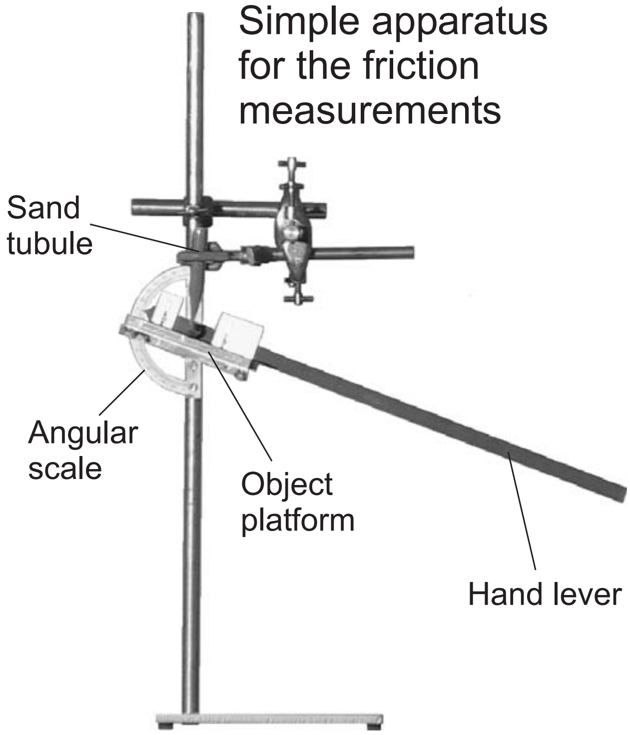
Sand stream measurements

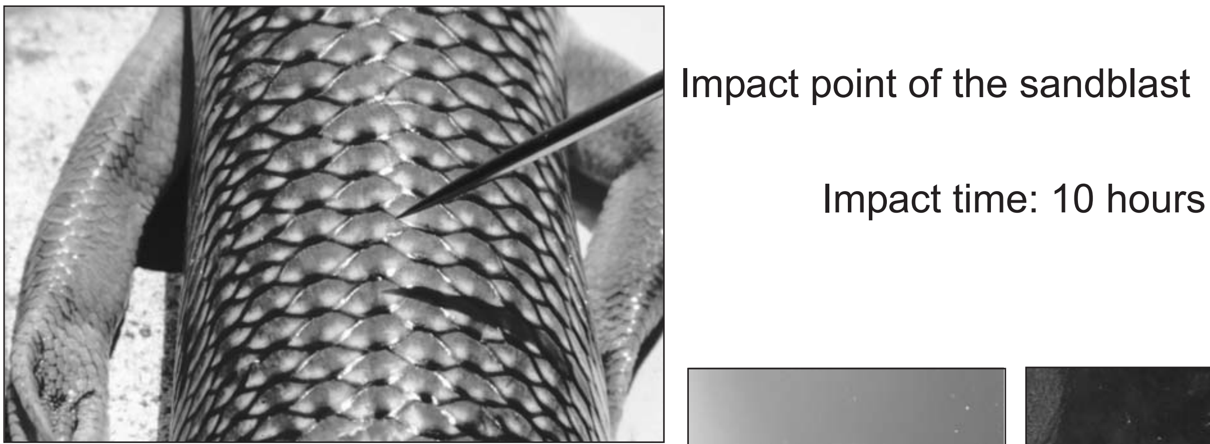


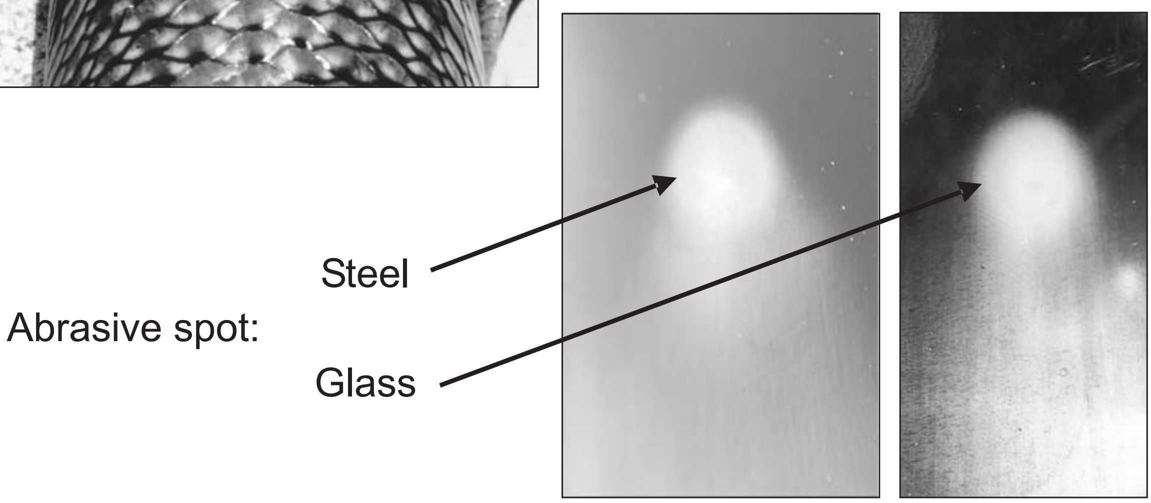


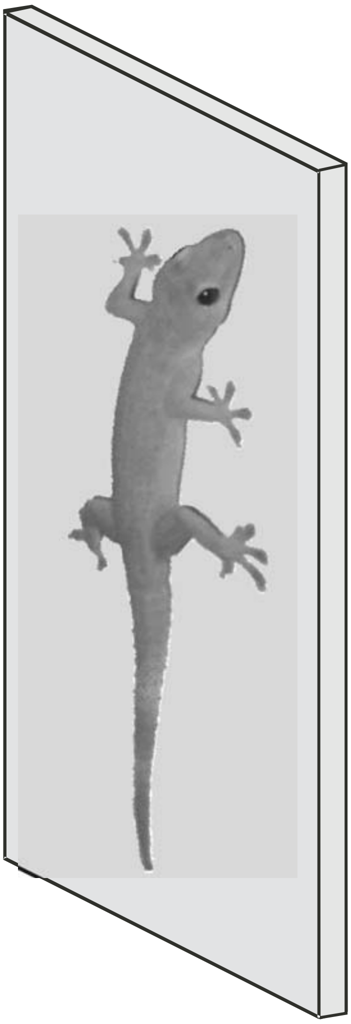
Sand cylinder measurements


Simple apparatus for the abrasion tests
Sandfunnel
Sandblast
30 cm
Objectplatform


Simple apparatus for the friction measurements
Sand tubule
Angular scale
Object platform
Hand lever


Impact point of the sandblast
Impact time: 10 hours


Abrasive spot:
Steel
Glass



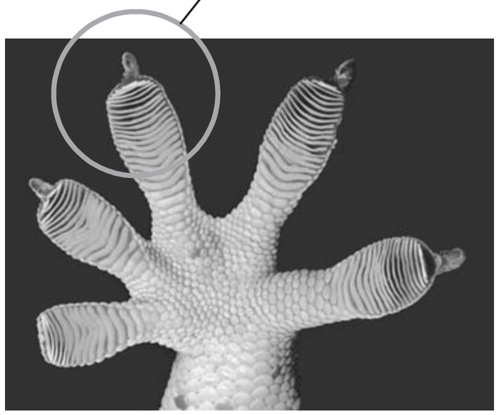


Photo: M. Moffet

Geckos get a grip using van der Waals forces

The wonder of the dry adhesion of the Gecko toes

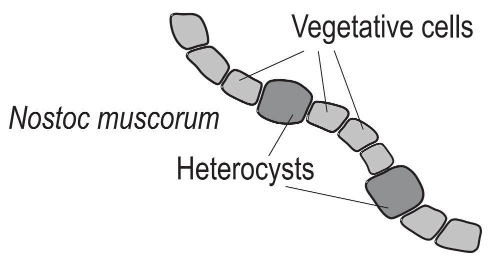
Kellar Autumn, Ronald Fearing, Metin Siiti

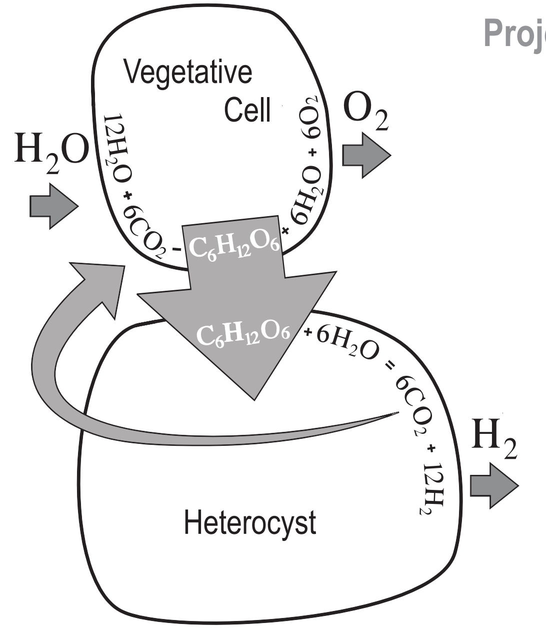
A future vision

Synthetic Gecko hairs promise walking up walls

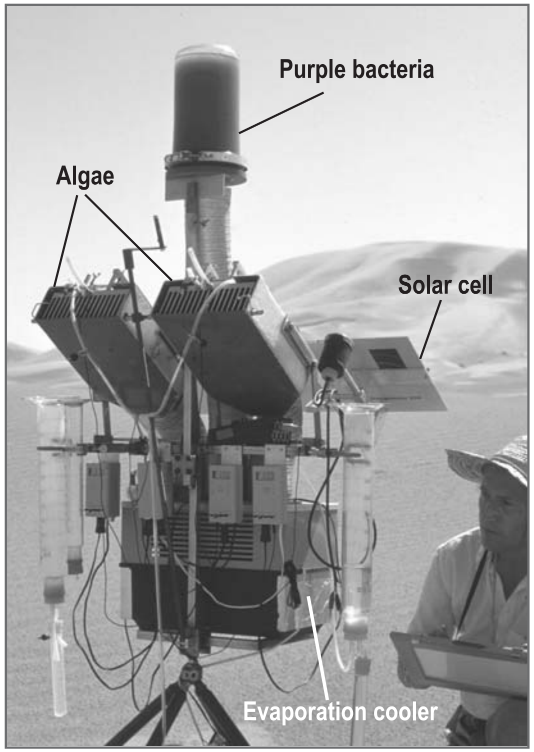
(New Scientist 15. 05. 2003)

Project ArBAS: Artificial Bacteria-Algae-Symbiosis

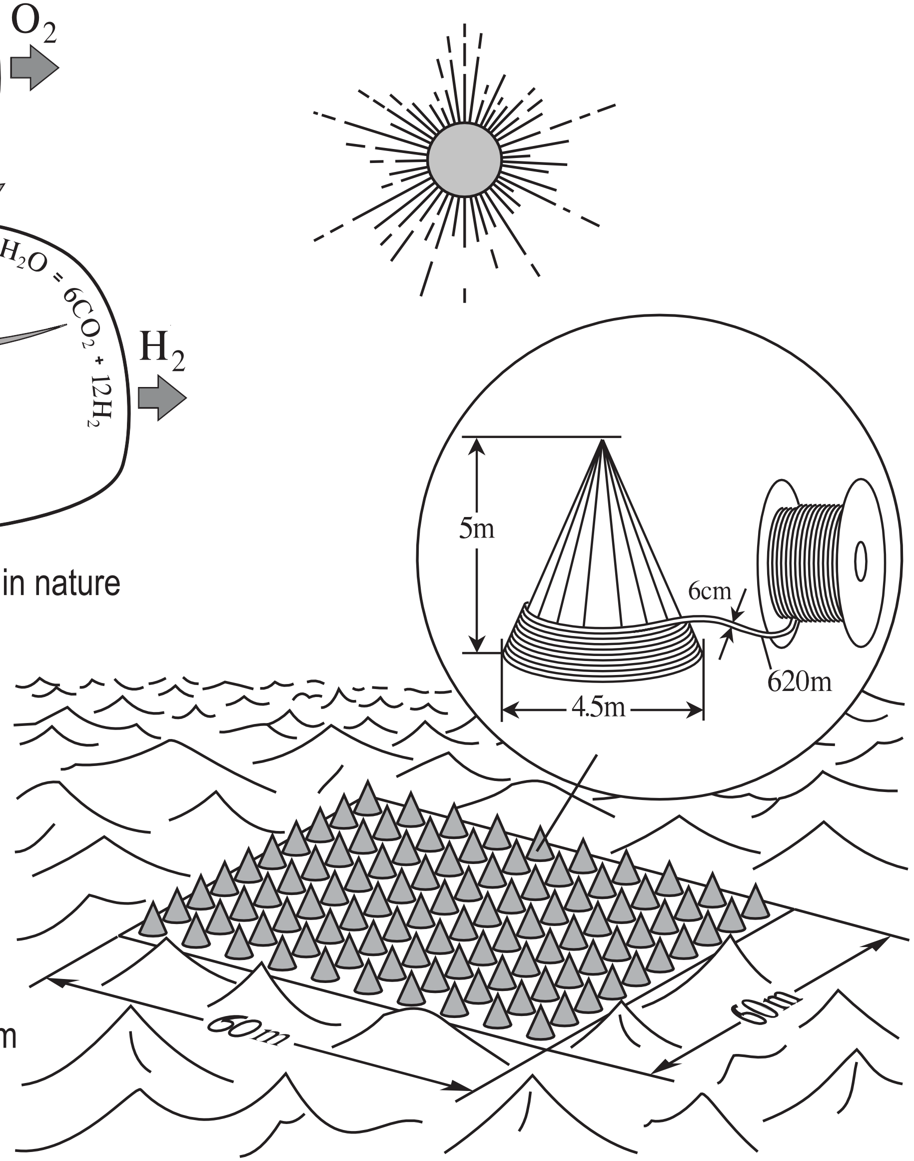




Hydrogen generation in nature

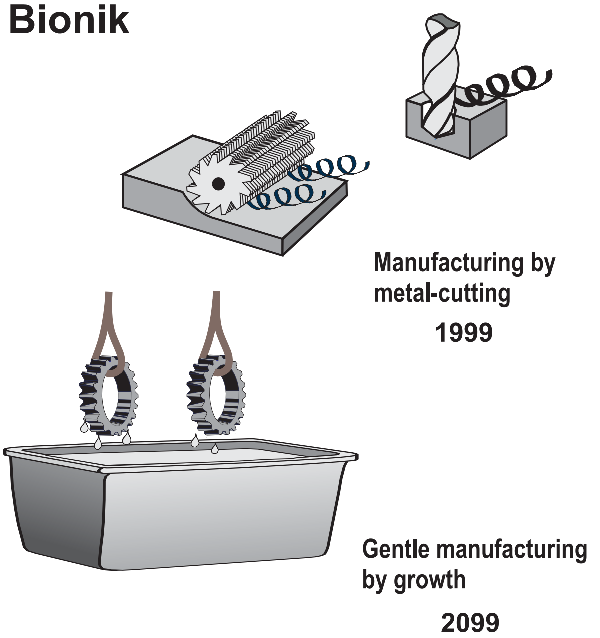


Bioreactor design: Algae and purple bacteria in the Sahara

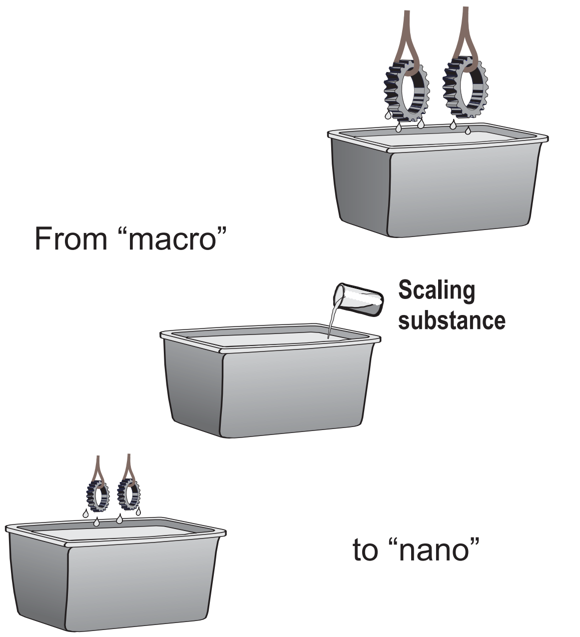


Heliomites in the Sahara - Futuristic view of a 100 kW solar hydrogen farm

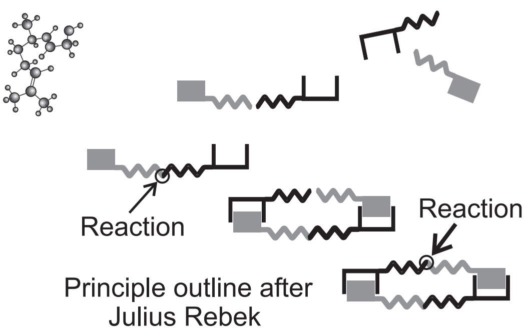
Future of Bionik



The "New Age" of manufacturing



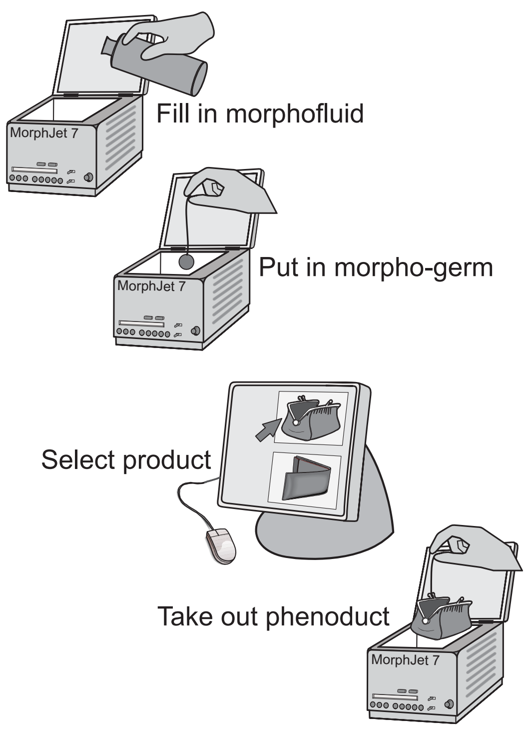
Scale reduction of a growing gearwheel



Created molecule which reproduces itself

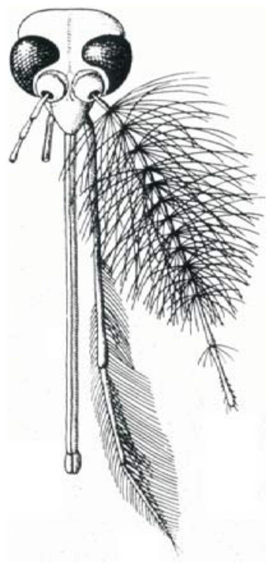
Two new fields of Bionics in the 21th century:

Replionics
Auxonics

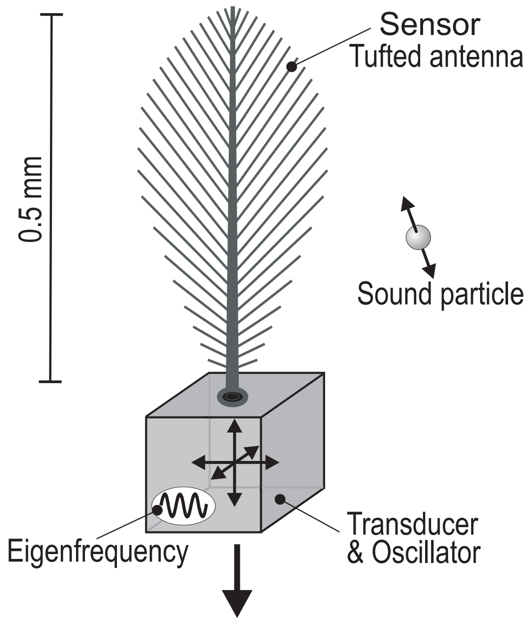


Instructions for the Morphojet 7

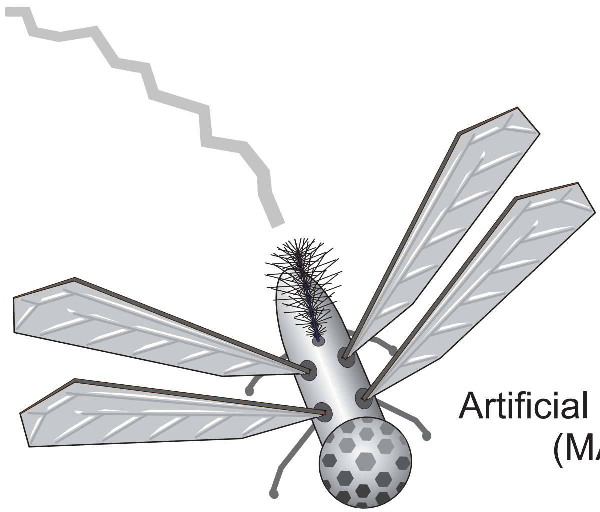
Future of Bionik



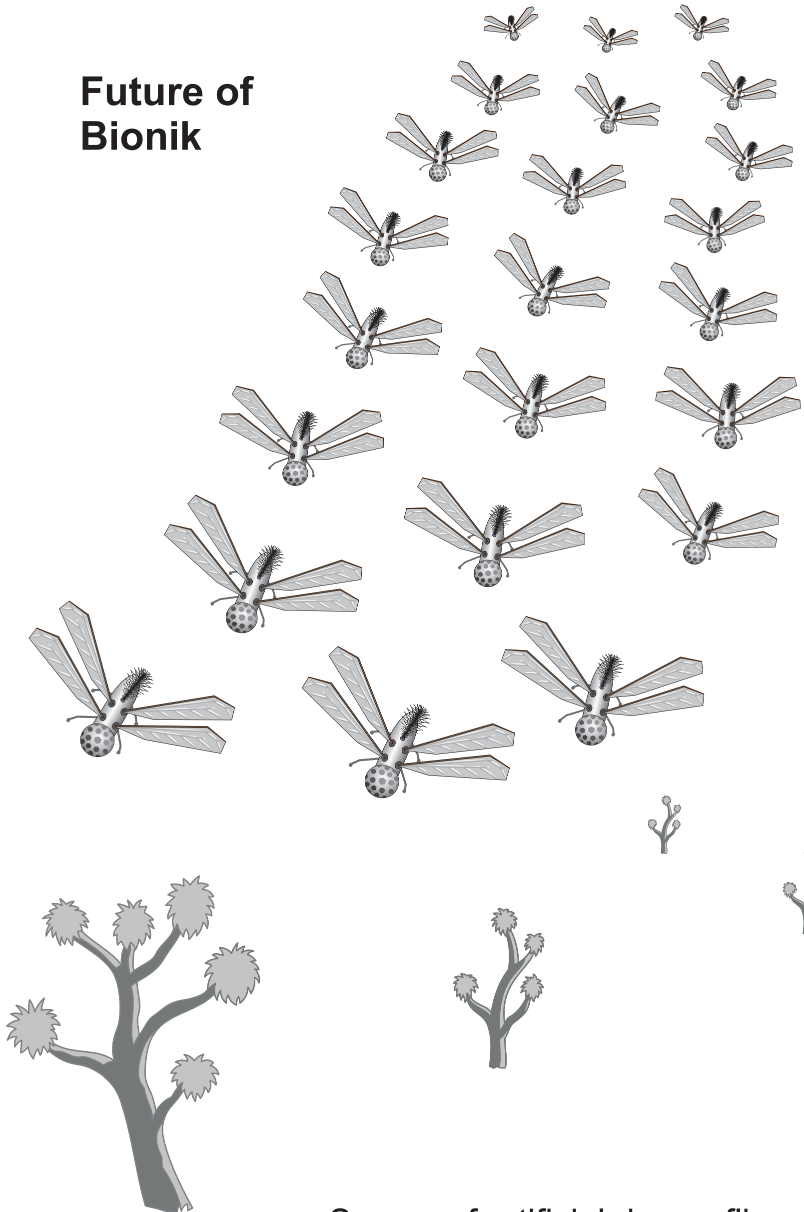
Antenna of male midge



Microsystem “Johnston’s Organ”

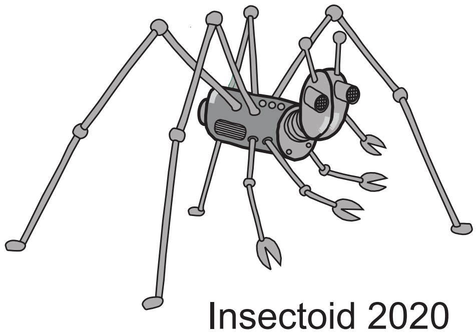


Artificial dragonfly
(MAV)

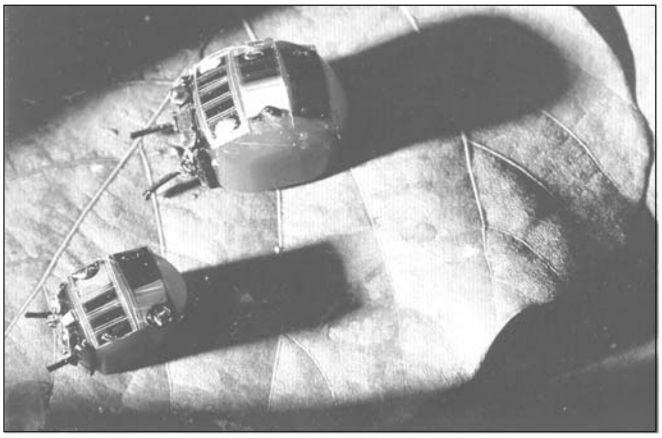


Swarm of artificial dragonflies

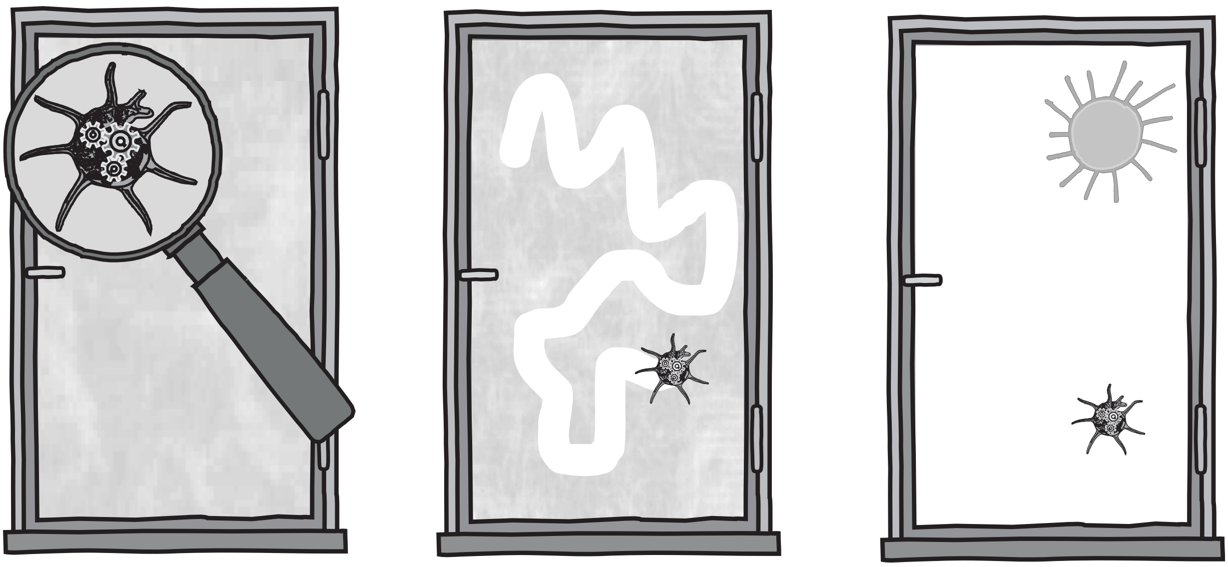
Future of Bionik



Insectoid 2020



Artificial Ladybug -
a study of miniatur robots



Cochloid cleaning the window

Artificial consciousness 2099