

Welcome



Environmental Advisory Board Meeting

**Robins Air Force Base
February 5, 2009**



Welcome and Program Introduction

**Ms. Becky McCoy
EAB Installation Co-chair**



Environmental Advisory Board



An Exploration into Biomimicry and It's Application in Engineering and Environmental Restoration

R. Neil Davies, C. Eng., MICE, P.E.

&

Herwig Goldemund, Ph.D.

Geosyntec Consultants

February 5, 2009



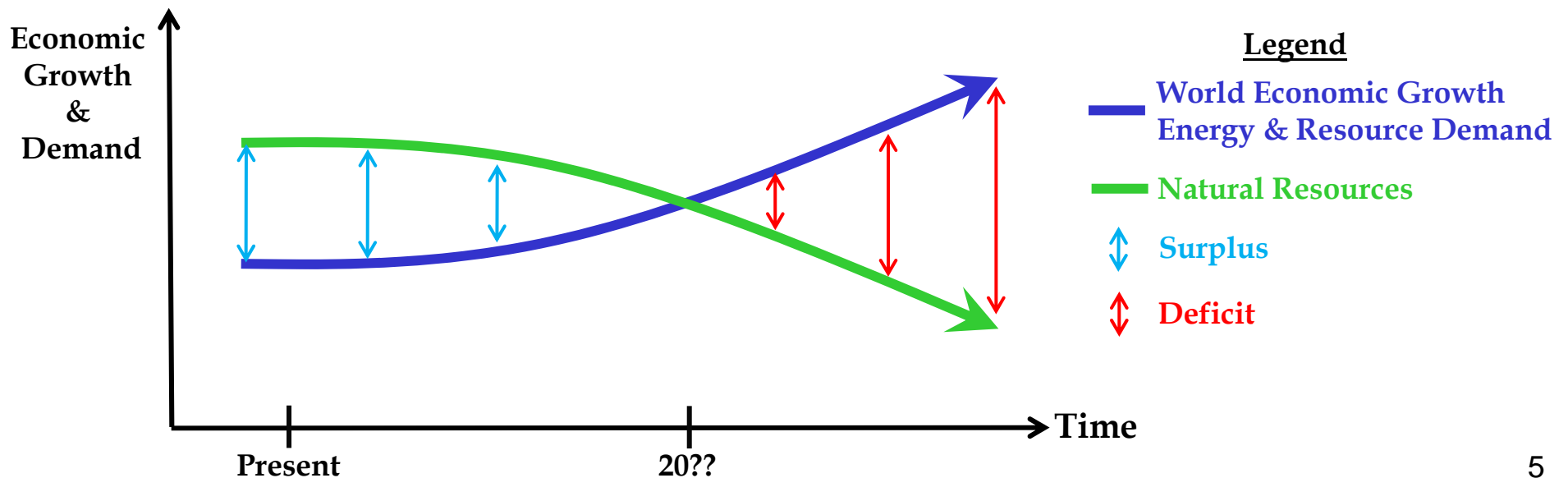
OVERVIEW

- **Background**
- **Definition of Biomimicry**
- **Why Biomimicry?**
- **Biomimicry History**
- **Application of Biomimicry - Direct Approach**
- **Application of Biomimicry - Indirect Approach**
- **Biomimicry at Robins AFB**
- **Summary**
- **Questions/Comments**



BACKGROUND

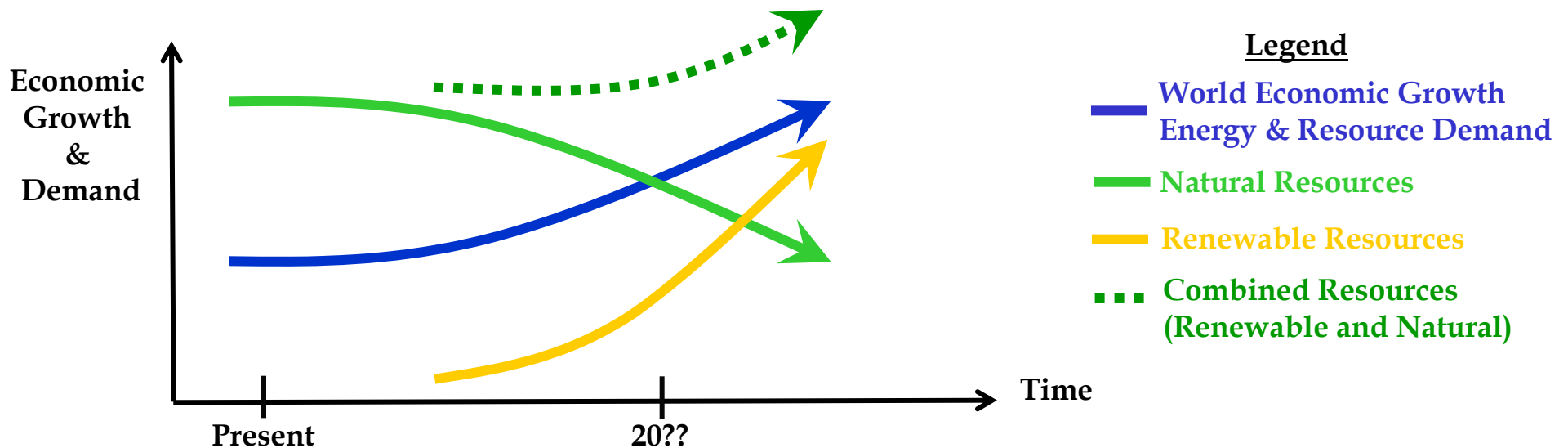
- **Increasing World Economic Growth and Population will Result in:**
 - Increased energy demand - world's energy demand may more than double by 2030
 - Increased demand for food, water, and other natural resources
 - Increased quantities of waste generated





BACKGROUND

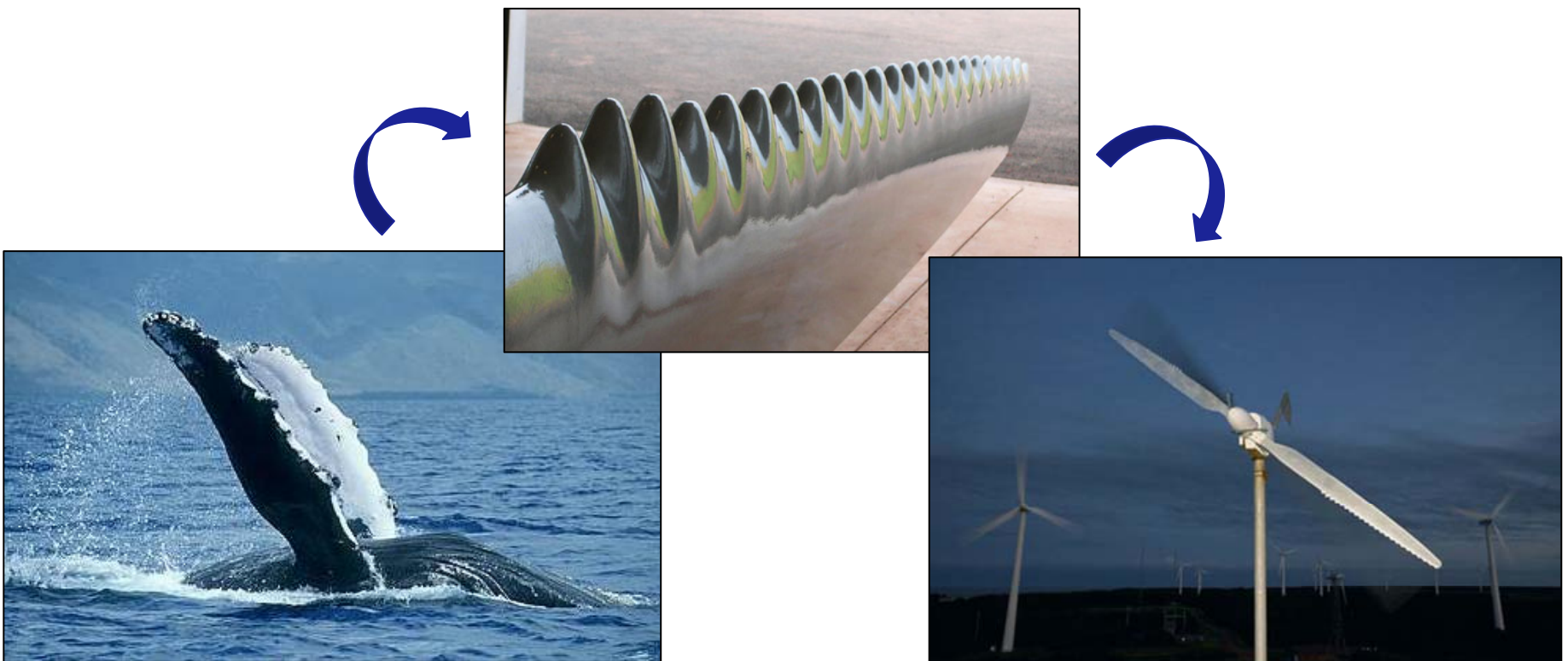
- Energy and Natural Resources Supply from Traditional Sources will not Match Future Demand
- Adverse Impacts on Ecosystems will Occur due to Waste and Emissions
- Develop Renewable Resources and Manage Energy and Resource Demand through More Efficiency





BACKGROUND

- How Can We Move to a More Sustainable Future?
- One Option is to Adopt Biomimicry Principles





DEFINITION OF BIOMIMICRY

- **BIO-MIMICRY [From the Greek *bios*, life, and *mimesis*, imitation]**
 - **Study of nature's designs and mimicking them to solve human challenges**
 - Innovation inspired by nature
 - Nature's system can be directly applied to our human systems
 - **After 3.5 billion years of research and development, nature has learned...**
 - What works
 - What is appropriate
 - What will last



DEFINITION OF BIOMIMICRY

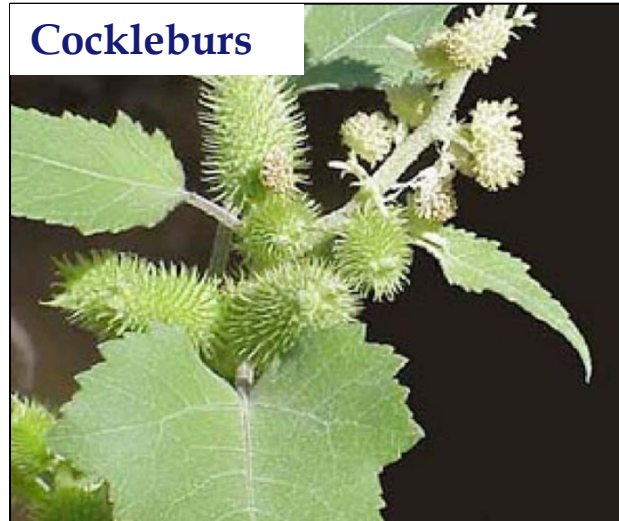
Thorn



Barbed Wire



Cockleburs



Velcro





DEFINITION OF BIOMIMICRY

Buzzard



The Wright Brothers Flyer



Kingfisher's Beak

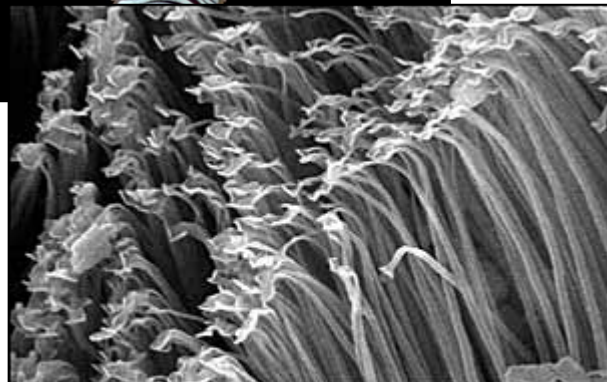
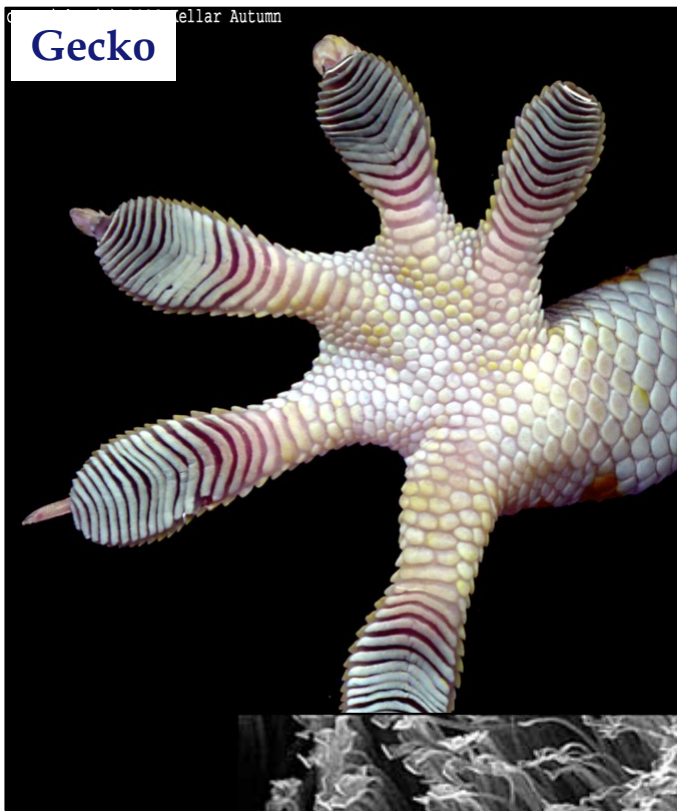


Bullet Train

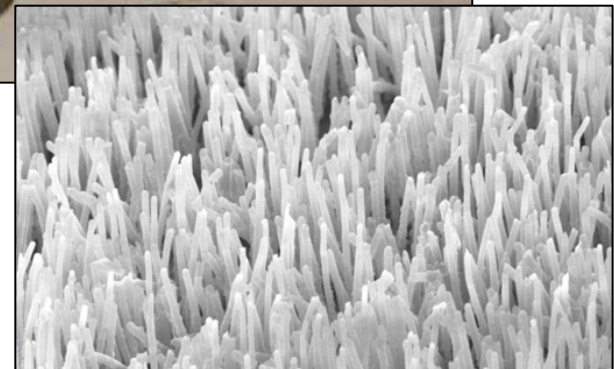
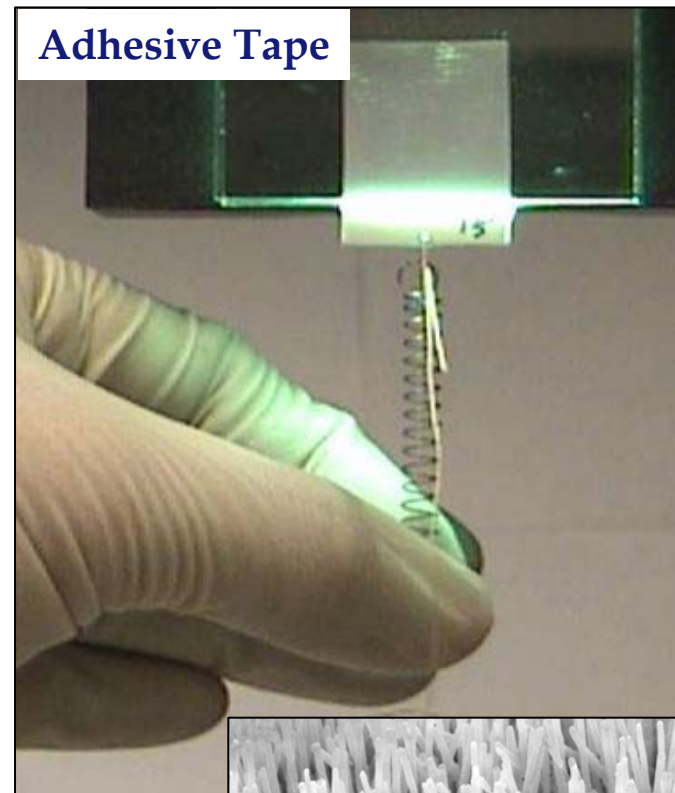




DEFINITION OF BIOMIMICRY



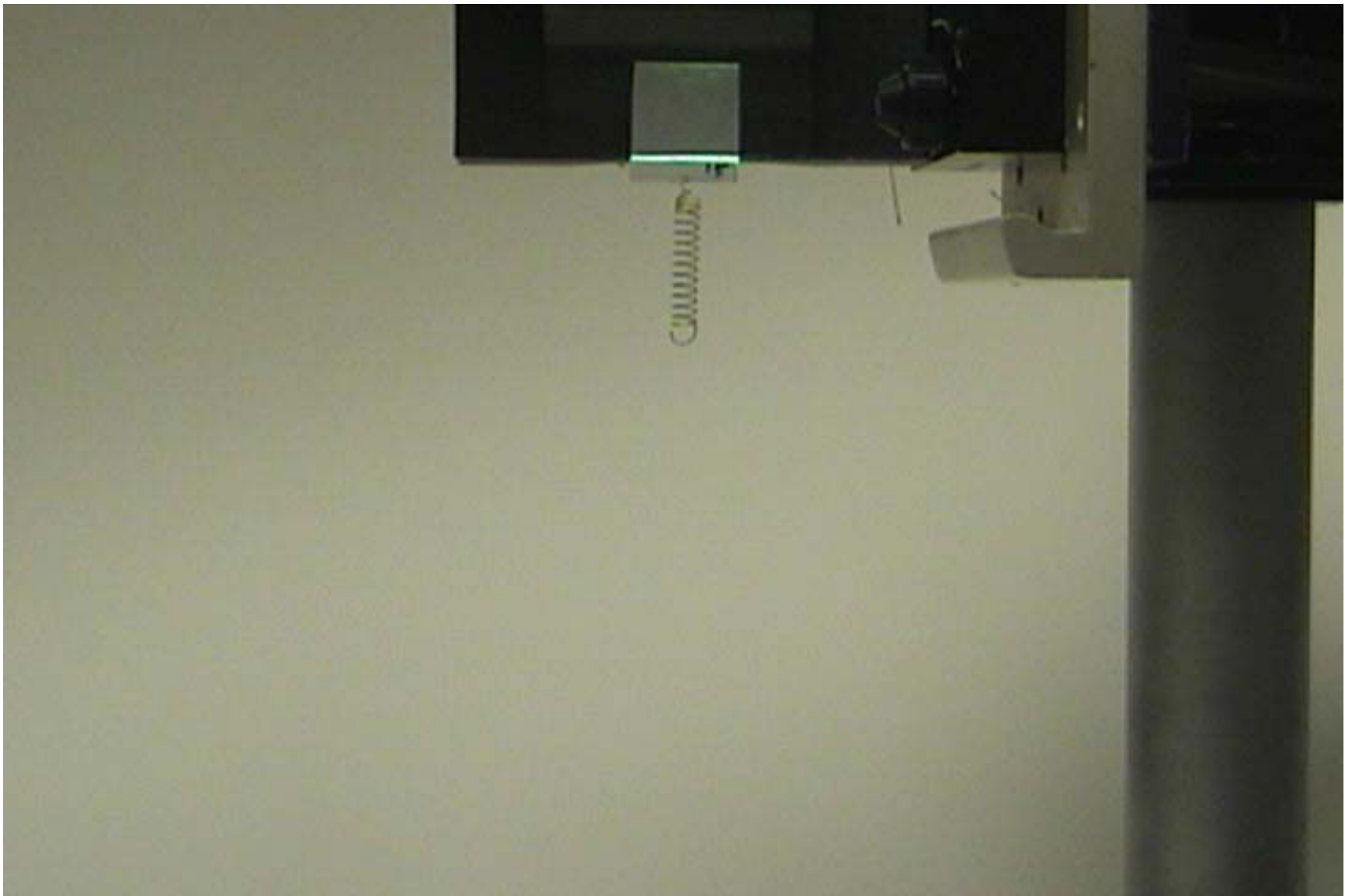
Magnified Image of Gecko's Toe



Magnified Image of Tape



DEFINITION OF BIOMIMICRY





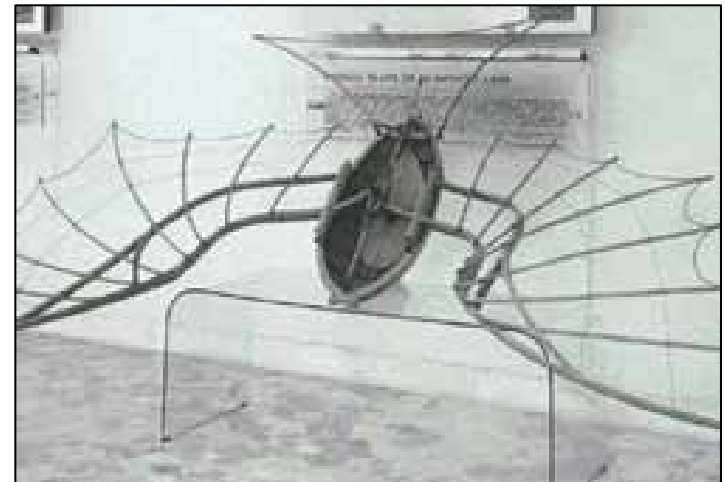
WHY BIOMIMICRY?

- **Understand Nature to Help Solve Problems – Use Nature as:**
 - **Model** – emulating nature’s forms, processes, and systems to solve human problems
 - **Measure** – evaluating our designs and solutions against those of nature, in terms of efficiency, simplicity, and sustainability
 - **Mentor** – implies a shift in our relationship to nature by accepting that we are part of it
- **Improve Our World through Designs that Take Advantage of Nature’s Ingenuity**



BIOMIMICRY HISTORY

- **Terminology is Relatively New...Practice Around for a Long Time**
 - Leonardo da Vinci's inventions closely linked to designs found in the natural world
 - Wright Brothers and other flight pioneers inspired by birds
- **Science of Biomimicry was Solidified in 1997**
 - Book - *'Biomimicry: Innovation Inspired by Design'*
 - Author - Janine Benyus



Da Vinci's Winged Glider with Flappable Wings



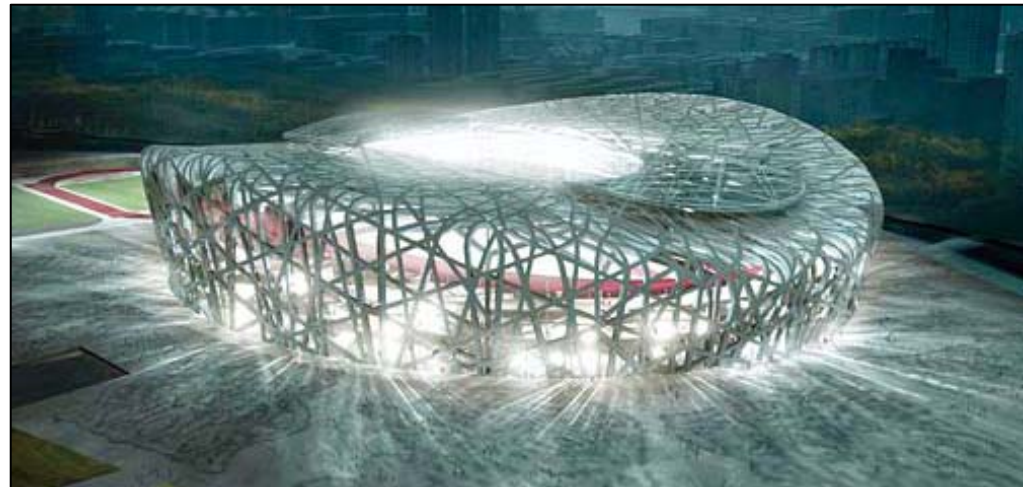
APPLICATION OF BIOMIMICRY

Direct Approach

- **Direct Approach – Solutions Based on Close Replication of Nature**
 - Thorns → Barbed Wire
 - Cocklebur → Velcro



A Bird's Nest



Beijing Olympic Stadium, China
"Bird's Nest"



APPLICATION OF BIOMIMICRY

Direct Approach - Shark Skin

- **Bio-fouling - Growth of Barnacles, Mussels, Algae, and Other Organisms**
 - Increase drag by up to 15 percent
 - Adds to fuel costs
- **Impact military and shipping industry**
 - Navy spends about \$600 million each year to power ships
 - At least \$50 million directly related to bio-fouling
 - Paints laced with deadly biocides curb the problem, but are toxic

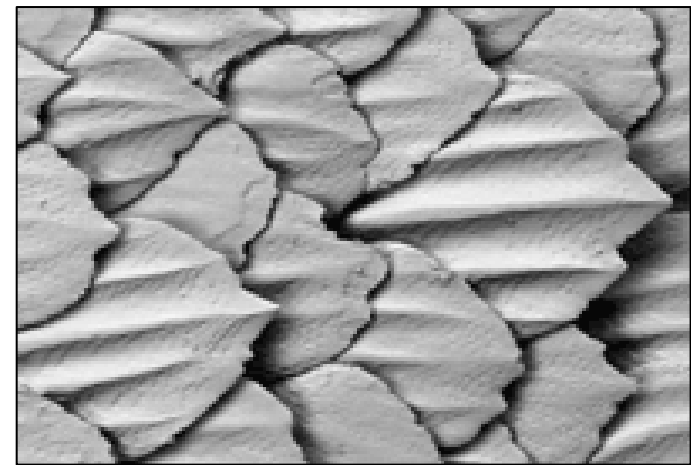
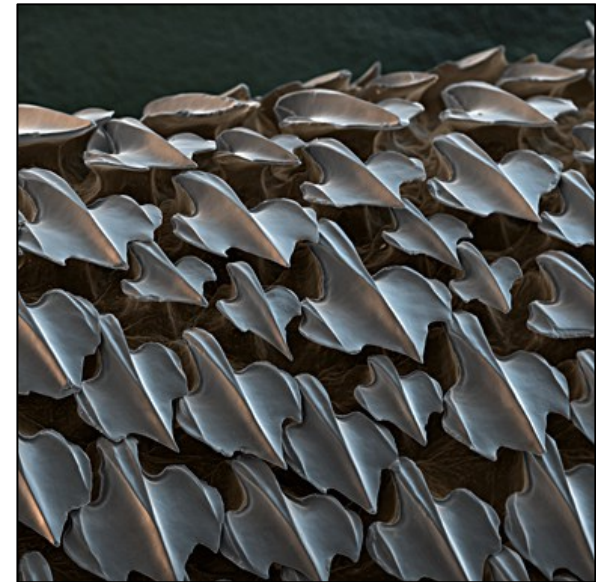




APPLICATION OF BIOMIMICRY

Direct Approach - Shark Skin

- **Some Fish and Whales Fouled by Hitchhiking Marine Life, but not Sharks**
- **Shark Skin Composed of Tiny Scale-like Elements**
 - Able to flex in and out to impede growth
 - Surface texture ribbed with grooves
 - Speeds up water movement by channeling flow
 - Increases water movement efficiency



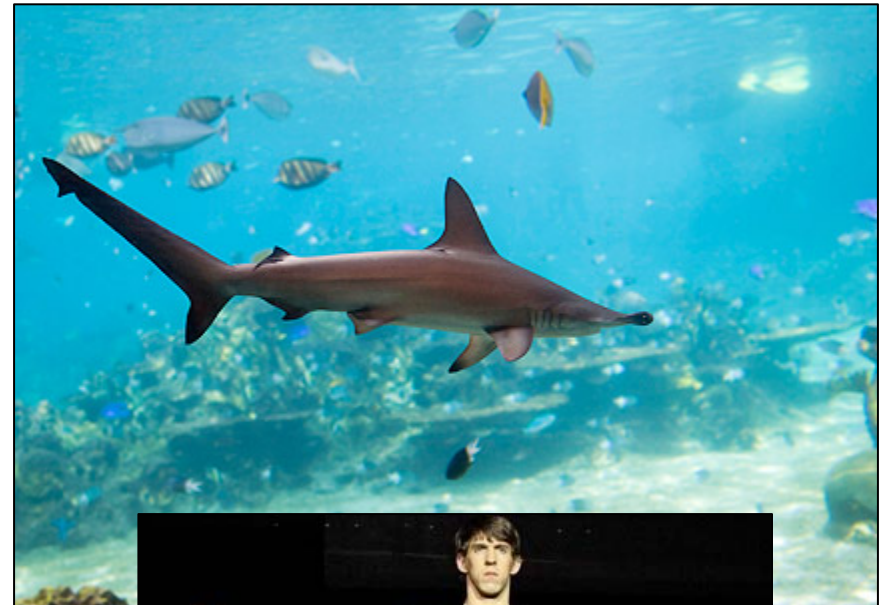
Magnified Image of Shark Skin



APPLICATION OF BIOMIMICRY

Direct Approach - Shark Skin

- **New Surface Coatings for Boats Emulates Shark Skin Texture and Fine-scale Movement**
 - Reduces fouling by 67 percent
 - Completely self-cleaning at 4 to 5 knots
 - Much more energy efficient
 - Toxic biocides not required
 - Reduces transportation of invasive aquatic species
- **Other Applications - Medical Implants to Faster Swimsuits**



Swimsuit Based on Shark Skin Design



APPLICATION OF BIOMIMICRY

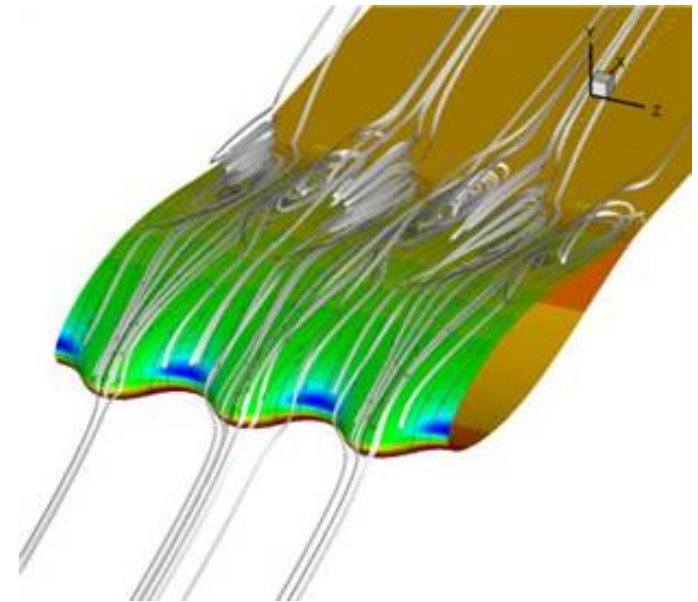
Direct Approach - Whale Fin

■ Learning from Humpback Whales How to Create Efficient Wind Power

- Humpback whales
 - 50-feet long
 - Weighing 80,000 pounds
 - Efficient swimmers and very agile
- Key to their dexterity
 - Unique fin features
 - Large irregular bumps (tubercles) on leading edge of pectoral fins
 - Sheets of water passing through tubercles maintain even channels of fast moving water



Humpback Whale

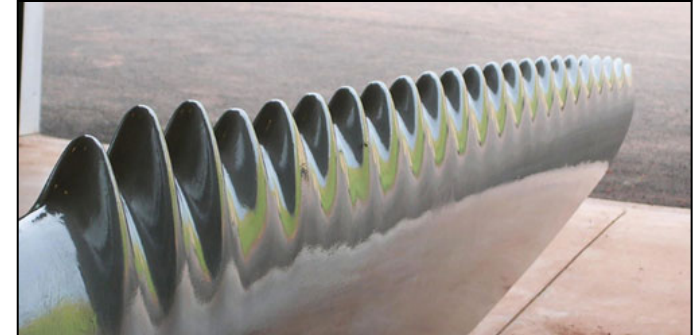




APPLICATION OF BIOMIMICRY

Direct Approach - Whale Fin

- **Humpback Whale Fins Studied to Create Energy-Efficient Turbine Blades**
- **Tubercle Fin vs. Smooth Fin - Wind Tunnel Tests:**
 - 32 percent less drag
 - 8 percent improved lift
 - 40 percent increase in operating angle
- **Technology Successfully Applied to Wind Turbines**
 - Stalling at the tip eliminated
 - Handle higher wind speeds better
 - Viable technology under low wind flow
 - Quieter and more efficient



Blade Design Inspired by Whale Fin



Wind Turbine Field



APPLICATION OF BIOMIMICRY

Direct Approach - Whale Fin

■ Other Potential Applications

- Aircraft
- Helicopters
- Ship rudders

■ Anticipated Benefits

- Fuel efficiency
- Maneuverability
- Safety



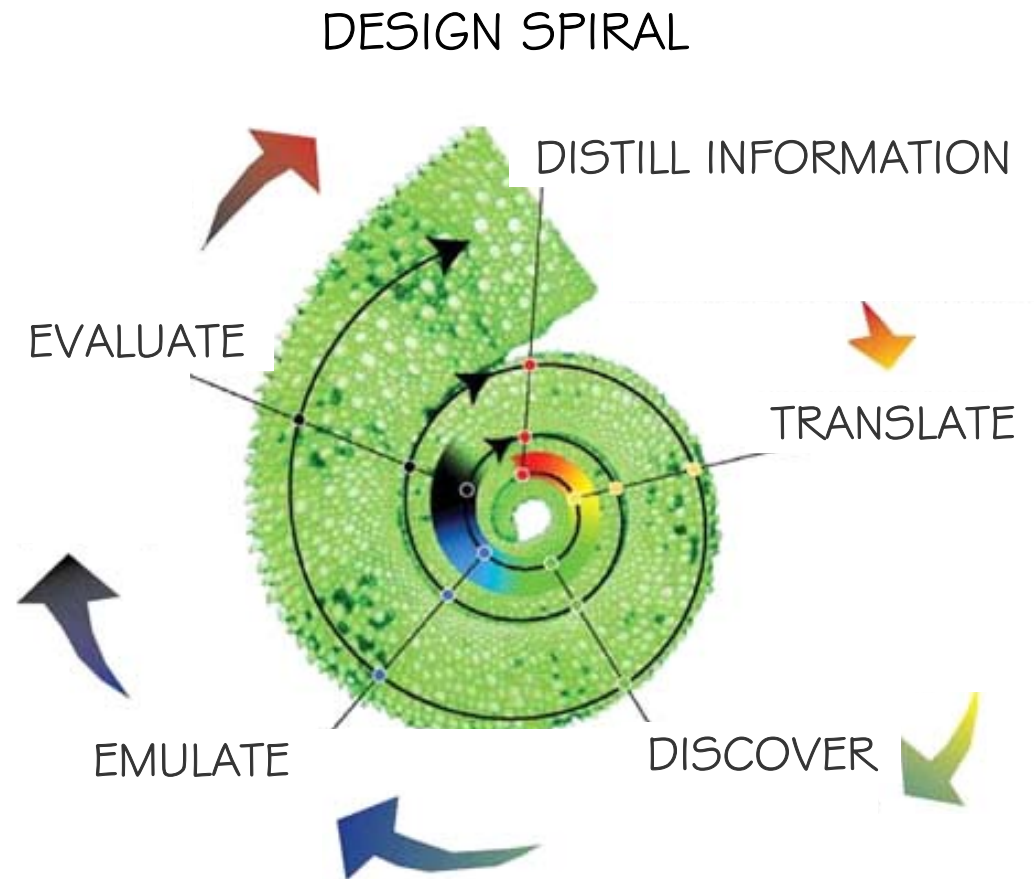


APPLICATION OF BIOMIMICRY

Indirect Approach

■ Indirect Approach - Solutions Based on General Principles of Nature

- Emulate nature on the process level - learning from the way nature produces things or evolves
- Examine how nature deals with things like waste and regeneration inside closed-loop lifecycles





APPLICATION OF BIOMIMICRY

Indirect Approach

- **Successful Organisms Lived Competitively for Millions of Years within Ecosystems without Consuming Their Ecological Capital**
- **Biomimicry Principles:**
 - Use waste as a resource
 - Diversify and cooperate
 - Gather and use energy efficiently
 - Optimize, not maximize
 - Use materials sparingly
 - Cleanup, don't pollute
 - Do not drawdown resources
 - Remain in balance with the biosphere
 - Run on information
 - Use local resources



Household Water Re-use System



"Green" Homes and LEED Buildings



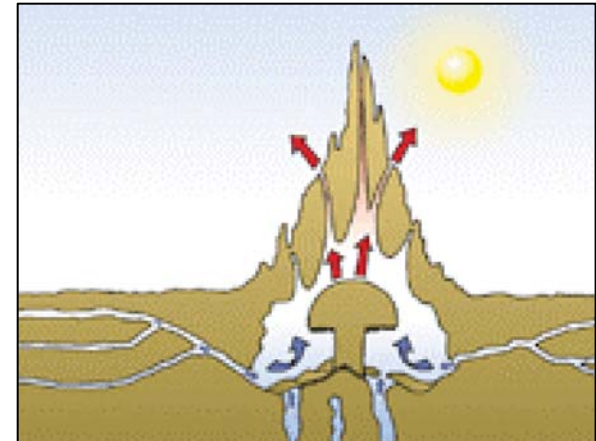
APPLICATION OF BIOMIMICRY

Indirect Approach - Termite Mound

- How Does Nature Stay Cool?
- Termites Mounds Provide One Solution
 - Simple but effective ventilation system
 - Mounds include flues venting from top and sides
 - Outside structure effectively captures breezes
 - Termites open and block tunnels to control air flow



Cathedral Termite Mound



Termite Mound Ventilation

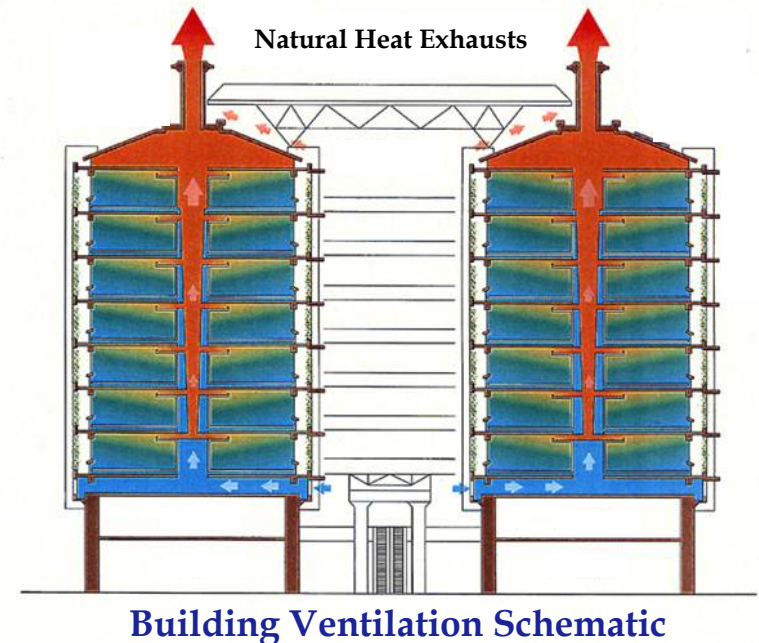


APPLICATION OF BIOMIMICRY

Indirect Approach - Termite Mound

■ Eastgate Centre, Harare, Zimbabwe

- Country's largest office and shopping complex
- Design inspired by self-cooling mounds of African termites
- Temperature stays regulated year round
- No conventional air-conditioning or heating - \$3.5M cost savings
- Uses less than 10 percent of the energy of a conventional building its size
- Translates to 20 percent savings for tenants in rental rates





APPLICATION OF BIOMIMICRY

Indirect Approach - Termite Mound

- Designs Created by Termites Provide for a Sound Climate Control Solution
- Cost-effective
- Ventilated and Cooled Entirely by Natural Means



Building Interior



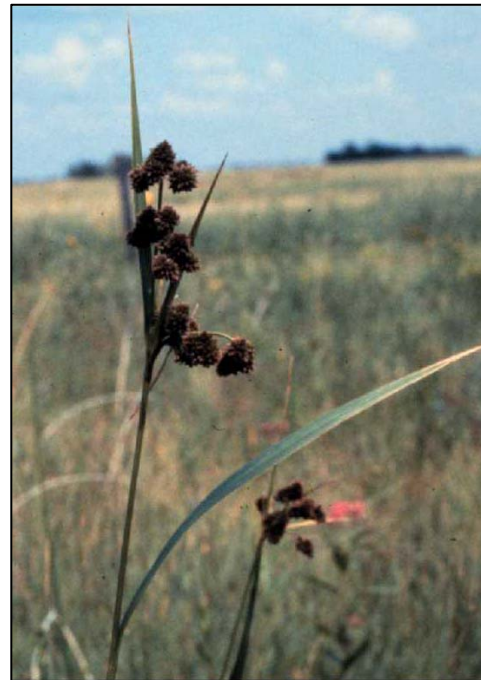
African Termite Mound



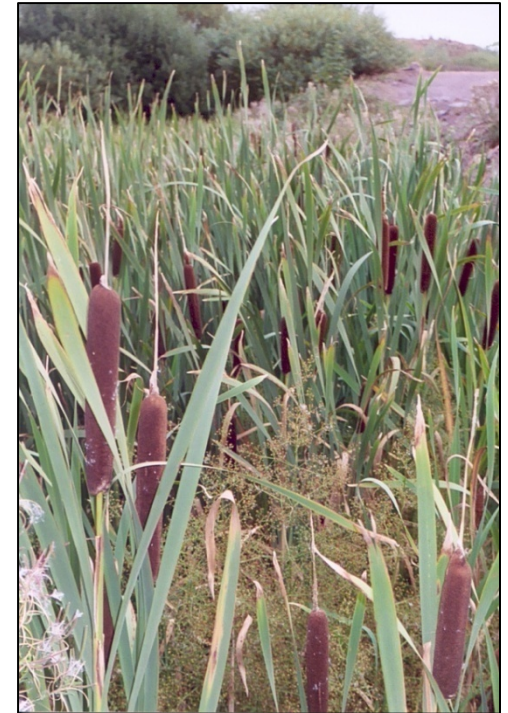
APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

- **Natural Wetlands - Long and Successful History in Treating Variety of Waste Streams**
- **Main Treatment Mechanisms - Microbiological Processes Mediated by Plants**
- **Why not Mimic what Works in Nature?**



Green Bullrush



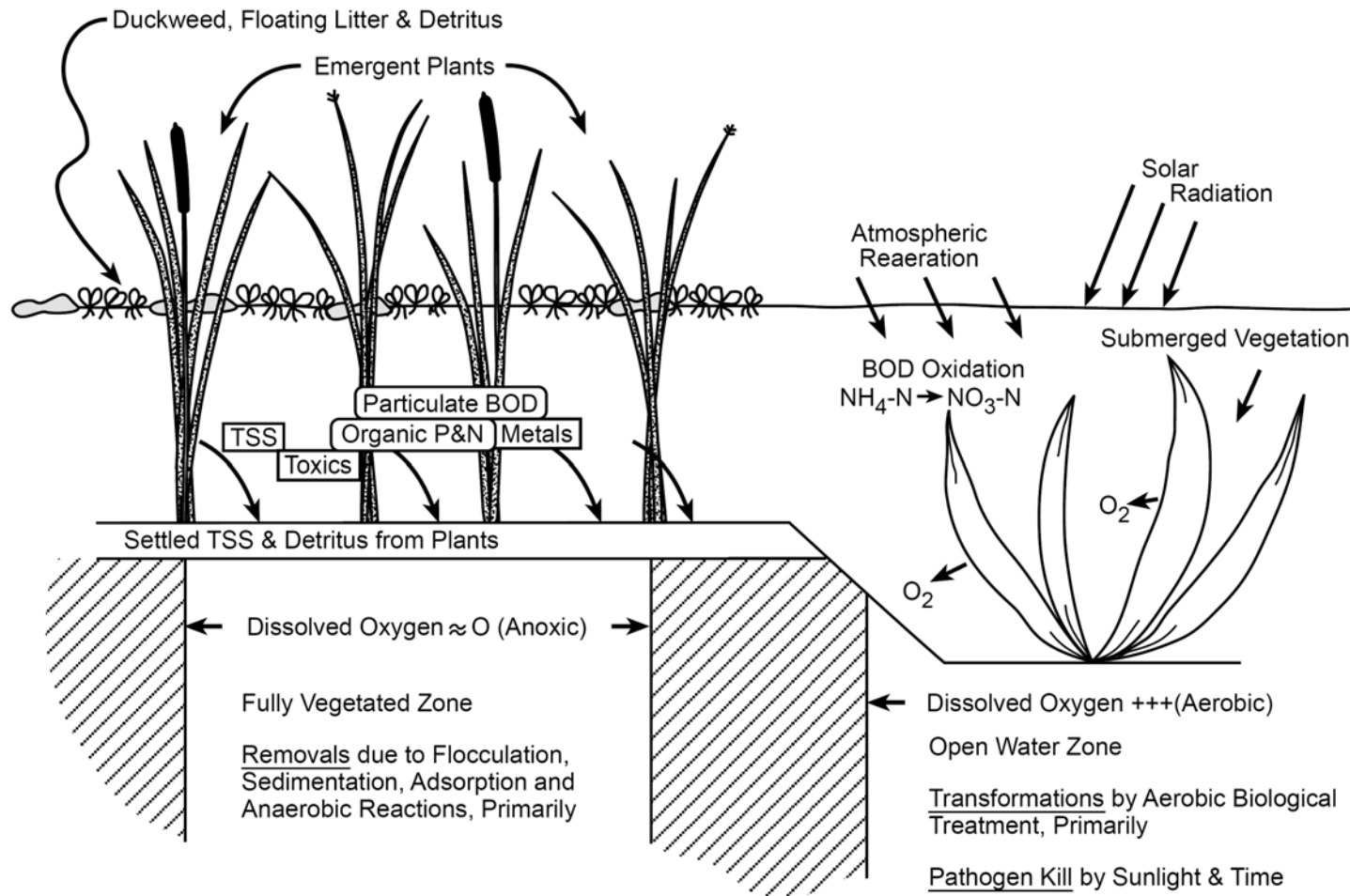
Cattails



APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

- Plant Uptake Plays a Minor Role
- Anaerobic and Aerobic Geochemical Processes





APPLICATION OF BIOMIMICRY

Indirect Approach – Constructed Wetlands

- **Two Main Wetland Types**
 - **Surface-flow wetland**
 - **Subsurface-flow wetlands**
 - Horizontal flow
 - Vertical flow



Plant Growth in Subsurface Flow Wetland



Common Reed

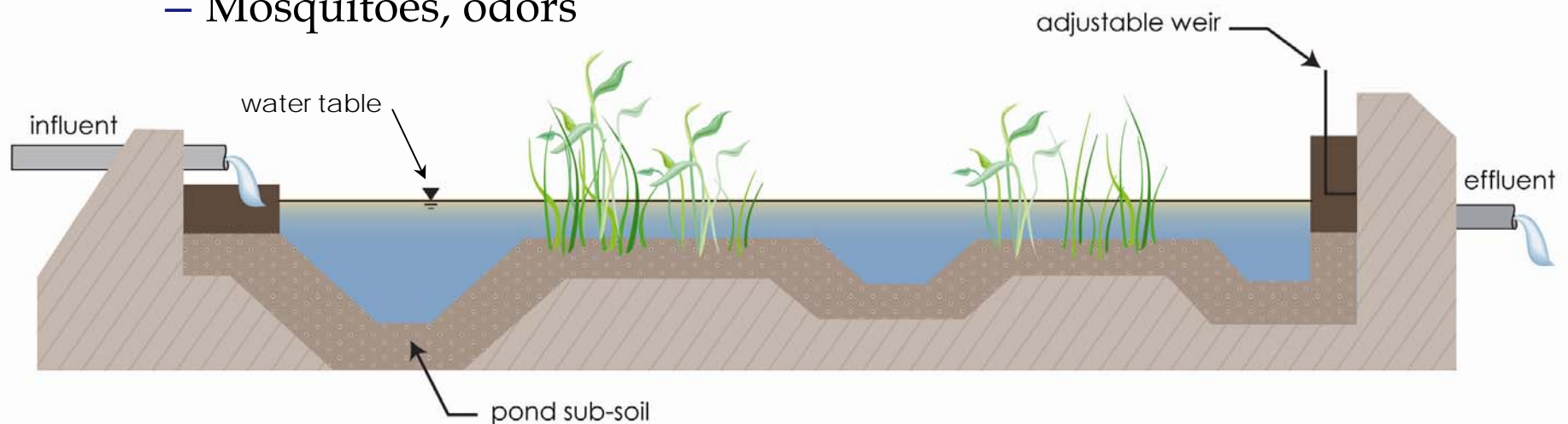


APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

■ Traditional Surface Flow Wetlands

- Mimics natural wetland systems
- Vegetation cultivated in shallow channels
- Wastewater flows through at low velocity
- Potential limitations
 - Poor winter performance
 - Requires significant land area
 - Potential for direct contact with wastewater
 - Mosquitoes, odors



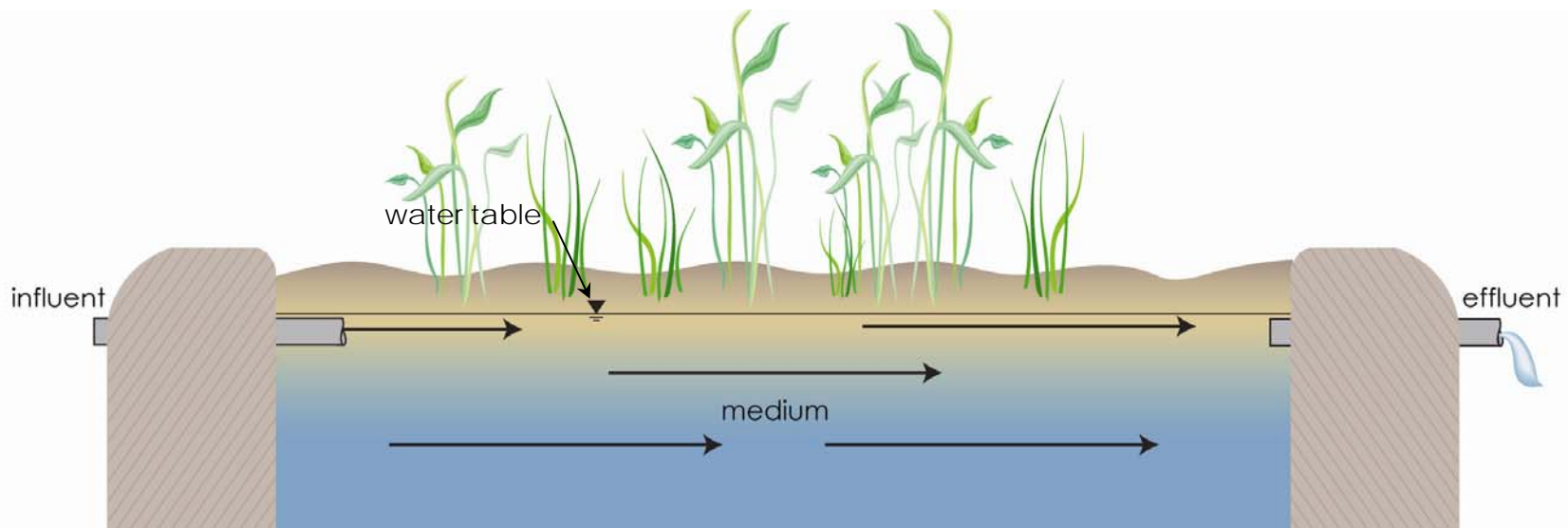


APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

■ Horizontal Sub-Surface Flow Wetlands

- Sand or gravel medium supports aquatic plants
- Water level maintained below the sand/gravel
- Wastewater flows horizontally
- Potential limitations
 - Insufficient aerobic zones to allow for ammonia reduction
 - Plugging of sand media may lead to 'short circuiting'



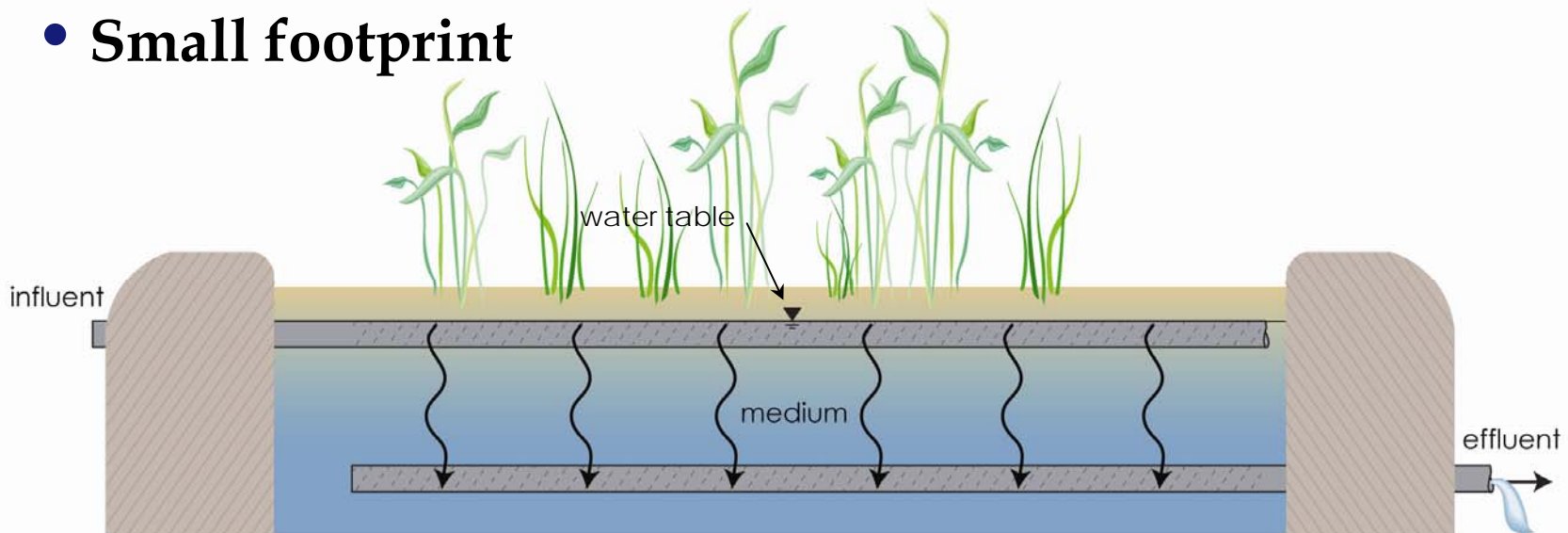


APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

■ Vertical Flow Wetlands

- Water percolates vertically down through medium
- Draws oxygen through the medium
- Allows for increased contact between wastewater, sand, and aerobic bacteria
- Efficient treatment, even in winter
- Small footprint





APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

- Case Study - Active Landfill in Southern Alabama
- Landfill Leachate Treatment



Wetland Construction - Liner Installation



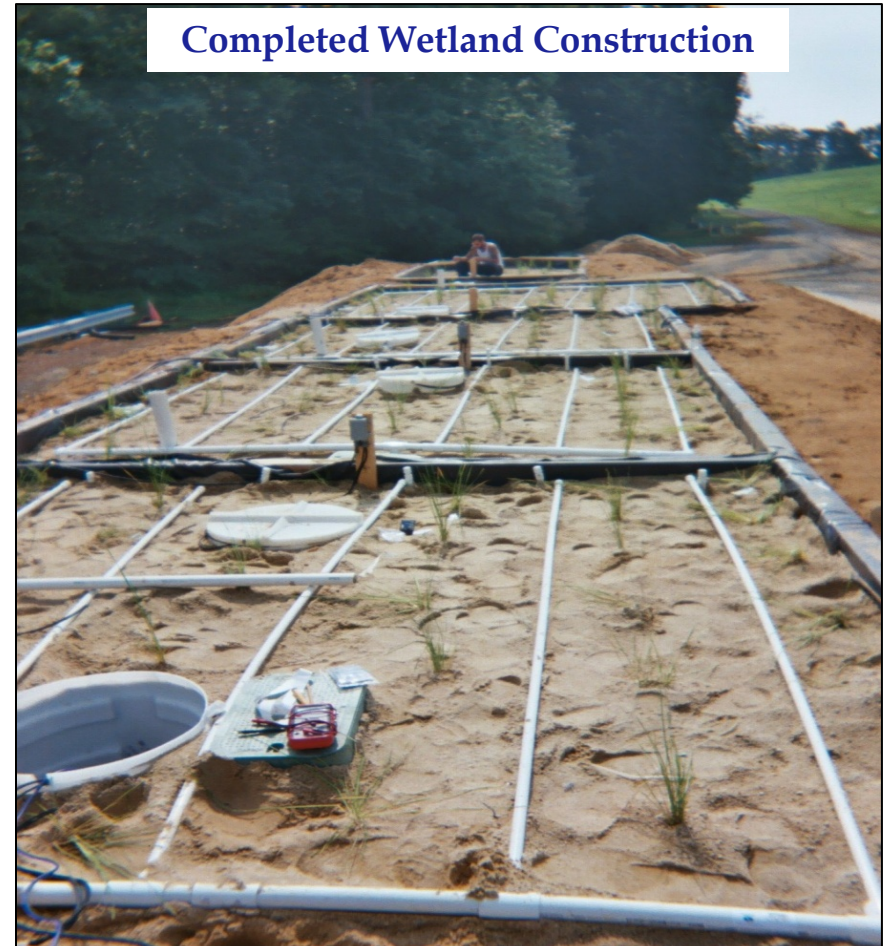
Wetland Construction - Placement of Pond Subsoil



APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

- Case Study - Delaware Solid Waste Authority
- Landfill Leachate Treatment Pilot Testing

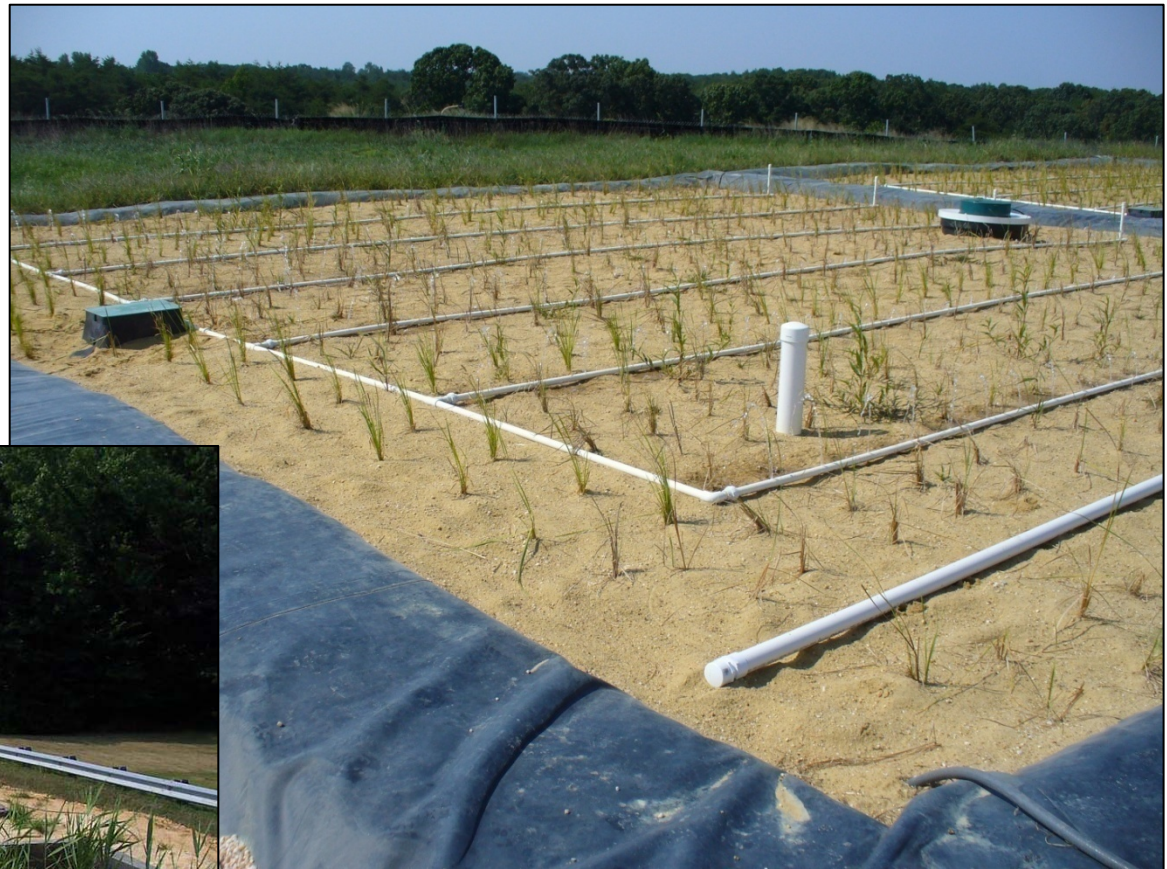




APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

Pilot-Scale Wetland - Operational



Full-Scale Wetland - Completed Construction

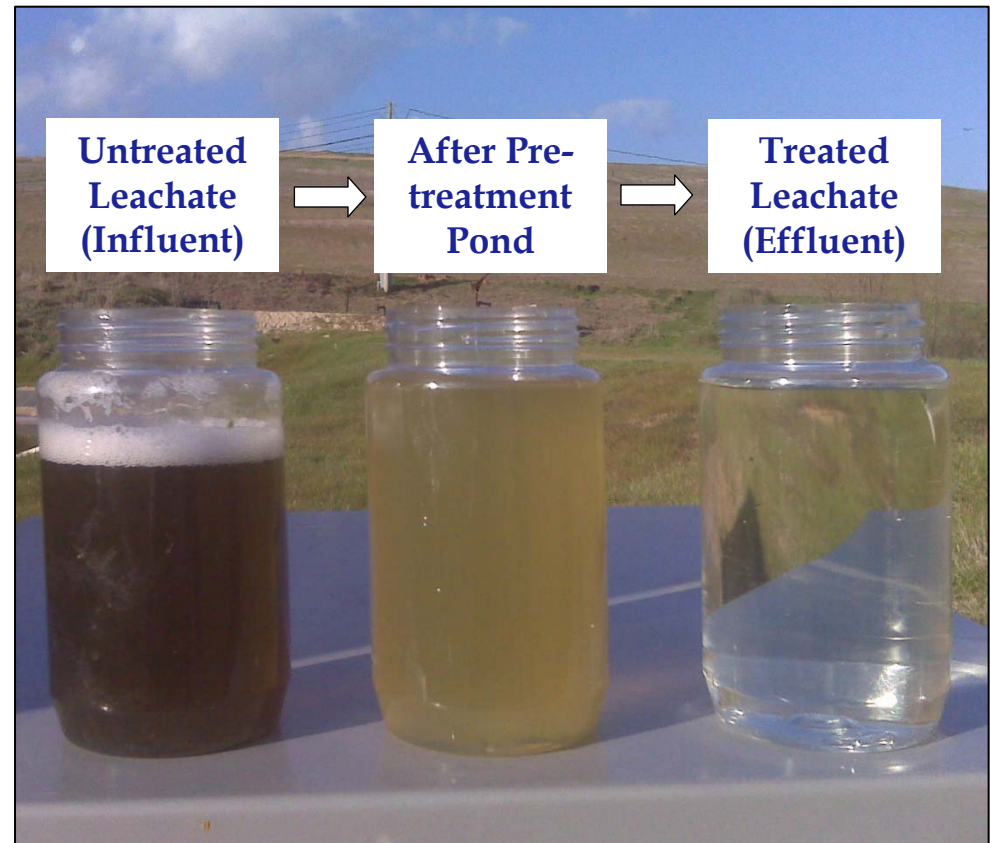


APPLICATION OF BIOMIMICRY

Indirect Approach - Constructed Wetlands

■ Wetlands Treatment - Remarkable Results

	Influent	Effluent	Discharge Limit
pH	7.6	6.5	6 - 9
Biochemical Oxygen Demand (mg/L)	550	~2	37
Ammonia (mg/L)	810	<0.5	4.9
Total Suspended Solids (mg/L)	89	<1.4	27
Fecal (#/100 mL)	<50	<1	1,000



Leachate Treatment Progression

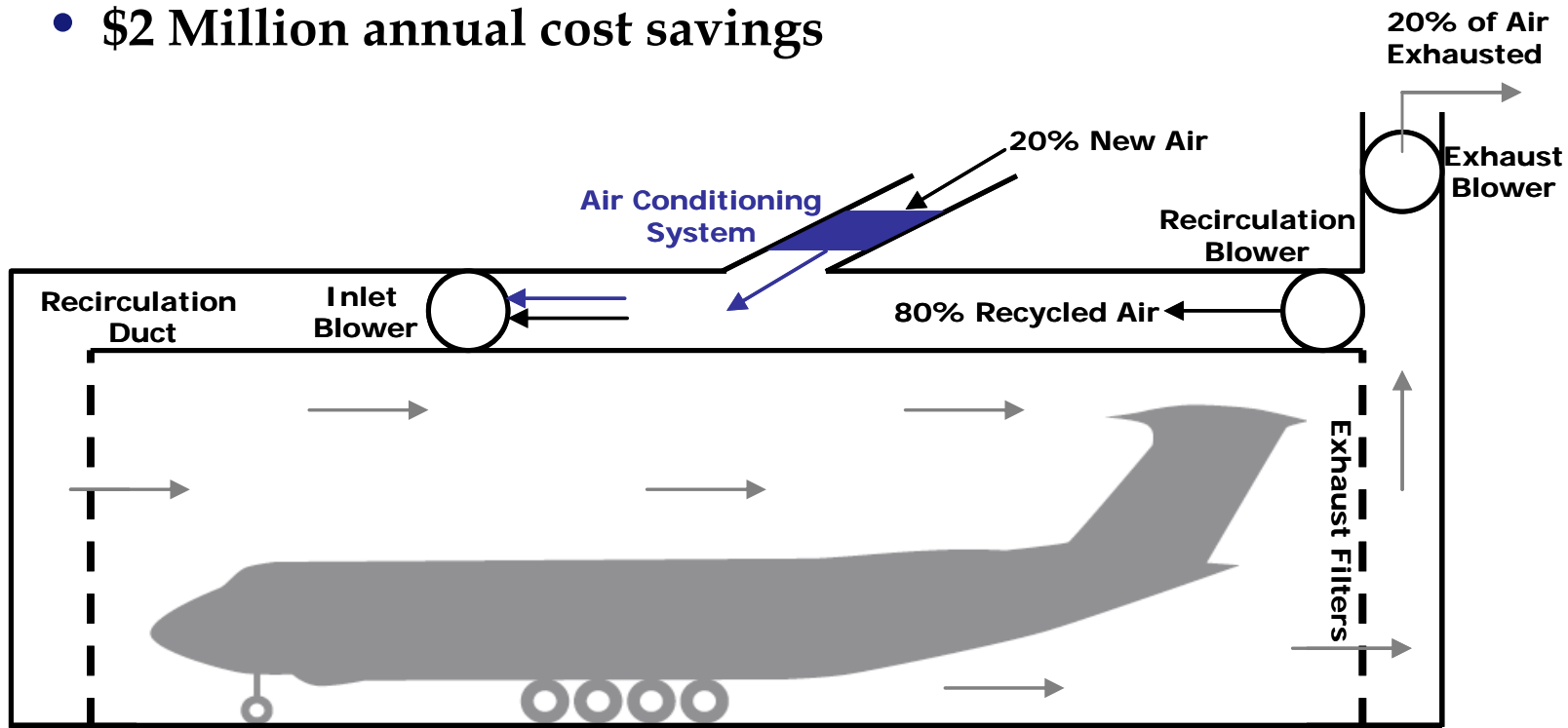
Non-detect results for most other permit parameters, only trace detections of metals (e.g., 7 ppb of zinc), no accumulation of nitrite and nitrate



BIOMIMICRY AT ROBINS AFB

■ Building 59 Paint/Depaint Facility

- Biomimicry Principle - Gather and Use Energy Efficiently
- 80 percent of the conditioned air is re-circulated and reused, reducing both electrical and gas demands
- \$2 Million annual cost savings



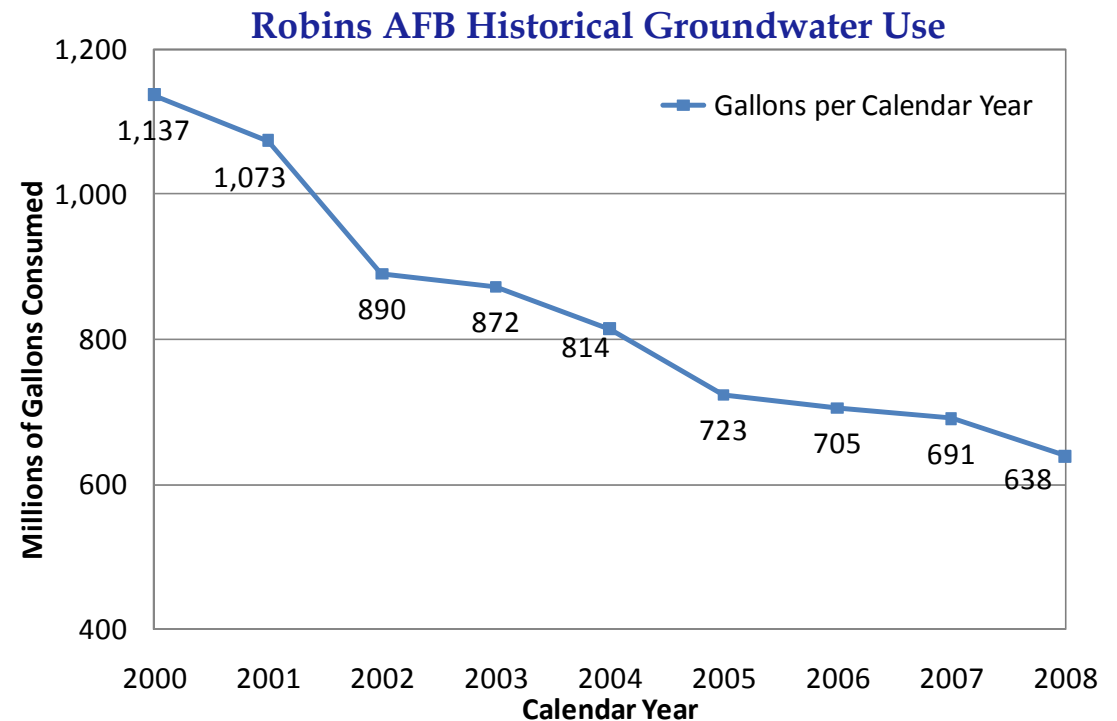
Air Recirculation System at Building 59



BIOMIMICRY AT ROBINS AFB

■ Water Resources Conservation

- Biomimicry Principles - Do Not Drawdown Resources & Optimize, Not Maximize
- Industrial Process Improvements
- Leak Detection Surveys and Infrastructure Improvements
- Education Efforts
- Low Flow Plumbing Fixtures





BIOMIMICRY AT ROBINS AFB

- **Composting Facility**
 - Biomimicry Principle - Use Waste as a Resource
- **Bioremediation Studies at LF03, OT17, and Horse Pasture**
 - Biomimicry Principle - Cleanup, Don't Pollute



Composting Facility



Biotreatability Study



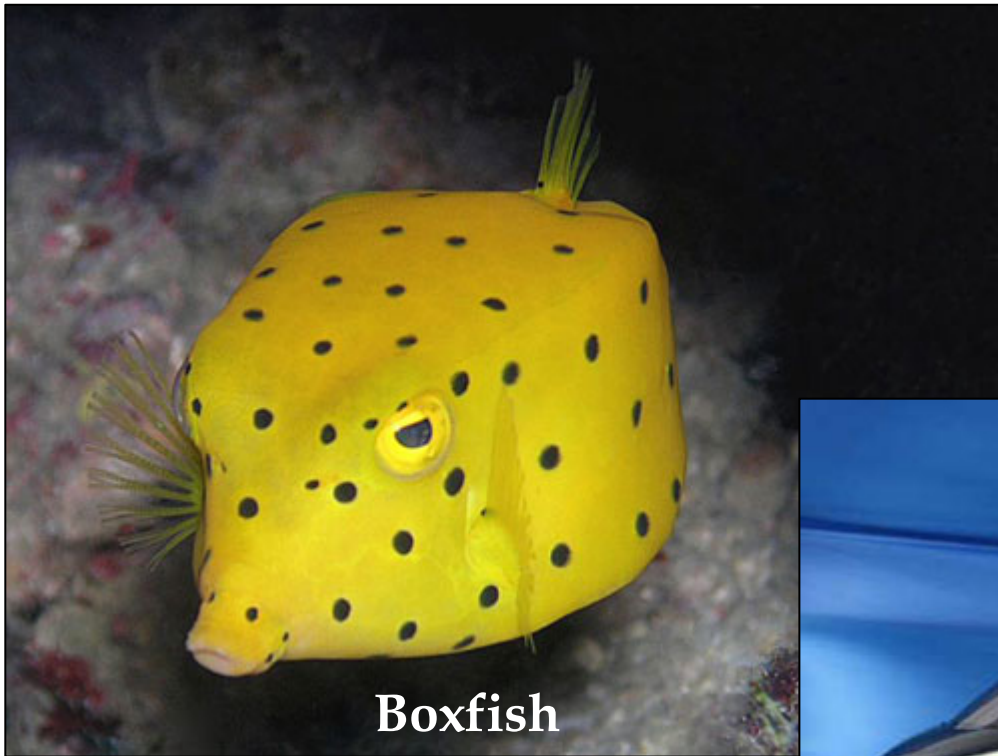
SUMMARY

- **Global Demand for Natural Resources will Exceed Supply**
- **Adopting Biomimicry Principles is Part of the Solution**
- **Robins AFB Proactively Evaluates Technologies Consistent with Biomimicry Principles**





QUESTIONS / COMMENTS



Boxfish



Mercedes-Benz Bionic Concept Vehicle



New Business and Program Closing

**Ms. Becky McCoy
EAB Installation Co-chair**



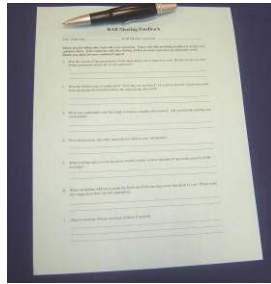
Next EAB Meeting

Thursday, 7 May, 2009





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meeting.**



Thank you!