向大自然學習
Learn from the Nature

方煒 台大生機系

老子　道德經 第25篇

人法地

地法天

天法道

道法自然

生物機電工程系的精神

Bring Engineering to Life

and vice versa

Bring Life to Engineering

is Biomimicry

仿生學 (Biomimicry)

這個名詞來源於
希臘文「Bio」-- 意思是「生命」
「mimic」-- 意思是「模仿」

仿生科技是一種仿效生物 38 億年演化經驗的科技，舉凡型態、過程以及生態系統都是模擬的基礎。

仿生 Biomimicry

- 以自然為學習典範　Nature as model
  - 由自然的設計與過程中仿效或擷取靈感，以解決人類的問題
- 以自然為衡量標準　Nature as measure
  - 以歷經38億年的自然界的標準來衡量創新的適當性
    - **心臟跳動次數：75 x 60 x 24 x 365 x 80 = 3,153,600,000　31億5360萬次**
- 以自然為師　Nature as mentor
  - 人類重新看待自我在生態中存在的角色
  - 引領一個利基於學習自然而非榨取自然的新世代
    - **過去：天生萬物以養人 (EGO)**
    - **現在：人類只是生物中的一環 (ECO)**

仿生的核心理念

- 生命創造有利於生命存續的環境

  Life creates conditions conductive to life

- 生命不會為了解決問題而產生新問題
- 生命會自己找到出路

- 生命強調非單純追求效率與效能
- 仿生的設計與研發應由宏觀角度思考長期的影響

生命運行的6大準則

- 演化以利生存 evolve to survive
- 面對變化隨時調適 adapt to changing condition
- 通達在地適地回應 locally attuned & responsive
- 發展與成長整合並存 integrate development with growth
- 高效運用資源 resource efficient
- 使用對生命友善的化學 use life-friendly chemistry

仿生的發展潛力

生物界面對問題的因應之道
與 人類科技的方法
僅有 12 % 的相似度

J. Vincent, 英國生物學家 2009

這代表
運用生物策略的仿生設計，
將擁有突破人類既有思考框架，
開發出嶄新技術的潛力

Introducing

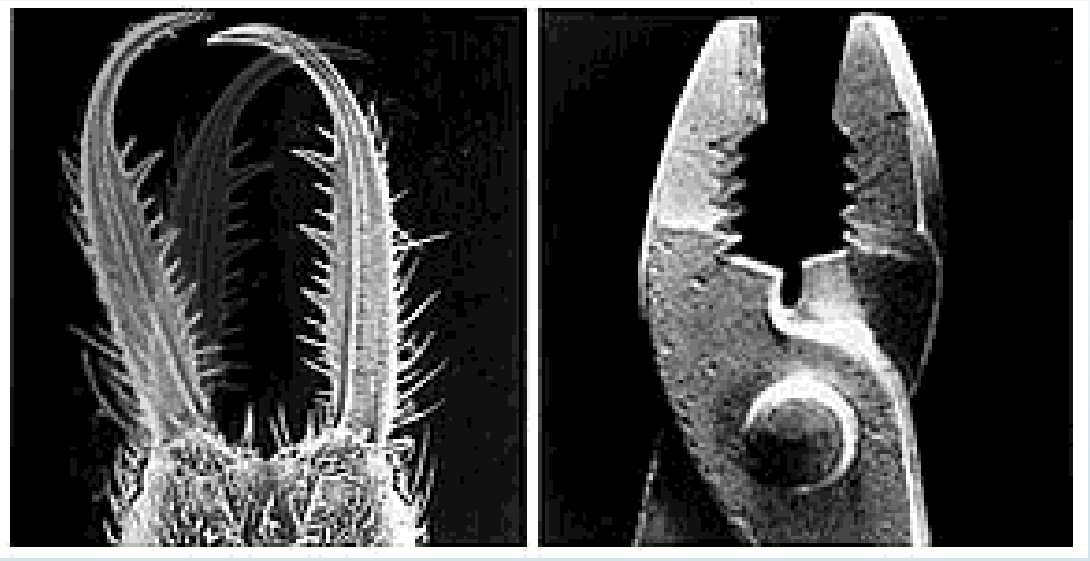
Learn from the Nature

- Nature (Evolution) accomplishes it`s Targets always
  - economically
  - With a minimum amount of energy

- It is not the direct copying of nature, which seems to be at the surface, but the discovering of the underlying principles and methods for the implementation in valuable solutions.

Bionics：BIO-logy and tech-NIC

BIONICS is a science dealing with solutions, which nature has developed in trial-and-error-processes within millions of years.



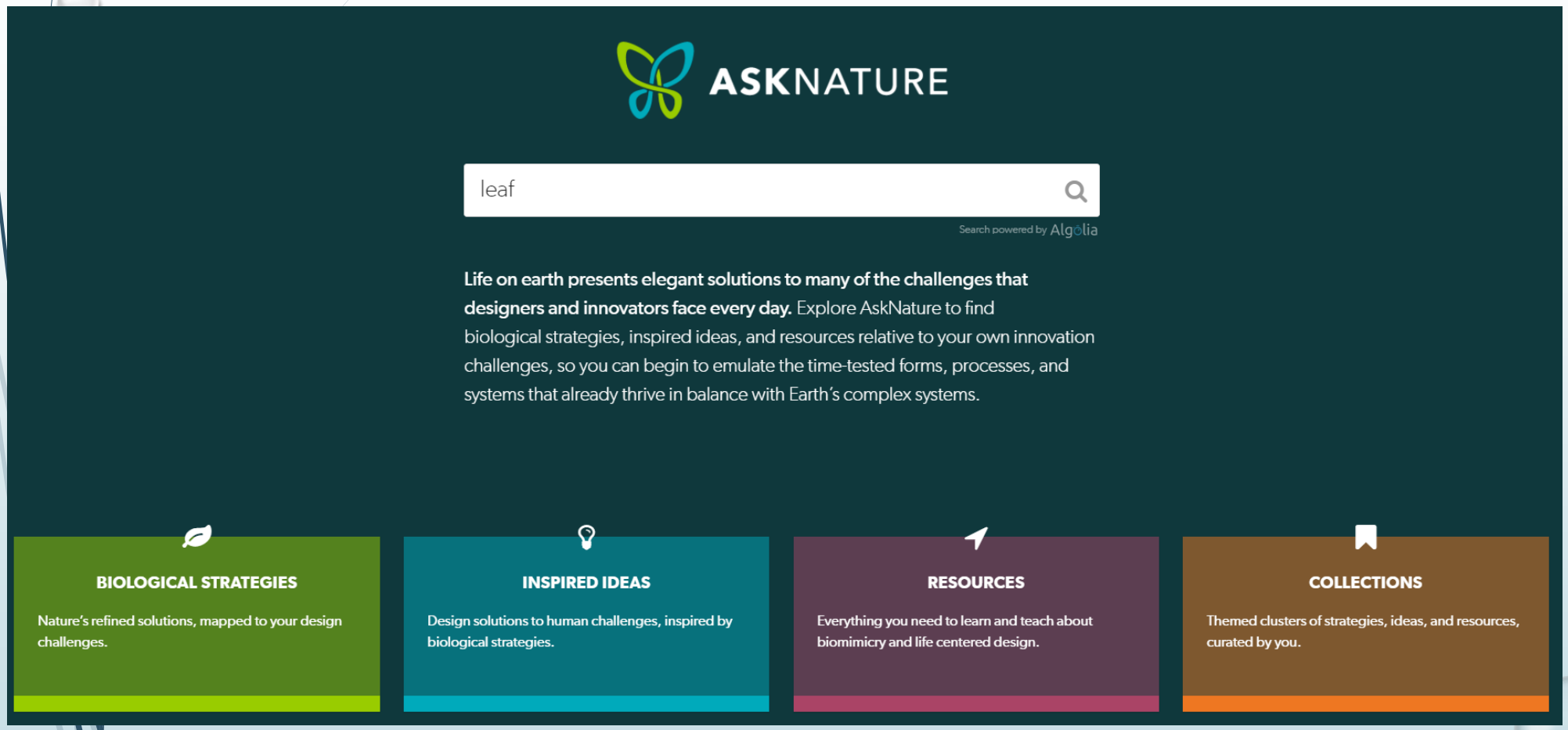
Solutions are optimal and show a high degree of efficiency.

仿生學 Biomimicry

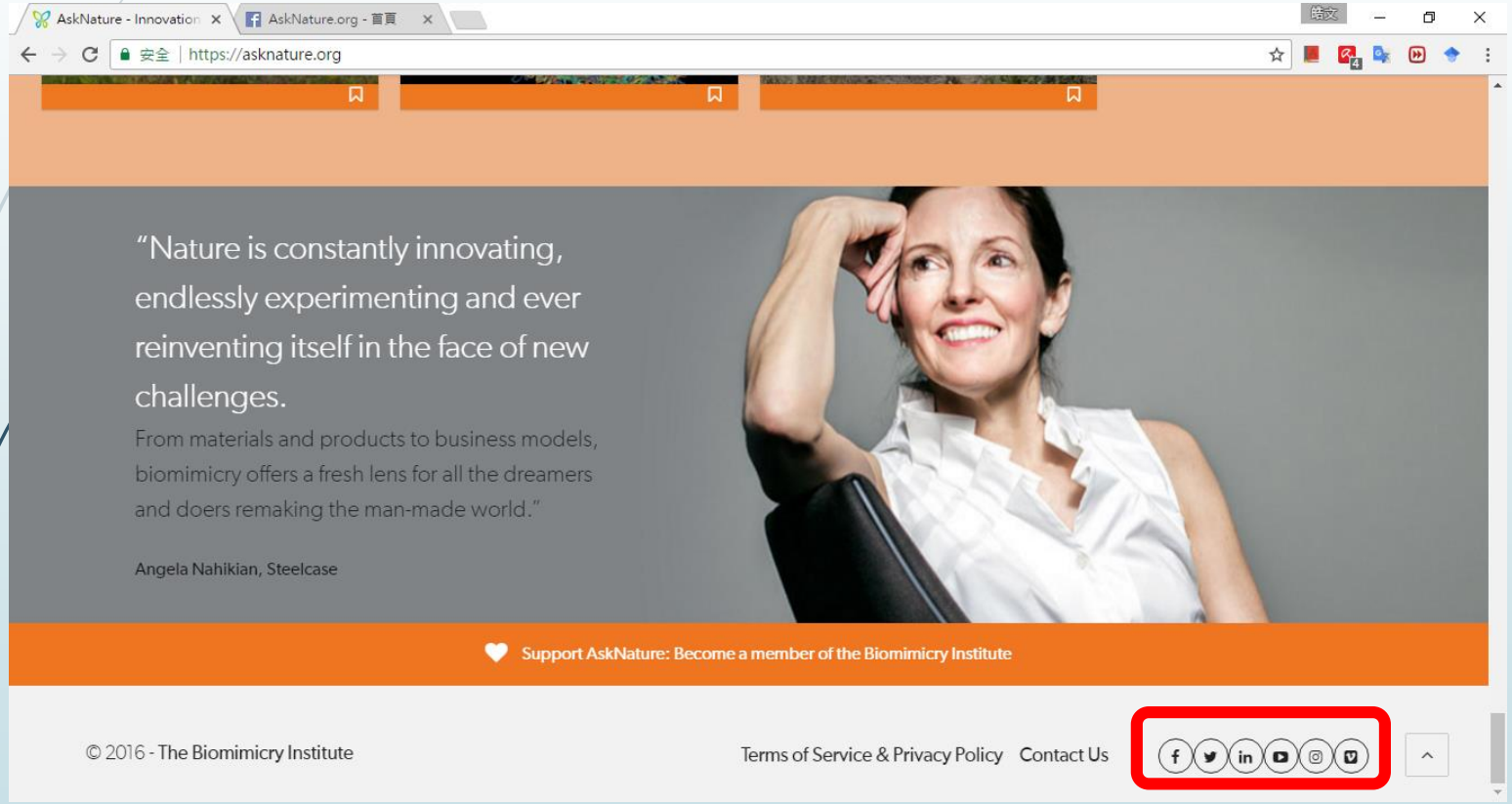
- 仿生學可定義為研究大自然的設計、模式與系統，以從中模仿、調整或獲得啟發，為日常問題創造可行的解決之道。
- 仿生學是人類學習生物與環境共存的智慧。
- 從自然中汲取靈感
  - ✓ 適應性強
  - ✓ 靈活的
  - ✓ 節能的
  - ✓ 環保的
  - ✓ 容錯的
  - ✓ 多功能的
  - ✓ 智慧的

Asknature.org

- Algolia公司成立於2012年
- 用戶可在網站取得直觀的動態搜尋應用及即時體驗與上傳資料。
- 這個網站提供你創新挑戰尋找生物策略、思想啟發、資源和收集等訊息，
  您可以去模擬過去地球已經存在的複雜平衡系統中的設計、模式和系統。


ASKNATURE
leaf
Search powered by Algolia
Life on earth presents elegant solutions to many of the challenges that designers and innovators face every day. Explore AskNature to find biological strategies, inspired ideas, and resources relative to your own innovation challenges, so you can begin to emulate the time-tested forms, processes, and systems that already thrive in balance with Earth's complex systems.
BIOLOGICAL STRATEGIES
Nature's refined solutions, mapped to your design challenges.
INSPIRED IDEAS
Design solutions to human challenges, inspired by biological strategies.
RESOURCES
Everything you need to learn and teach about biomimicry and life centered design.
COLLECTIONS
Themed clusters of strategies, ideas, and resources, curated by you.

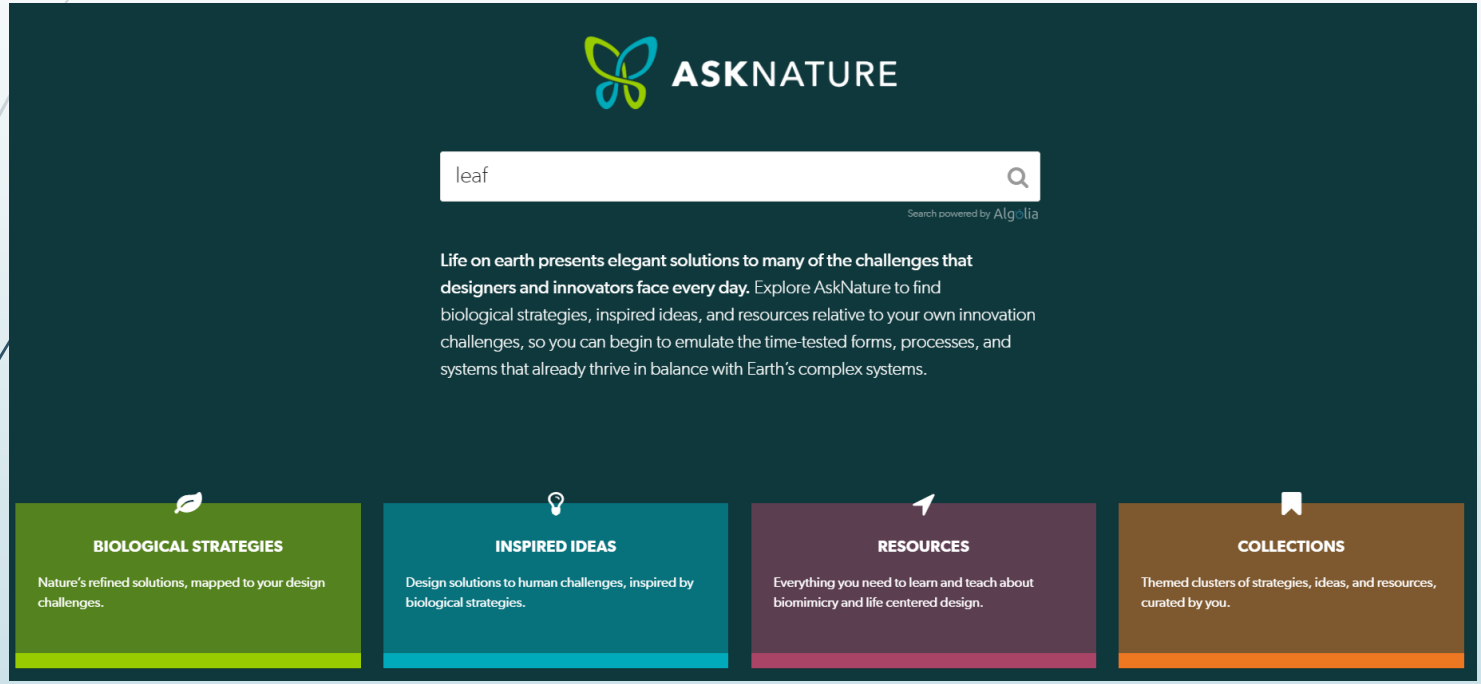
Asknature網站



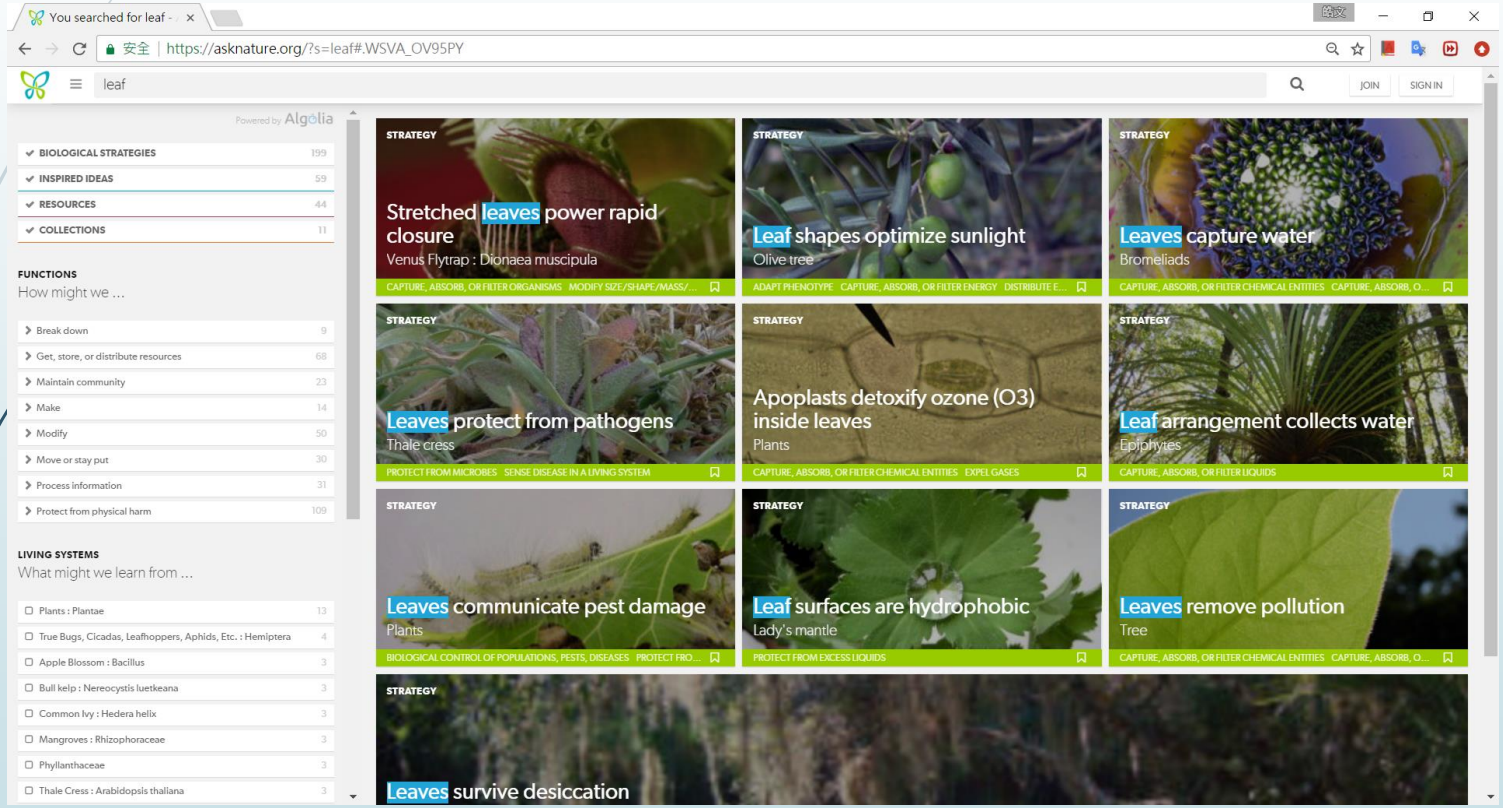
Asknature臉書社群

- 臉書持續更新中，有許多新文章，值得追蹤！

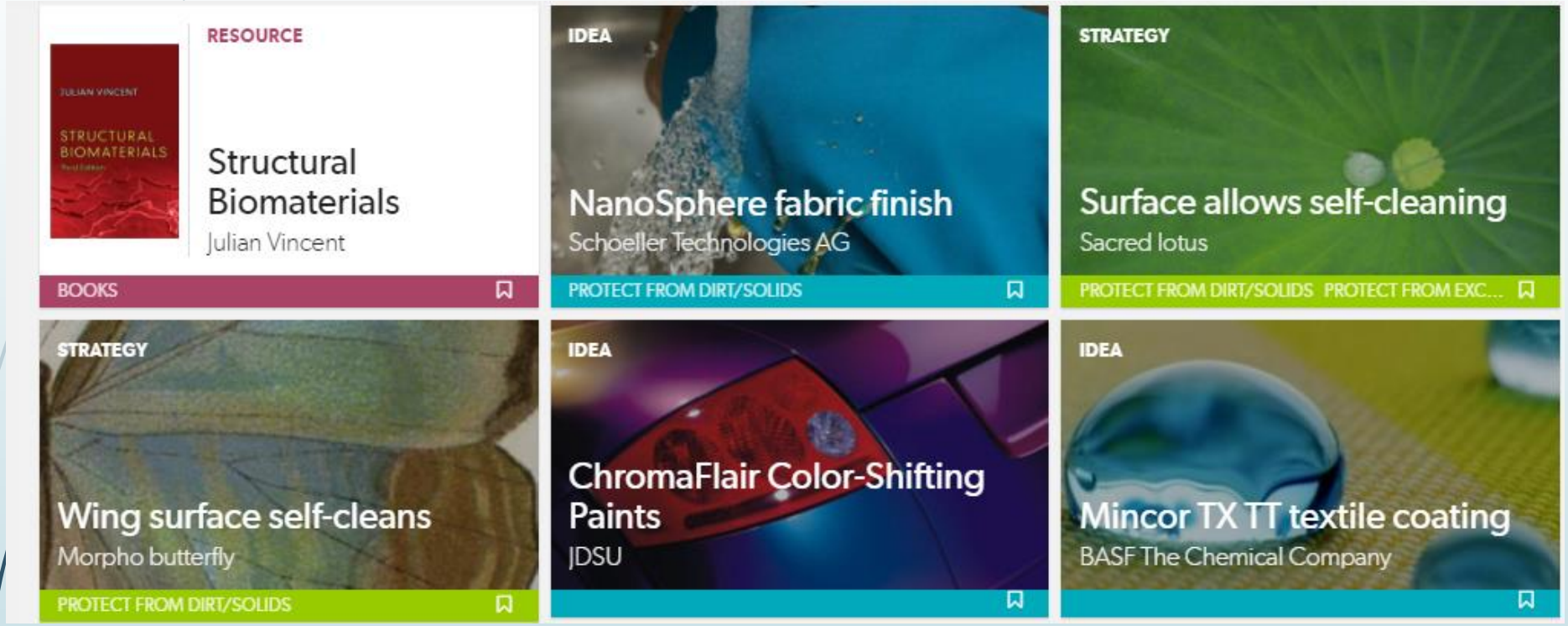
Asknature搜尋資料



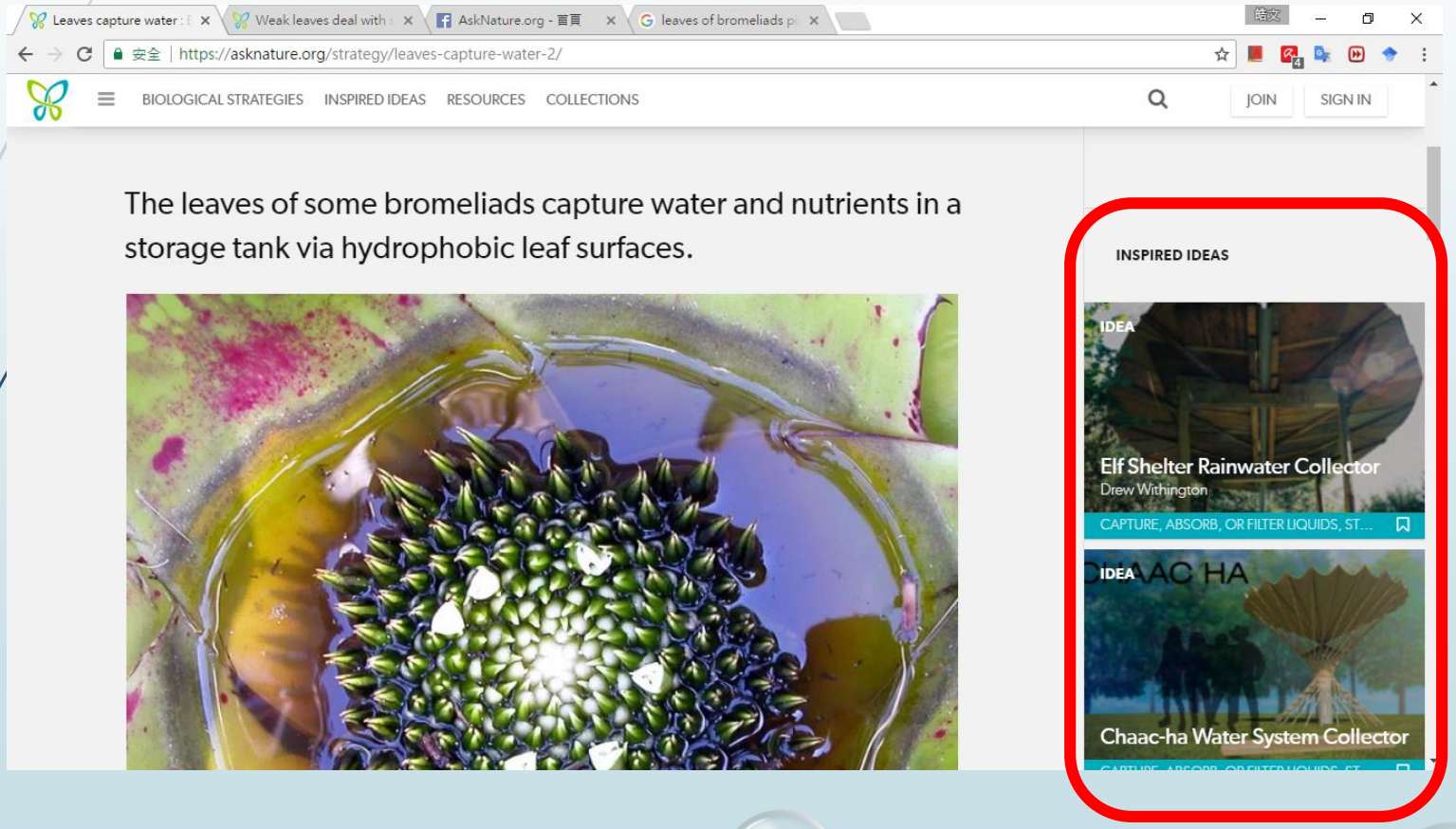
Asknature搜尋資料



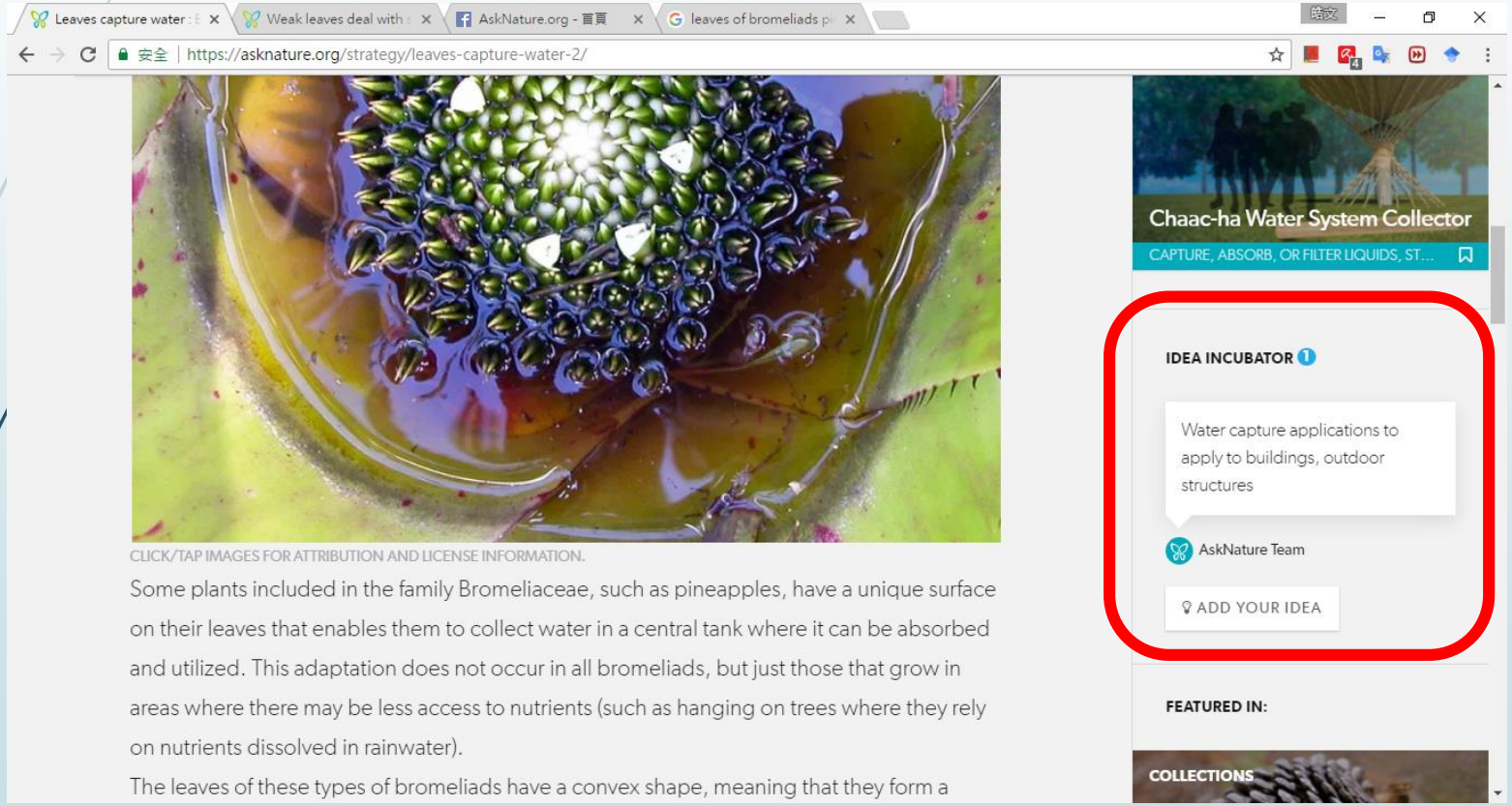
AskNature


RESOURCE
JULIAN VINCENT
STRUCTURAL BIOMATERIALS
Structural Biomaterials
Julian Vincent
BOOKS
IDEA
NanoSphere fabric finish
Schoeller Technologies AG
PROTECT FROM DIRT/SOLIDS
STRATEGY
Surface allows self-cleaning
Sacred lotus
PROTECT FROM DIRT/SOLIDS PROTECT FROM EXC...
STRATEGY
Wing surface self-cleans
Morpho butterfly
PROTECT FROM DIRT/SOLIDS
IDEA
ChromaFlair Color-Shifting Paints
JDSU
IDEA
Mincor TX TT textile coating
BASF The Chemical Company

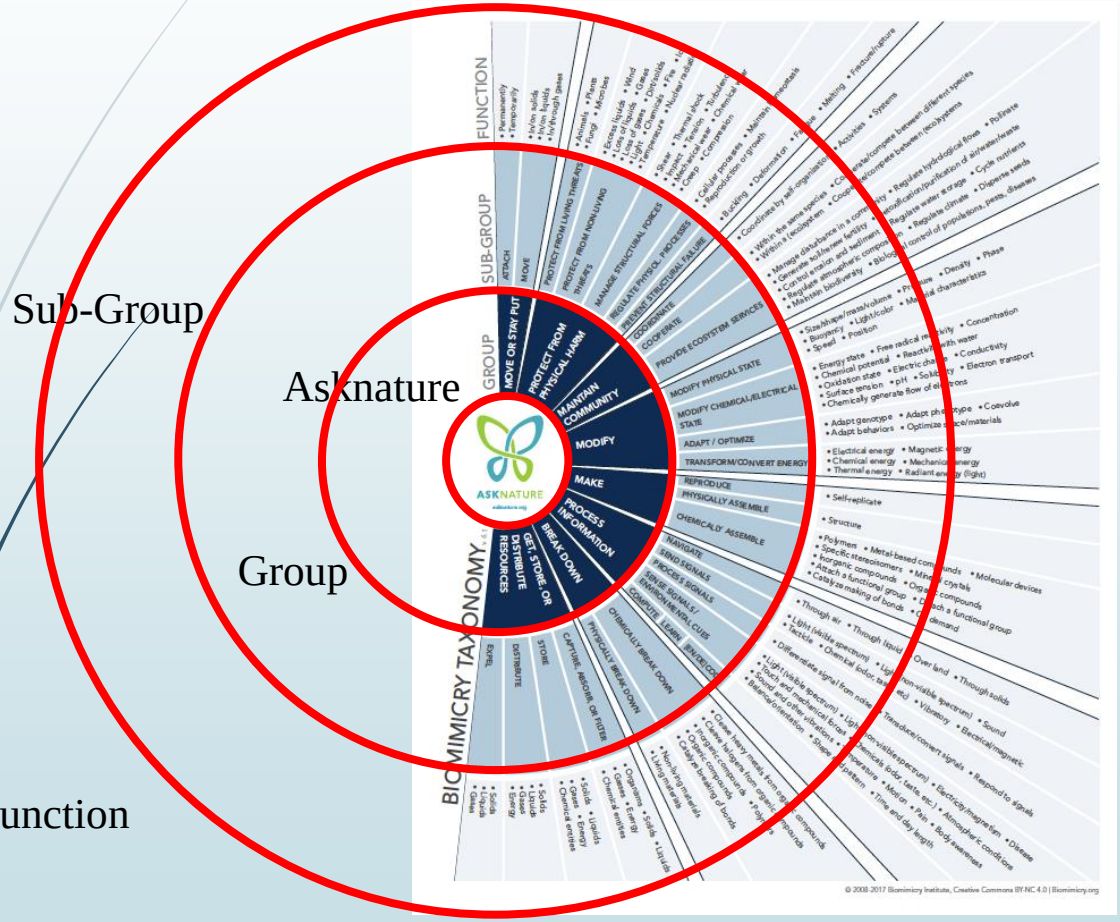
Inspired ideas



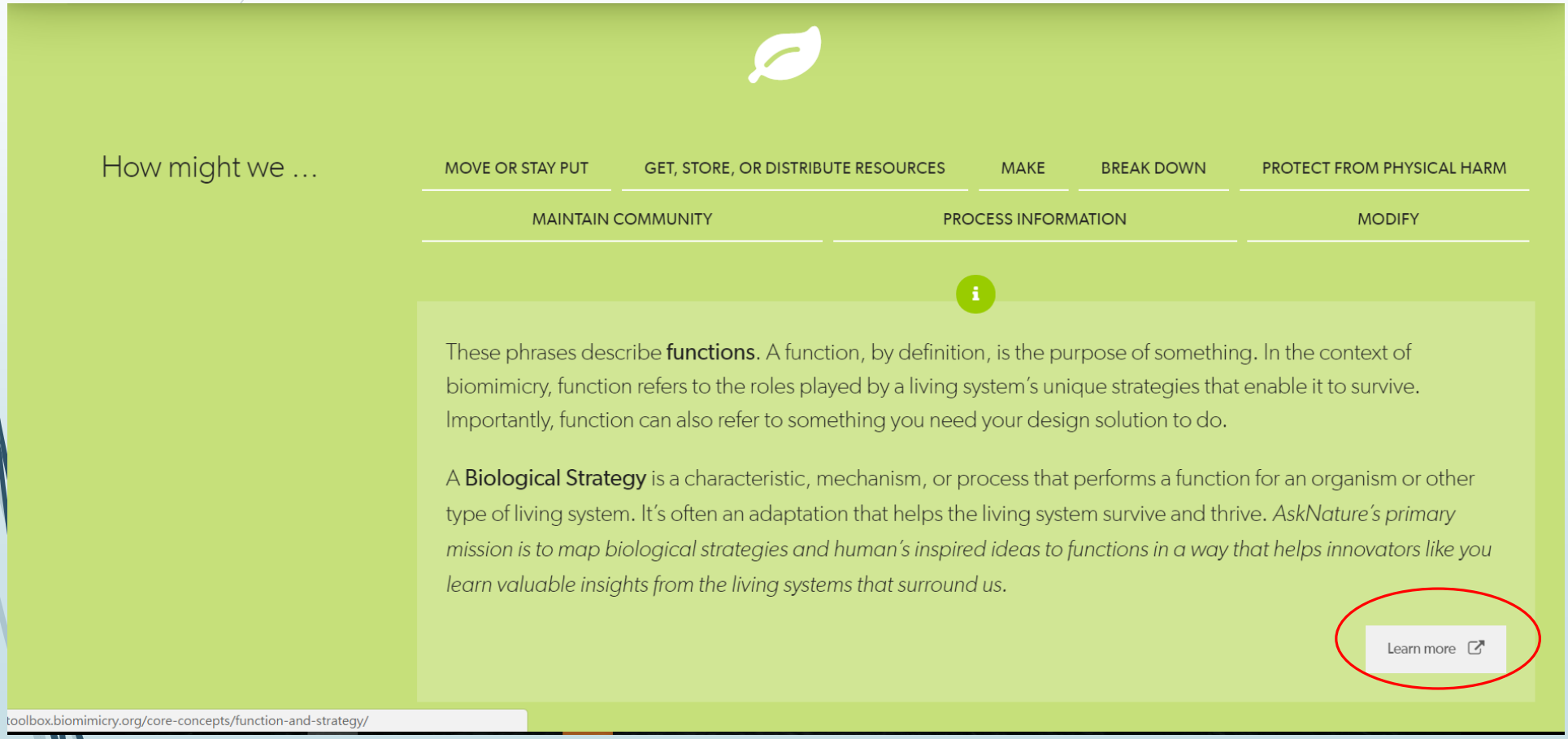
Idea incubator

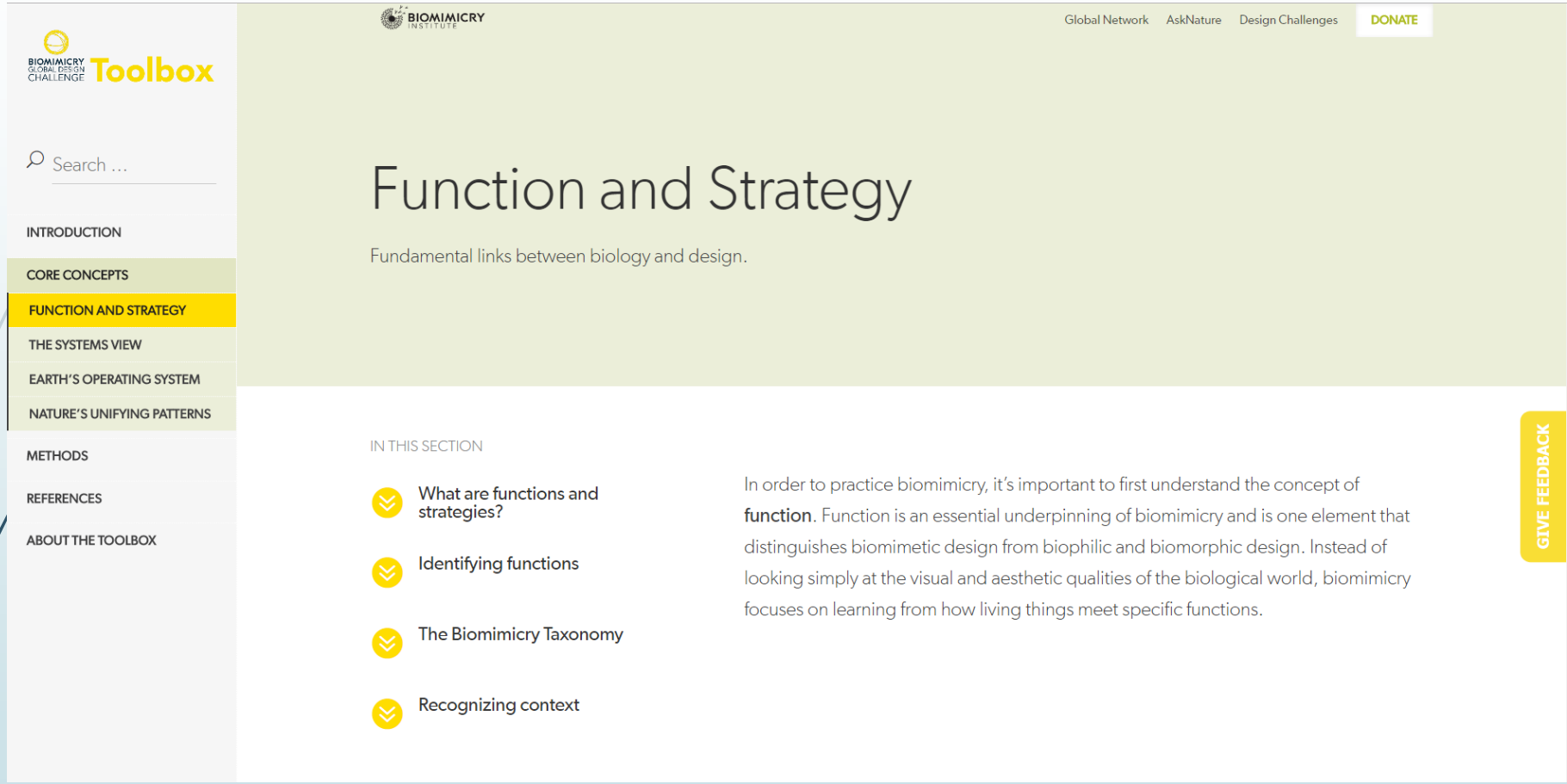


了解 AskNature 的架構



The Biomimicry Taxonomy


How might we …
MOVE OR STAY PUT
GET, STORE, OR DISTRIBUTE RESOURCES
MAKE
BREAK DOWN
PROTECT FROM PHYSICAL HARM
MAINTAIN COMMUNITY
PROCESS INFORMATION
MODIFY
These phrases describe functions. A function, by definition, is the purpose of something. In the context of biomimicry, function refers to the roles played by a living system's unique strategies that enable it to survive. Importantly, function can also refer to something you need your design solution to do.
A Biological Strategy is a characteristic, mechanism, or process that performs a function for an organism or other type of living system. It's often an adaptation that helps the living system survive and thrive. AskNature's primary mission is to map biological strategies and human's inspired ideas to functions in a way that helps innovators like you learn valuable insights from the living systems that surround us.
Learn more
toolbox.biomimicry.org/core-concepts/function-and-strategy/



BIOMIMICRY GLOBAL DESIGN CHALLENGE Toolbox

Search ...

- INTRODUCTION
- CORE CONCEPTS
- FUNCTION AND STRATEGY
- THE SYSTEMS VIEW
- EARTH'S OPERATING SYSTEM
- NATURE'S UNIFYING PATTERNS
- METHODS
- REFERENCES
- ABOUT THE TOOLBOX

BIOMIMICRY INSTITUTE

Global Network AskNature Design Challenges DONATE

Function and Strategy

Fundamental links between biology and design.

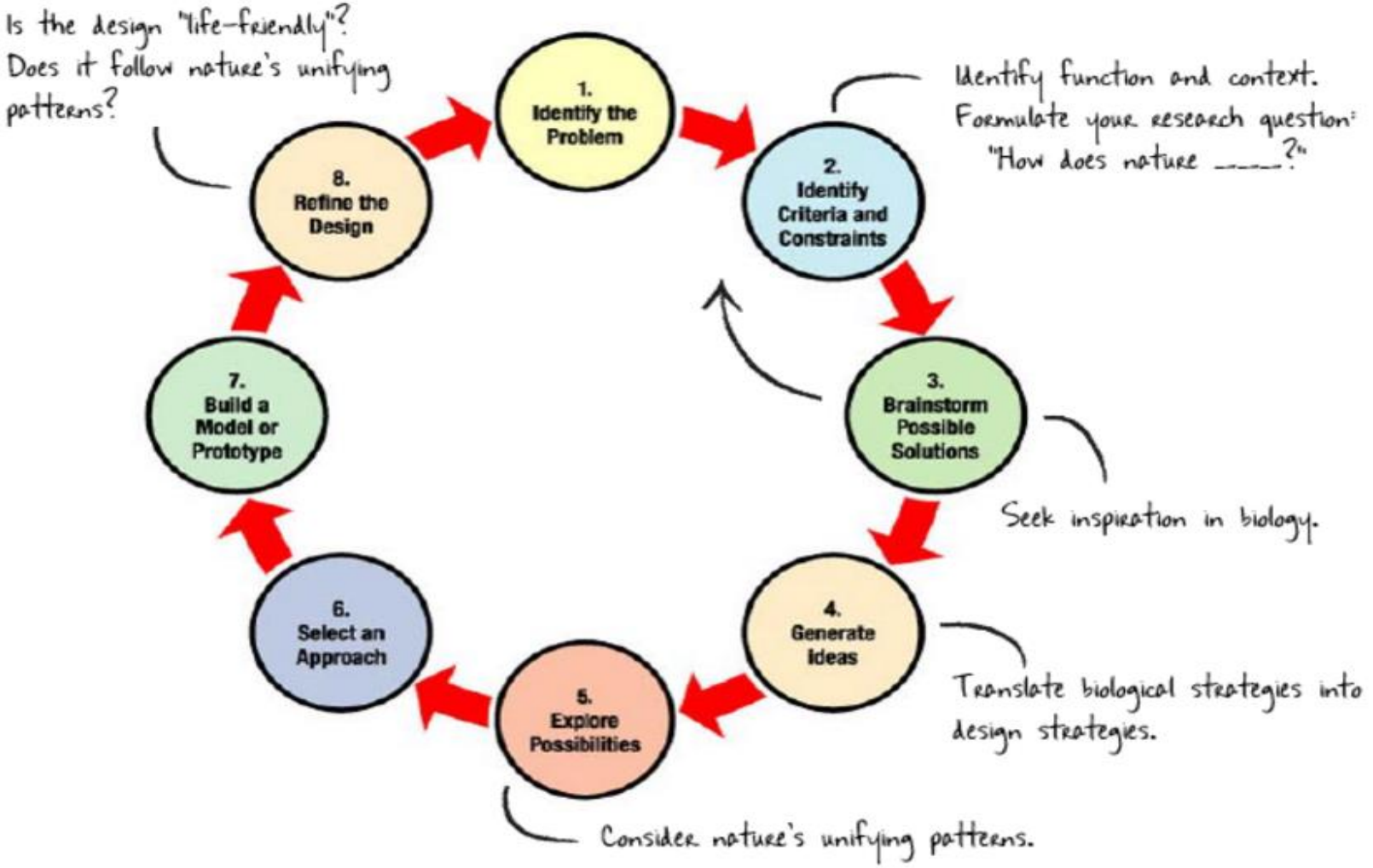
IN THIS SECTION

- What are functions and strategies?
- Identifying functions
- The Biomimicry Taxonomy
- Recognizing context

In order to practice biomimicry, it's important to first understand the concept of **function**. Function is an essential underpinning of biomimicry and is one element that distinguishes biomimetic design from biophilic and biomorphic design. Instead of looking simply at the visual and aesthetic qualities of the biological world, biomimicry focuses on learning from how living things meet specific functions.

GIVE FEEDBACK

如何仿生


Is the design "life-friendly"? Does it follow nature's unifying patterns?
1. Identify the Problem
2. Identify Criteria and Constraints
Identify function and context. Formulate your research question: "How does nature _____?"
3. Brainstorm Possible Solutions
Seek inspiration in biology.
4. Generate Ideas
Translate biological strategies into design strategies.
5. Explore Possibilities
Consider nature's unifying patterns.
6. Select an Approach
7. Build a Model or Prototype
8. Refine the Design

第一步

What do I want my design to "DO" ?

Verb : Function

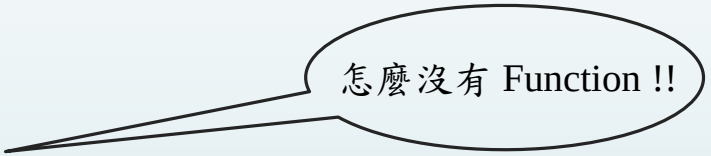
A **function,**

by definition, is the purpose of something.

In the context of biomimicry, function refers to the role played by an organism's adaptations or behaviors that enable it to survive.

問題的設計　很重要

For example :



- I want to design a bicycle helmet.

➡ 生物不會教你如何設計自行車安全帽。

- I want to design a way to protect a bicyclist's head from impact.

➡ 生物會教你如何進行保護的方法。

學習如何仿生 (Methods)

- Scoping a Biomimicry Challenge
- Finding Biological Strategies
- Crafting Design Strategies
- Integrating Biology into Design

Methods - Scoping a Biomimicry Challenge

- Define the Challenge:

  - 此階段，並不是要討論出任何解決某問題的方法，而是要清楚地提出想要解決的問題，並且要確認夥伴們都理解你的理念。

我想要解決體溫保暖的問題~你們懂我的理念嗎?

共識

Methods - Scoping a Biomimicry Challenge

- State the challenge as a question

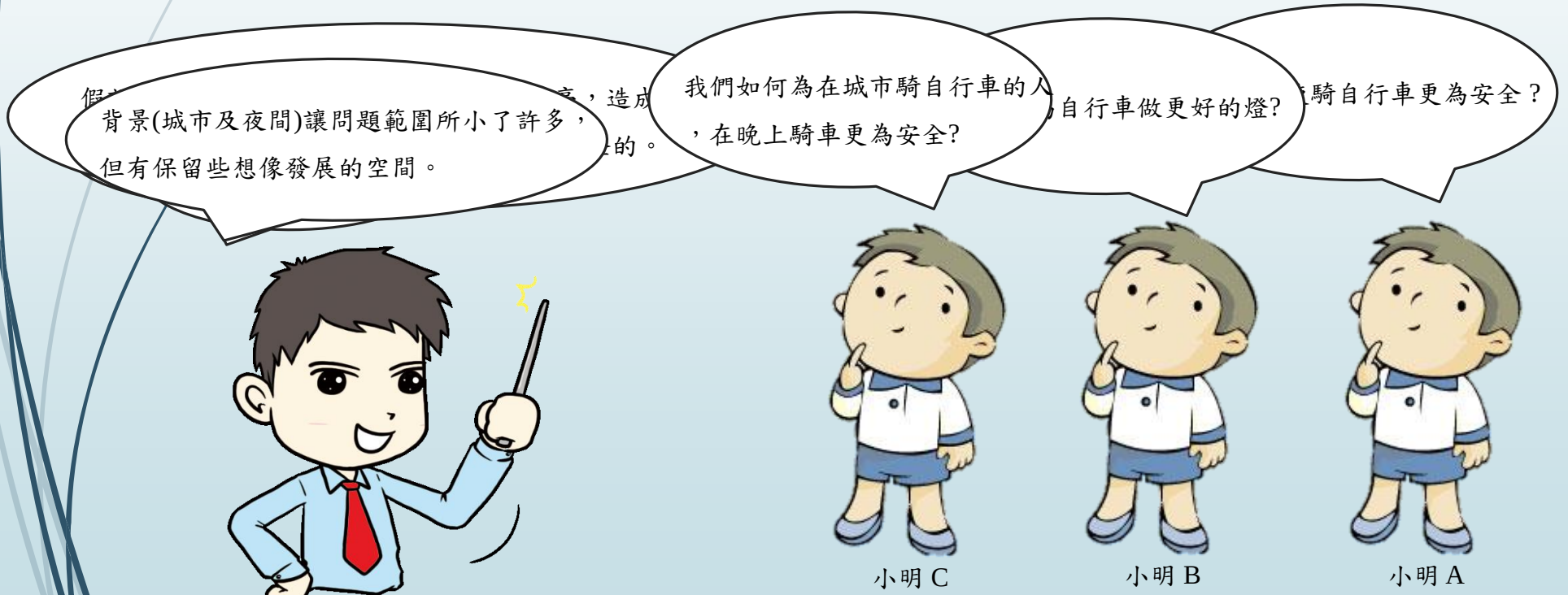
  - 此階段，是將想要解決的問題，用一句話來表達出來。

How might we…?

How might we help corn farmers in Iowa reduce their dependency on synthetic fertilizers?

Methods - Scoping a Biomimicry Challenge

- Sample design questions
  - A good design question is neither too broad nor too narrow.



Methods - Scoping a Biomimicry Challenge

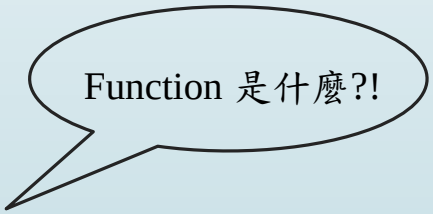
- Biologize the Design Question

➢ 此階段，是將已構想好要解決的問題，轉變成生物的問題設計。

How does nature…?

For example :

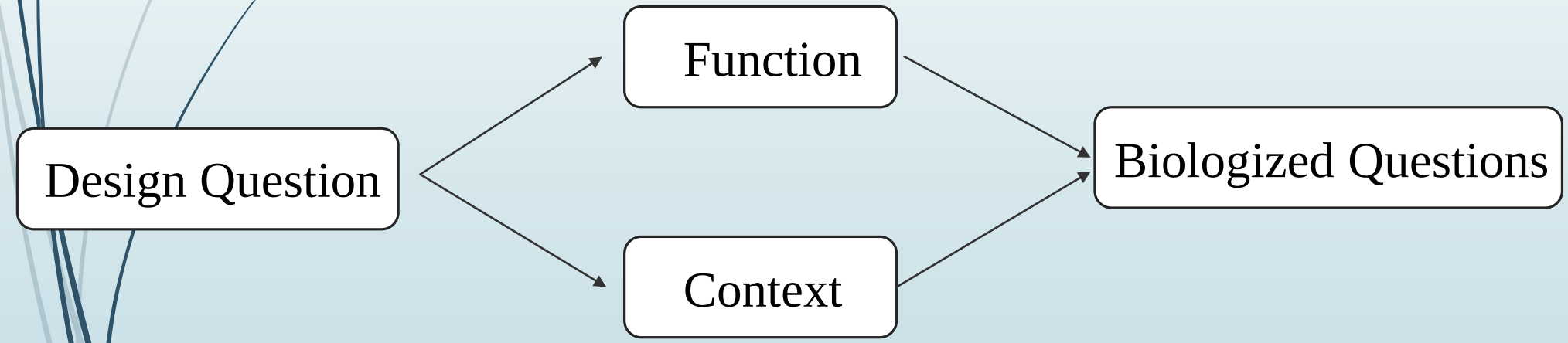
➢ How does nature make urban [illegible]ists more visible to drivers at night?



Methods - Scoping a Biomimicry Challenge

- Biologize the Design Question

➢ 如何將已構想好要解決的問題，轉變成生物的問題設計如下:



Methods - Scoping a Biomimicry Challenge

- Biologized the Design Question

For example :

Design Question:

How might we make urban cyclists more visible to drivers at night?

功能 **Functions:** *enhance visibility; produce light; reflect light; sense/send signals*

背景 **Context:** *dark, low light; chaotic, busy environment; moving quickly*

Biologized Questions:

指令工程師

How does nature …

- …enhance visibility in low light environments?
- …enhance visibility in chaotic environments?
- …sense movement in the dark?

指令工程師

- 創造厲害的大型語言模型急需善於下指令和教學的人才。**指令工程師**可以思考出指揮AI工具完成各種任務的最佳方式。
- 鑽研指令程式的英國軟體開發者威利森(Simon Willison)說，自己和同儕被企業徵詢的機會真的大大增加，因為「我們被視為與人工智慧溝通的專家」。
- 指令工程師並不是真的使用程式語言，但精通於制定精確的指令，促使AI工具輸出更符合需求、彷彿真的經過思考的結果。許多企業開始找這樣的人，因為需求太高，甚至已經有專門找接案指令工程師的人力平台。

Methods - Finding Biological Strategies

- 當我們已確認所要之功能(function)及背景(context)時，下一步即是尋找相對應的生物策略 (biological strategies)

  - Direct observation
  - Research

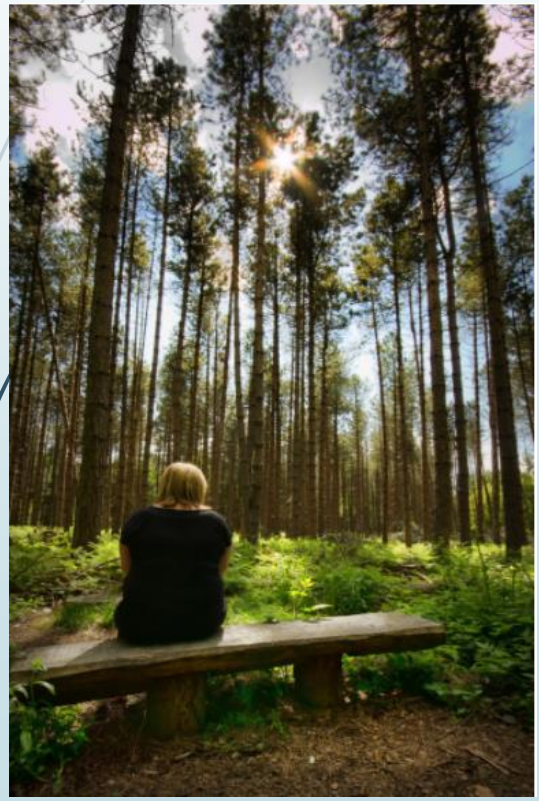
Methods - Finding Biological Strategies

➢Direct observation:

- 將自己融入至大自然中，體會書本上無法給你的感覺，並觀察自然界之生態系統，及生物為了生存而衍生出獨特的生物策略
- 利用繪製草圖，除了讓自己更了解生物如何運用自己獨特的function外，更能夠跳脫出原本的思維，來重新架構原有的想法。

Methods - Finding Biological Strategies

- Direct observation:



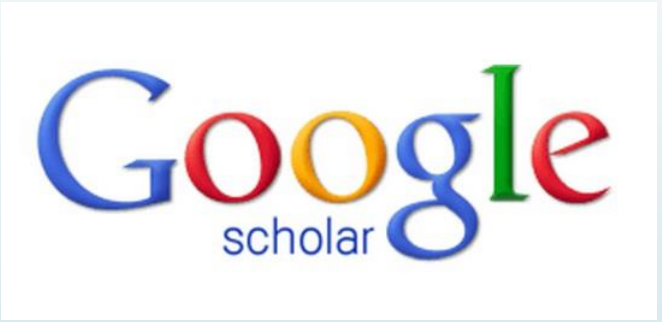
Methods - Finding Biological Strategies

- Research

- 觀察大自然的奧妙，需要花費相當多時間。假設已從大自然中得到了一些結論，但為了能夠佐證自己的結論是正確的，可從文獻中得到更多的資訊。

Methods - Finding Biological Strategies

- Research



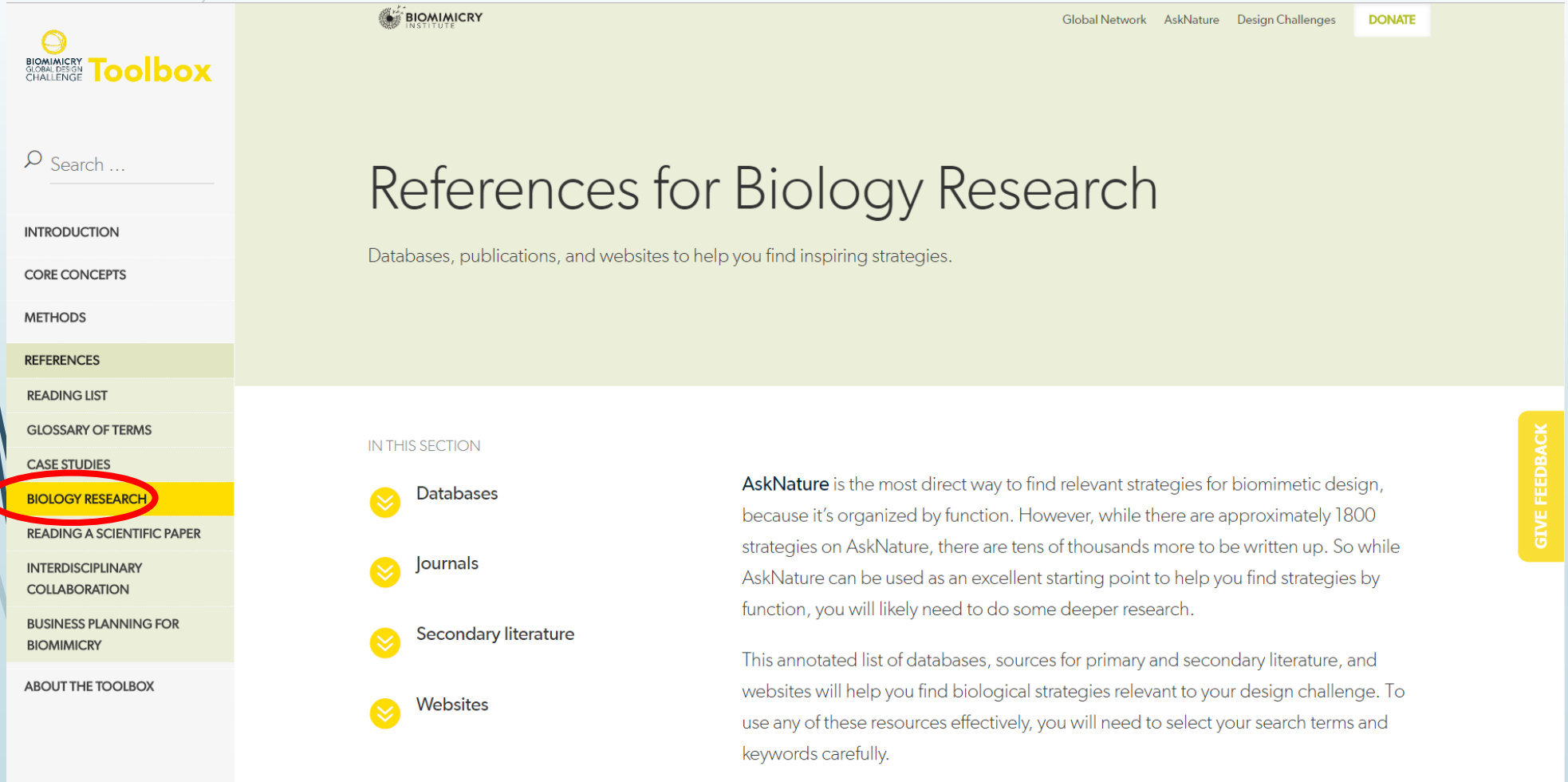
Google search

百度

chatGPT

Methods - Finding Biological Strategies

- Research



Methods - Crafting Design Strategies

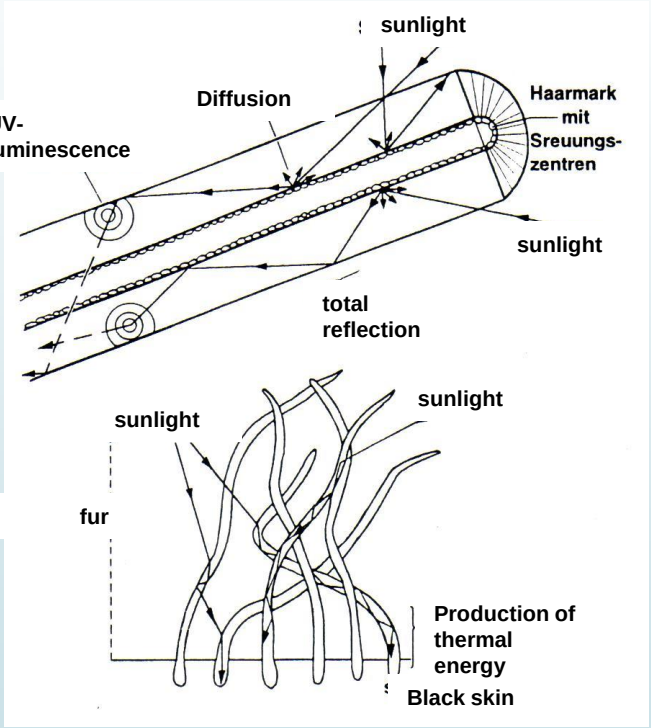
- 當已找尋到所需之生物策略時，我們需要將生物策略轉換為設計策略，這個步驟主要是讓我們能夠順利地進行工程加工。

◆*How does polar bear insulate?*

Animals as inspiring examples for heat insulation

仿生設計實例

Heat insulation



Transparent Heat Insulation due to the Hair Structure of Icebear furs (acc.to Tributsch 1990)

Methods - Crafting Design Strategies

這些為生物策略喔!

這些為設計策略喔!

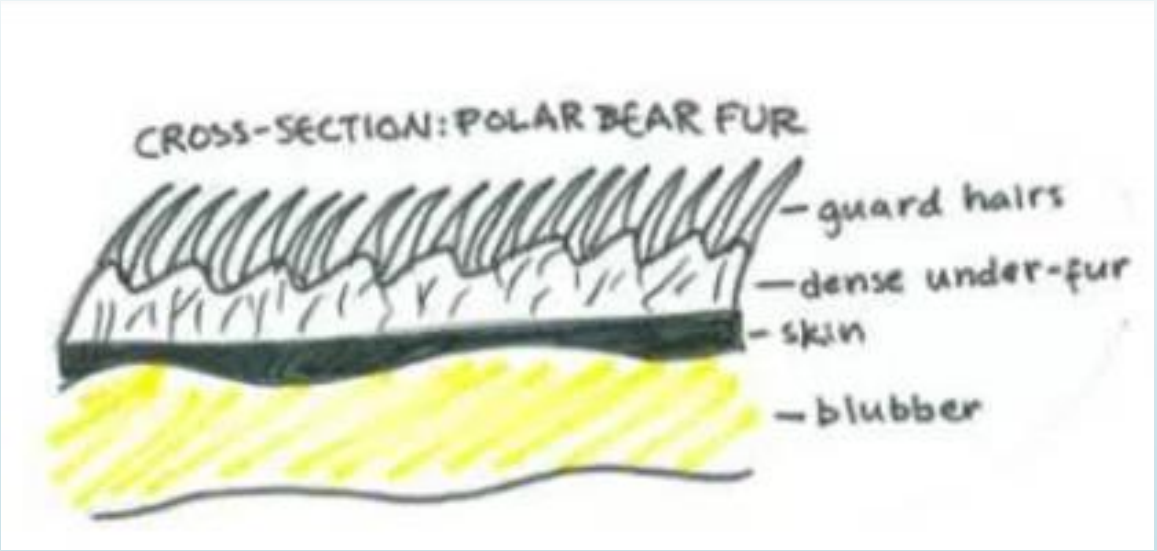
◆ *How does polar bear insulate?*

- 北極熊外層的毛是中空半透明的，其能夠將太陽之熱源傳送至皮膚內層，而內層之皮毛是由很多的細小絨毛所組成，這些絨毛可避免體內之溫度散失。

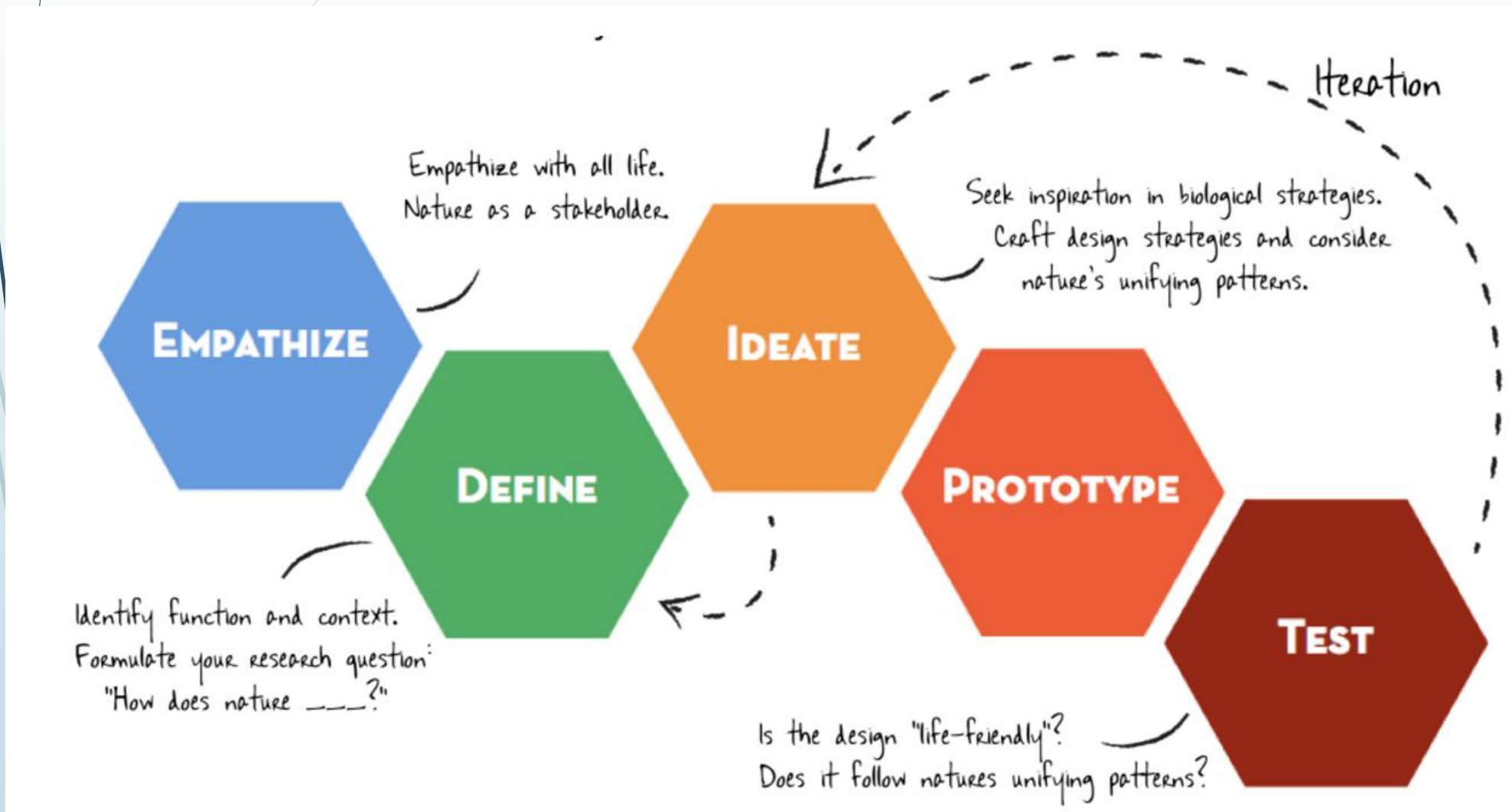
- 在覆蓋物上，設置多個半透明之中空管，使熱從中空管傳至底部，而我們也需要在底部處披上高密度之細小纖維(覆蓋物)，來防止熱量的散失。

Methods - Crafting Design Strategies

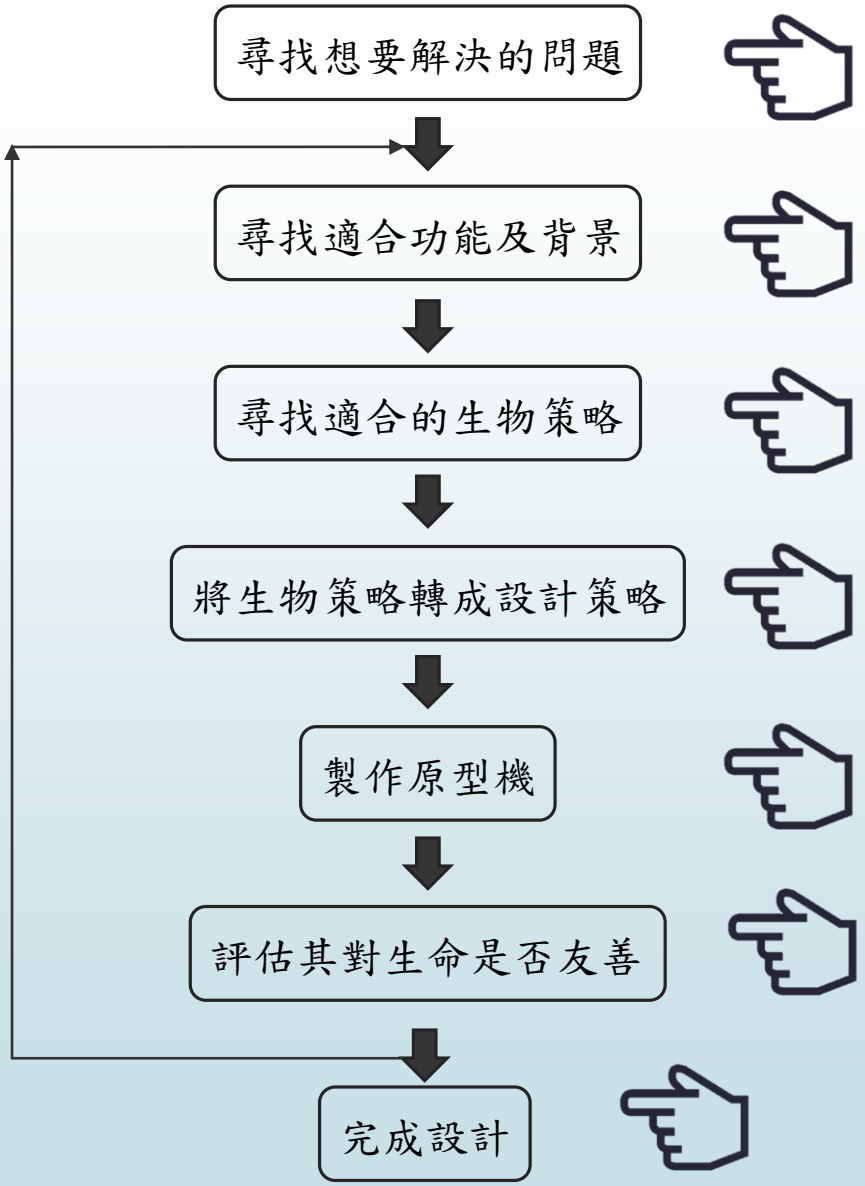
生物專業術語 → 工程專業術語



仿生流程


Iteration
Empathize with all life.
Nature as a stakeholder.
Seek inspiration in biological strategies.
Craft design strategies and consider
nature's unifying patterns.
EMPATHIZE
DEFINE
IDEATE
PROTOTYPE
TEST
Identify function and context.
Formulate your research question:
"How does nature ___?"
Is the design "life-friendly"?
Does it follow natures unifying patterns?

仿生流程


尋找想要解決的問題
尋找適合功能及背景
尋找適合的生物策略
將生物策略轉成設計策略
製作原型機
評估其對生命是否友善
完成設計

仿生設計 實例

VS

設計問題

如何減少鳥類撞上UAV
如何警示鳥類

尋找功能及背景

如何警示鳥類

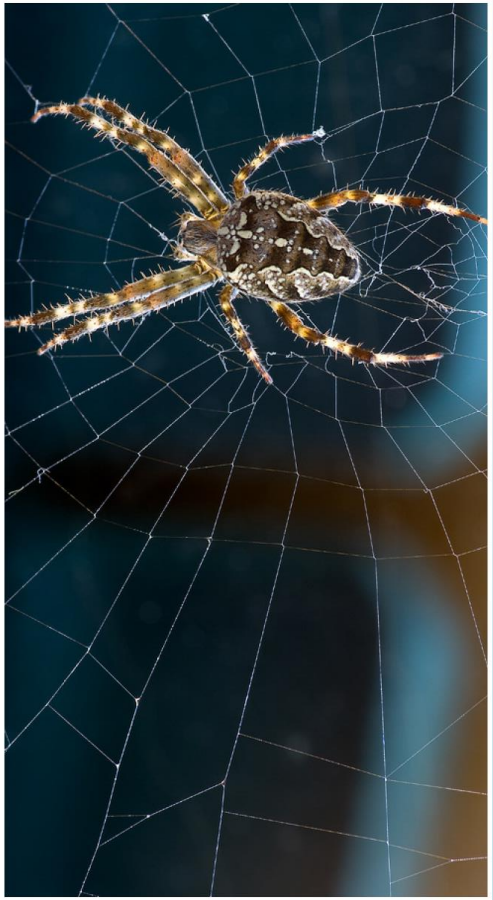
功能:

- 警告效果
- 光反射
- UV
- 增加可見度

背景:

- 鳥
- 白天
- 氣流
- 光線

尋找適合的生物策略



Strands in orb-weaver spider webs warn birds, attract insects using UV-reflecting silk.

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將生物策略轉成設計策略

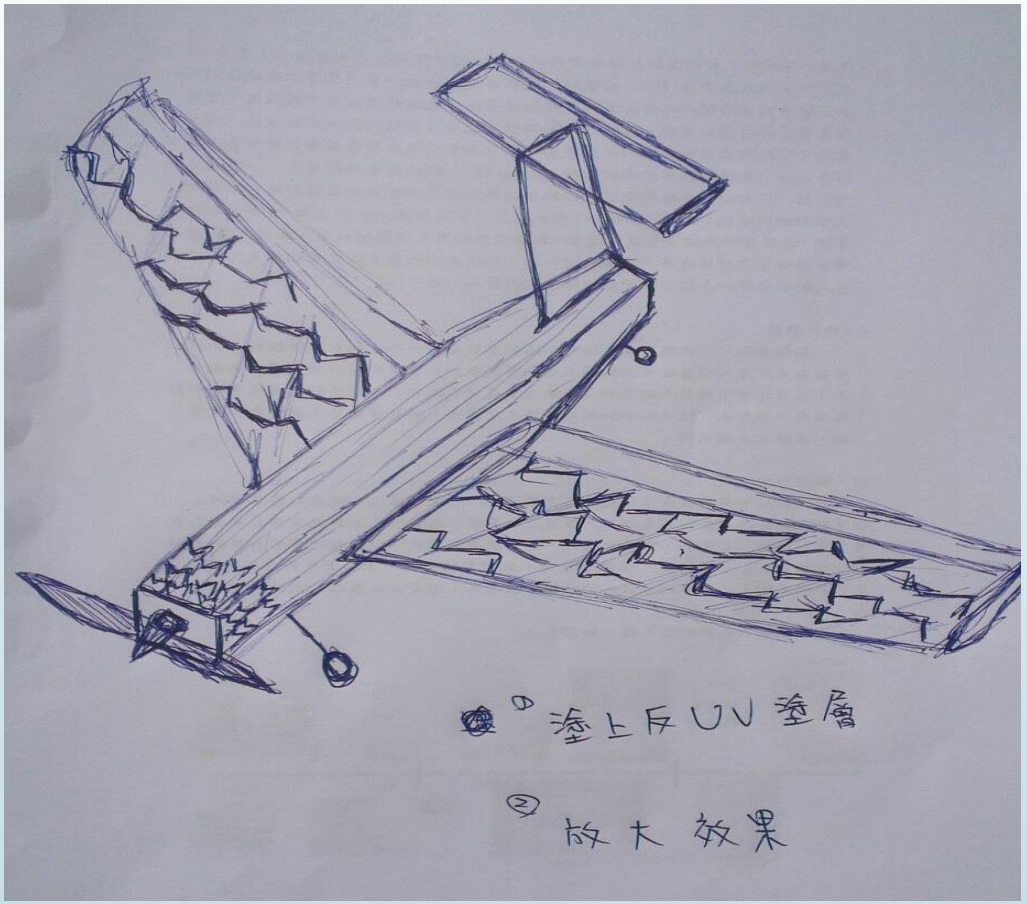
這些為生物策略喔!

- 為了能夠有效的讓食物落網及避免蜘蛛網被鳥或蜜蜂摧毀， Orb – Weaver Spider 的生物策略為具有能夠反射陽光 UV 範圍的蜘蛛絲，及放大危險警訊。

這些為設計策略喔!

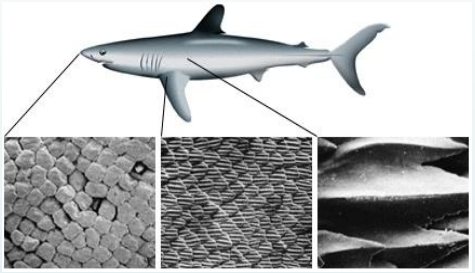
- 需在UAV之表面上，塗抹或披上可反射 UV 的材料 (如: 燙布，非金屬材質) 並放大局部危險警訊。

原型機設計



Bionics - product

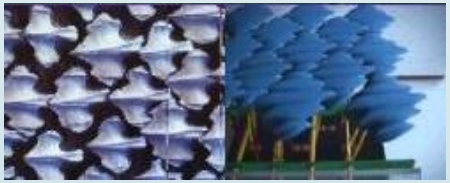
仿生設計實例



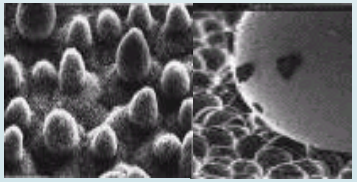
Optimal streaming sharks skin

Dirt repellent lotus flower

Communication of dolphins



Structural Elements enhancing streaming-possibilities of e.g. submarines



Micro-structure
for
dirt repellent
surfaces

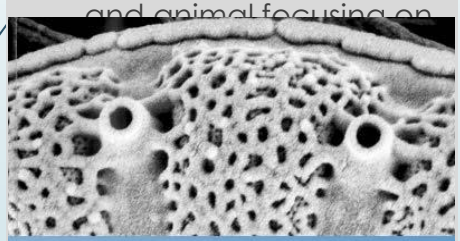
Dolphin Modem

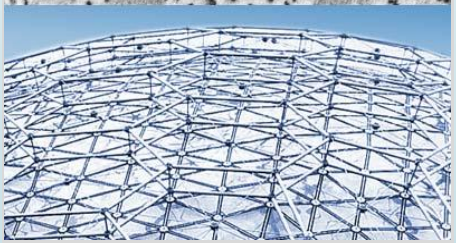
Bionics application in Building

仿生設計實例

Biomechanics

- Analysis of internal resistance mechanisms in plants and animals against external force.
- Research of mechanical movements of Man and animal focusing on



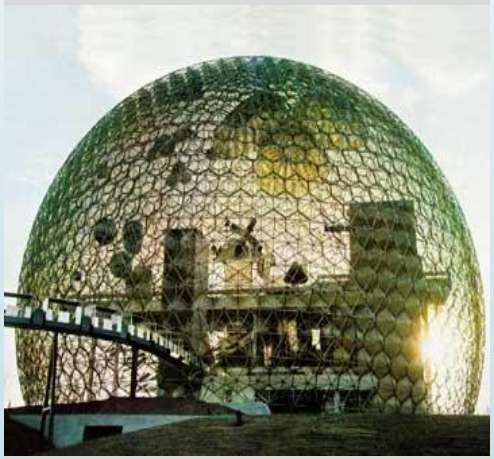


Bioarchitecture

- Analysis of development of forms in nature.

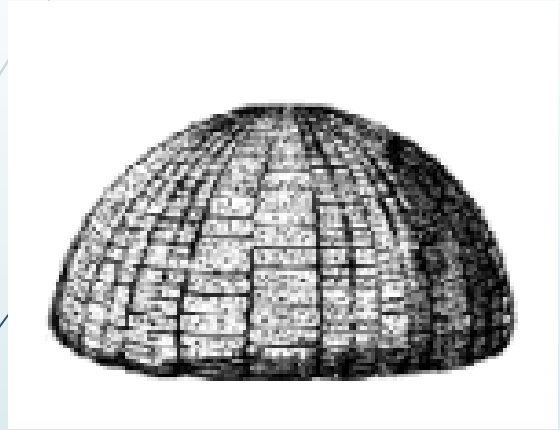
Biomechanics

- Analysis of growth processes
- Application of Standardizing – and Installationprocesses and manufacturing principles in construction.



Sea hedgehog Shell

仿生設計實例

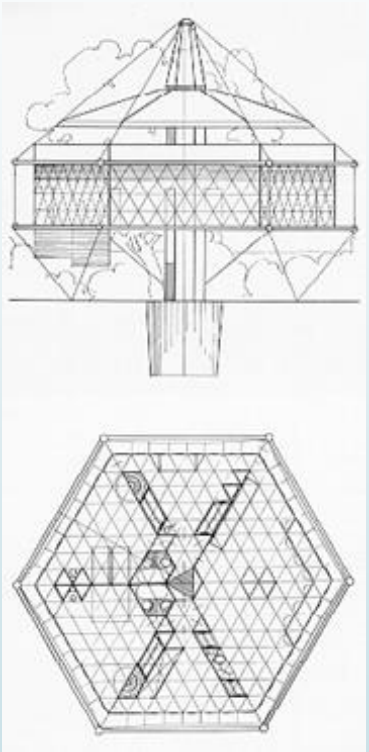


海膽，用最少的材料做出很穩定的結構

Sea Hedgehog Shell Ursus Maritimus (minimum amount of struts resulting in tremendous Stability)

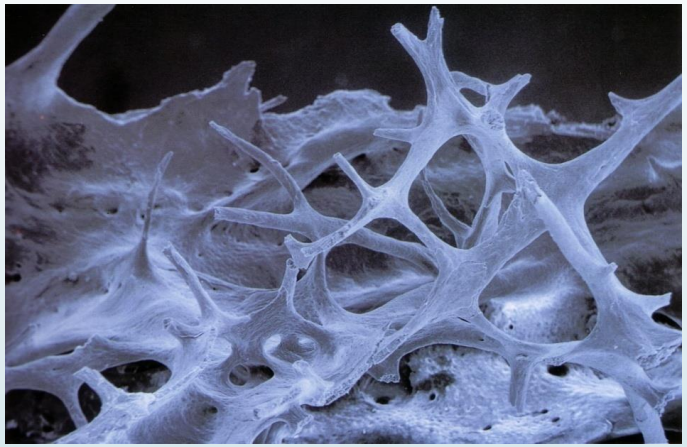
Honeycombs-structure 蜂窩結構

仿生設計實例



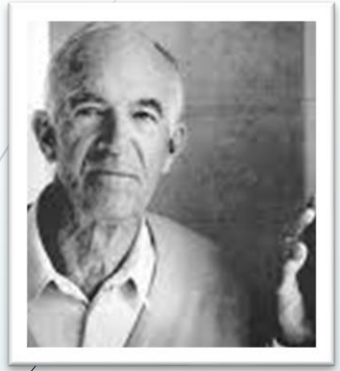
仿生設計實例

Cut through Bone Structure 骨頭內部的結構



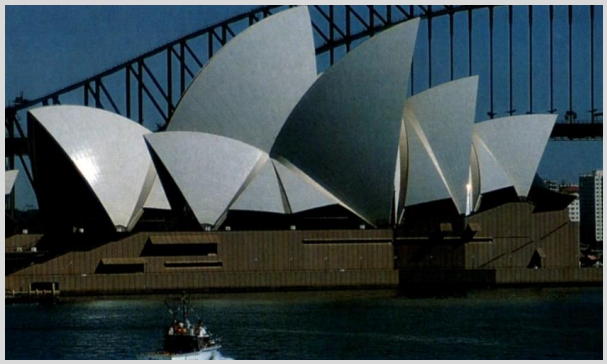
The Sydney Opera House.

仿生設計實例



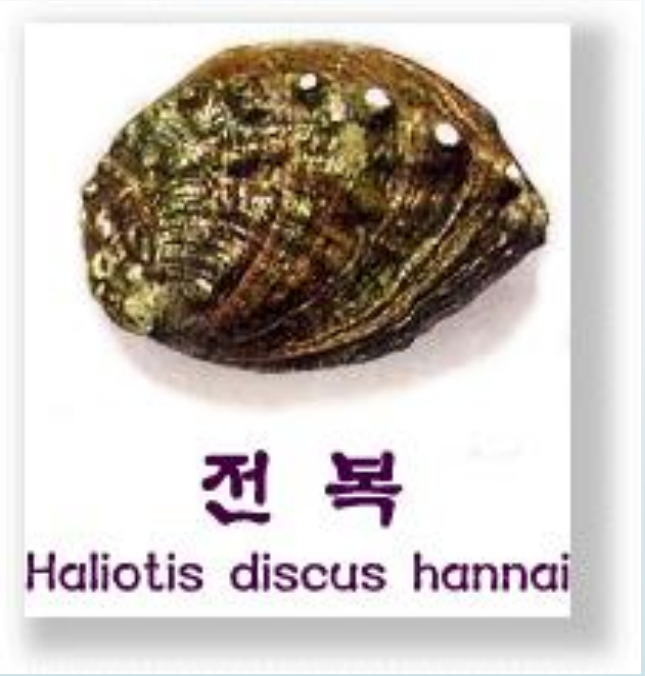
Jorn Utzon (1918-2008)

- Architekt: Jorn Utzon
- Construction: 1957 – 1973
- Most fotographed Building of the 20th century
- Desribed in literature as freestanding sculpture of spherical roofs and sail-like shells“



仿生設計實例

The Sydney Opera House.



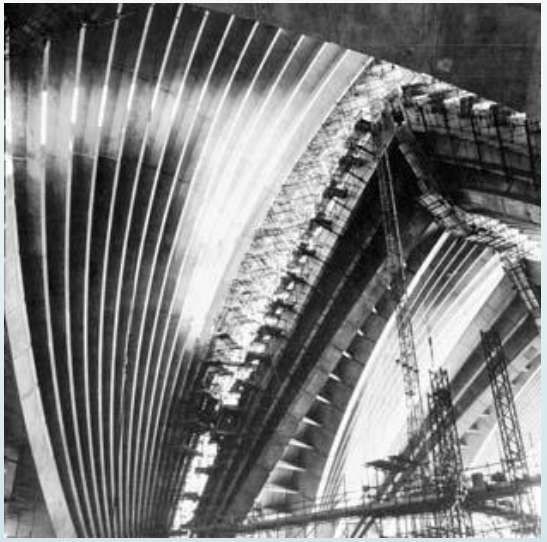
The Sydney Opera House.

仿生設計實例

仿生設計實例

The Sydney Opera House.

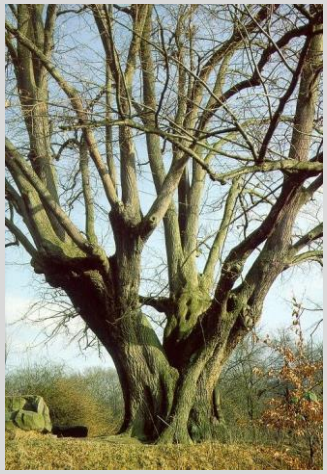
扁平化設計，摺疊設計以求穩定



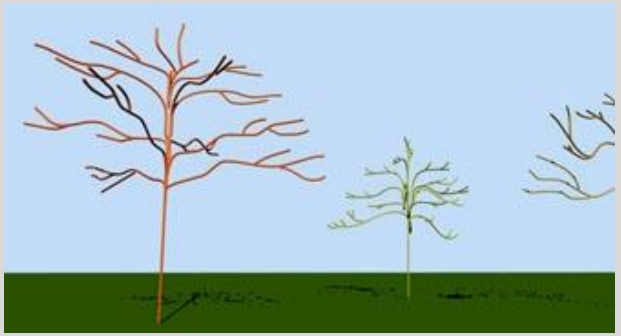
Faltdesign (foldingdesign) for Stability; Mr. Miura Japan… Sun Reflectors satellites in space

Trees as Inspiring Examples in Design

仿生設計實例



- Inspiring example: limetree
- Sails imitating leafs



Trees as Inspiring Examples in Design

仿生設計實例

Airport Designs Cologne, Jeddah

Trees as inspiring Examples in Design

仿生設計實例

位於德國，專門販賣玻璃Glaskosh公司本部。建築物的名字Leonardo Glass Cube－其實本來是Glaskosh公司的玻璃商標名。Glaskosh公司為了使Leonardo Glass Cube這個商標名更受到注目，就把這個近未來的建築物名字也取名成Leonardo Glass Cube。它可以容下900人。Glaskosh公司拿來做為經營本部，同時也是拿來做展示會，會議的場所。

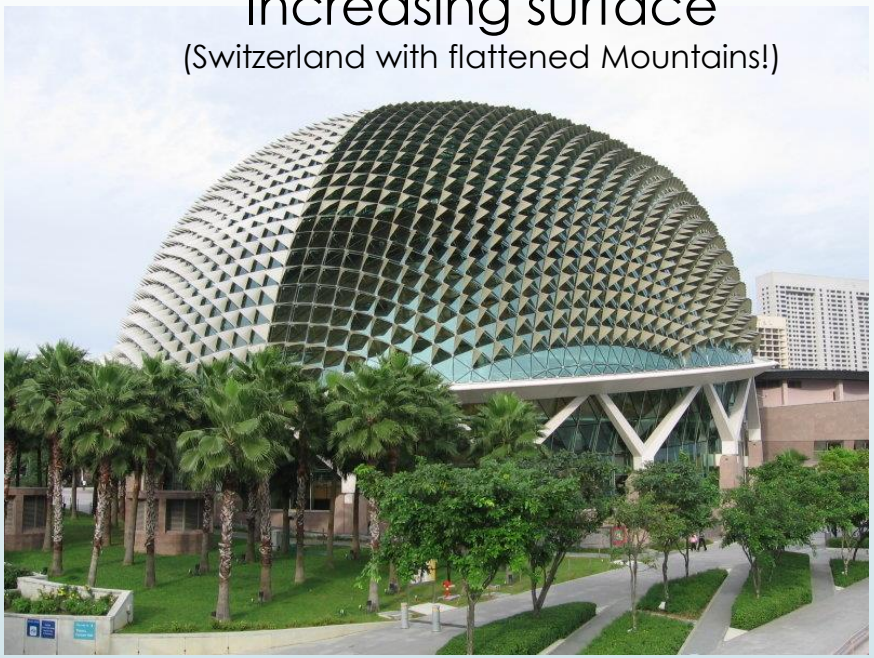
Trees as inspiring Examples in Design

仿生設計實例

仿生設計實例

Fruits as inspiring examples for optimized shadowing

Increasing surface
(Switzerland with flattened Mountains!)

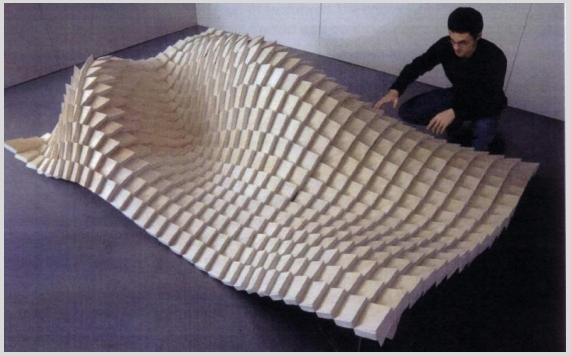


The skin of the *Durian* supports shadowing and reduces heat development by simultaneaously allowing light transmission.

Fruits as inspiring examples for regulating air humidity.

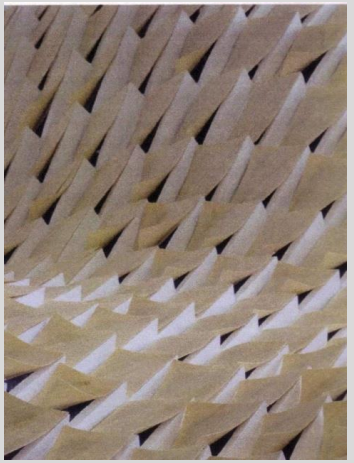
仿生設計實例

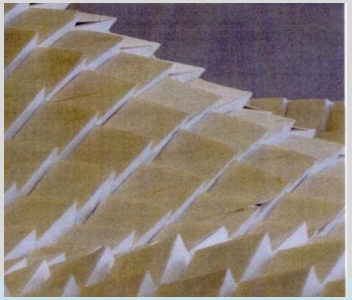
- Spruce cone opens at water shortage



Material:

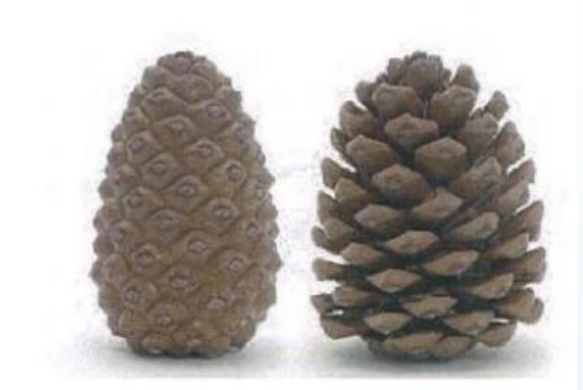
- PVC-Foil / veneer (beech)





Responsive Surface Structure

濕度管理

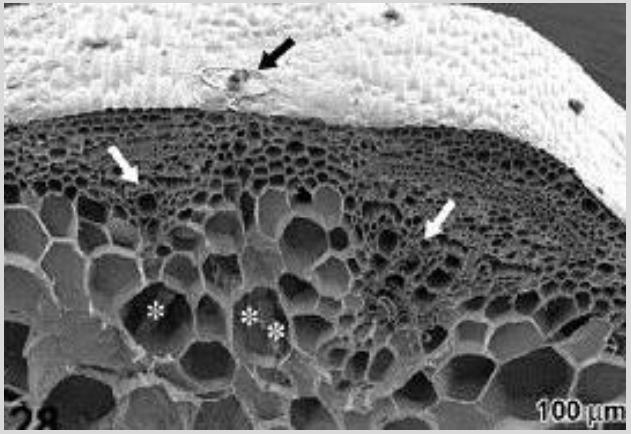


- **松果效應**：會回應濕度的變化而開合；當空氣乾燥，松果會開啟，讓裡面的種子被風散布出去；當空氣潮濕，松果會緊密閉合。

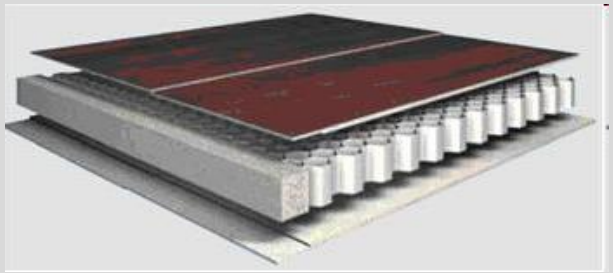
- c_change 是一種防風及防水的親水性薄膜，其彈性的聚合體結構對改變的溫度有獨立反應：
  - 高溫時，當身體濕度上升，薄膜結構開啟讓過多的熱氣與濕氣散逸。
  - 較冷時，結構收縮，有助身體保持熱氣，防止冷卻。

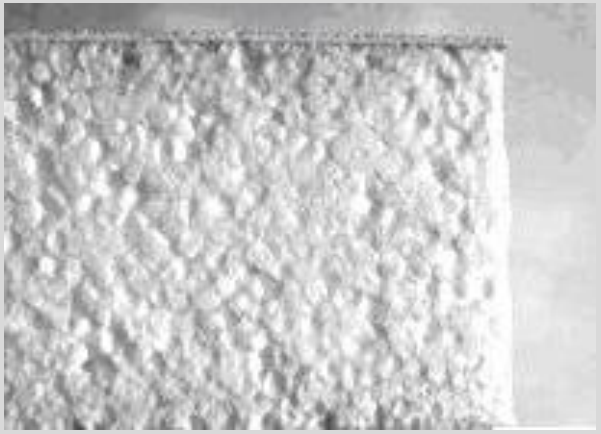
Plants as inspiring examples for lightweight design.

仿生設計實例



- Section through plant tissue





- Cross section of Sandwich-Element made of GFK and Styrol

GFK: 一種玻璃纖維
Styrol: 苯乙烯

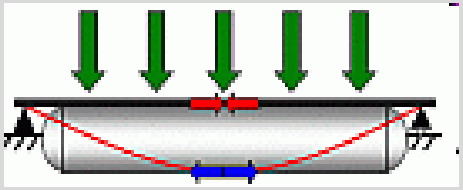
Advantage:

- High stability
- minimum required material
- Recycle ability

The new Lightweight structure

仿生設計實例

- lowest weight
- compact volume of transport
- fast erection
- great load-bearing capacity
- Selfrepair capability analog pipevines



更多 仿生設計 實例

1. Bionic CAR
2. 水資源
3. 太陽光反射鏡的安置
4. 企鵝
5. 貓科動物
6. 仿生機能性成衣
7. 空氣集塵
8. 防鳥撞玻璃
9. 機翼設計
10. 葉片 vs. 受光最大化、抗風、降溫
11. 光合作用 – Bionic Leaf
12. Solar Water Plant - Still & Pump
13. 真菌

Topic 1. 汽車

bionic car

BIOLOGICAL STRATEGIES

Lightweighting: Scots pine : Scots Pine

... fiber-composite materials. For example, car parts and entire cars ...

Enzymes catalyze cellulose breakdown at high temperatures : hyperthermophillic archaeabacteria

... the presence of detergents, high salinity, and high ionic content.

INSPIRED IDEAS

CAO and SKO design software :

Department of Biomechanics at the Institute for Materials Research II of the Karlsruhe Research Centre

... AG´s (formerly Mercedes-Benz) Bionic Car also used the ...

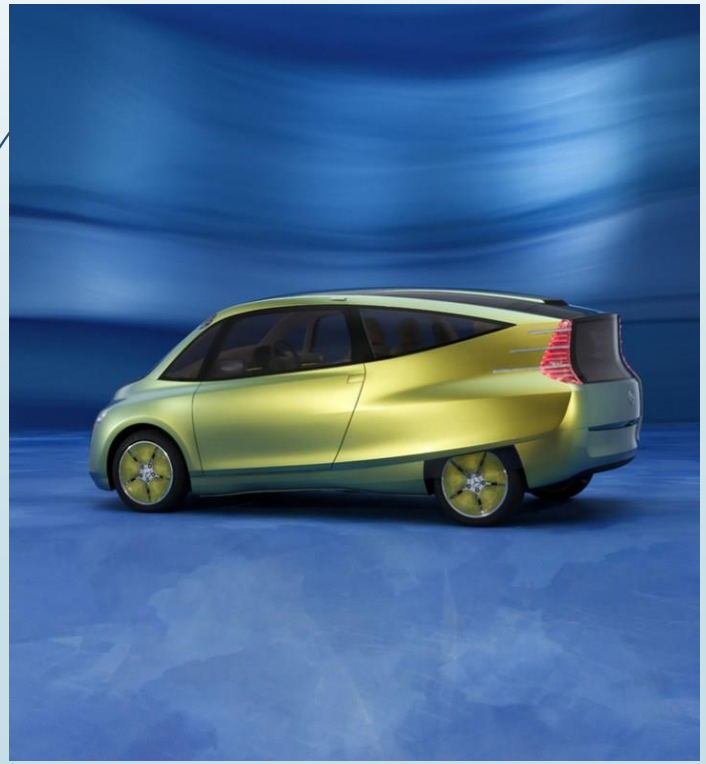
COLLECTIONS

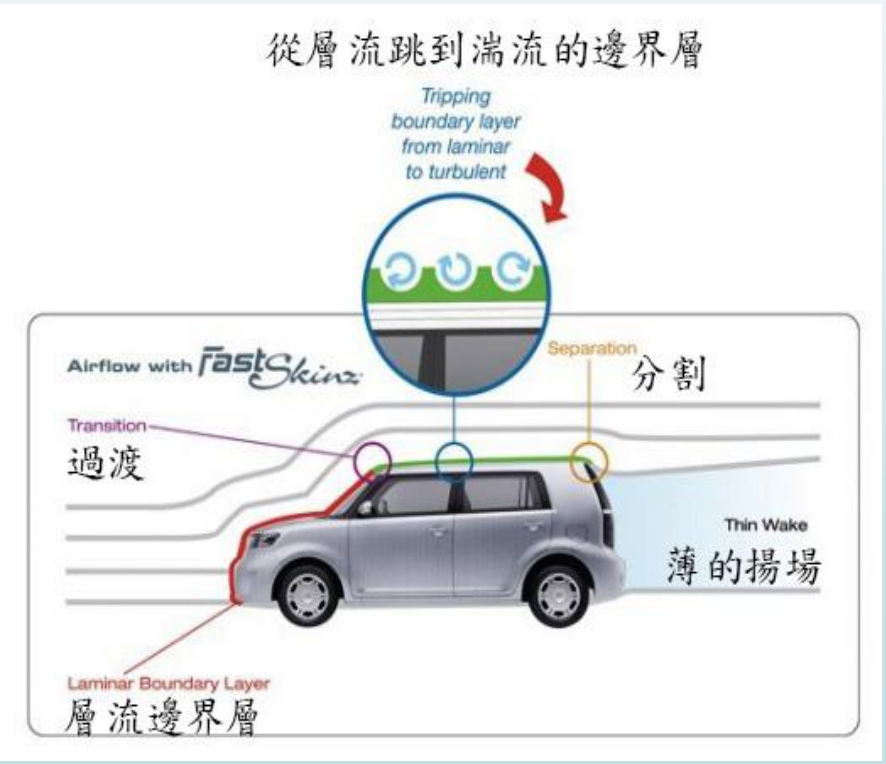
Bionica

Powered by Algolia

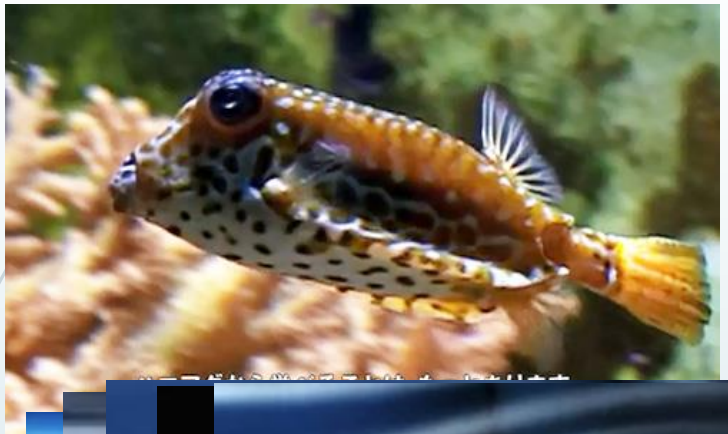
Select two references

- 1. The Idea of the Bionic Car
- 2. Fastskinz MPG-Plus car covering





1. The Idea of the Bionic Car-shape



- Boxfish無刺河豚
- We used the shape and structure of this amazing fish.

The Idea of the Bionic Car-structure

- 外皮由許多骨頭的六角形板組成，它們是相互連接的，形成一套剛性的裝甲套裝。
- 這種骨骼的裝甲結構使魚體的身體具有很大的剛性，保護身體免受傷害。

The design of the Bionic Car

The advantages of the Bionic Car-1

剛體在運動方向上的投影面積為S，空氣密度為ρ，剛體以速度v運動時對前方空氣的推力為F。

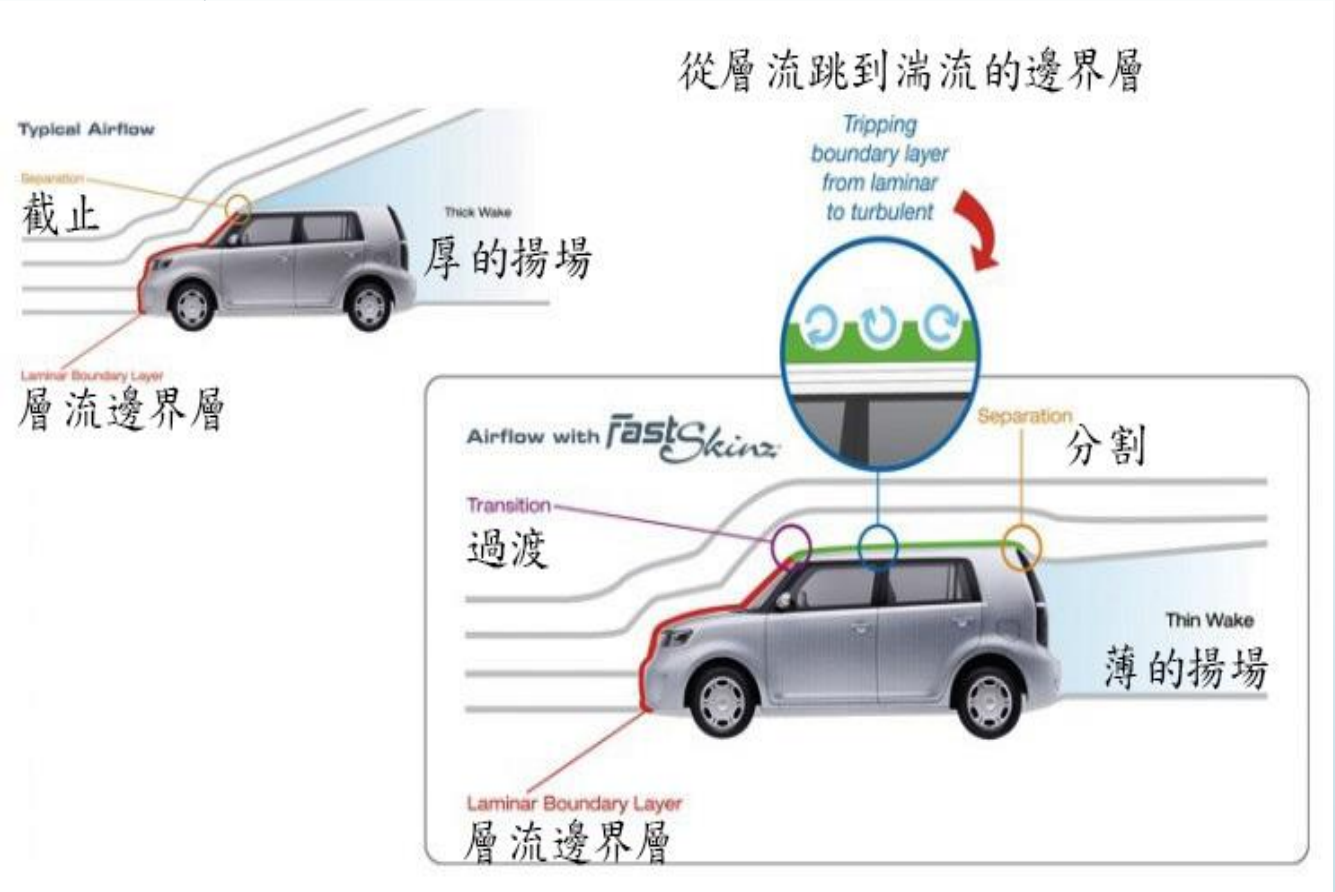
$Cd = 2F / (\rho S v^2)$ 。

- 一般汽車的cd值約在0.25到0.45之間)
- Mercedes-Benz 概念車的製作保留著優異的空氣動力學特性：cd值為 0.19
- 通過計算機計算和精確風洞測試的模型魚，在 Mercedes-Benz 工程師的努力實現了非常接近理想的 cd值= 0.06 – 這是重大突破。

The advantages of the Bionic Car-2

- 使用SKO軟體設計的Opel發動機支架比使用傳統設計過程設計的安全殼輕25%及多出60%的穩定性。同樣利用CAE來模擬配置汽車中的其他車身和懸架元件，使得承受較低負載的區域中的材料可以減少阻力，甚至可能完全消除，導致汽車重量減少30%，同時保持穩定性、安全性和操控性。
- 它提供高達75 mpg (miles per gallon)的燃油效率，最大速度為190 km/h。

2. Fastskinz MPG-Plus car covering(汽車罩)

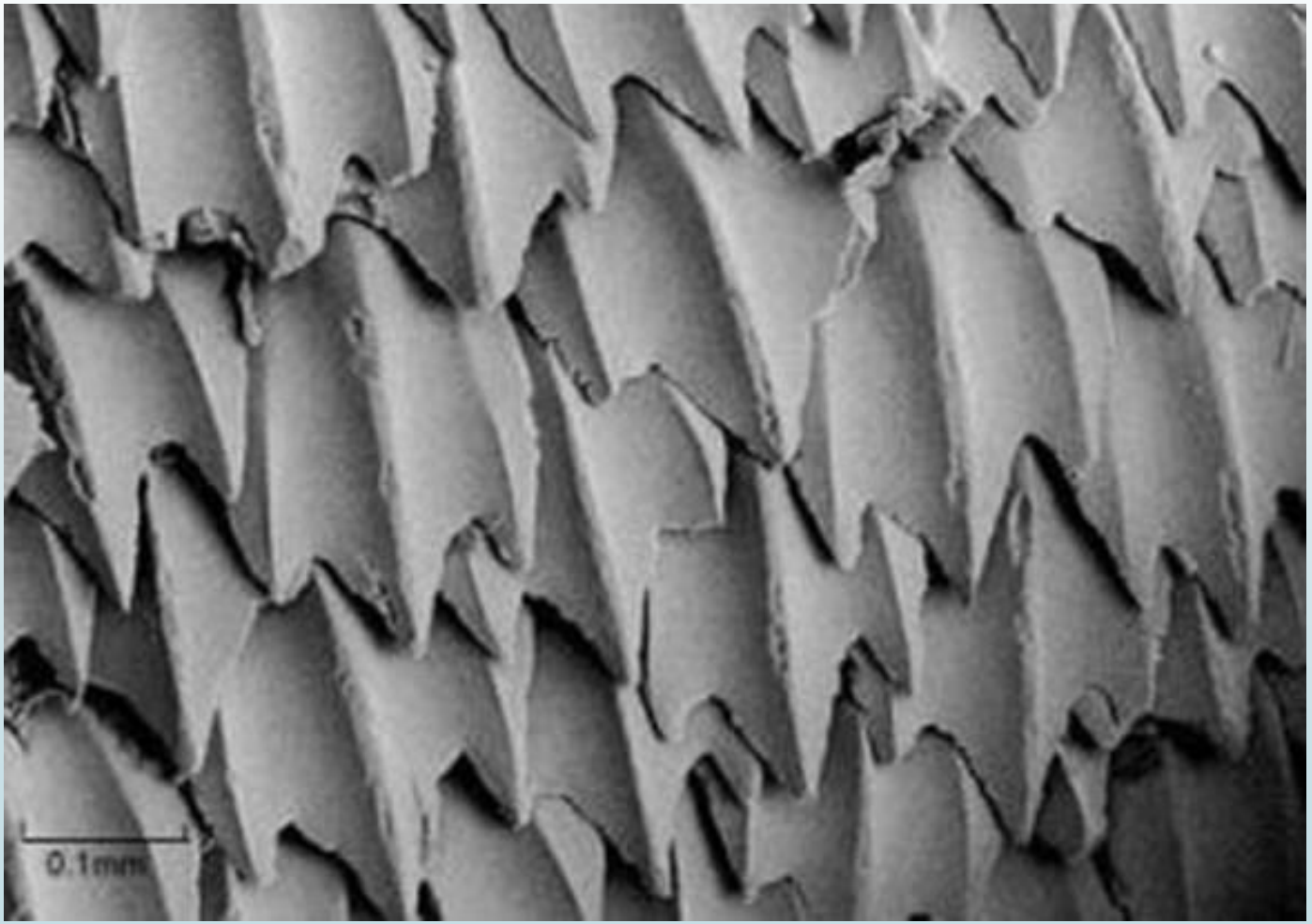


83

汽車覆蓋物覆蓋著微小的空隙，在整個FastSkinz表面上形成一層湍流空氣。這種湍流空氣減少了車輛上的阻力，因此增加了燃油里程。

Shark-inspired "skin" for cars improves gas mileage

(來自鯊魚皮膚的靈感–**Shark paint**)

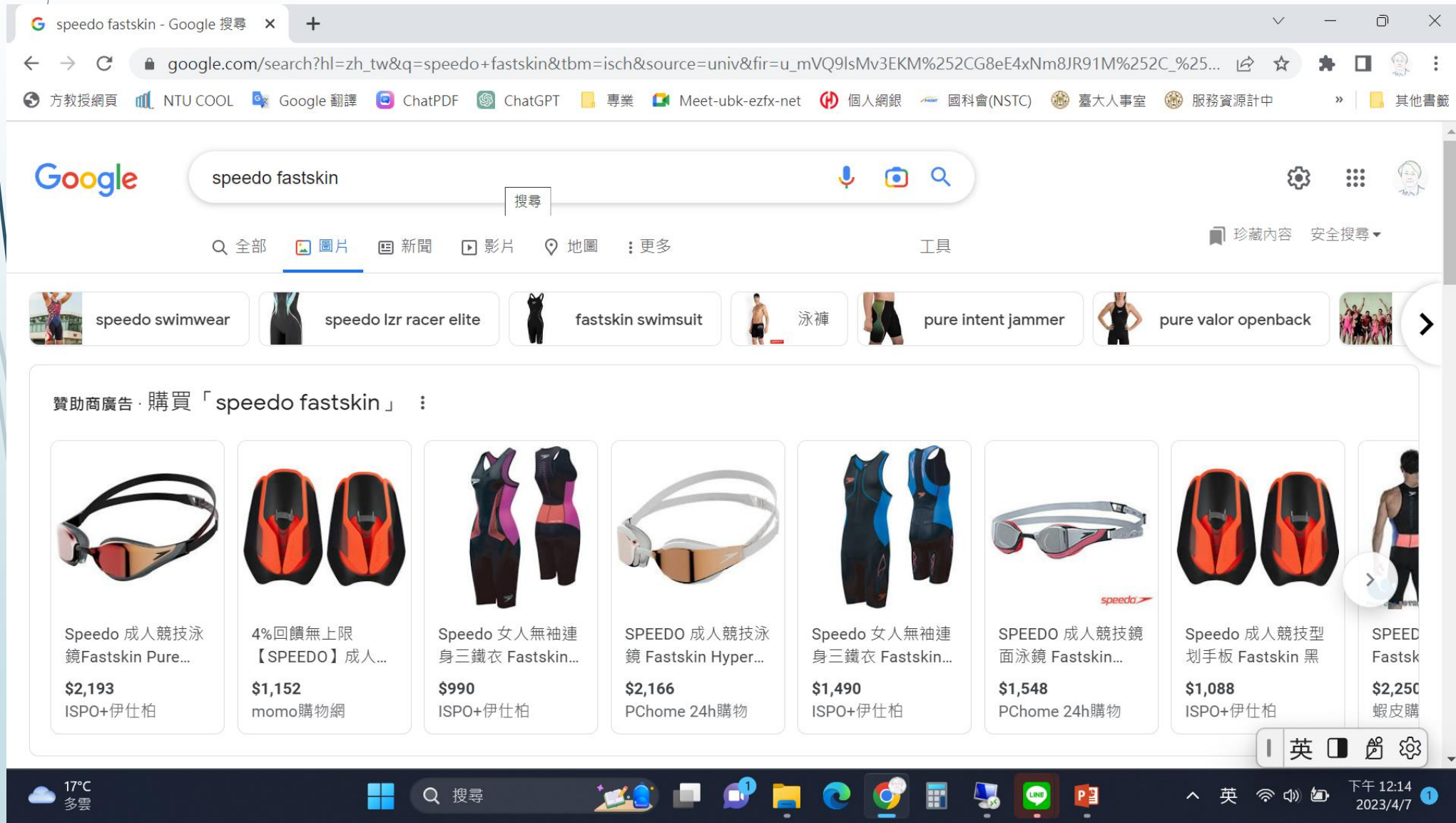


降阻

- 自然界最大的靈感來源是模仿鯊魚皮產生的降阻作用
  - ✓藉助一種遍布皮膚名為皮質鱗突（註：皮膚上的鱗甲或凸脊。）的 V 形結構通行水中。這種鱗突長度僅 0.2-0.5 厘米，並呈連鎖狀，排列的方式可引導水流，當鯊魚在水中移動時並在其周遭產生小渦流，減少摩擦阻力。

- 上個世紀 90 年代開始，Speedo公司發明了一種叫「快速皮膚」的泳衣，這種新式泳衣通過模仿鯊魚皮膚結構，減少水的阻力、提高游進速度，從而減少游泳時的水阻，讓選手們游得更快。從此，「鯊魚皮」就成了高科技泳衣的代名詞。

Speedo fastskin



Biomimicry Story

- 鯊魚皮膚被微小的鱗狀突起覆蓋，稱為真皮牙本質（“皮膚牙齒”）。在鯊魚身上形成小凹坑後，變成所謂的“湍流器”，引起圍繞鯊魚身體的水層湍流，當鯊魚游泳時，這個湍流的水層可以減少阻力。
- 鯊魚可以50公里/小時（31英里/小時）的速度游泳。
- 減少通過鱗片表面附近的湍流交叉流動，從而減少剪切應力，並通過控制身體周圍的流動分離來實現減少壓力阻力。
- 當身體彎曲時，鯊魚鱗片超過30-50°角度的作用能力會改變流體流動的性質。證實了椎間孔內嵌入的旋渦的形成。

The advantages of the **Shark paint**

- 鯊魚皮層油漆塗料的應用，塗層使用模板進行施塗，從而在漆面上形成微小的脊孔，可減少阻力和紫外線損傷。此外，該應用不會有任何額外的塗層，對容器不加額外的重量，並且可以應用於復雜的三維表面。
- 經過德國弗勞恩霍夫製造工程與應用材料研究所(IFAM)開發聲稱，如果世界上每架飛機上都塗上這種鯊魚皮，每年可以節省448萬噸燃料。在海上，海上的船舶摩擦力可以降低5%，每年可以節約大型集裝箱船2,000噸左右的燃料。

Summary

- 使用無刺河豚(boxfish)的外型及其身體結構建構現代新型汽車的低cd值，以其自然的剛性和輕量化的結構使車體鋼架強度夠且安全的變形，能高效率的節省能源。
- 在車體表面塗上鯊魚塗層油漆，讓車體表面產生湍流器效益，更能減少cd值，降低氣流阻力。
- 整合上述優點實現飛天汽車的再提升版4.0。

捷克Stefan Klein 1990年開始發展，2017量產

AeroMobil 3.0 -飛天汽車

從AeroMobil 1.0、2.0、2.5、到3.0，使用傳統商用飛機的Rotax 912引擎???，非常省油，飛行及路上行走都可以有700公里。捷克2017年開始量產。

AeroMobil won't say where it got the motor, but the earlier AM 3.0 prototype used a Subaru motor and cutaway diagrams in the AM 4.0 brochure show an engine that looks exactly like a Subaru FA motor. However, AeroMobil representatives tell us the company is in talks with "a major European automaker," which means Porsche. Regardless, a car engine is used because an aircraft engine would never pass emissions testing on the road.

AeroMobil 4.0

In the air, the AM 4.0 will go an estimated 460 miles with a single occupant and 320 miles with two people aboard.

Topic 2. 水資源

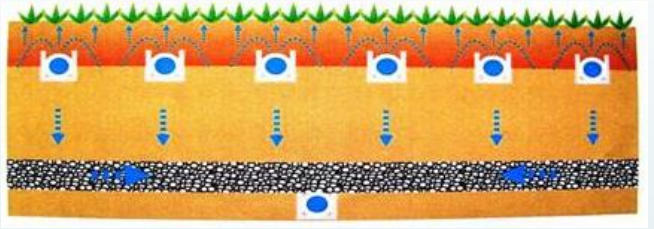
水資源的匱乏與有效利用的重要性

如何集水?

如何再利用?

AskNature Idea:
Stormwater control through mimicking nature

- 背景：下大雨時如何收集與利用降下的雨水
- Inspiration：種植植物的土壤可減緩水流、並且將水中的雜質過濾乾淨。
- Solution：將土壤或狀似土壤的物質放置於城市規劃中的集水孔、集水道等。



AskNature Idea:
Chaac-ha Water System Collector

- 背景：收集並利用尤加敦雨林地區的雨水、露水
- Inspiration：
  - 鳳梨葉：防水材質、輻射狀架構
- Solution：
  - 以竹子和防水纖維做出輻射狀架構的集水裝置。降水或露水凝結時就會順著架構流進底下收集桶中，每個晚上約可收集2.5公升的水。

STRATEGY

Leaves capture water

Bromeliads

AskNature Team · May 18, 2016 · Shared with everyone

The leaves of some bromeliads capture water and nutrients in a storage tank via hydrophobic leaf surfaces.

CLICK/TAP IMAGES FOR ATTRIBUTION AND LICENSE INFORMATION.

CLICK TAB IMAGES FOR ATTRIBUTION AND LICENSE INFORMATION

AskNature Idea: Aiken Eco-Machine

- 背景：希望用非化學的方式進行廢水過濾與處理
- Inspiration：生態系淨化環境的能力
- Solution：實際模仿及建構不同的生態系(濕地)針對不同的廢水種類進行處理。
  - 生物將汙染物降解、從水中分離出來
  - 分離出的物質可轉變為生質能

Topic 3. 太陽光反射鏡的安置

Optimal arrangement of solar array mirrors

Alexander Mitsos, assistant professor of mechanical engineering, MIT

Gemasolar plant in Spain, Andalucía

- 在西班牙南的沙漠中有超過 600 個大鏡片。這些鏡片被稱為 heliostats，是用於反射日光的設備。
- 這些鏡片可追蹤太陽，並且將陽光集中照射到中央的高塔。高塔再將太陽的熱能轉換成電能。

Problem

http://www.torresolenergy.com/TORRESOL/home/en

How it works?

- ✓ Hundreds of heliostats reflect concentrated sunlight toward a central tower.
- ✓ Water is heated to steam
- ✓ Drives a turbine that produces electricity

→ These heliostats takes up a lot of space.

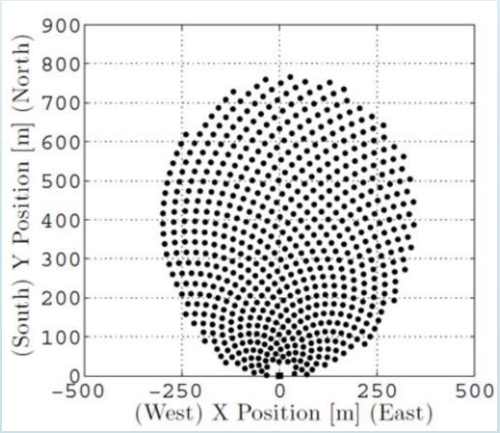
Solution

1st attempt: Put spaces between the mirrors and staggered them. → Some mirrors shaded parts of others.

2nd attempt: Used numerical optimization; brought the fanned-out layout closer together, building a spiral-like pattern.
→ reduced land use by 10% without affecting efficiency.

Solution

3rd attempt: look to sunflower; twisted each mirror to be 137 degrees relative to its neighbor.
→ the optimized layout took up 20 percent less space, and even increased total efficiency.

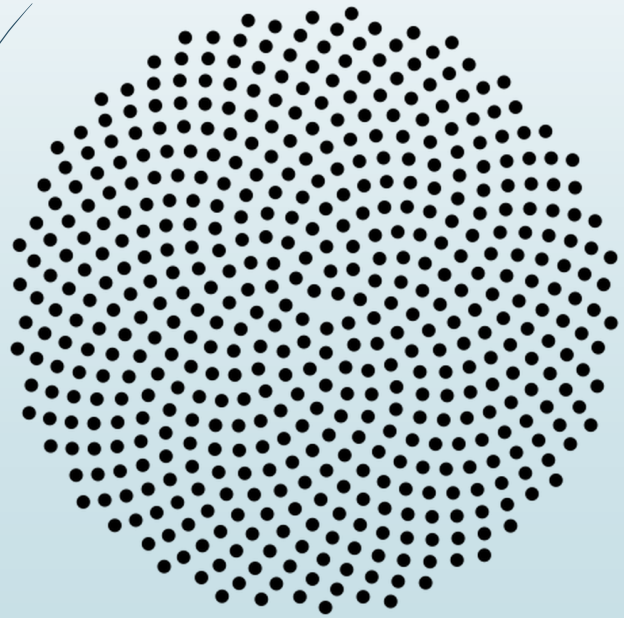


http://mitsoslab.scripts.mit.edu/index.php?id=1

向日葵花蕊的秘密

花蕊以螺旋方式排列。

花蕊之間約有 137 度的黃金角度



Optimal arrangement of solar array mirrors

Aim	1st attempt	2nd attempt	3rd attempt
Optimally arrange heliostats	Some mirrors shaded parts of others	Reduced land use by ten percent	Took up 20 percent less space, and increased total efficiency.

- 讓鏡片的排列更集中，也減少鏡片的陰影遮蔽到其他鏡片。
- 這些日光反射設備佔用較小的土地面積（減少約 20%的用地）
- 提高發電效能

仿照向日葵的花蕊排列，太陽能發電廠中的日光反射設備的排列得到了最佳化。

延伸閱讀

Heliostat Field Optimization: A New Computationally Efficient Model and Biomimetic Layout

Corey J. Noone (MIT), Manuel Torrilhon (RWTH) and Alexander Mitsos (MIT,*)
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Center for Computational Engineering Science
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Schinkelstr. 2, 52062 Aachen, Germany

* corresponding author: amitsos@alum.mit.edu

December 22, 2011

MIT research:
A new sunflower-inspired pattern increases concentrated solar efficiency

Topic 4. 企鵝

- 企鵝有一個獨特的跳出水面的方式，能使它像“魚雷”般從水中發射至一到兩米遠的岸上。在離開水面之前，先潛水深達15至20米。
- 企鵝壓縮羽毛為空氣儲存和釋放微氣泡創造更少的空間。
- 在上升期間，企鵝以受控的方式釋放這些氣泡，在其大部分身體表面上形成一層微氣泡。
- 這氣泡層能減少阻力，使企鵝能夠更快地游泳，克服重力，然後像更炮彈般地衝出水面。

延伸閱讀

ACCESS

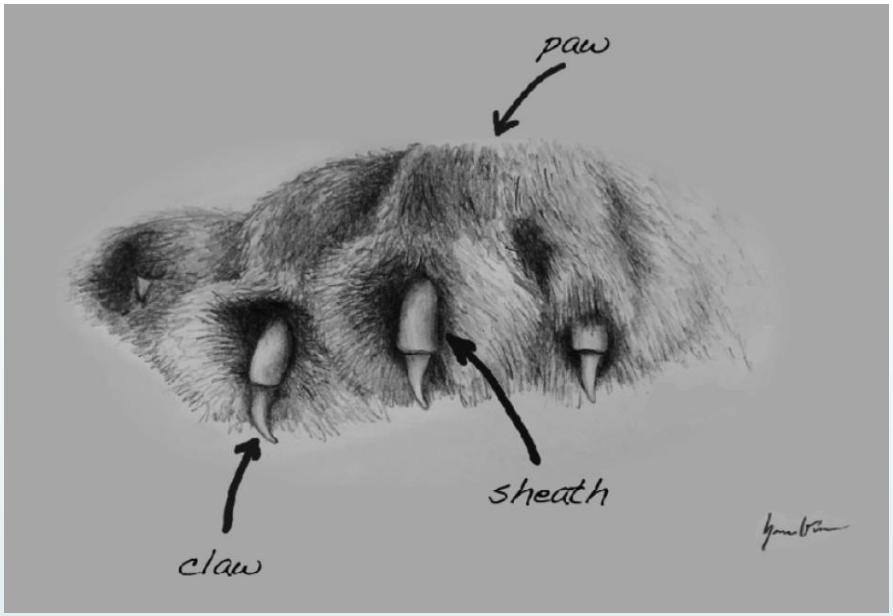
Drag reduction by air release promotes fast ascent in jumping emperor penguins—a novel hypothesis

John Davenport[1,*], Roger N. Hughes[2], Marc Shorten[1], Poul S. Larsen[3]

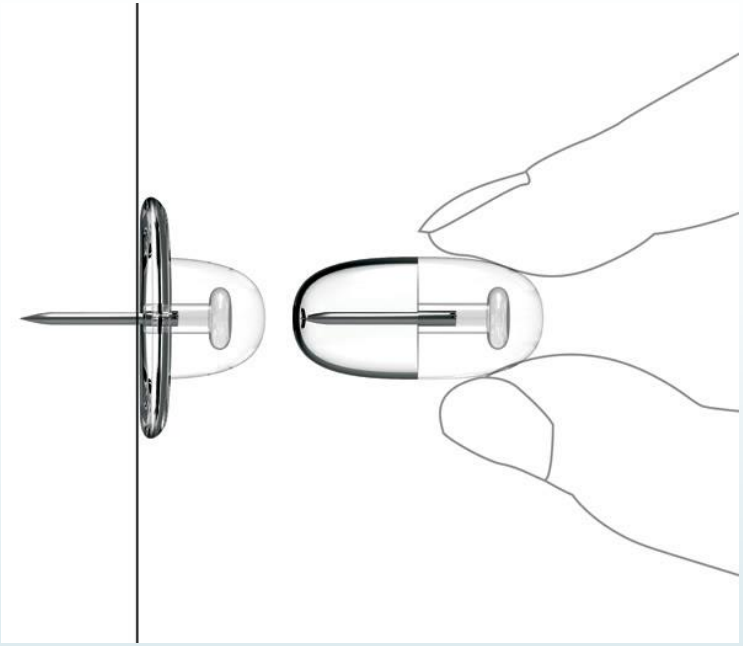
[1]Department of Zoology, Ecology and Plant Science, University College Cork, Distillery Fields, North Mall, Cork, Ireland
[2]School of Biological Sciences, Bangor University, Deiniol Road, Bangor, Gwynedd LL57 2UW, UK
[3]Department of Mechanical Engineering, Fluid Mechanics Section, Technical University of Denmark, Building 403, 2800 Kgs. Lyngby, Denmark

Topic 5. 貓科動物

- 腳掌上有肉墊。有了這些肉墊，走路的時候可以不發出聲音，就像是在腳掌上裝了消音器一樣。
- 多數貓科動物都會有”運動長爪”



- 在爪子鬆弛的狀態下，彈性韌帶和肌腱將爪子夾在皮膚的鞘內。在這種狀態下，爪子可以免受在粗糙的地面上行走的磨損。
- 當獅子準備狩獵時，會使用肌肉來伸直腳趾，並將其刀狀爪從護套上延伸出來。



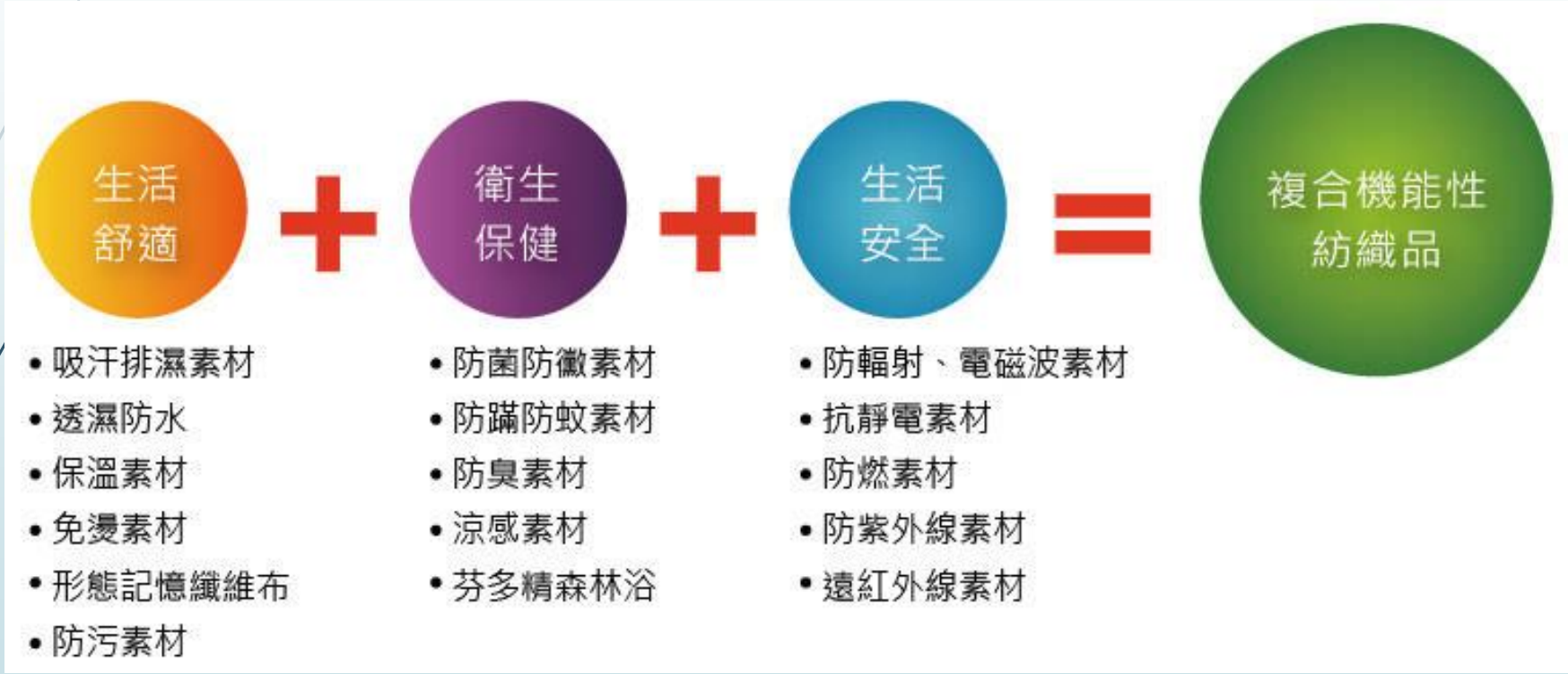
- 將圖釘尖端包裹在具有延展性的矽氧樹脂（silicone）膠囊中。
- 當使用者按壓圖釘時，圖釘尖端才會顯露出來；圖釘被拔下來之後，膠囊就會回復原本的形狀，將尖端包覆起來。

Topic 6. 仿生機能性成衣

- 由於生物科技與奈米科技的進步，仿生學自 1980 年代起有快速的進展，因而發展出功能性大為改善的材質與裝置。紡織成衣工業是這個發展的最大受益者之一，從仿生布料及材質相關文獻的大量出版得以證之。

- 機能性成衣領域的仿生學從 1990 年代初期開始快速發展，反映出一個日益普及的體認，亦即這個產業的公司尋找多時的科技突破可能已存在於大自然。這也反映出，現行紡織業採用的許多高汙染、浪費與缺乏效率的製程，急需找到替代方法；更進一步而言，反映出這個產業現行製造的被視為有害人體的產品，急需找到替代方法。

機能性紡織品概述


生活
舒適
+
衛生
保健
+
生活
安全
=
複合機能性
紡織品
• 吸汗排濕素材
• 透濕防水
• 保溫素材
• 免燙素材
• 形態記憶纖維布
• 防污素材
• 防菌防黴素材
• 防蹣防蚊素材
• 防臭素材
• 涼感素材
• 芬多精森林浴
• 防輻射、電磁波素材
• 抗靜電素材
• 防燃素材
• 防紫外線素材
• 遠紅外線素材

仿生學與機能性成衣

- 仿生學概念特別適用於機能性成衣
  - ✓大多數機能性成衣是由纖維製成，而纖維是構成大自然基本結構的材料
  - ✓製成大部分機能性成衣的布料有相對大的表面積，有助於發揮更大的功能

https://i1.read01.com/uploads/0FU97mQa6H.jpg

發展機能性成衣功能特性的靈感曾經汲取自範圍廣泛的動物、植物及其他生物有機體

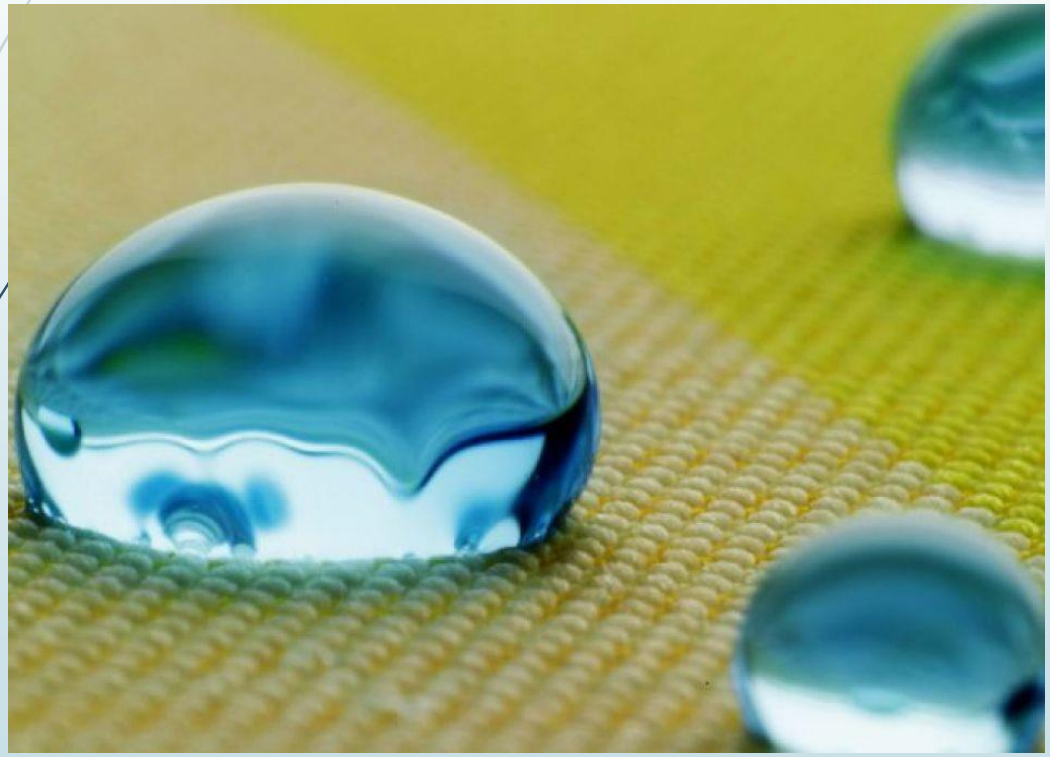
有機體與自然材質	機能特性
水生動物	降阻作用、抗菌效用
細菌	生物動力
生物系統	自我修復
鳥類	結構性發色、偽裝、保暖
骨頭、魚鱗、獸角、貝殼、牙齒	高強力
蛙類、昆蟲、蜥蜴、蜘蛛	超疏水性、乾濕環境中的可逆轉附著力、結構性發 色、偽裝
植物	超疏水性、自我清潔能力、降阻作用
北極熊毛皮	保暖
蜘蛛網	高強力

許多大自然啟發的機能特性被期待出現在機能性成衣上，有些甚至被認為是基本必備功能

- ✓抗菌效用
- ✓生物性發光
- ✓偽裝
- ✓降組能力
- ✓高強力
- ✓乾附著力
- ✓濕度管理
- ✓自我修復
- ✓保暖
- ✓色彩鮮艷
- ✓撥水性

自潔性

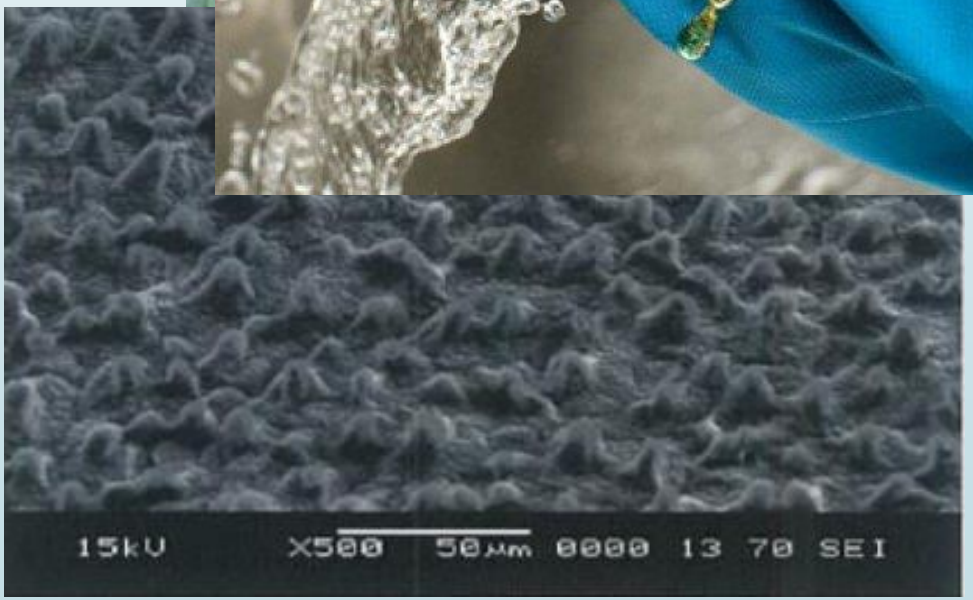
- Self-cleaning coating for textiles reduces need for cleaning chemicals.



巴斯夫生產的奈米技術是一種創新的整理材料，可為遮陽棚，帆船和帳棚提供技術性紡織品，具有自潔的效果。

疏水性

- 許多植物與昆蟲的表面具有撥水特性，啟發撥水材質研發靈感。這類的表面例如：
  - 水鳥羽毛
  - 昆蟲翅膀
  - 植物葉子
- 撥水性、防汙性與自我清潔



抗菌效用

- **BioFriend Anti-Microbial**
  - Targeted filtration technology traps and kills microbes

- Biommicry story

  BioFriend 通過模擬通常附著在人細胞上的位點捕獲微生物，然後通過破壞它們的表面（病毒）和細胞壁（細菌）來破壞微生物。

- Challenges solved

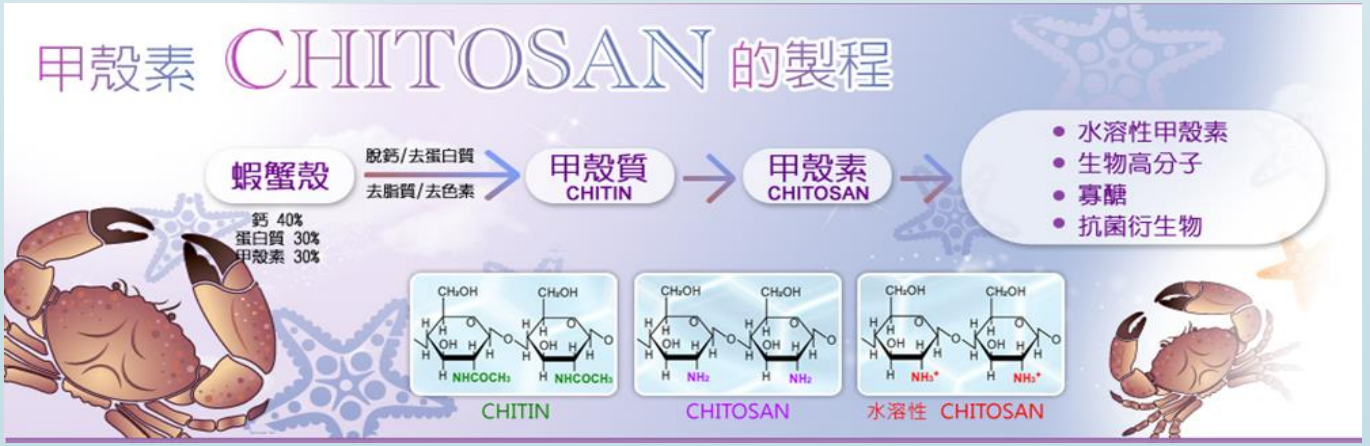
  BioFriend 滅活病原體，包括那些可能導致H1N1型，H5N1型，SARS型，麻疹，肺炎，感冒，皰疹，MRSA和胃腸炎的病原體。具有殺死廣泛微生物的能力。

抗菌效用

➡甲殼素

甲殼素是具抗菌效用的材質，廣泛使用於機能性成衣，來自於名為幾丁質（殼質）的自然物質。幾丁質是一種強韌的防水材質，是螃蟹、蝦等甲殼類動物用以形成保護外殼的產物。

甲殼素的結構類似纖維素與角蛋白質，已經證明對抗微生物高度有效，包括引起體味的 微生物，因此被用於製造具有防臭特性的休閒運動服布料。



- **鯊魚皮**

鯊魚皮的組織可以防止汙染生物體附著在表面，因此被用來當做醫療設備與醫院家具用抗菌薄膜的原型。

藉助一種遍布皮膚名為皮質鱗突（註：皮膚上的鱗甲或凸脊。）的 V 形結構通行水中。這種鱗突長度僅 0.2-0.5 厘米，並呈連鎖狀，排列的方式可引導水流，當鯊魚在水中移動時並在其周遭產生小渦流，減少摩擦阻力。

生物性發光

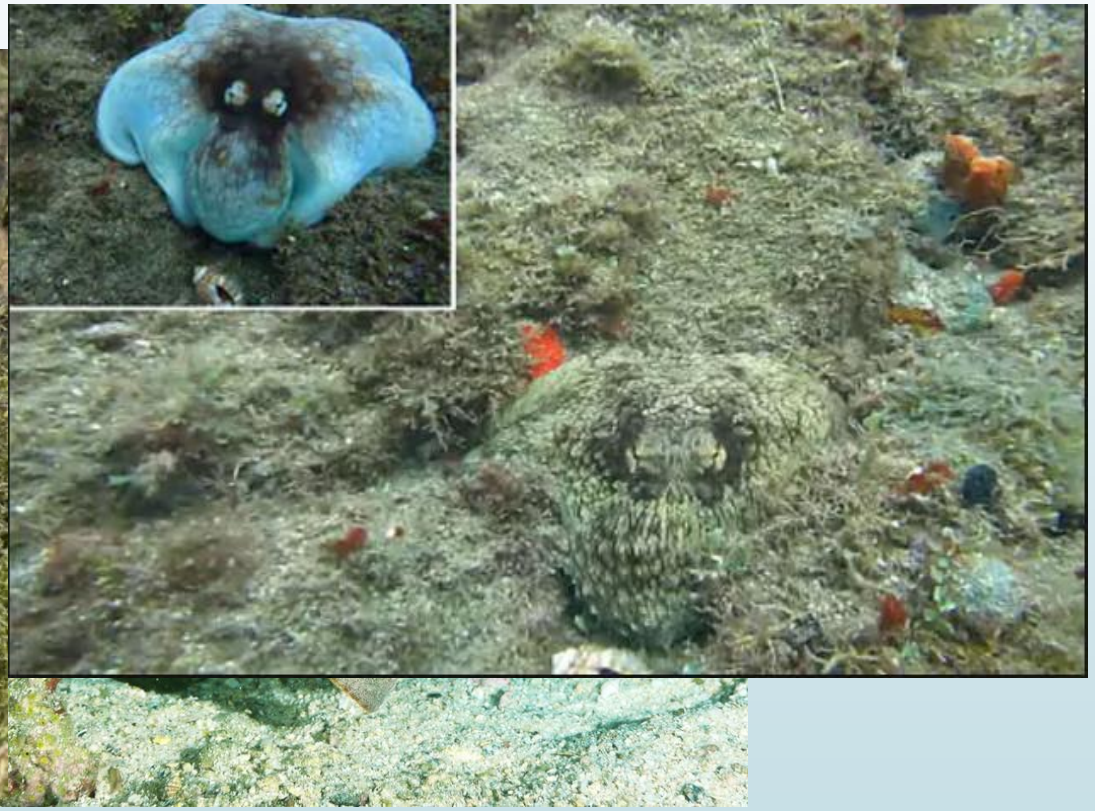
- 是生物有機體產生光的作用。這類生物包括海藻、鰻魚、螢火蟲、真菌類及某些種類的水母、千足蟲、蘑菇與蠕蟲

生物性發光可以用於加強
下列服裝的可視度：

休閒服裝、企業服裝、流行服裝、形象服裝、工業防護服裝、運動及娛樂服裝

偽裝

- 許多動物及生物幾乎可以立即偽裝自己以躲避潛在捕食者
- 墨魚、章魚、魷魚



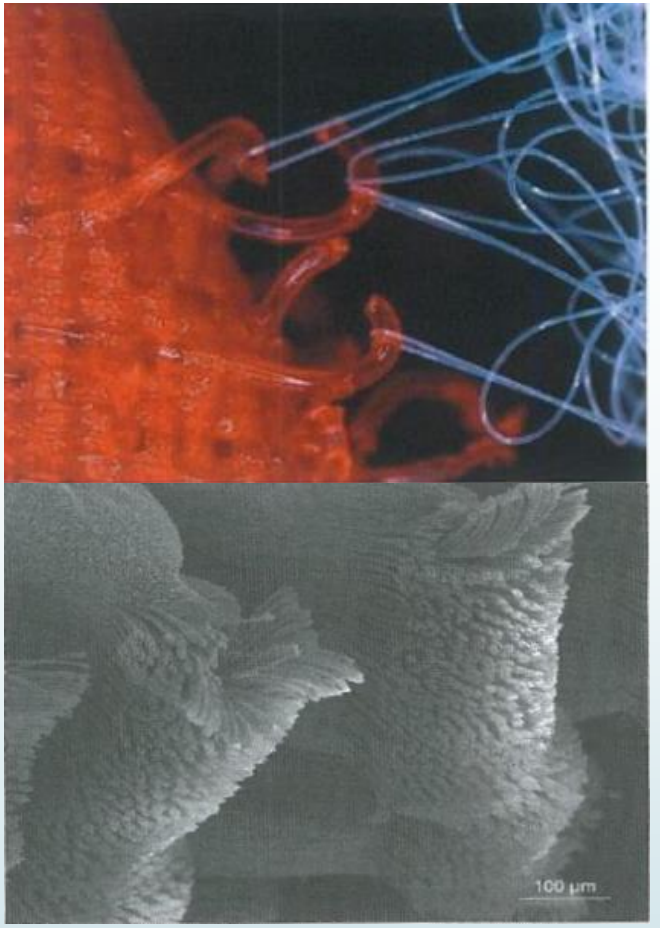
乾附著力

➡牛蒡

牛蒡是蔓科植物的一種，啟發了黏扣帶的產生

• 壁虎腳

數以百萬計的匙突狀絨毛構成，在與平滑表面接觸時協助產生凡得瓦力



科學家運用在大自然發現的機制，特別是牛蒡與壁虎腳，調適成能讓紡織品具備乾附著力的特性。

黏扣帶是一種固定用布料，廣泛用於機 能性成衣與鞋類，其靈感來源是 1940 年代末瑞士電機工程師 George de Mestral 的觀察。他與狗在鄉間散步時注意到狗的毛皮及他自己的衣服黏到一些毛刺。他對附著性來源的好奇心讓他在顯微鏡下觀察這些毛刺，發現它們包含細微得像鉤子的矛刺，附著到他衣服布料上圈狀的紗線。

高強力

笠貝齒

- 笠貝牙齒裡發現的一種礦物質與蛋白質的合成物，構成有始以來試驗過最強硬的生物材質。
- 每一根纖維的張力約為 5 GPa，大約是大多數蜘蛛絲張力的五倍；這個力道可以類比為，用一條義大利麵懸掛住 3,000 包每包重 500 公克的糖，義大利麵也不會斷。

蜘蛛絲

- 蜘蛛絲線是以蛋白質為基質的生物聚合體絲，具有獨特的特性組合。相同的重量下，蜘蛛絲的強力是鋼的五倍，彈性卻大得多。
- 蜘蛛網雖然很輕但很強韌，不溶於水，對風、雨及日光都有抵抗力

美國猶他大學研究團隊研發出三種生產蜘蛛絲蛋白質的方法：

- 將蜘蛛絲基因轉移入細菌內，細菌就可製造蜘蛛絲蛋白質，再紡成纖維。
- 改造山羊基因讓牠們的奶水含有蜘蛛絲蛋白質。
- 在蠶身上注射蜘蛛絲基因，蠶就會製造蜘蛛絲蛋白質與自己原有的蛋白質再製成繭絲。

保暖

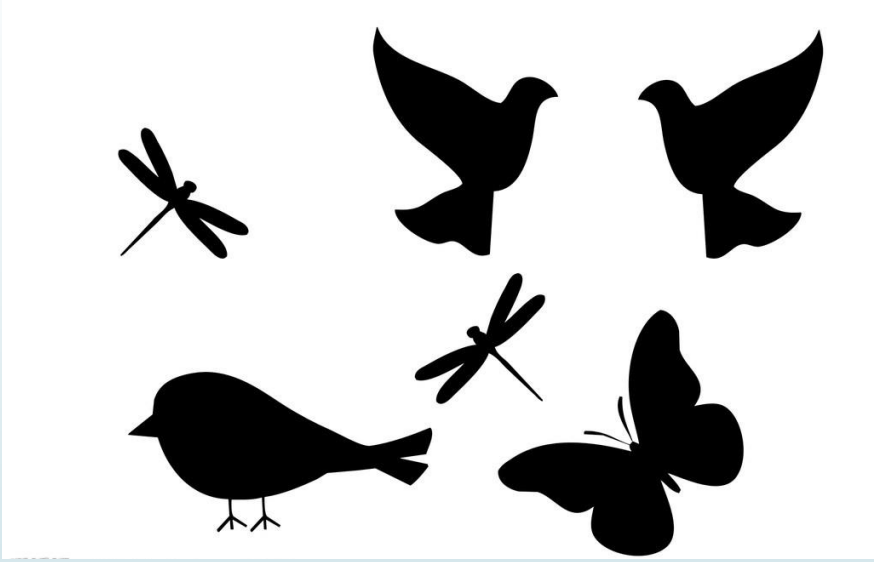
- 鳥羽
  - 材質性:
    氮、硫五
    保溫性高
  - 氣孔構造
    可以吸收
    可避免寒
- 北極熊毛皮
  - 北極熊的
    使得動物
  - 毛皮是一
    吸管的毛
    緣層，有

Topic 7. 空氣集塵

?

How Might We actively collect PM2.5 on the road of urban areas at low cost?

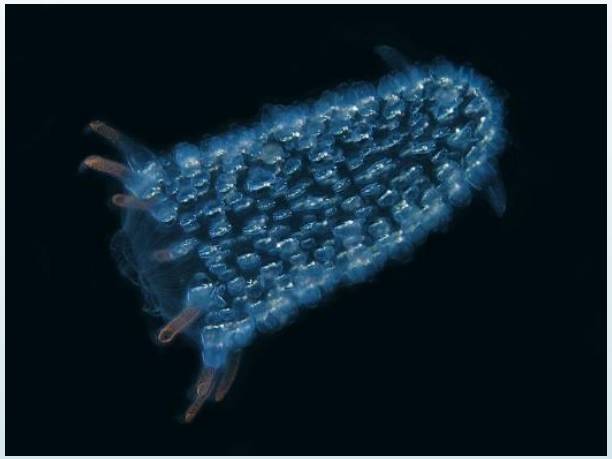
Biologized Challenge

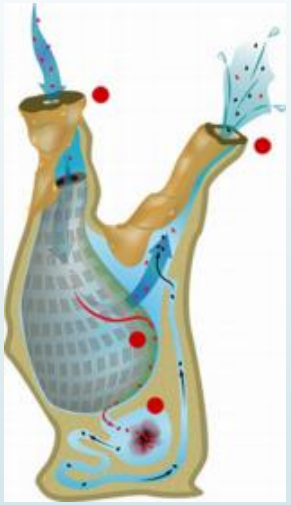


How does nature actively collect micro particles?

AskNature Idea

Salps (海鞘) capture tiny algae for food by filtering seawater through a net of mucus.

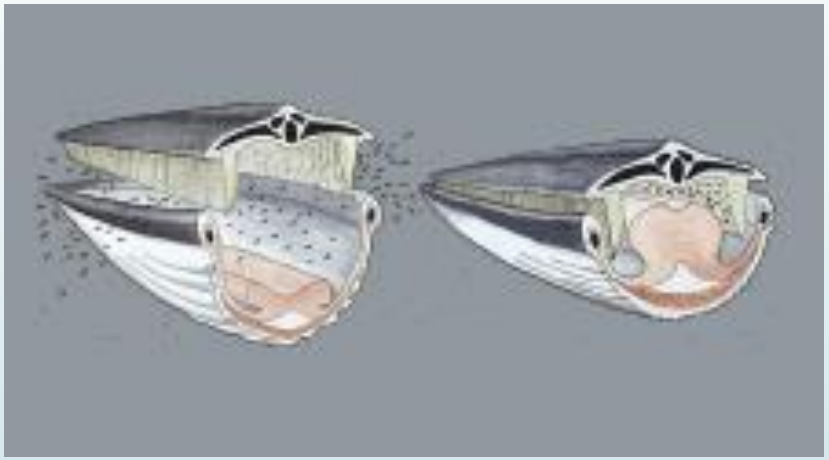




By muscle, salps create a clam and orderly flow to pull surrounding water into body. Particles such as bacteria and plankton diffuse into and adhere to the sticky net. In this filtration system, slaps can capture parcels smaller than the size of the net.

AskNature Idea

Baleen plates filter food



Baleen (鯨鬚) is a special structure in the mouth of baleen whale. After taking food, whales use fallen to green out water while its food, such as krill (磷蝦), remain in the mouth because of bigger size.

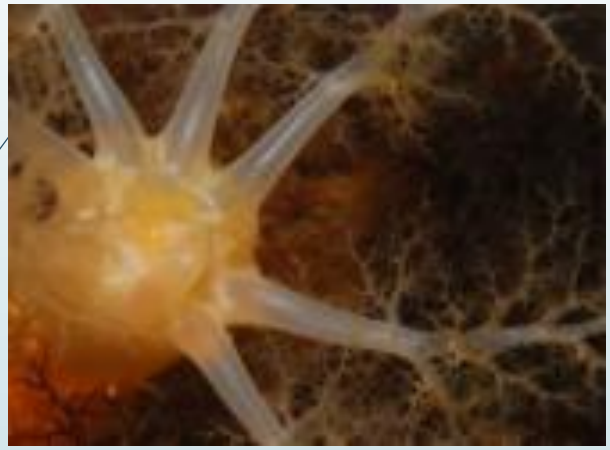
AskNature Idea

Baleen Filters water filters

The Baleen filter is a highly efficient, non-pressurized self-cleaning separation technology that offers reliable, trouble-free filtration to 25 microns without chemical assistance.

Other Idea

Sea cucumber (海參): use tentacles (觸手) to sweep particles into collection zone.

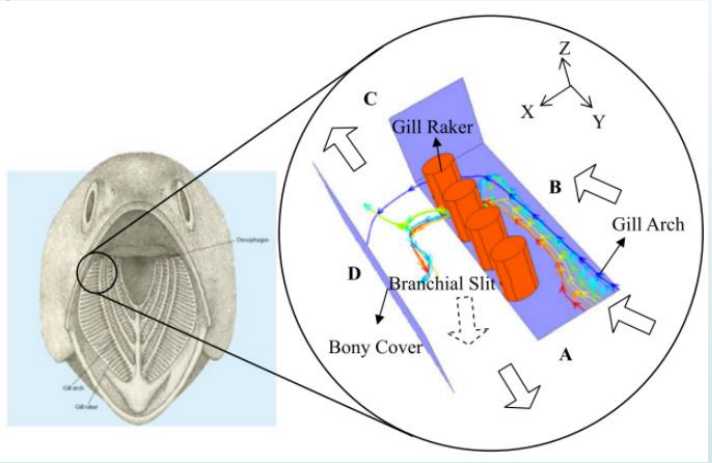


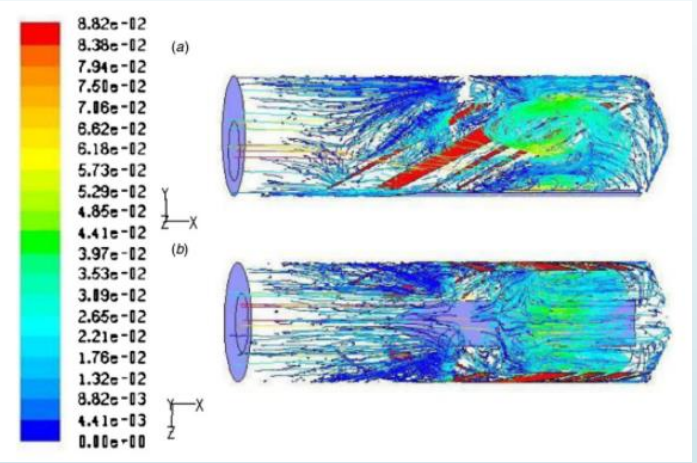
Sea cucumber position themselves in currents and catch food that flows by with their open dendritic tentacles.

鰓鰓耙

Other Idea

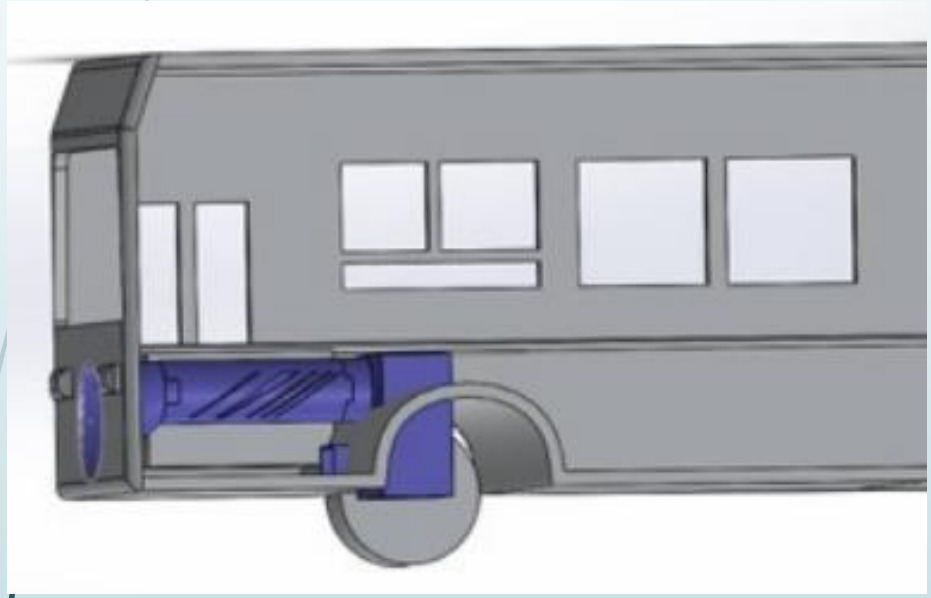
Gizzard ((鳥等的)砂嚢, (雞鴨的)胗)
gather particles by crossflow filtration

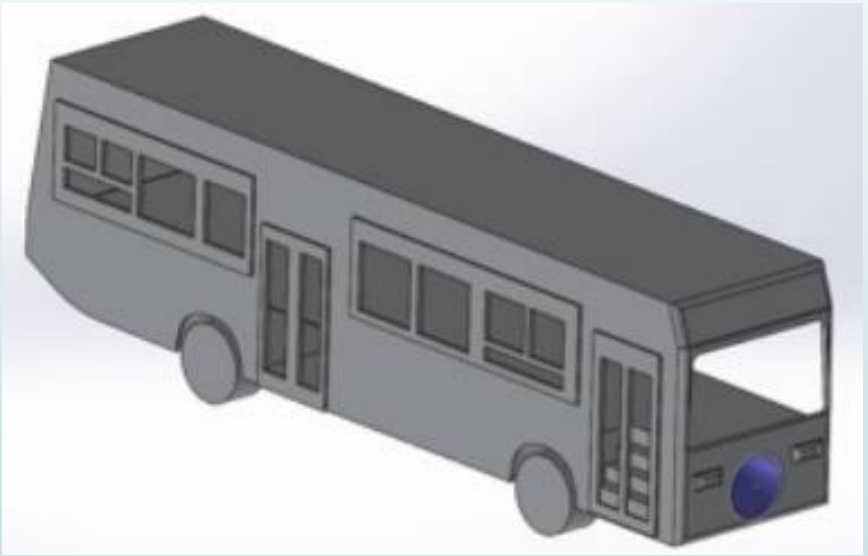




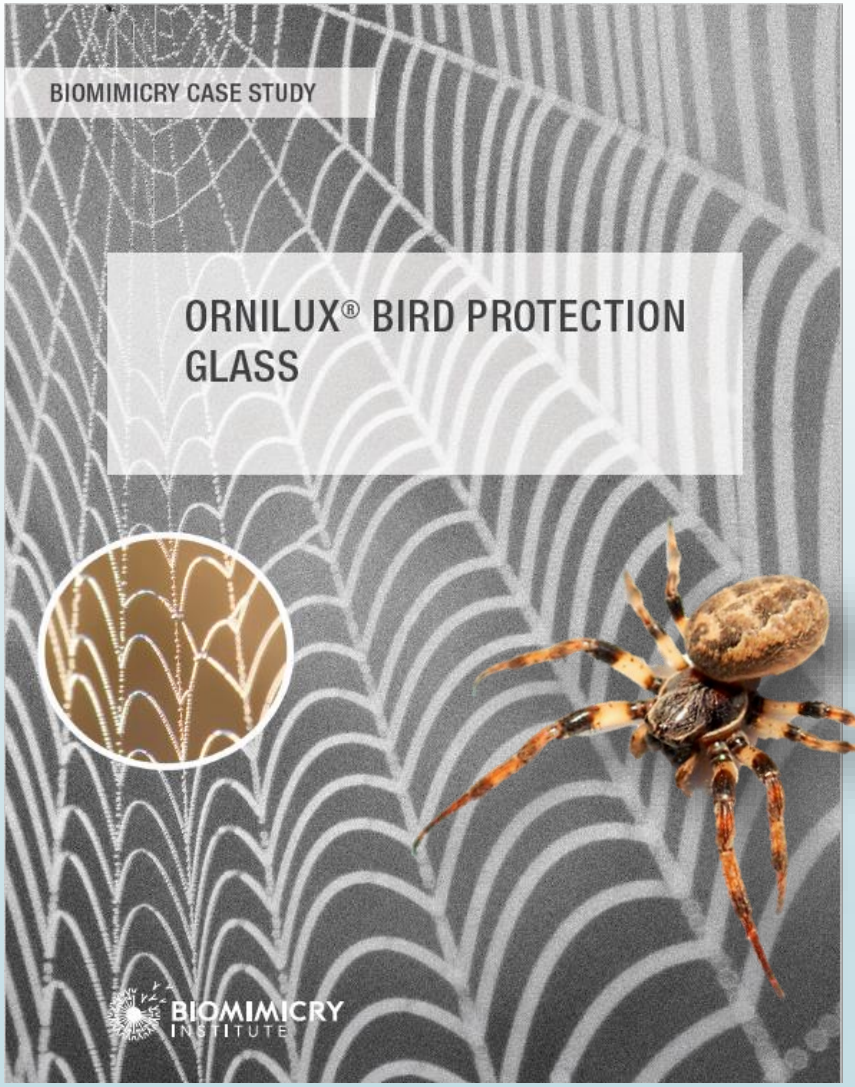
Gizzard shad concentrate the particle foods in suspension as main stream flow tangential to the filter (branchial arches and gill rakers 鰓耙) surface. This filtration mechanisms is possible to retain particles smaller than the mesh size.

Some Solutions

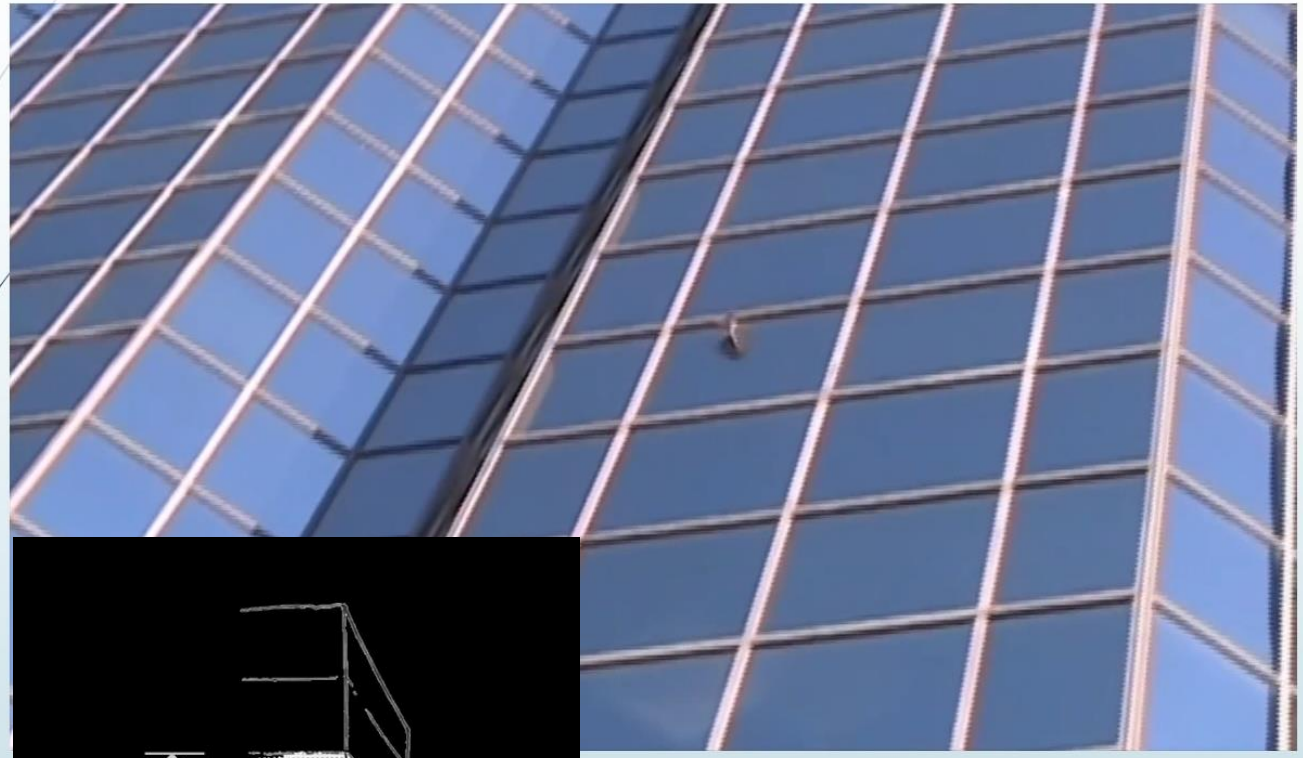




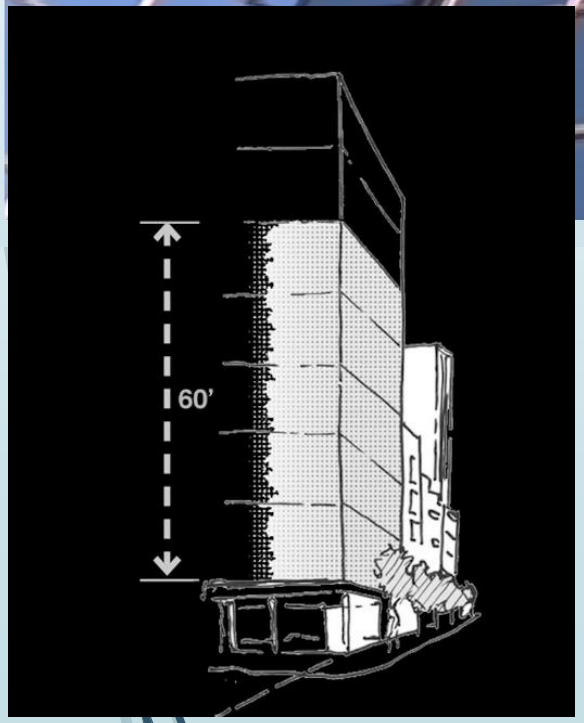
Topic 8. 防鳥撞玻璃



BIOLOGY TO DESIGN: MOTIVATION



1 to 10 birds killed per building per year

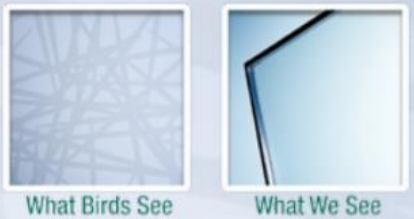


60 ft (18 m) 約6 樓以上高度的玻璃建築，最容易遭遇飛鳥撞擊，造成死亡。

Innovation by ARNOLDGLAS

PRODUCT	ORNILUX® Bird Protection Glass
INNOVATORS	Researcher | Arnold Glas
	Company | Arnold Glas

© ORNILUX



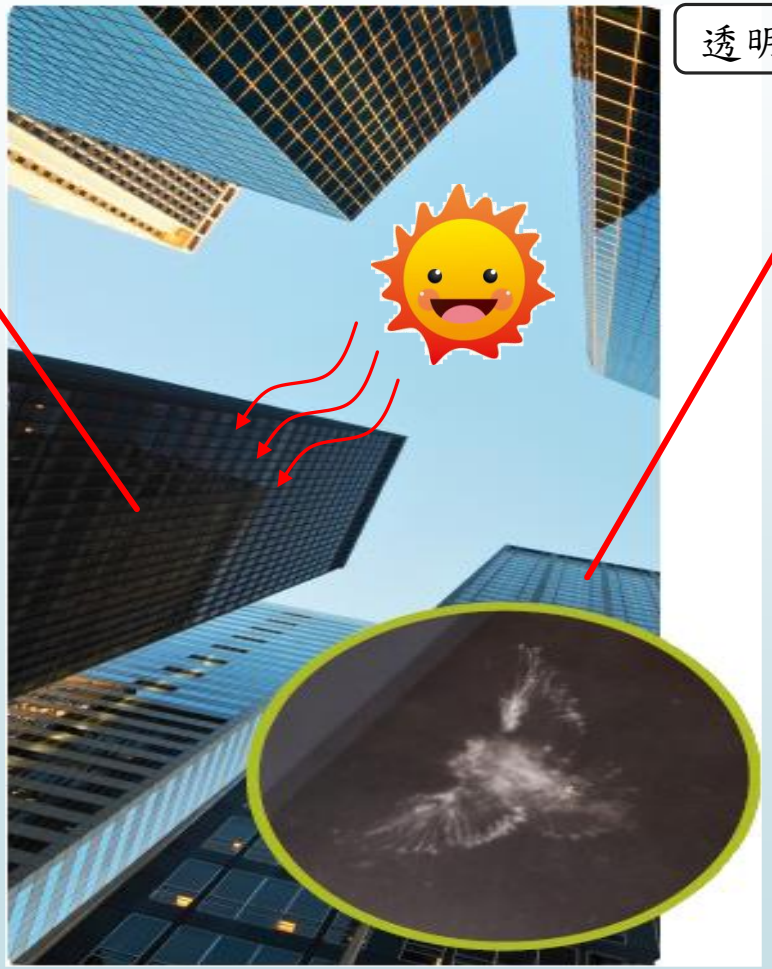
5

CASE STUDY | ORNILUX
Biomimicry.org | AskNature.org

BIOLOGY TO DESIGN: MOTIVATION

天空、植物等自然景色

透明到不知前方有障礙物

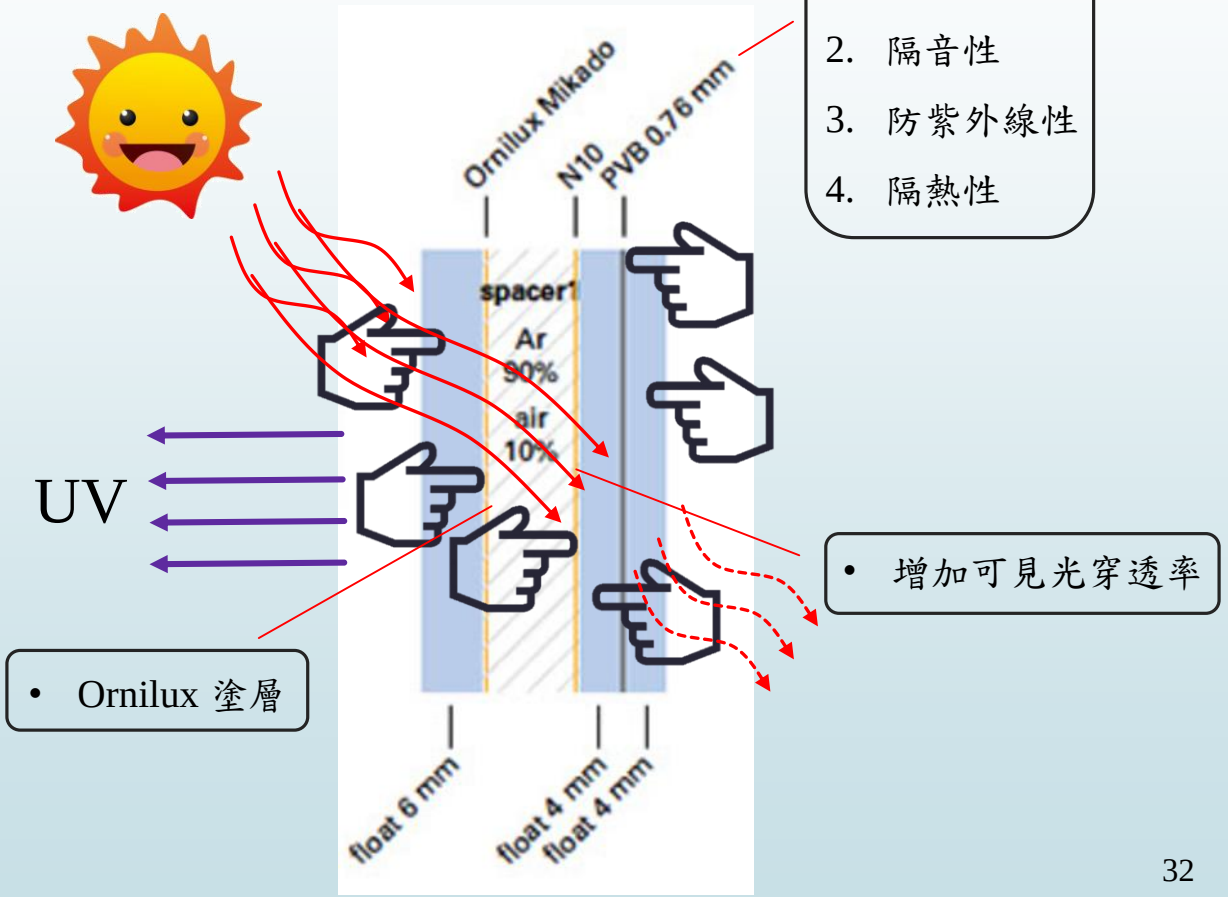


3億至10億

Dr. Meyerhuber

Mr. Arnold

TECHNICAL DESIGN



EXPERIMENT

- 此產品在進行實驗時，是在長30英尺的隧道中進行，在隧道的底端有兩片並排的玻璃，其中一片未塗上Ornilux塗層，而另一片有塗上Ornilux 塗層，其目的為觀察鳥類會往那個方向行進。
- 最後由實驗結果顯示，大部分的鳥類會往未塗上Ornilux塗層的玻璃行進。

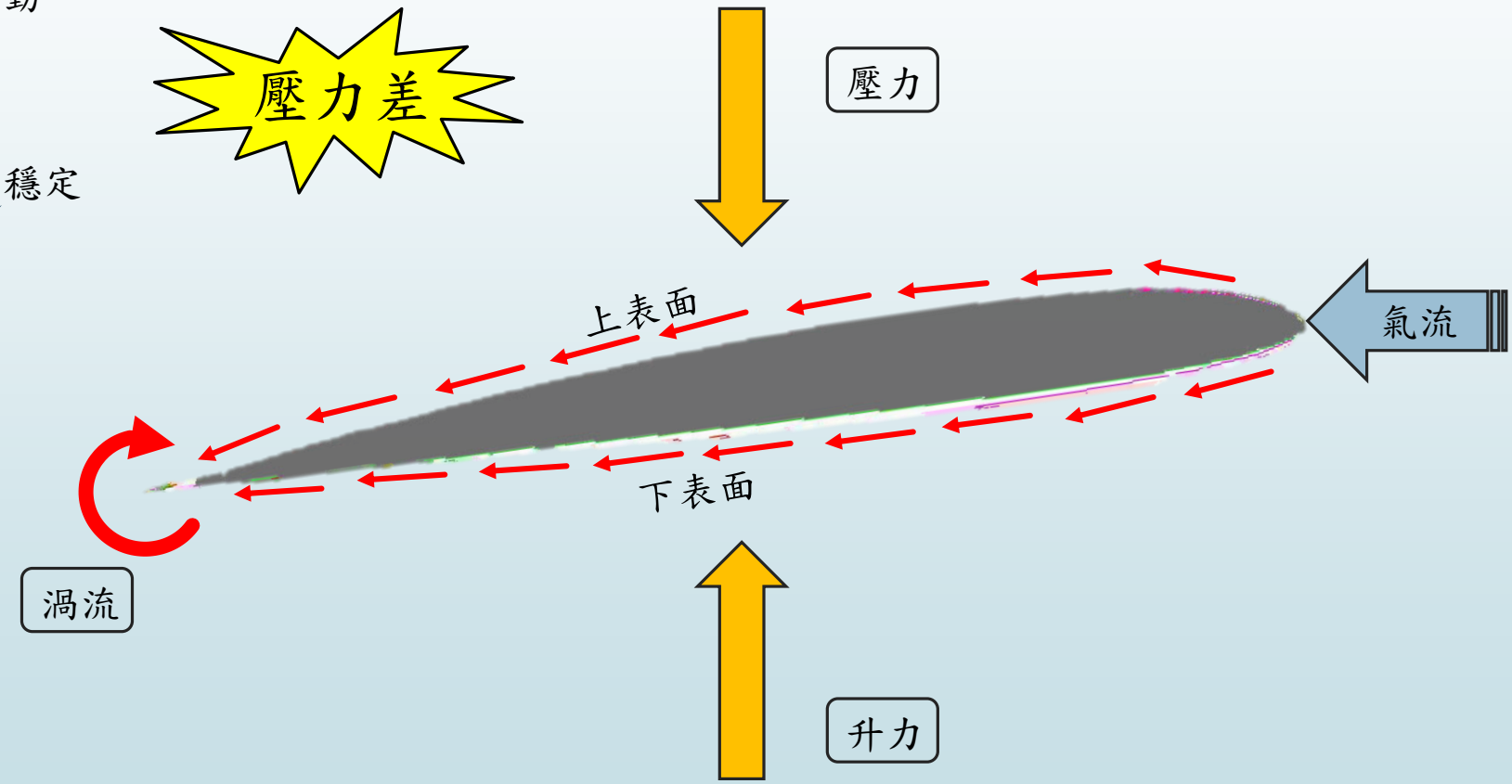
EXPERIMENT

Topic 9. 機翼設計

Design Question	如何開發出一個寂靜的機翼。
Function	寂靜、吸音、吸震動、降低噪音
Context	氣流、空中、快速飛行

Biological Strategy and Design Strategy for an Owl Feather

- 機翼震動
- 耗油
- 阻力
- 飛行不穩定
- 噪音



Biological Strategy and Design Strategy for an Owl Feather

WORKSHEET

Biological Strategy and Design Strategy for an Owl Feather

In the biological strategy summary below, highlight or underline the key words and phrases that show how the owl's wing feather reduces noise while in flight. Afterward, make a drawing of the biological strategy based on what you learned, use the words and phrases you underlined to write a design strategy that explains the key elements that help reduce noise as an object moves through the air and, draw the design strategy.

Owl Wing Feathers Enable Near-silent Flight

Owls are known as silent predators of the night, capable of flying just inches from their prey without being detected. The quietness of their flight is owed to the anatomy of their wing feathers, which have a leading edge that reduces turbulence. Turbulence typically creates a "gushing" noise when released in large forces. But the leading edge of the owl's feathers break up this large turbulence into smaller, micro-turbulences that reduce the amount of noise.

This leading edge is filled with different structures (hooks and bows) that create a stiff, serrated edge of various lengths. As air flows over and through a feather, these varied lengths and structures cause the air to be distributed into smaller vortices that disperse at different times into different directions (oscillations), breaking up an otherwise single, large air force. These smaller vortices oscillate at a higher frequency, creating a pitch that is above the hearing capabilities of most prey, as well as humans.

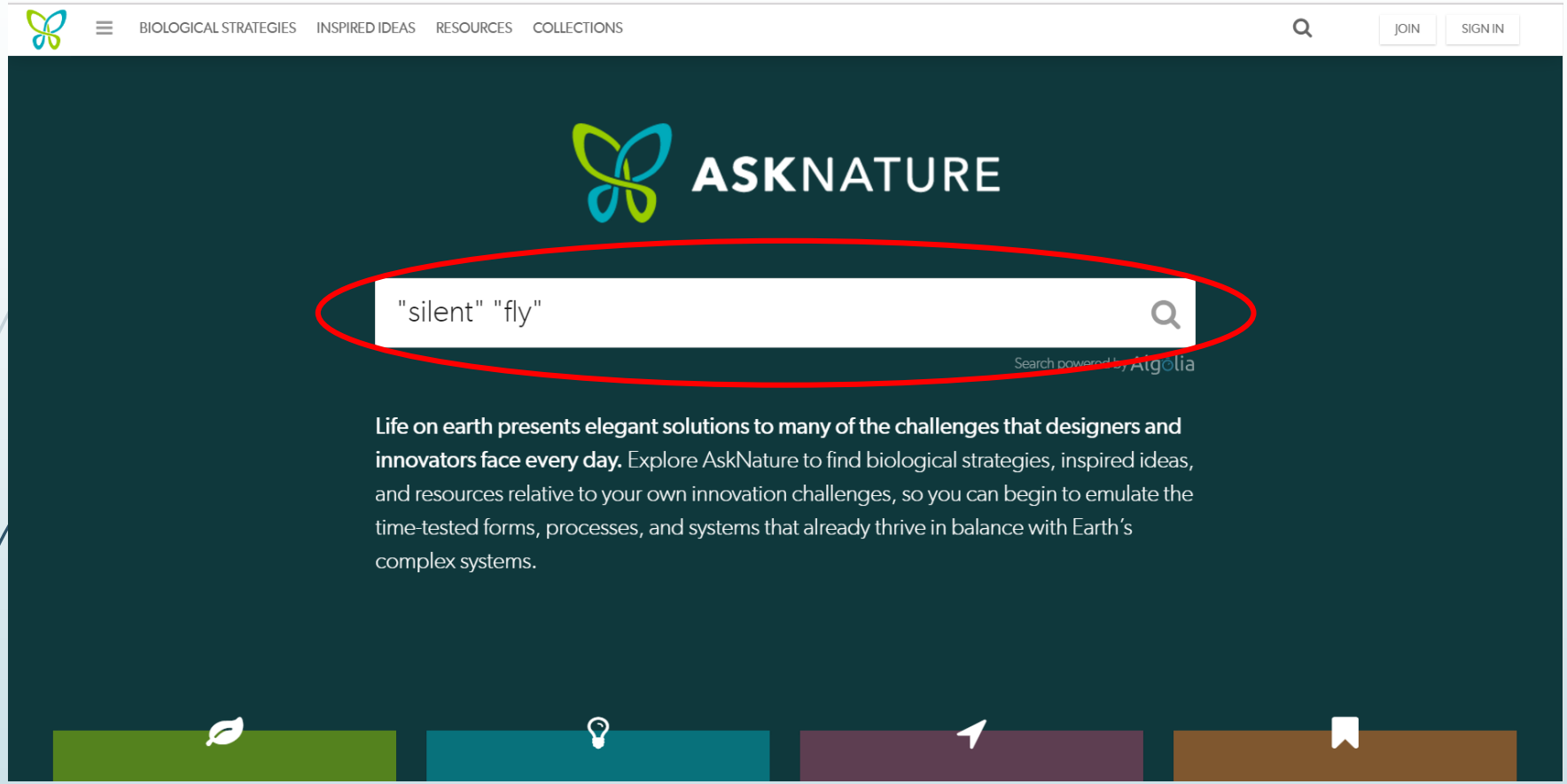
If not for the feather's serrated edges, there would be only one, large air vortex formed at the trailing edge of the feather's airflow. This large vortex would produce, in turn, a large force on the feather. That force would increase turbulence across the owl's entire wingspan and, ultimately, produce more noise.

In addition to the serrated edges, the owl's feathers are coated in a velvety upper surface and a soft, downy surface on the lower portion. The owl's legs are also coated in this soft down. This layer of softer plumage is believed to absorb more of the micro-turbulences created from air flowing over the leading edge of the feathers. However, the exact mechanism of sound absorption by this down layer is still under preliminary study.

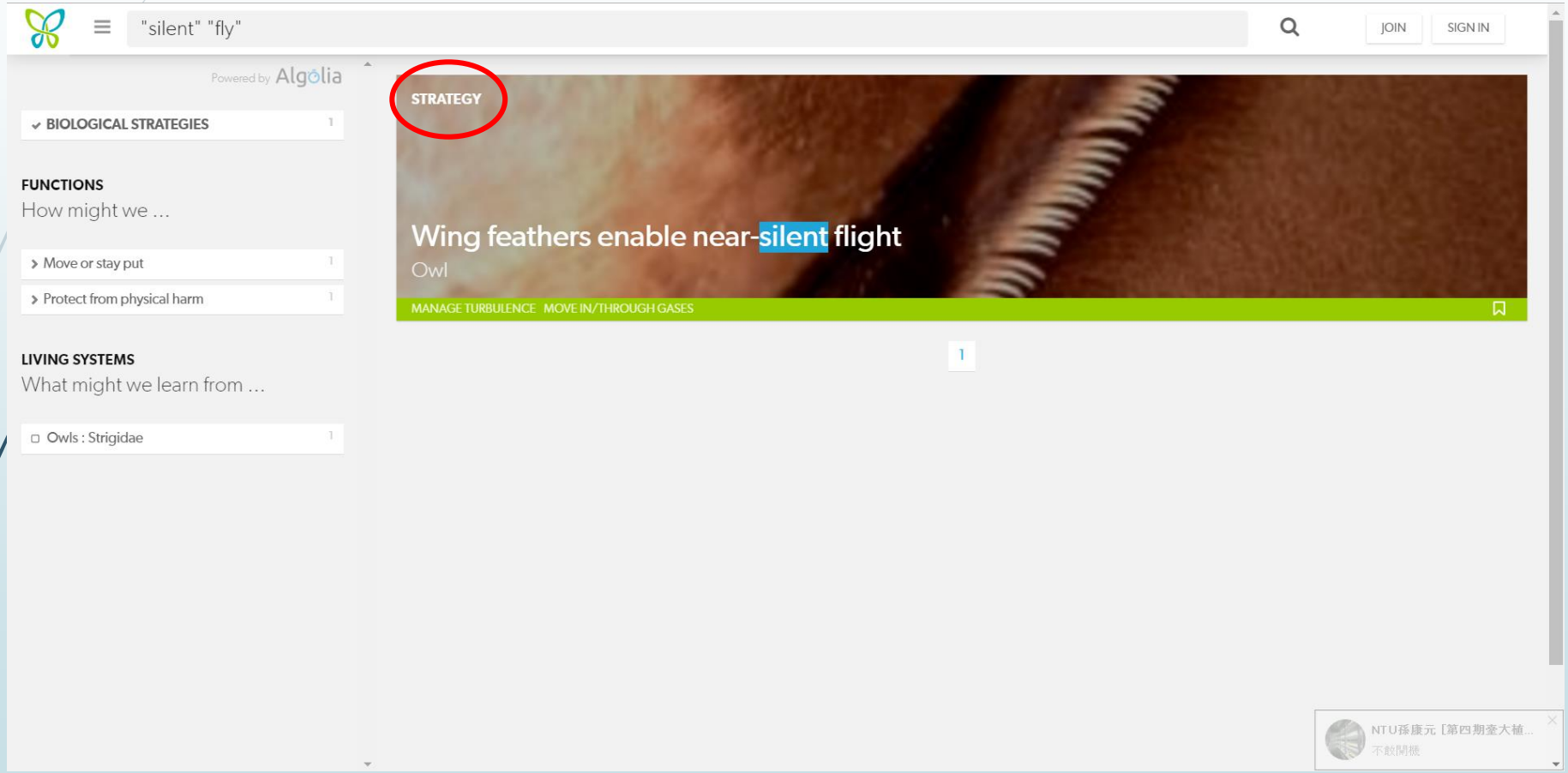
Image: Close up of the leading edge of an owl flight feather and the soft surface of the wing. Photo by Kersti Nebelsiek, CC-BY-SA, via Wikipedia.

Summary: Excerpt from Asknature.

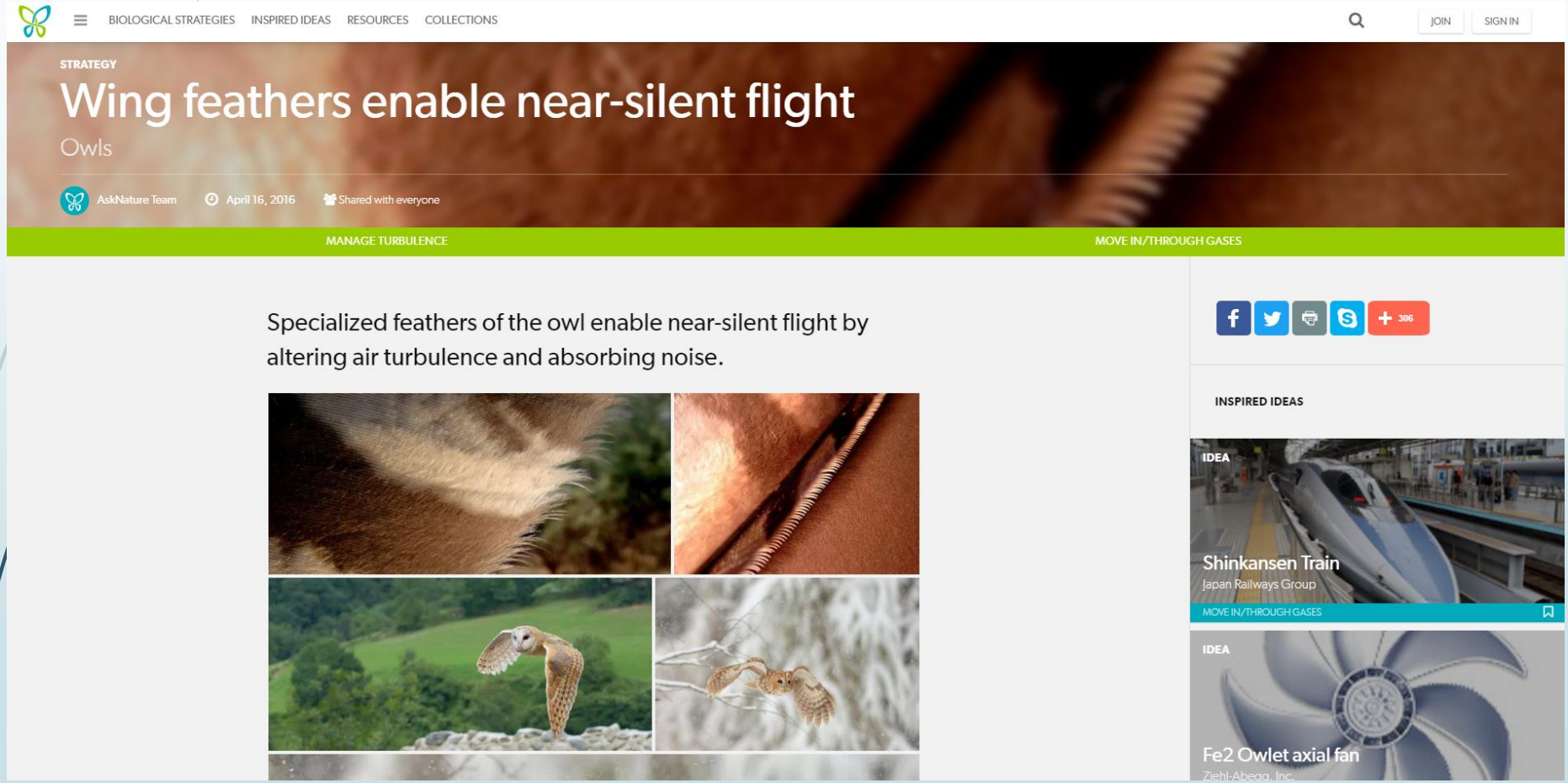
此篇文獻為利用貓頭鷹之生物策略來設計出低噪音的機翼。


BIOLOGICAL STRATEGIES
INSPIRED IDEAS
RESOURCES
COLLECTIONS
JOIN
SIGN IN
ASKNATURE
"silent" "fly"
Search powered by Algolia
Life on earth presents elegant solutions to many of the challenges that designers and innovators face every day. Explore AskNature to find biological strategies, inspired ideas, and resources relative to your own innovation challenges, so you can begin to emulate the time-tested forms, processes, and systems that already thrive in balance with Earth's complex systems.

Biological Strategy and Design Strategy for an Owl Feather



Biological Strategy and Design Strategy for an Owl Feather



Biological Strategy and Design Strategy for an Owl Feather

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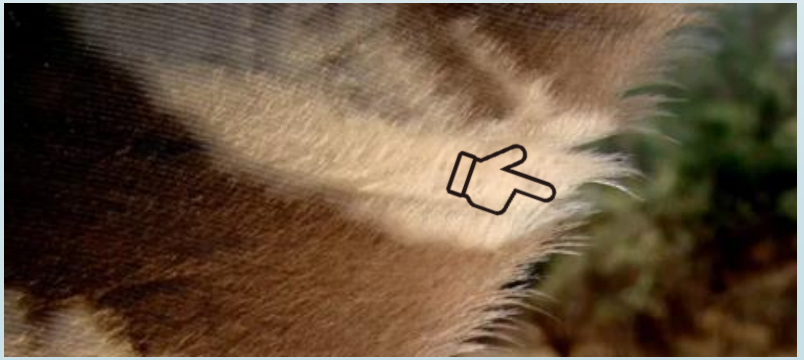
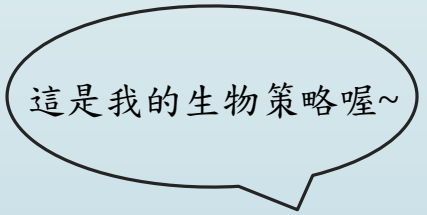
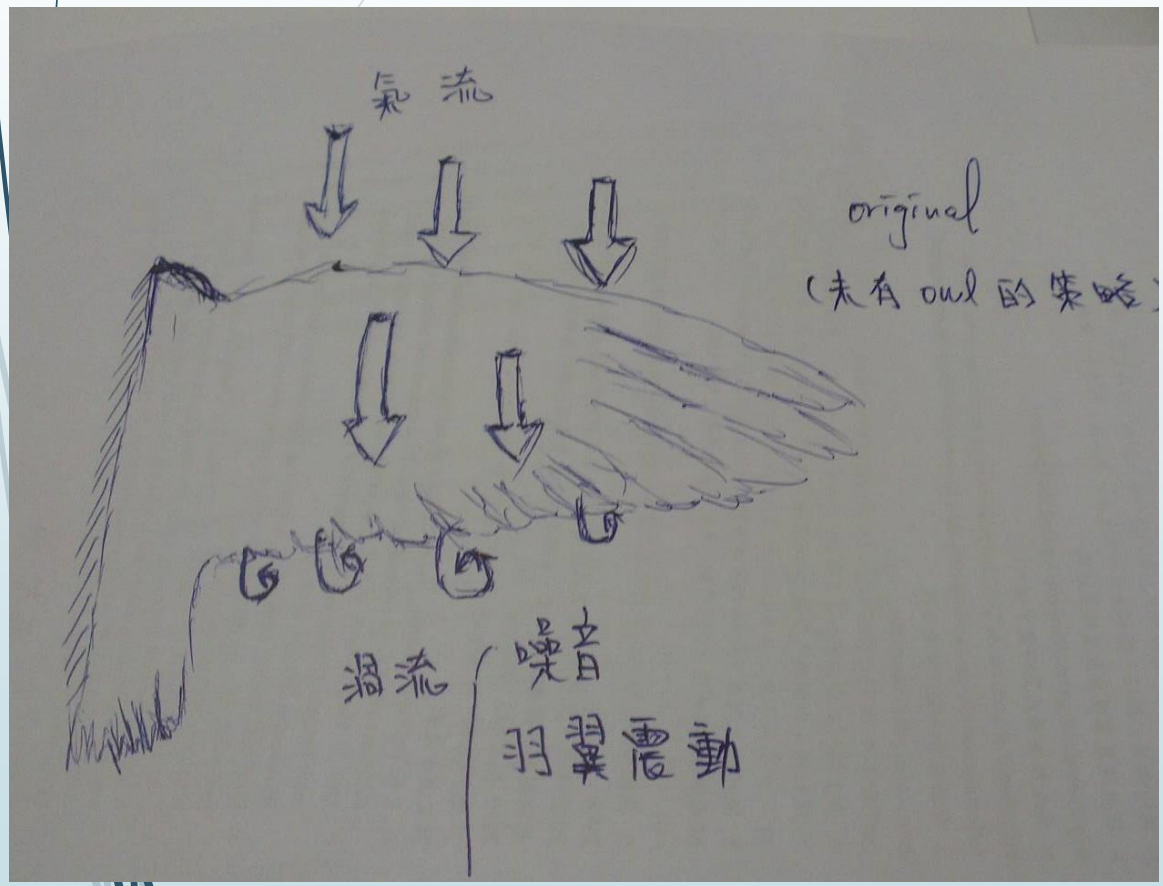




Biological Strategy and Design Strategy for an Owl Feather

Biological Strategy and Design Strategy for an Owl Feather

POOR design



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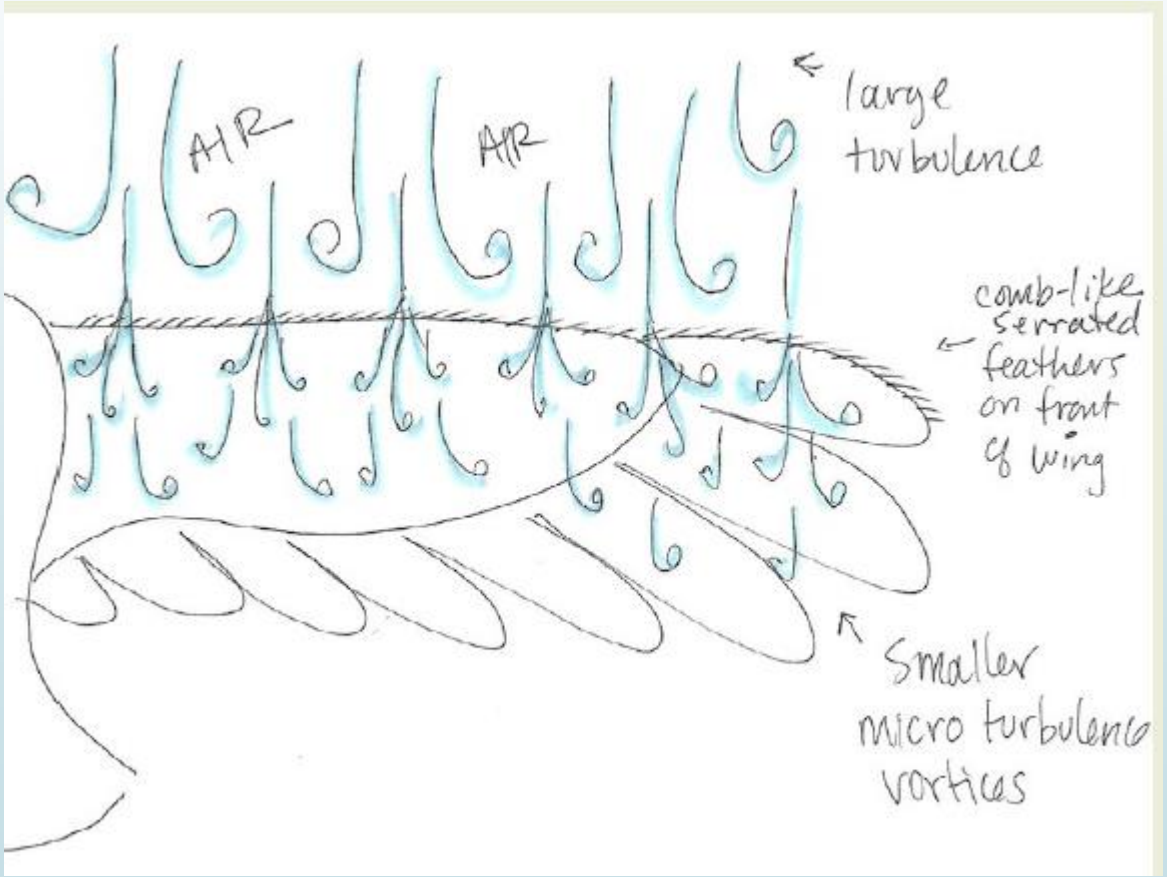
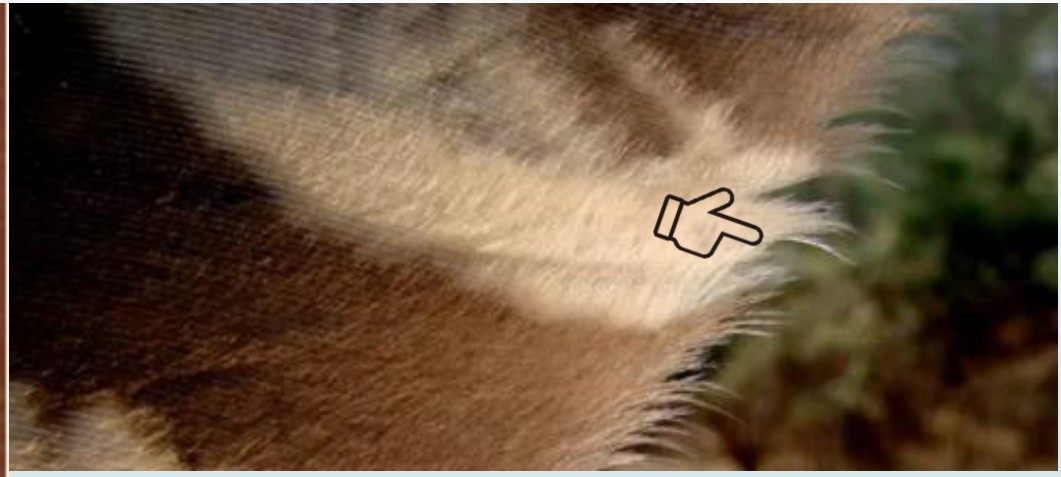
Biological Strategy and Design Strategy for an Owl Feather

充分了解了 生物策略



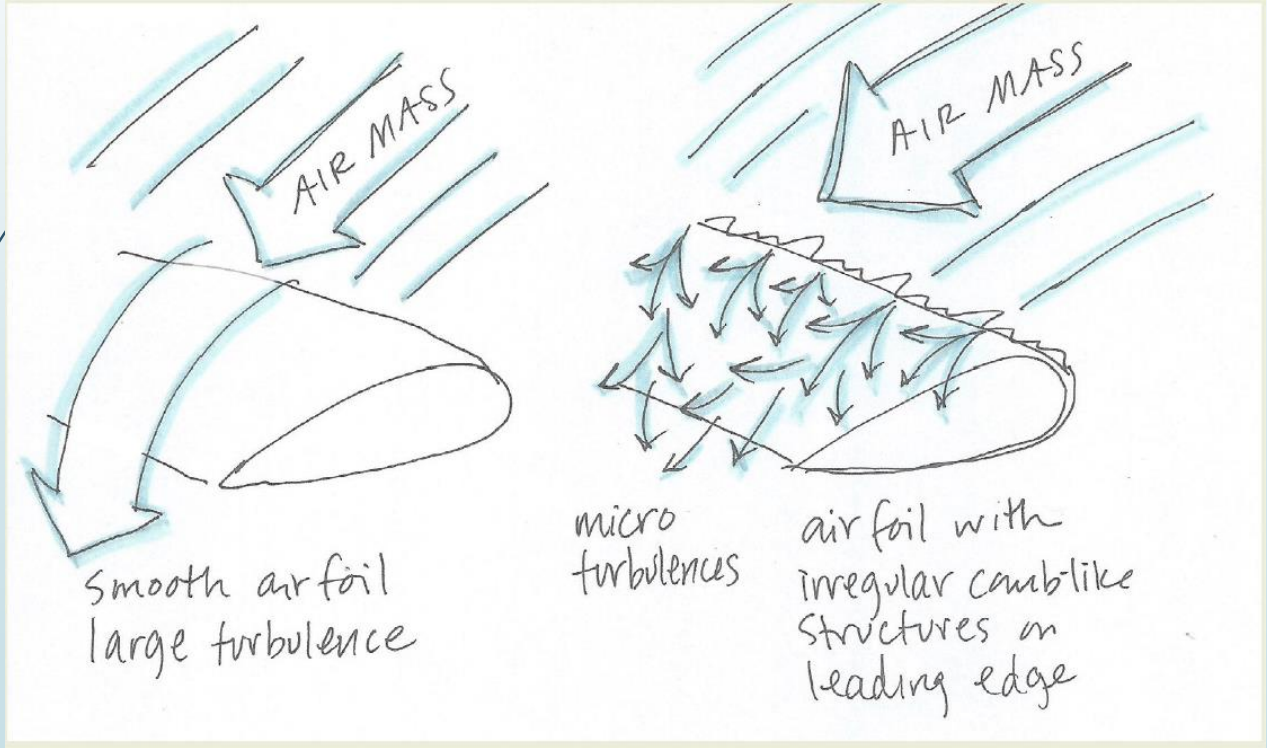
Biological Strategy and Design Strategy for an Owl Feather



這是我的生物策略喔~

Biological Strategy and Design Strategy for an Owl Feather

生物策略 → 工程設計



機翼表面材料可使用玻璃纖維，玻纖除了有一定的強度外，也具有吸震的能力。

Topic 10

STRATEGY

Leaf shapes optimize sunlight

Olive

AskNature Team | May 31, 2016 | Shared with everyone

Leaves of olive trees optimize sunlight harvesting by differing in shape and being flexible to changing conditions

CLICK/TAP IMAGES FOR ATTRIBUTION AND LICENSE INFORMATION.

Leaf shape

IDEA INCUBATOR 3

Optimizing rather than maximizing how light enters a building

AskNature Team

Altering shape of solar-collecting surfaces to take advantage of different types of radiation

AskNature Team

Designing structures to be responsive to changing light conditions and availability

STRATEGY

Weak leaves deal with strong winds

Tulip Poplar

AskNature Team · April 26, 2016 · Shared with everyone

Leaf vs. Strong wind

The leaves of trees deal with strong winds by adjusting their configurations in order to reduce exposure and limit flutter.

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STRATEGY

Leaf color and shape enhance cooling effect

Sang Drago

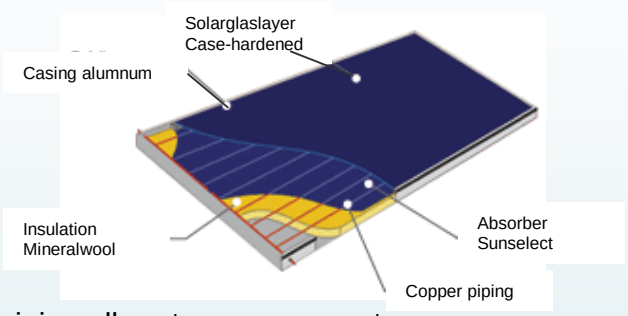
AskNature Team · April 22, 2016 · Shared with everyone

Leaf color & shape vs. cooling

The cooling effects of shade trees in subtropical regions are most influenced by foliage density and leaf thickness, leaf texture, and leaf color lightness.

Leaf as inspiring examples for solar energy production

Solar collector with bionic Absorber Design



- all-in-one Collector containing all system components
- Carrier of warmth flows – instead of pipes – directly on the Absorber plate in channels, branching out analogue the leaf of a tree
- Considerable improvement of performance at same cost expenditure
- Design of collector is optimal in size respo ut, inducing optimal perfusion

Topic 11

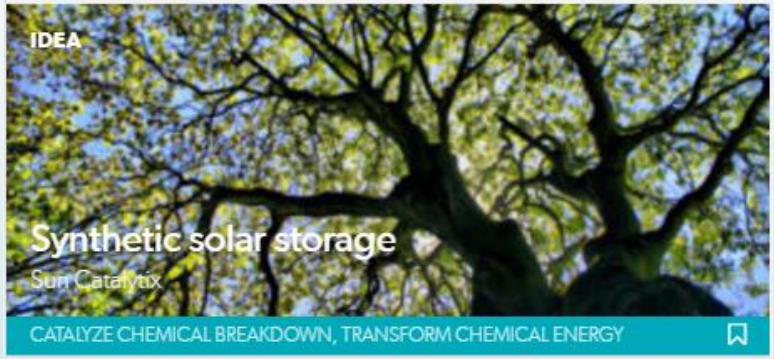
STRATEGY

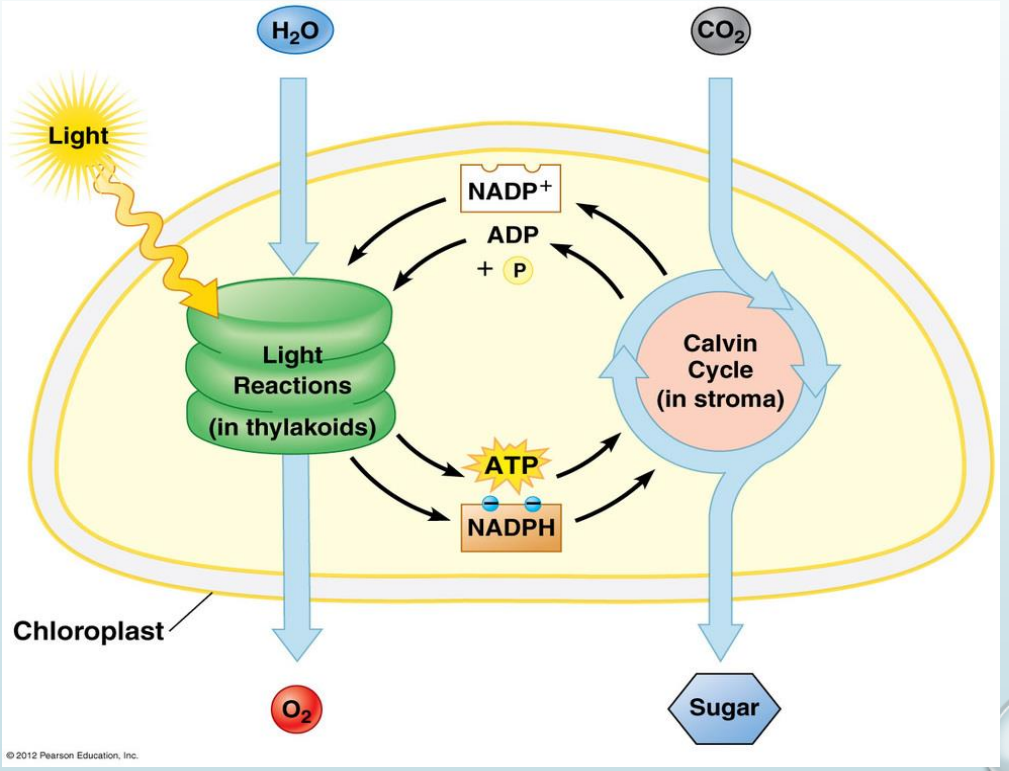
Photosynthesis converts solar energy into chemical energy

Plants

AskNature Team · November 29, 2015 · Shared with everyone

INSPIRED IDEAS



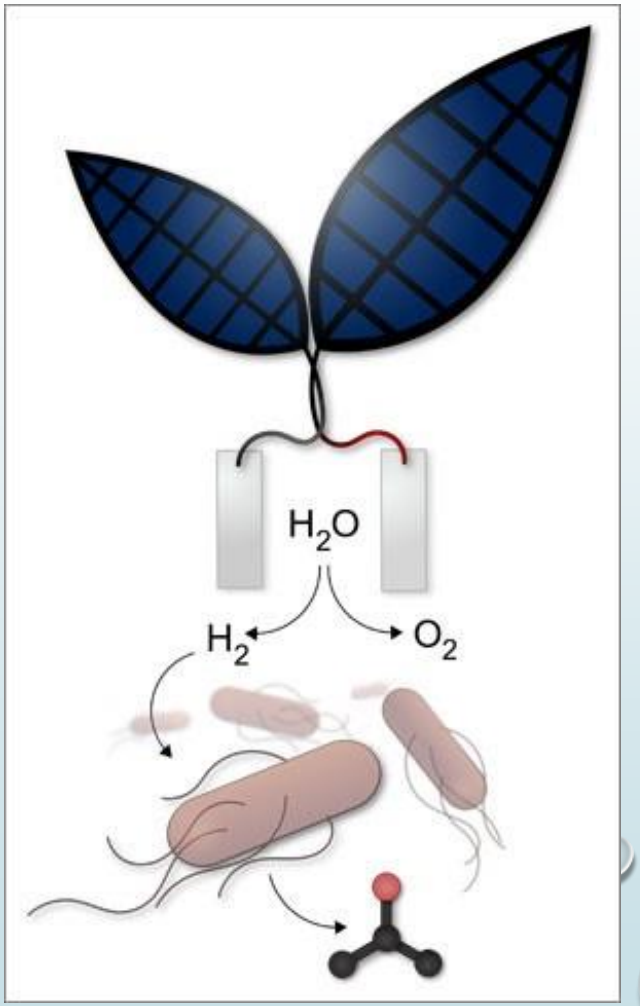


仿生葉（bionic leaf）

- 哈佛大學化學家諾塞拉（Daniel Nocera）與哈佛醫學院合成生物學家西爾弗（Pamela Silver）共同打造出一種活電池，稱之為Bionic leaf

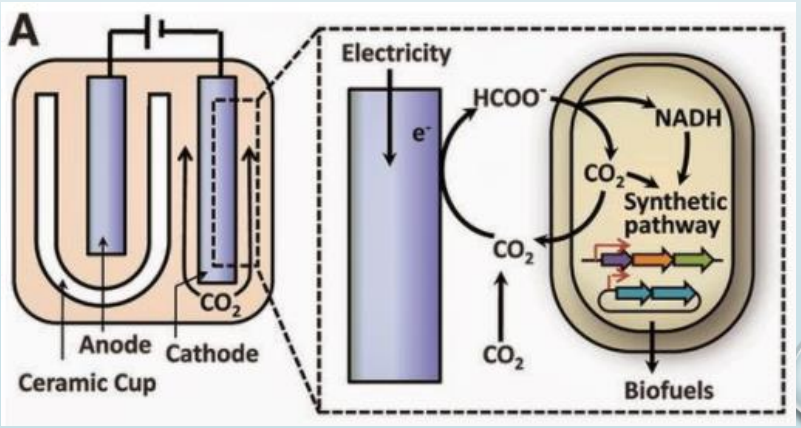
仿生葉

- 這項裝置從光電板得到太陽能電力來驅動化學反應，把水分解成氧氣和氫氣；裝置內的微生物得到氫，便可把空氣中的二氧化碳轉變成醇類，成為燃料。



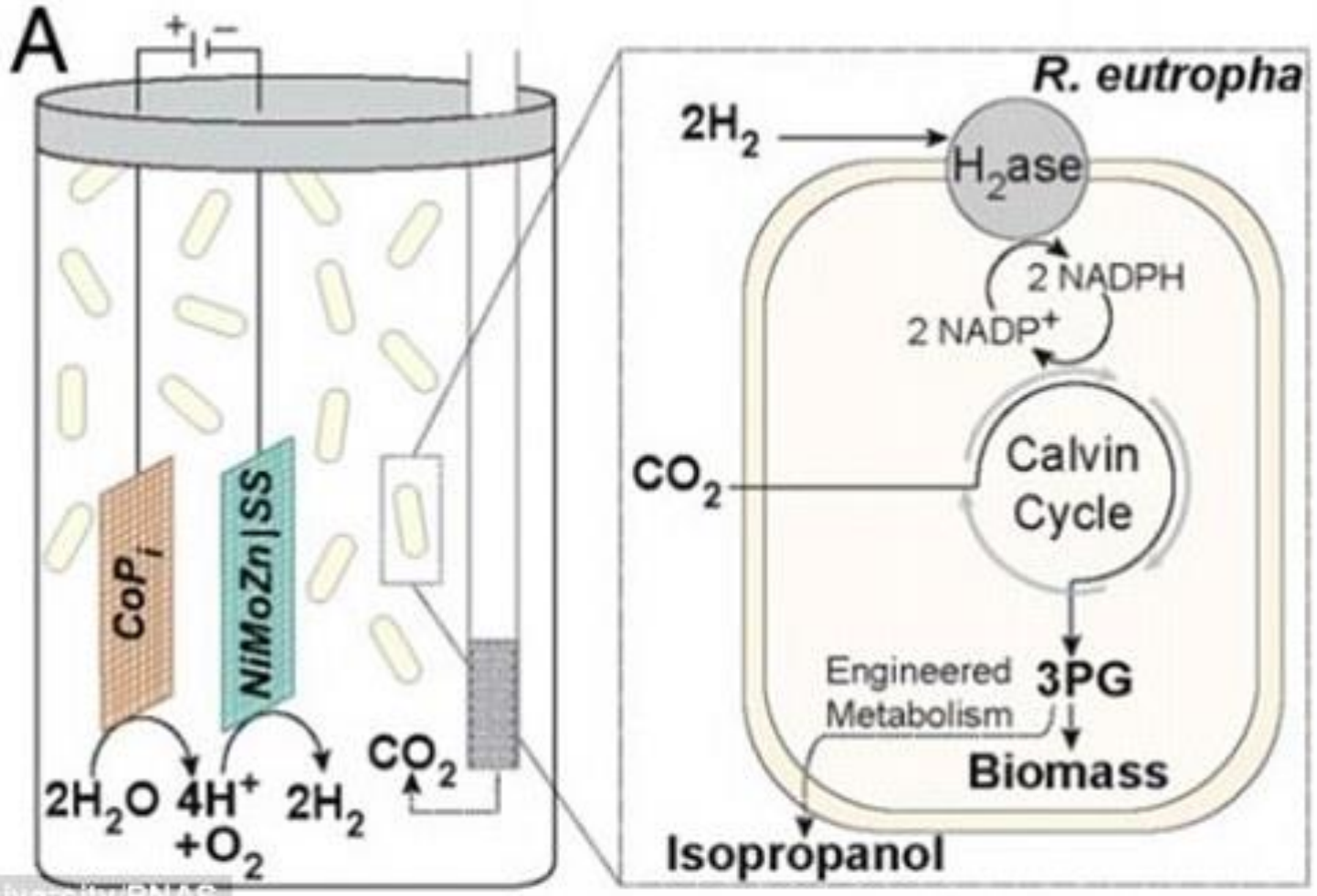
光合作用仿生技術應用－仿生葉

- 該團隊在2015年造出了第一款人工光合作用設備，用1升水可生產出216毫克的乙醇。
- 不過該系統所使用的鎳—鉬—鋅催化劑在參與化學反應後，可能會產生一定的副作用讓參與反應的微生物中毒，從而影響後續進程。因此，他們一直在尋找更好的催化劑。



結合細菌與晶片的
液態能源產生系統

仿生葉



仿生葉

- 2016年《科學》雜誌：藉助一種鈷磷合金作為新型的催化劑，可讓仿生葉生產乙醇的效率提高了10%以上。
  - 此種鈷磷合金過去都用於塑料和金屬元件加工，作為防腐塗料。
- 據稱，每千瓦時的電能讓升級版的仿生葉消化130克的二氧化碳，產出60克的異丙醇燃料。
  - 這種轉化效率大約是自然界光合作用的10倍以上。

Gigaton scale carbon removal

- 徵求每年可以處理一百億噸以上二氧化碳 $=10^{10}x10^{6}$ 克
- 仿生葉130 g/kWh
- 需要 $10^{16}/130 = 7.6923x10^{13}$ kWh
  = 約 7692.3 百億 度
  = 約 77 兆 度電力
- 電力需來自再生能源
- 但太陽能板的造價就遠高於獎金
- 話說回來，Elon Musk 有投資太陽能光電板的公司，所以 .....

獎金一億美元的挑戰

◎ 吳智遠

除了橫空出世的COVID-19疫情，氣候變遷可說是近年來最重要的全球性議題，非但攸關環境、科學，更牽動全球經濟與國際政治局勢。

氣候變遷探討的主要課題是全球暖化及其衍生的氣候異常現象，溫室氣體的人為排放，被認為是問題的根源，二氧化碳為溫室氣體大宗，約佔目前人為溫室效應的七十五%，因此在科技上，應對氣候變遷的核心挑戰，便是如何減排、捕捉、利用及儲存二氧化碳，以達成碳中和；碳中和相關科技發展深受矚目，特斯拉創辦人Elon Musk稍早便在專門舉辦超級大獎的XPRIZE平台上，發起「GIGATON SCALE CARBON REMOVAL」挑戰，**徵求每年可以處理一百億噸以上大氣中二氧化碳的創新技術，總獎金為一億美元**，打破XPRIZE的紀錄，也是歷史上規模最大的單一科技挑戰。

與前任川普政府不同，積極對治氣候變遷是美國總統拜登團隊的核心政策主張之一，為此，由於氣候的影響跨越國界且不具排他性，有言氣候變遷可能導致美國政府不得不與中國合作，並導致美國在其他議題上做出讓步；儘管甫結束的阿拉斯加會談氣氛緊張，**美中在氣候變遷方面的合作似已悄然展開**，美國氣候特使、前國務卿John Kerry參與了三月二十三日舉行的「氣候行動」部長級視訊會議，在國際場合與中國的氣候變化事務特使首次正式接觸。

中國做為最大的二氧化碳排放國（約佔全球二十八%），其態度與作為動見觀瞻，二〇二〇年九月底，中國政府首次宣布以二〇三〇年達到碳排放量高峰（一二〇億噸）及二〇六〇年達成碳中和為目標，並納入甫於兩會通過的「十四五」規劃中；為達成前述目標，中國須就其能源結構以及經濟模式，進行大規模調整，從以煤炭為主，轉向再生能源，減少低階生產活動以及固定資產投資，並轉向服務業以及消費驅動，此轉型過程或將創造新的商業機會，並**成為中國政府影響全球經濟與政治的籌碼**。

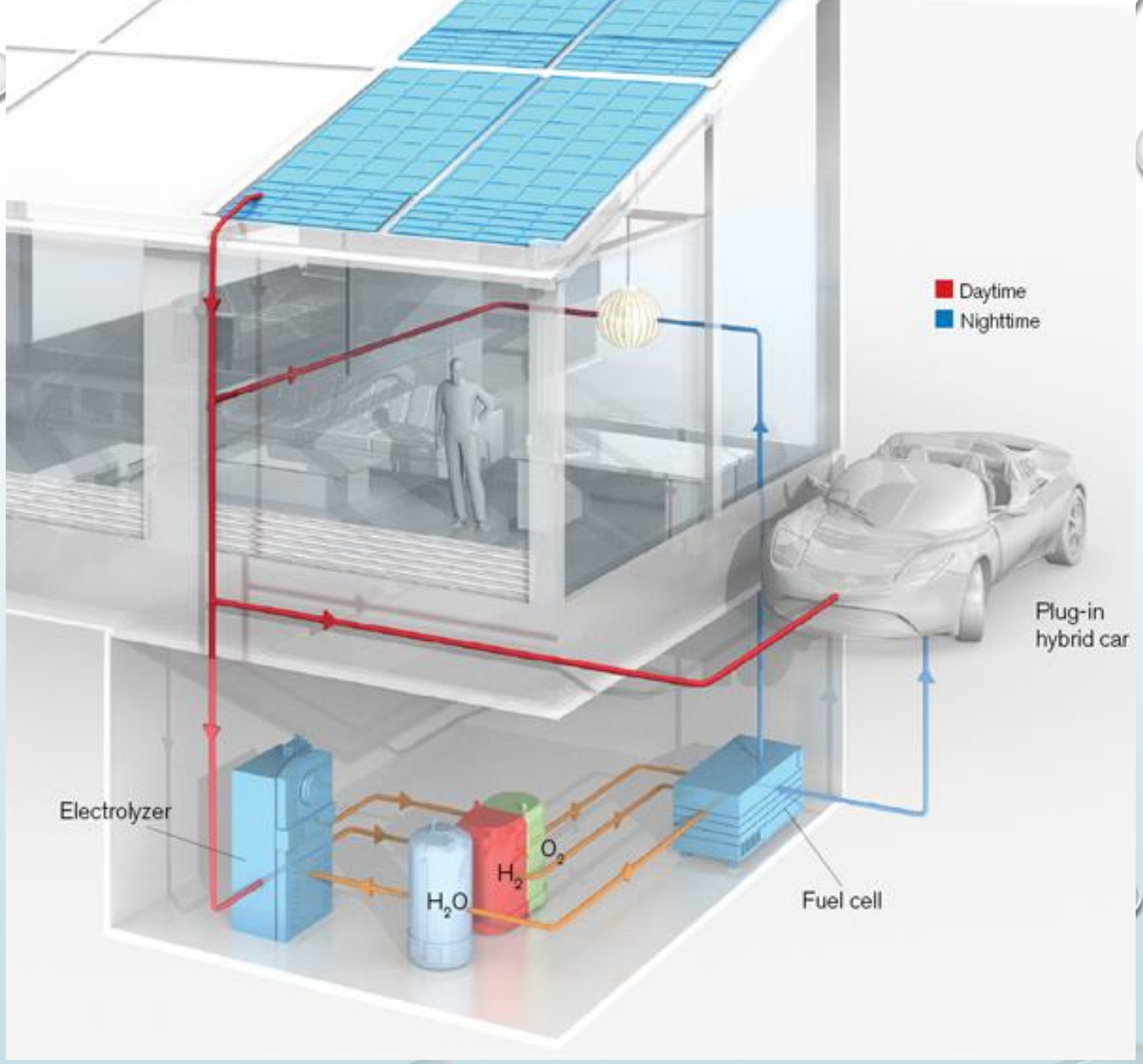
總結來說，雖然在科技上，氣候變遷的核心挑戰是如何處理二氧化碳，然而由此環境與科學議題，所衍生出的政治需要以及潛在商業誘因，可能為全球經濟與國際政治局勢投入新變數，對台灣而言，或將成為牽動地緣政治、攸關國家安全的重大課題，有賴相關單位提前研擬對策。（作者為生技研究人員及經理人）

仿生葉

- 此外，透過不同的微生物亦可以產生植物所需的肥料，且該系統具有比自然光合作用更高的效率。

- 研究人員種植了超過5輪的蘿蔔嬰。利用仿生葉所產生的肥料來種植蔬菜，產量要比對照組高150%。

仿生葉


Daytime
Nighttime
Plug-in
hybrid car
Electrolyzer
H_2O
H_2
O_2
Fuel cell

光合作用仿生技術

- 哈佛大學團隊開發的方法，可以將光能以化學能的方式儲存起來，產生的化學能還可直接用於內燃機。雖然異丙醇燃燒會產生二氧化碳，但這個方法所產製的異丙醇也是由二氧化碳而來，構成了一個完整的循環。
- 通過消耗空氣中的二氧化碳來產生燃料，新的生物反應器技術不但能幫助緩解全球暖化問題，還能產生更清潔的能源，解決能源短缺問題，可謂一石二鳥。

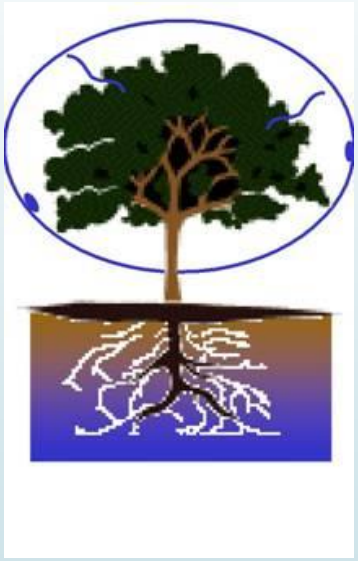
Topic 12 Solar Water Plant - Still & Pump

Stephen Salter, PEng and Joanne Posthumus with the model they built in an hour on April 6, 2003.

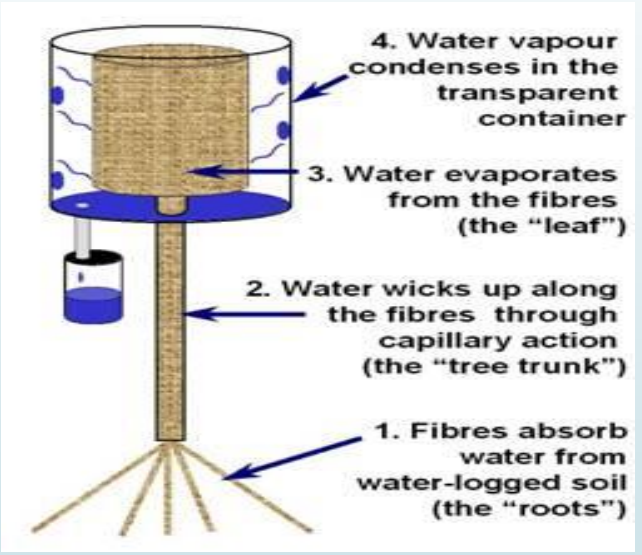
Willow- tree that grows near water and has long, thin branches

The Willow gave me an idea

A willow tree transpires hundreds of litres of water every day



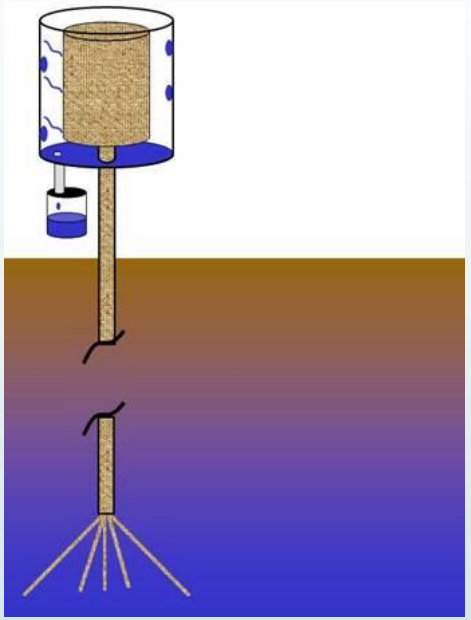
Collect the evaporating water from contaminated soils.



Solar water plant model

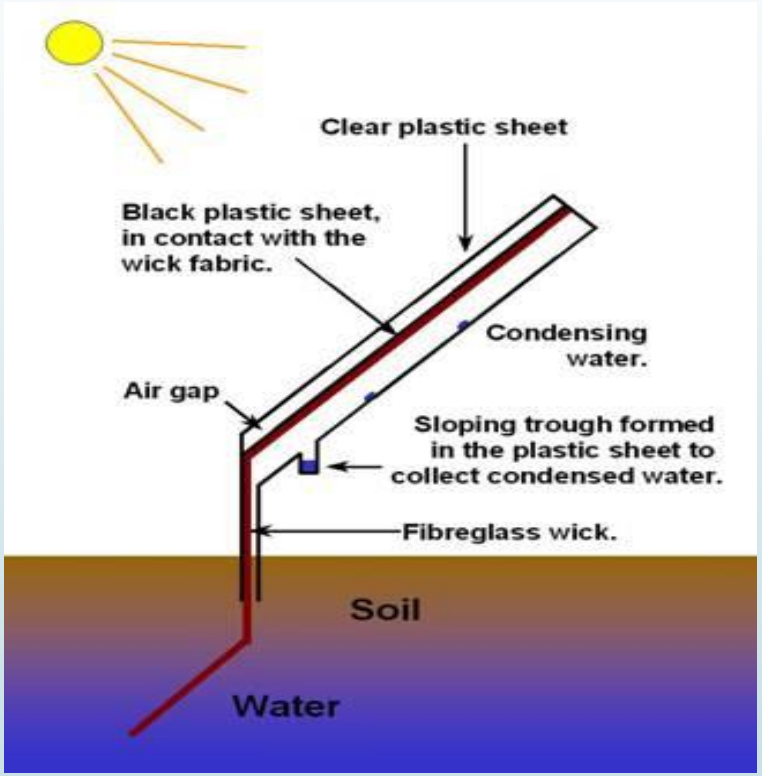
The first model

https://www.google.com.tw/search?biw=914&bih=454&tbm=isch&sa=1&q=groundwater&oq=groundwater&gs_l=img.3..0j0i30k1l9.286706.288499.0.288605.11.11.0.0.0.0.108.817.9j1.10.0....0...1.1.64.img..1.10.814...35i39k1.sPe4pFvDQ0g#imgrc=Y3eDt-r2A5ElpM:



The well shaft (the "trunk") could extend to a significant length, as it does in a tree. This length could be used to reach groundwater at some depth below the surface.

The second model



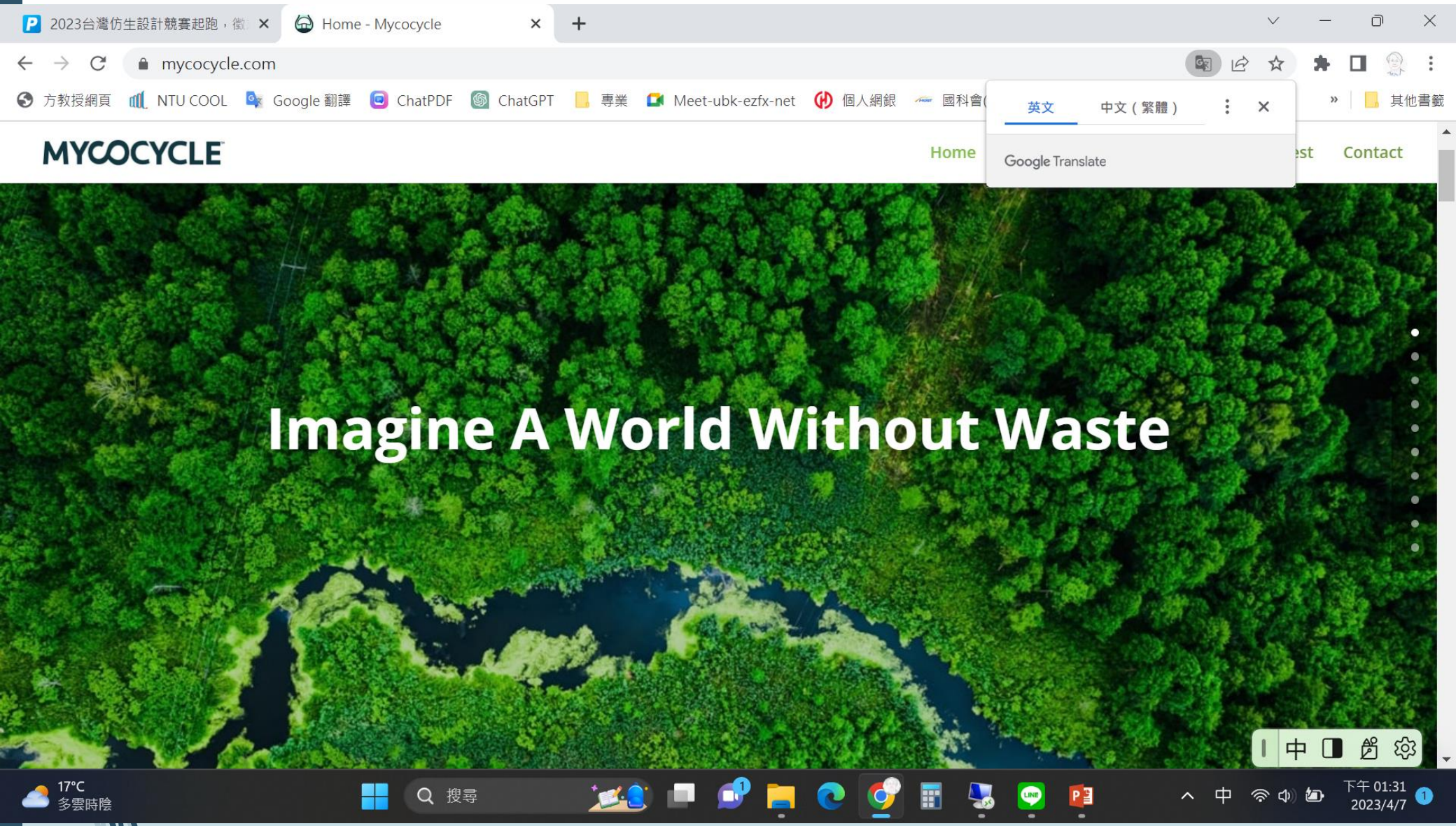
Condensing water collects on the back of the still, and so does not cause solar energy to be lost by reflection.

Solar Water Plant - Still & Pump

Function	Advantages	Current limitations
This design can extract water from water-logged soil, or from salt water, but does not need a body of water such as a stream or lake.	✓ Produces pure water from ground water, even if the source is contaminated with inorganic materials such as salt. ✓ Pumps water to the surface (through capillary action) and distils it at the same time. ✓ Can be made locally with recycled or inexpensive materials. ✓ Can be made in any size and shape. ✓ Has a low environmental impact. ✓ Has no moving parts.	✓ The still/pump needs strong sun and temperatures above freezing. ✓ The still/pump operates slowly: at the rate of insolation in equatorial countries, and at 50% efficiency, the pump should provide 2-3 litres of distilled water per m^2 per day. ✓ The evaporating section will need to be cleaned or replaced as mineral salts are deposited there by the evaporating water

Topic 13. 真菌

- 大自然裡，真菌類是「專業」的分解者，可以分解任何有機物，它們藉由分泌酵素到細胞外，將有機物質分解成可吸收形式的小分子，進而吸收這些養分維生。
- 美國新創Mycocycle公司透過研究不同真菌的酵素，模擬分解有機物的生態系統，與真菌合作來分解像是營建類(如屋瓦、瀝青、石化產品)的有毒廢棄物，將其「菌絲化」，之後將這些菌絲體再製為生物材料循環利用，減少廢棄物進入焚化爐與掩埋場的數量。


2023台灣仿生設計競賽起跑，徵
Home - Mycocycle
mycocycle.com
方教授網頁
NTU COOL
Google 翻譯
ChatPDF
ChatGPT
專業
Meet-ubk-ezfx-net
個人網銀
英文
中文（繁體）
Google Translate
其他書籤
MYCOCYCLE
Home
Contact
Imagine A World Without Waste
17°C
多雲時陰
搜尋
下午 01:31
2023/4/7

The New Recycling Economy

Mycocycle is addressing some of the world's hardest to treat toxic constituents created from plastics and petrochemical.

Eliminating a significant strain on our ecosystem our technology diverts materials from landfills, allowing for reuse into other applications

MYCOCYCLE
Home Markets FAQ Our Team Latest Contact

Solutions made through nature

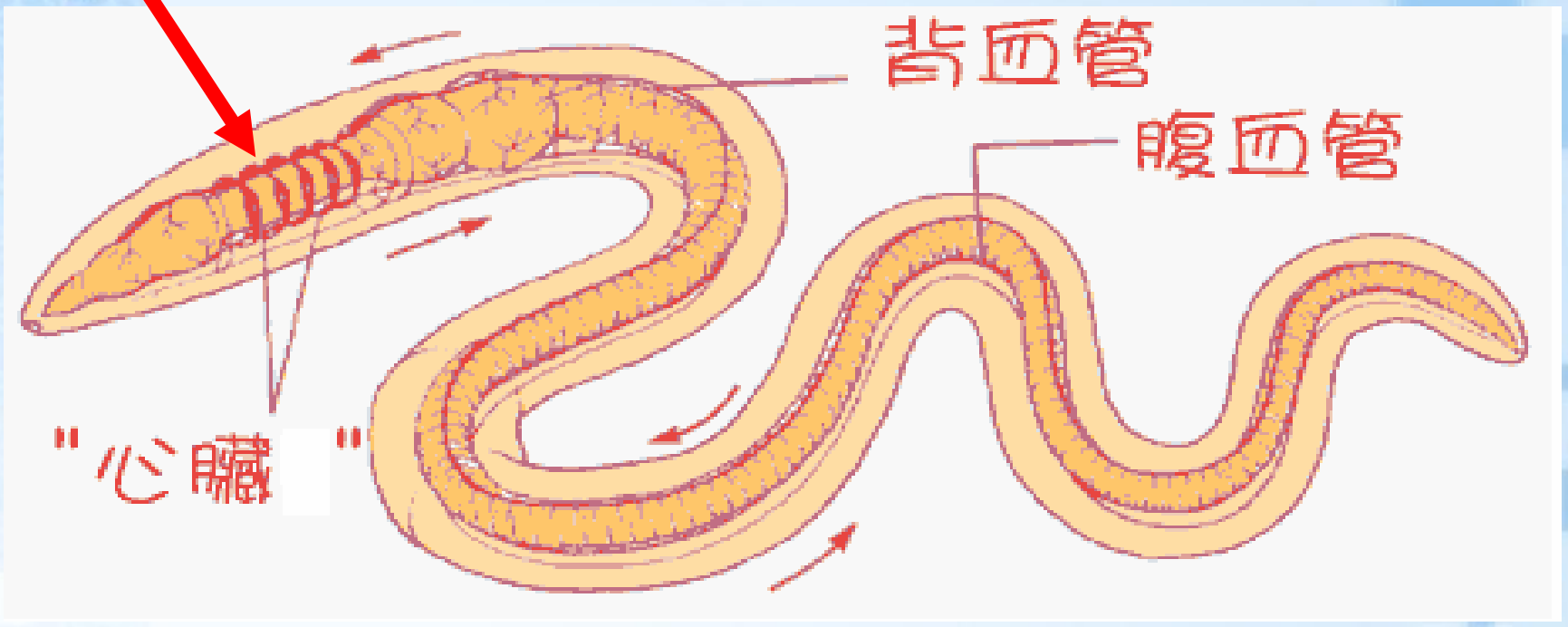
Mushrooms break down complex carbons in the natural world. We applied the science of Mycology to leverage this solution in the lab and are able to eliminate toxins naturally.

This process is both cost-effective and sustainable. Once remediated, the result is a renewable byproduct that is fire and water-resistant and can be manufactured into new products—allowing the process to further pay for itself within the closed-loop ecosystem.

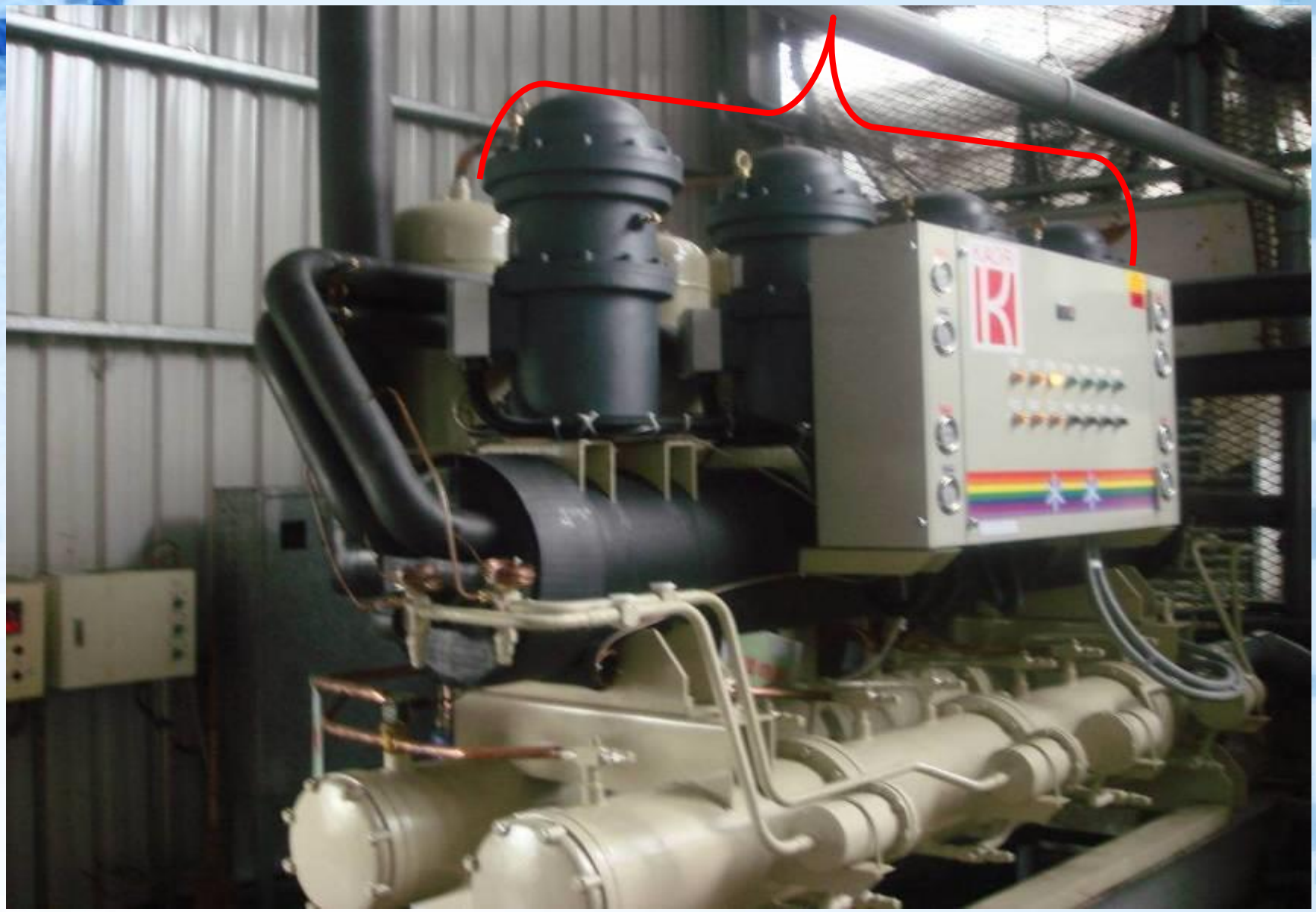
以下介紹過去應用仿生學
的成果

此部分內容於
第一週的課程已有介紹

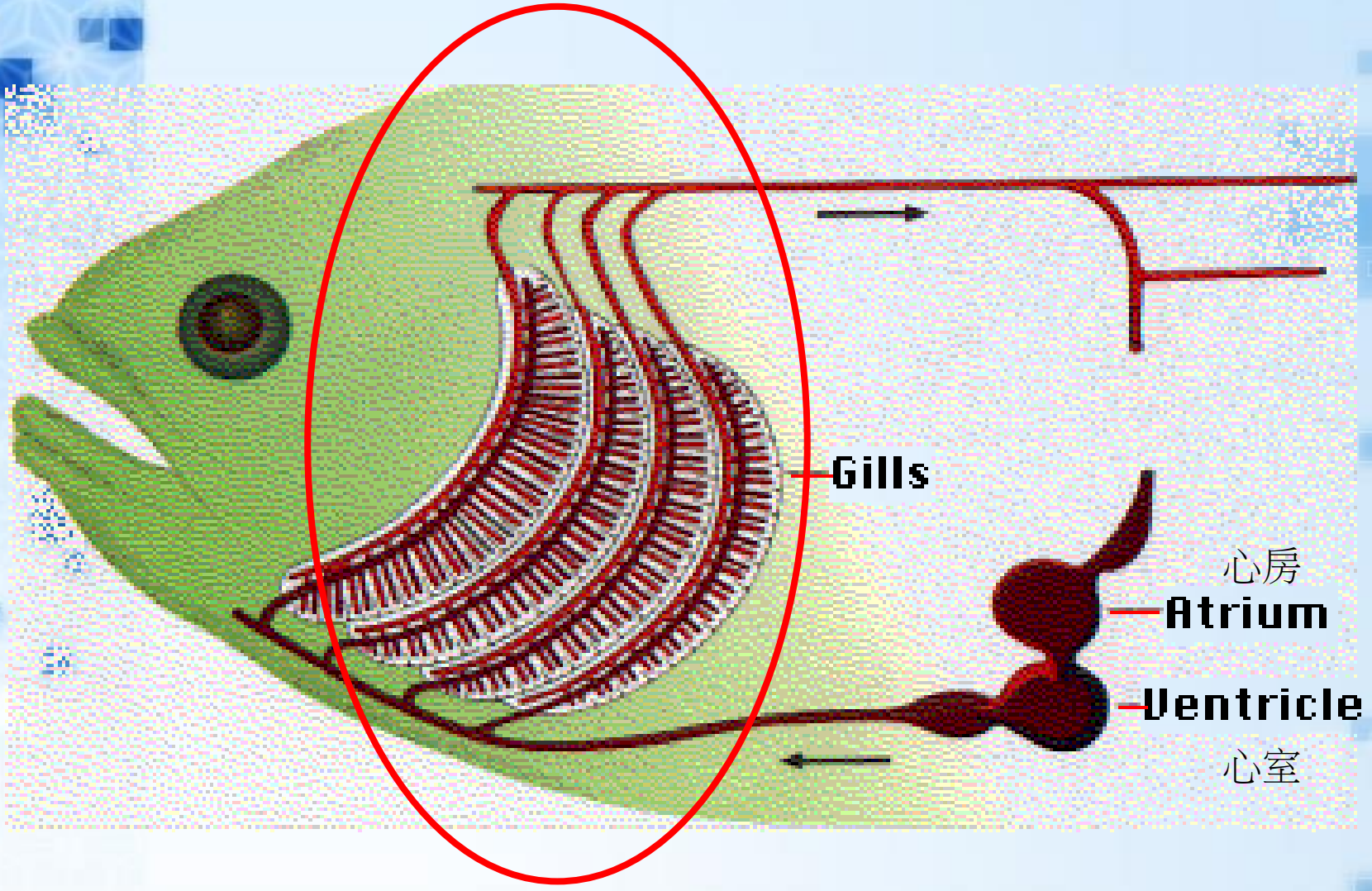
An example on ‘parallel installation of compressors’


背血管
腹血管
"心臓"

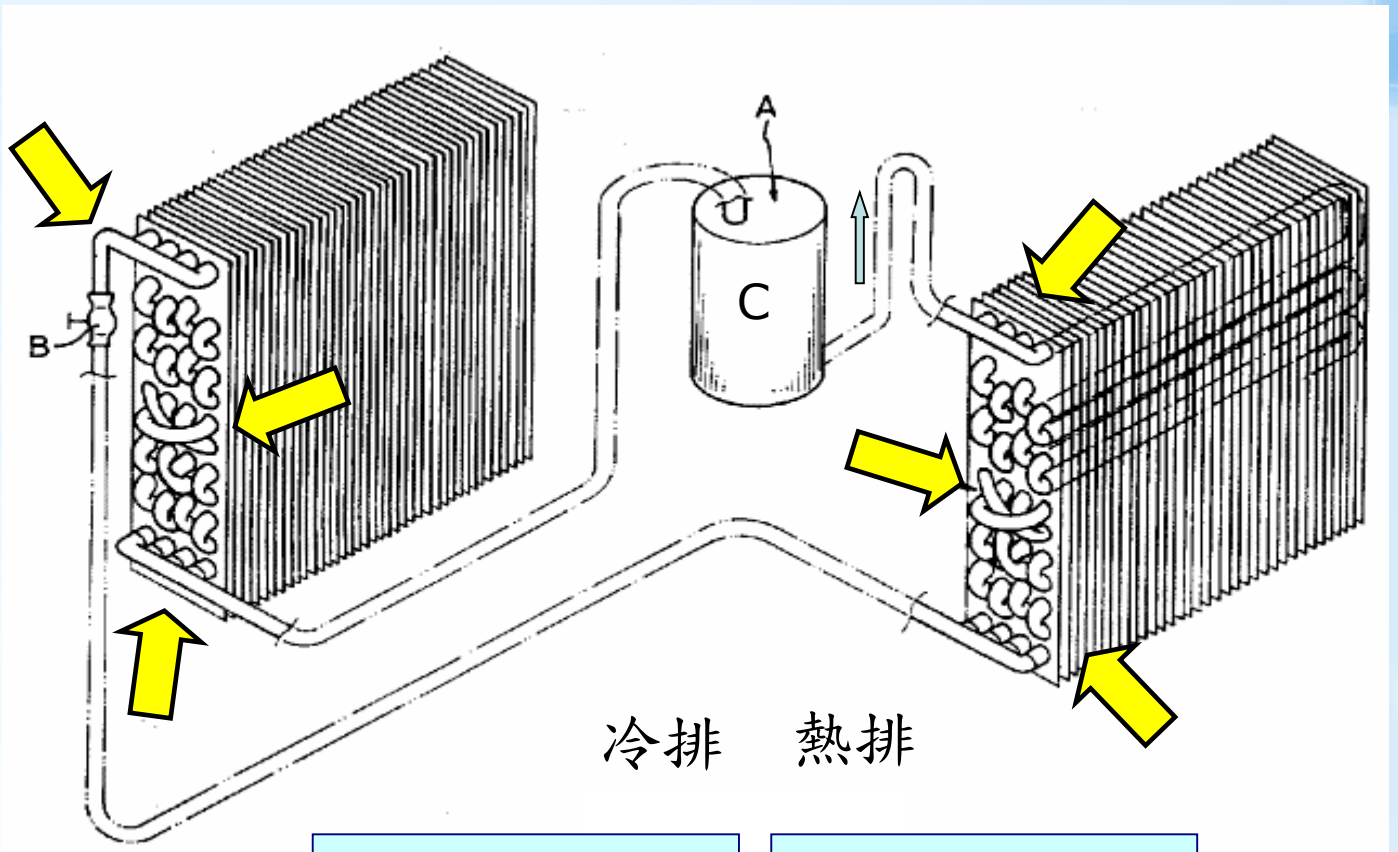
多台壓縮機並聯



An example on ‘parallel distribution of pipes’


Gills
心房
Atrium
Ventricle
心室

冷媒流向：分流，對調與合流

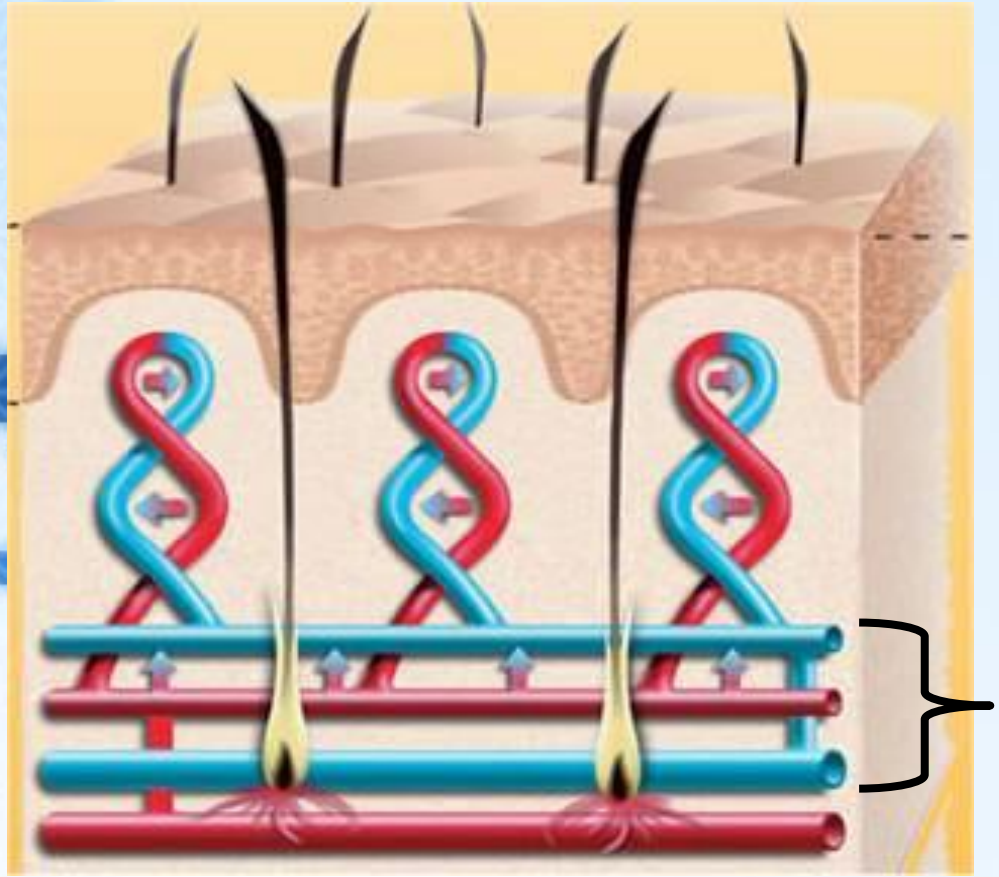


均勻吸熱

均勻散熱

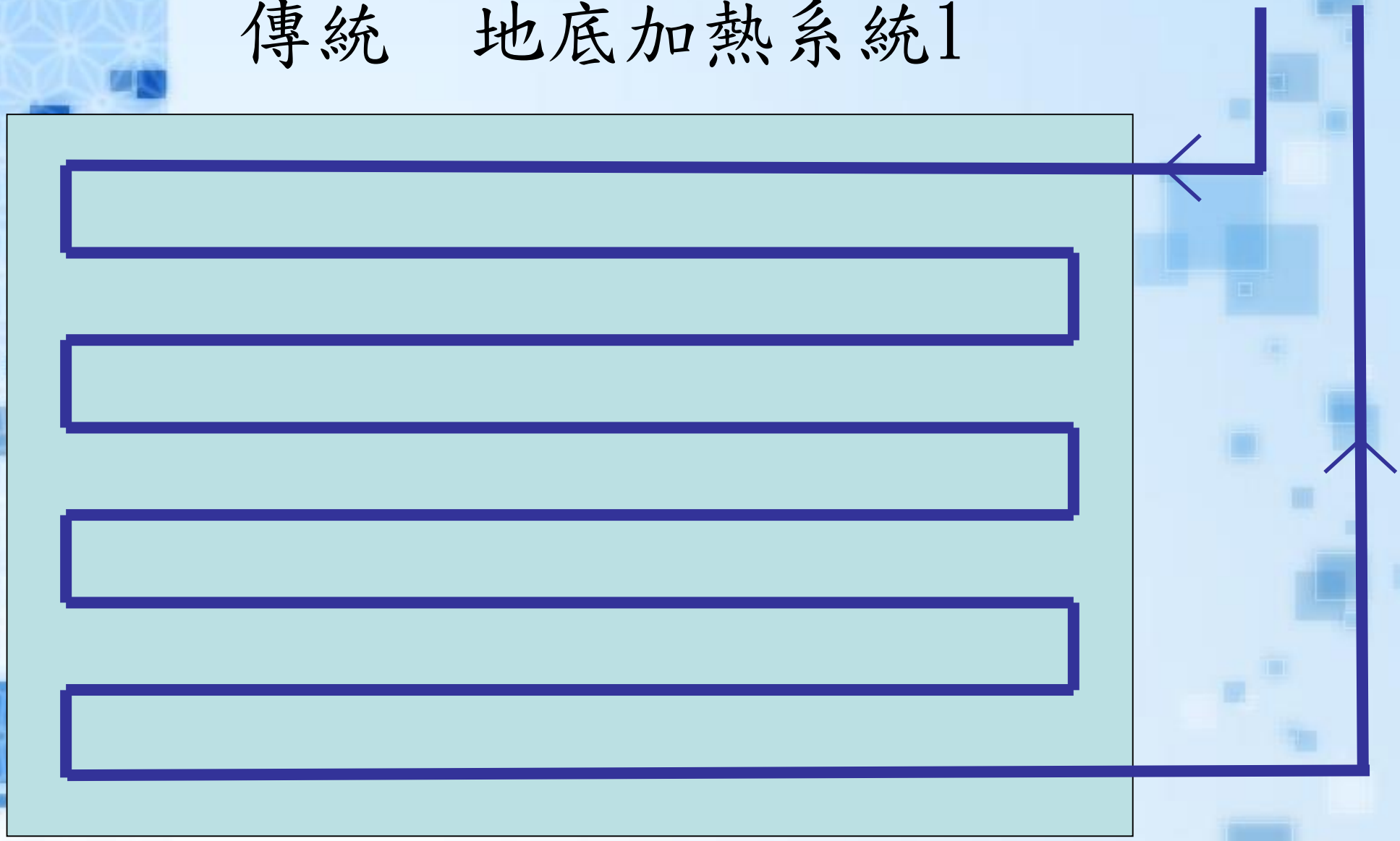
An example on
‘3 head pipes for even distribution’

血管：如何均勻輸送



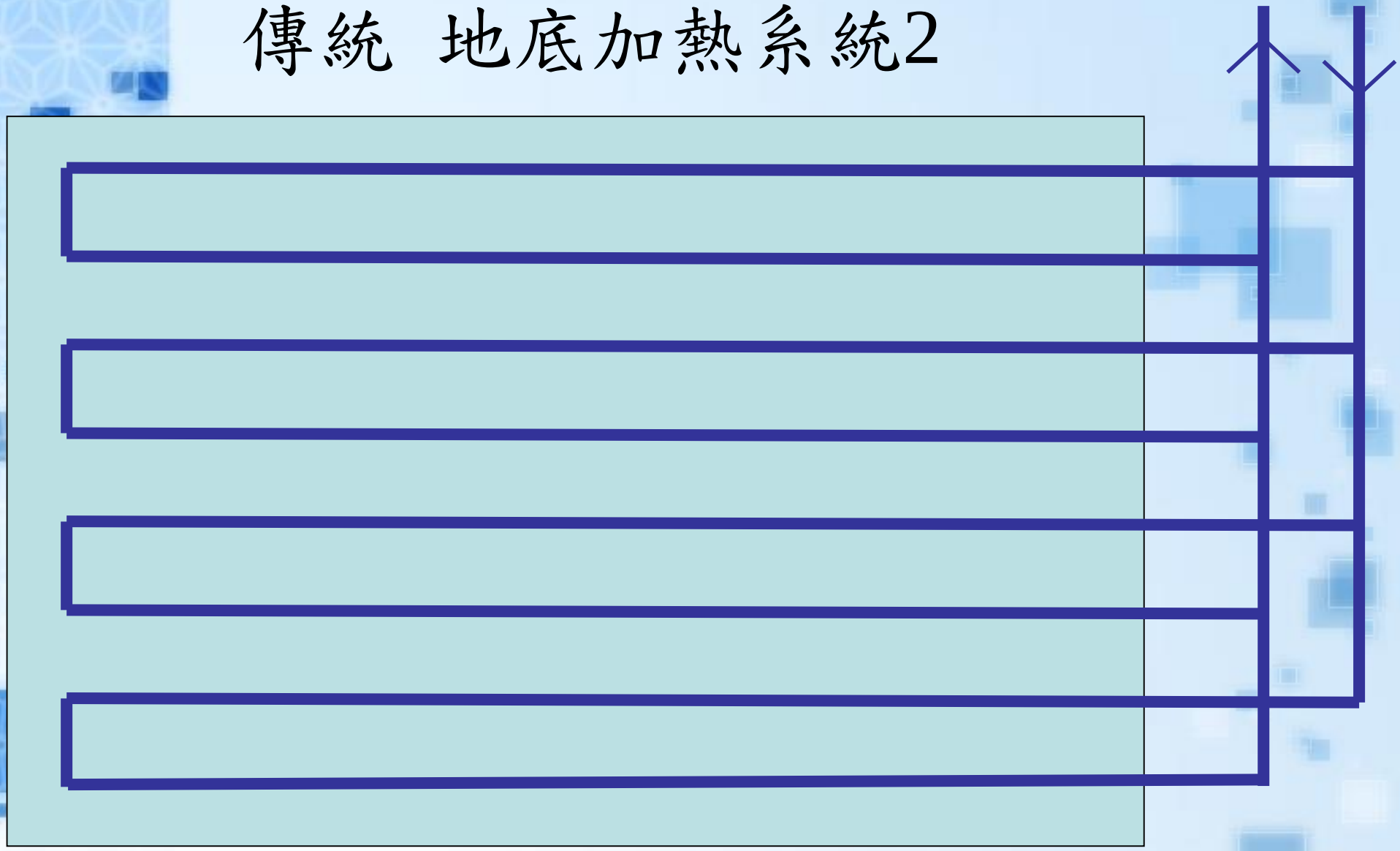
3 head pipes

傳統　地底加熱系統1



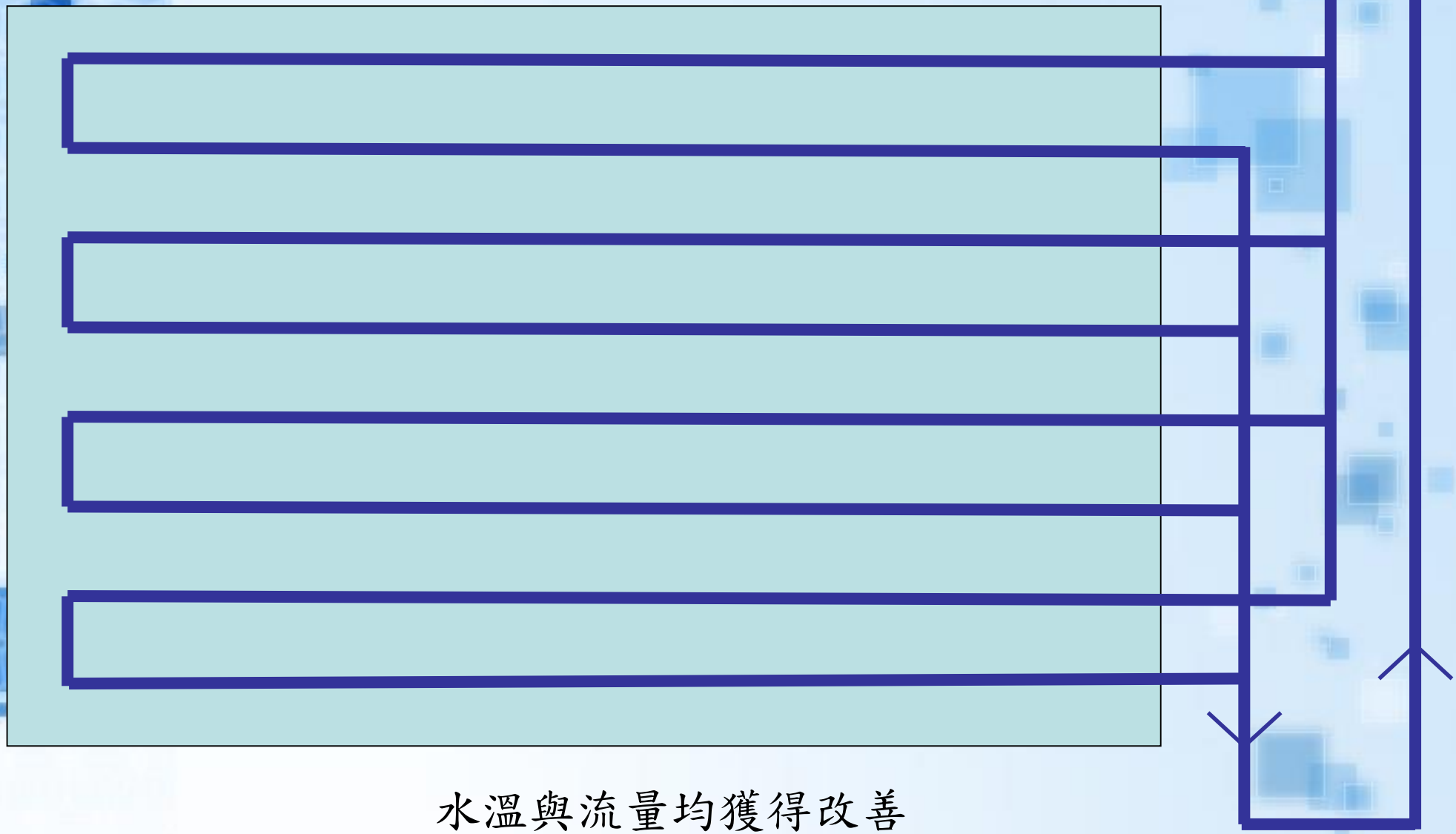
水溫不均勻為其缺點

傳統 地底加熱系統2



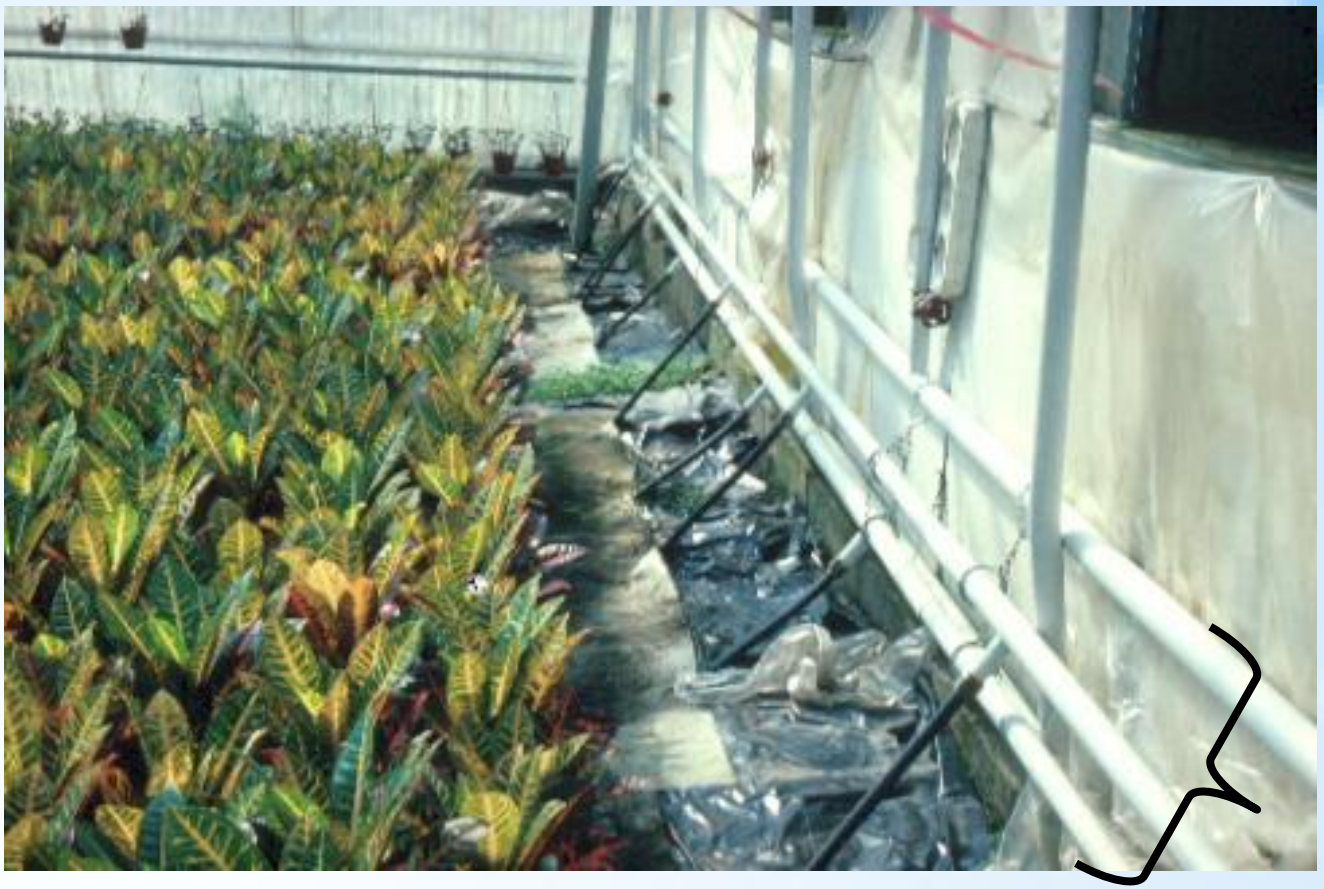
流量不均勻為其缺點，水溫也不均勻

修正的 地底加熱系統

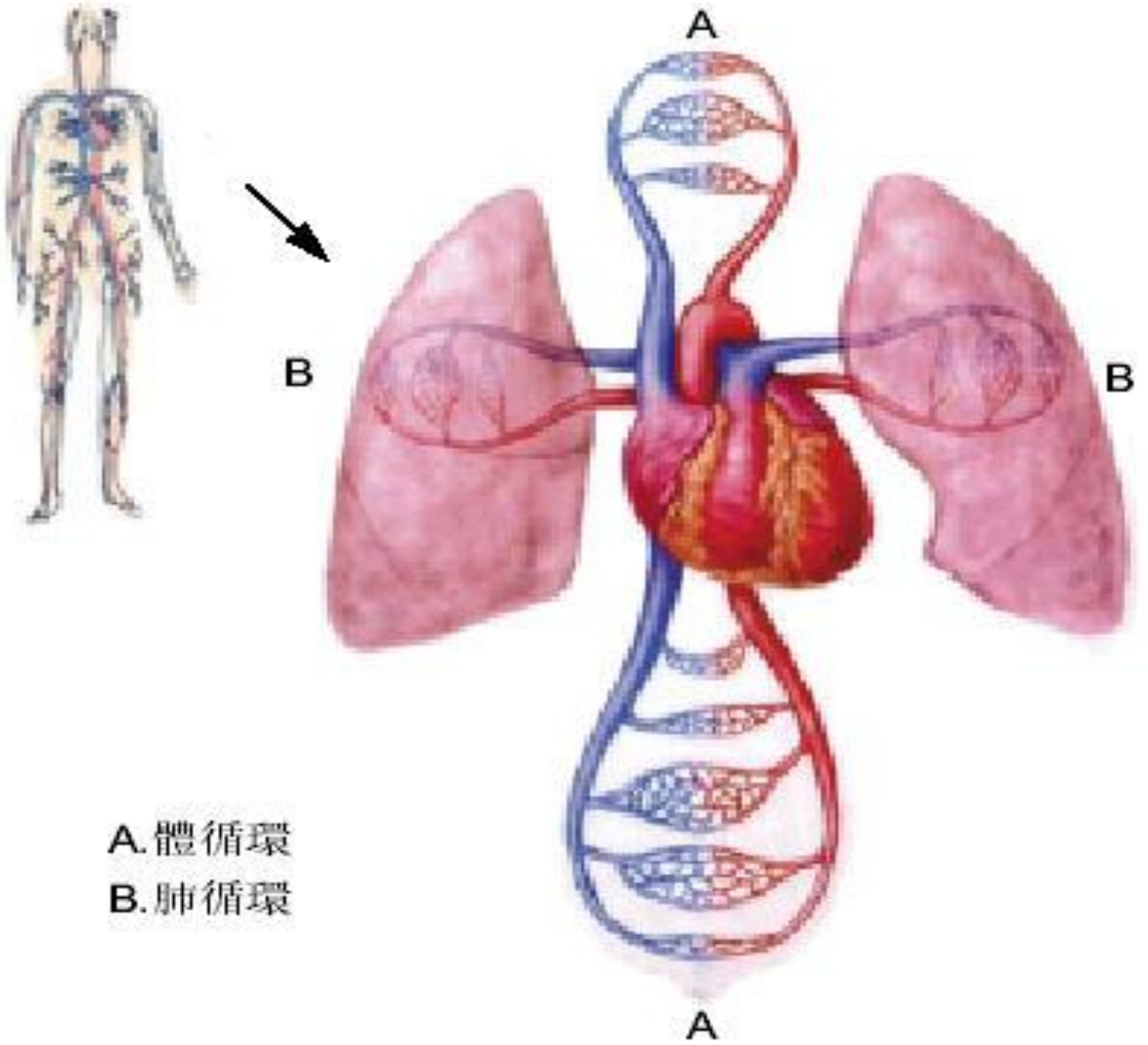


水溫與流量均獲得改善

修正的溫室地底加熱系統



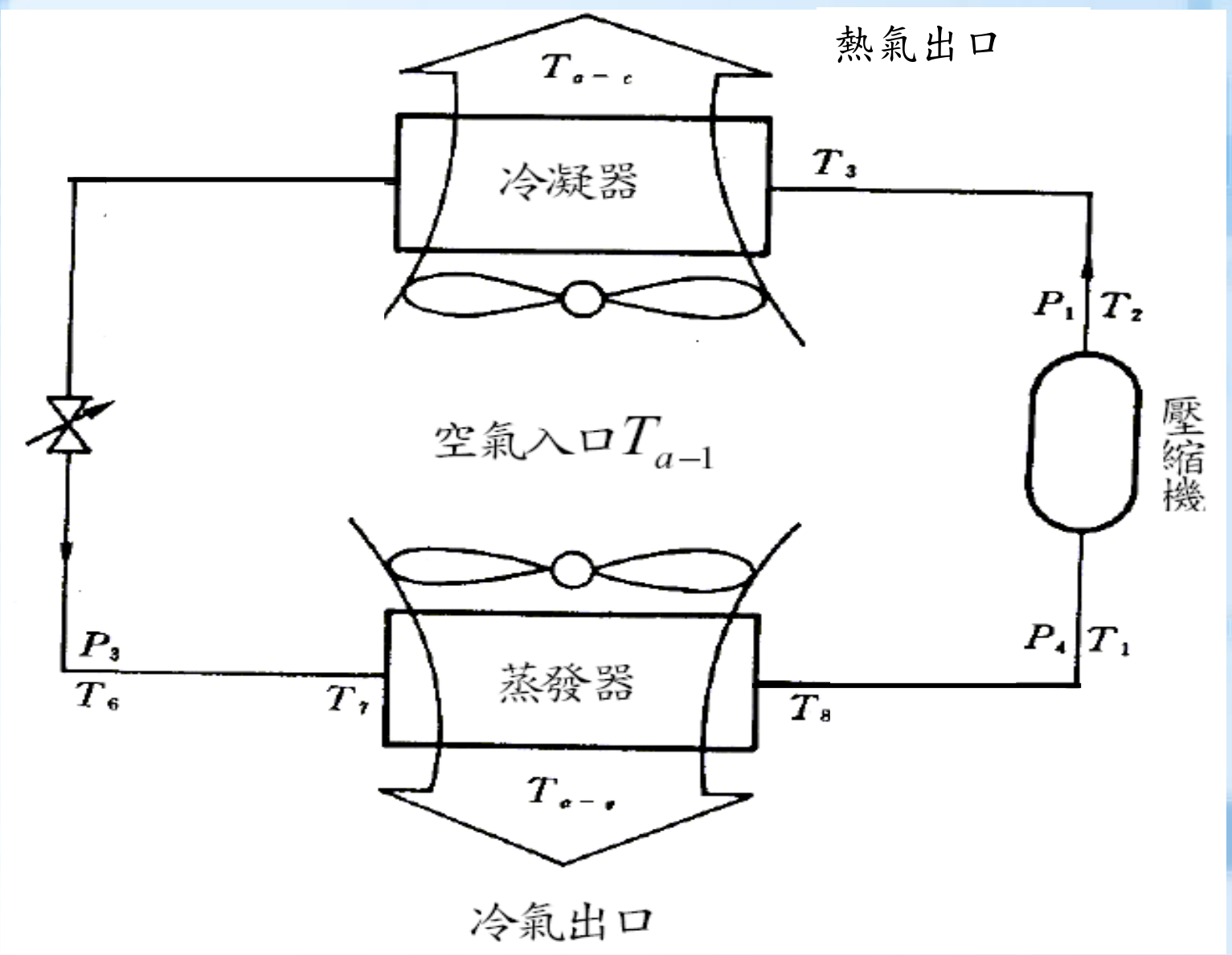
An example on ‘oxygen/heat exchange’



A.體循環

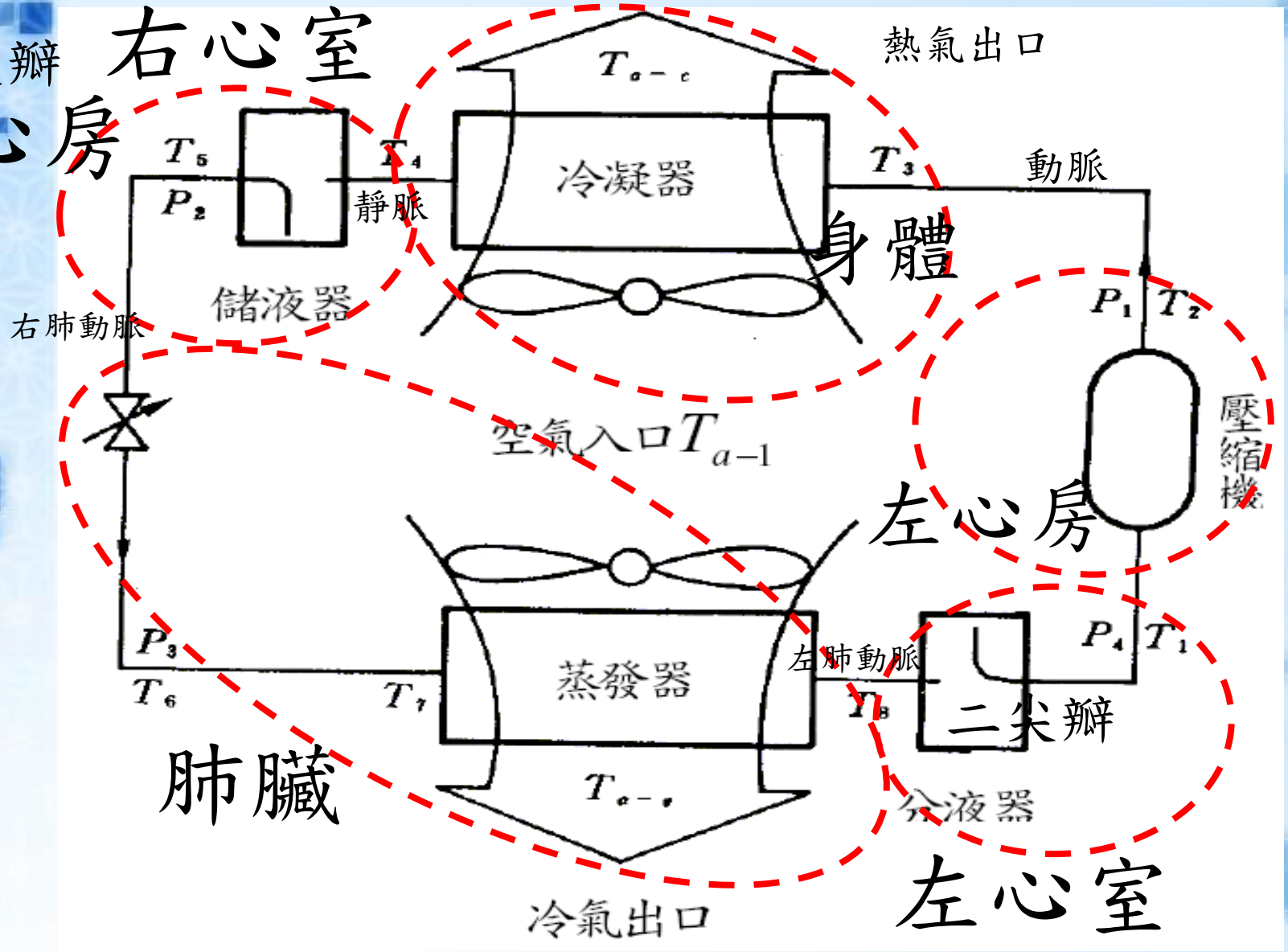
B.肺循環

傳統 冷凍空調系統

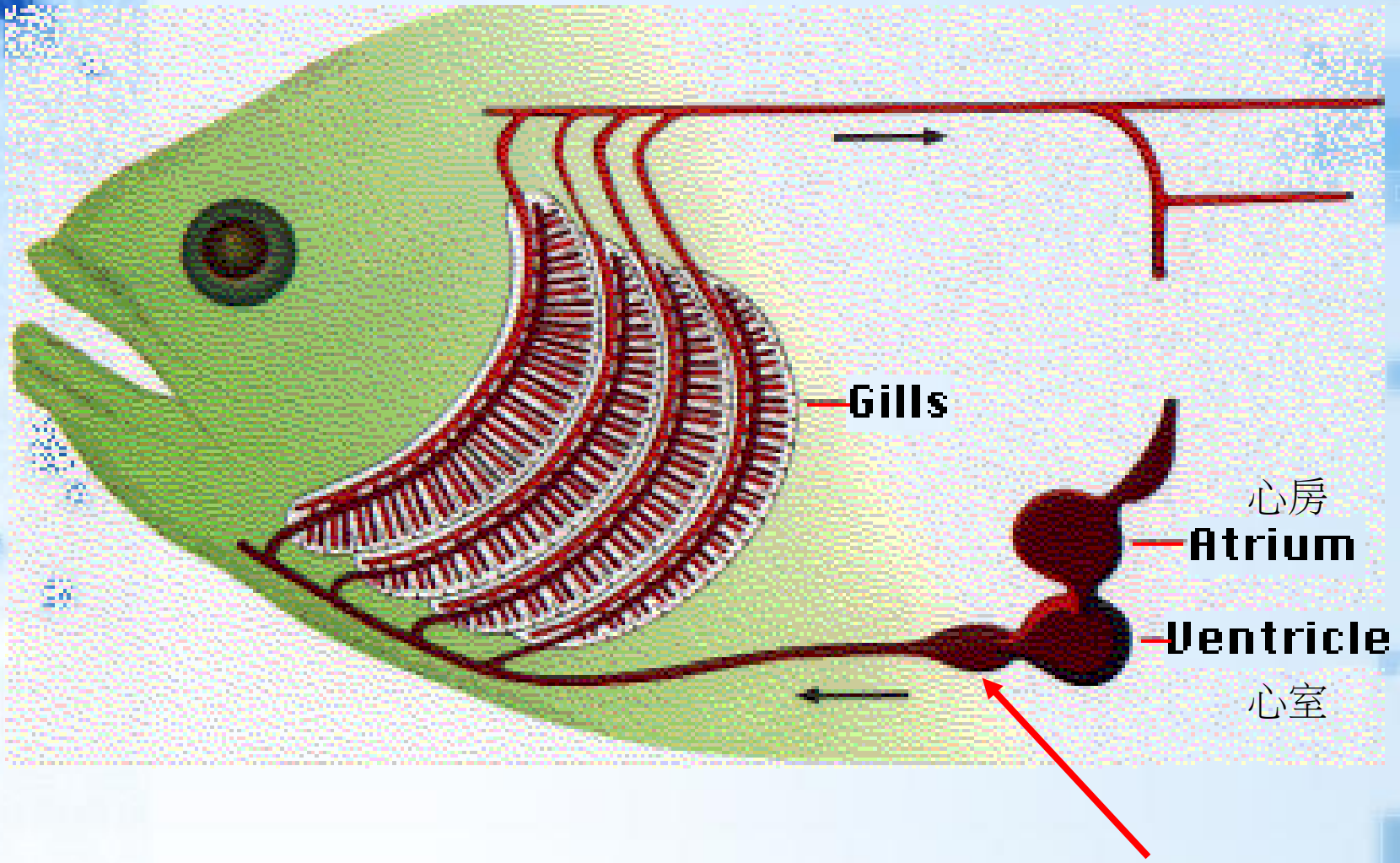


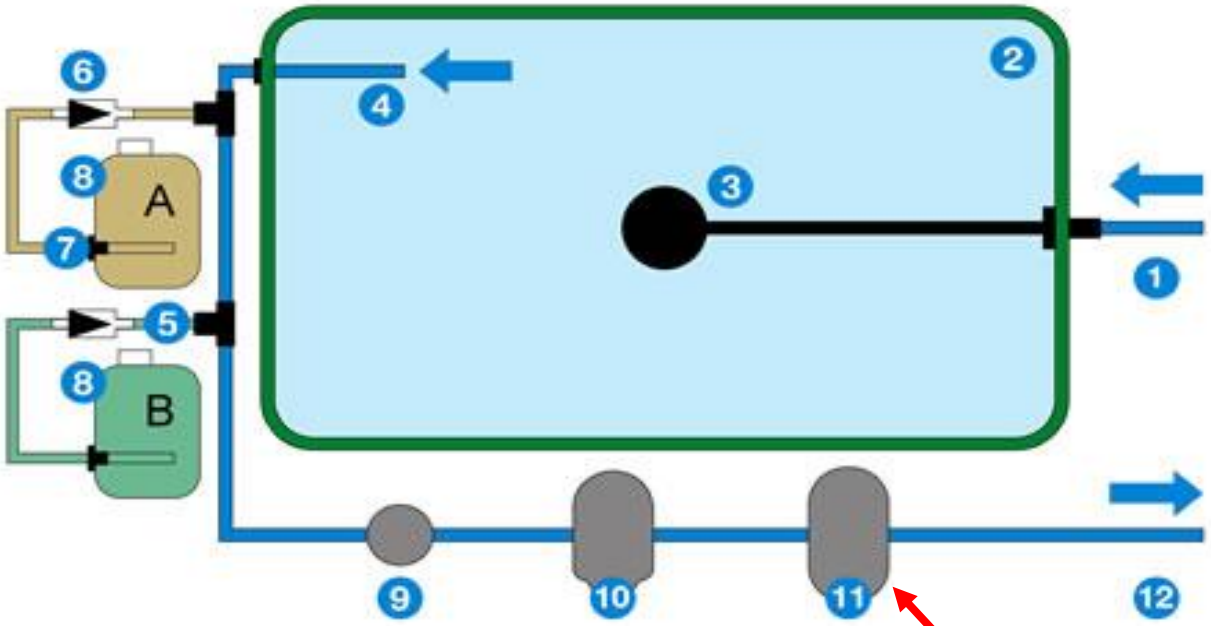
血液循環	冷凍空調
血管缺乏舒張壓就没有彈性位能，血管與器官都會扁掉	冷媒管缺乏低壓側壓力，大氣壓力與壓縮機的負壓會把冷媒管壓扁
收縮壓（血液擠向動脈） 動態調配血液的力量	高壓側壓力
舒張压（血液由動脈流出） 保持血管彈性的力量	低壓側壓力 讓冷媒流回壓縮機的力量
體循環供給身體氧氣	高壓側散熱
肺循環交換取得氧氣	低壓側吸熱

Modified 冷凍空調系統



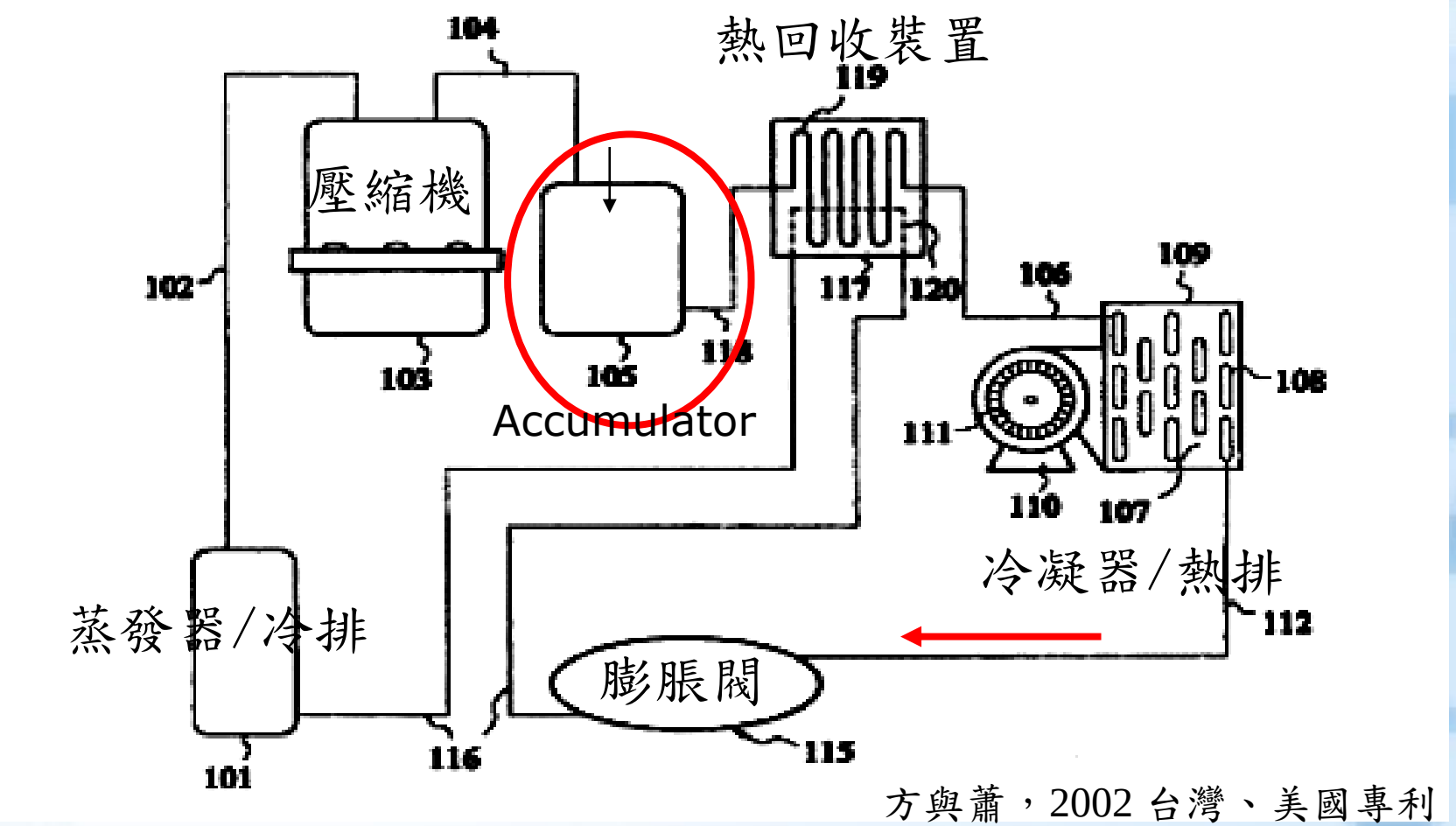
An example on ‘accumulator vessel’


Gills
心房
Atrium
Ventricle
心室



1. Incoming water Supply
2. Header Tank
3. High Pressure Float Valve
4. Water Flow
5. Venturi Feed Connectors
6. One Way Valves
7. 4mm i.d Grommets
8. Nutrient Containers
9. In-Line Filter
10. Diaphragm Pump
11. Accumulator Vessel
12. Water Outlet

Modified 冷凍空調系統



方煒、蕭瑋炯。 2002。 用於蒸氣壓縮式空調或冷凍機高壓側之蓄壓及廢熱再利用機構。中華民國發明專利第163710號

Fang, Wei and Way-Jone Hsiao. 2002. Pressure accumulator at high pressure side and waste heat re-use device for vapor compressed air conditioning or refrigeration equipment. US Patent. Number 6481243.

The

End