

# Nanotechnology

## What's the Big Deal?

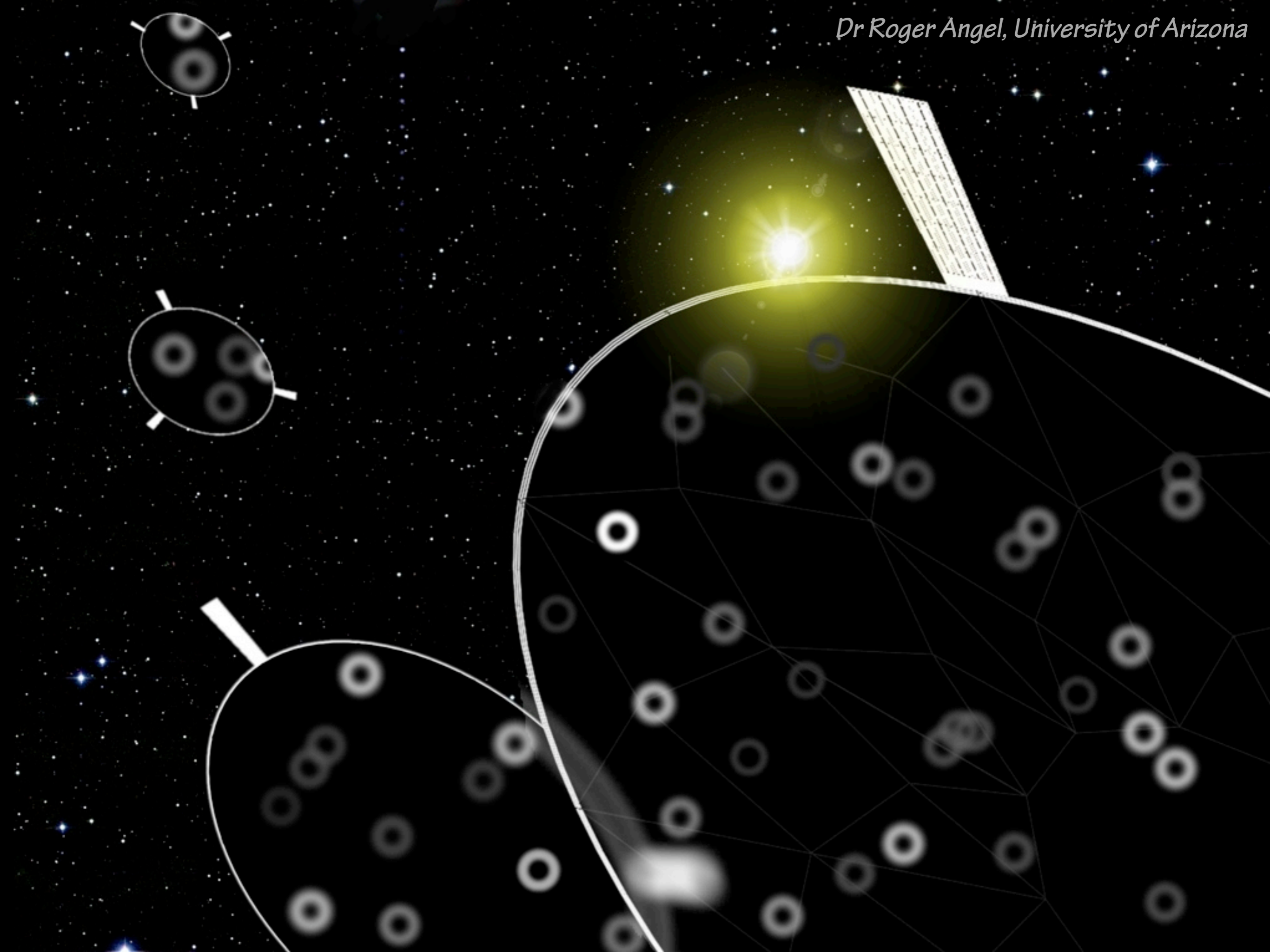
***Nanotechnology in context***

*Lecture 1 of 3*

**Andrew D. Maynard**

**Chief Science Advisor, Project on Emerging Nanotechnologies**

Woodrow Wilson International Center for Scholars (in partnership with the Pew Charitable Trusts)





A close-up portrait of Richard Smalley, an older man with white hair and a goatee, looking thoughtfully to the side. The image is dark and serves as a background for the text.

*Richard Smalley*

nano: The

*art* and *science*

of **building stuff**

that **does stuff**

at the nanometer scale

**Smallness**

**Strangeness**

**Sophistication**



# Human-scale

# Nano-scale

Tennis Ball



10 cm

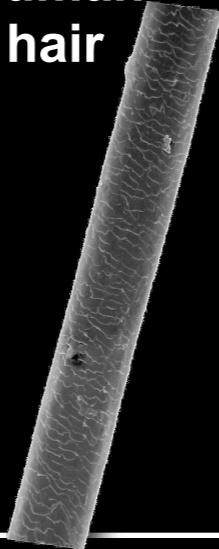
1 cm

Pin-head



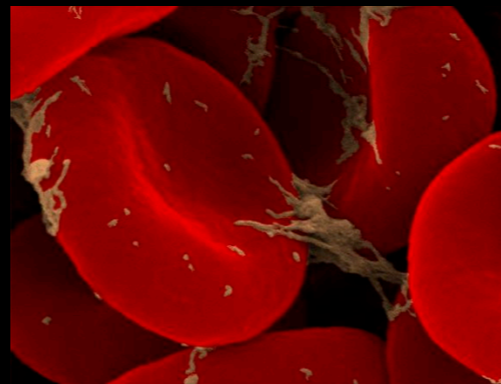
1 mm

Human hair



100  $\mu$ m

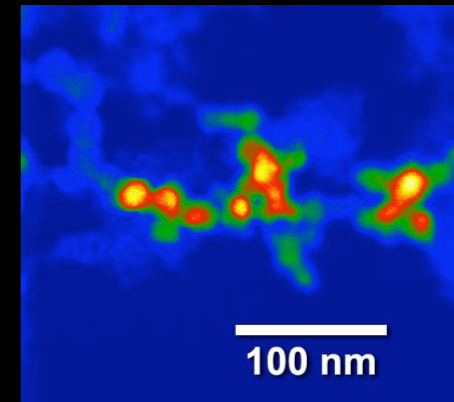
Red Blood Cell



10  $\mu$ m

1  $\mu$ m

Welding fume



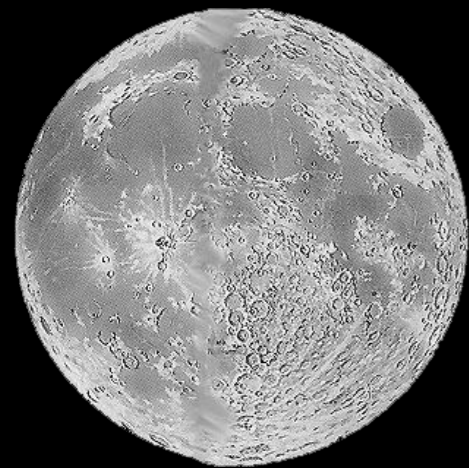
100 nm

10 nm

DNA



1 nm



# Relative sizes



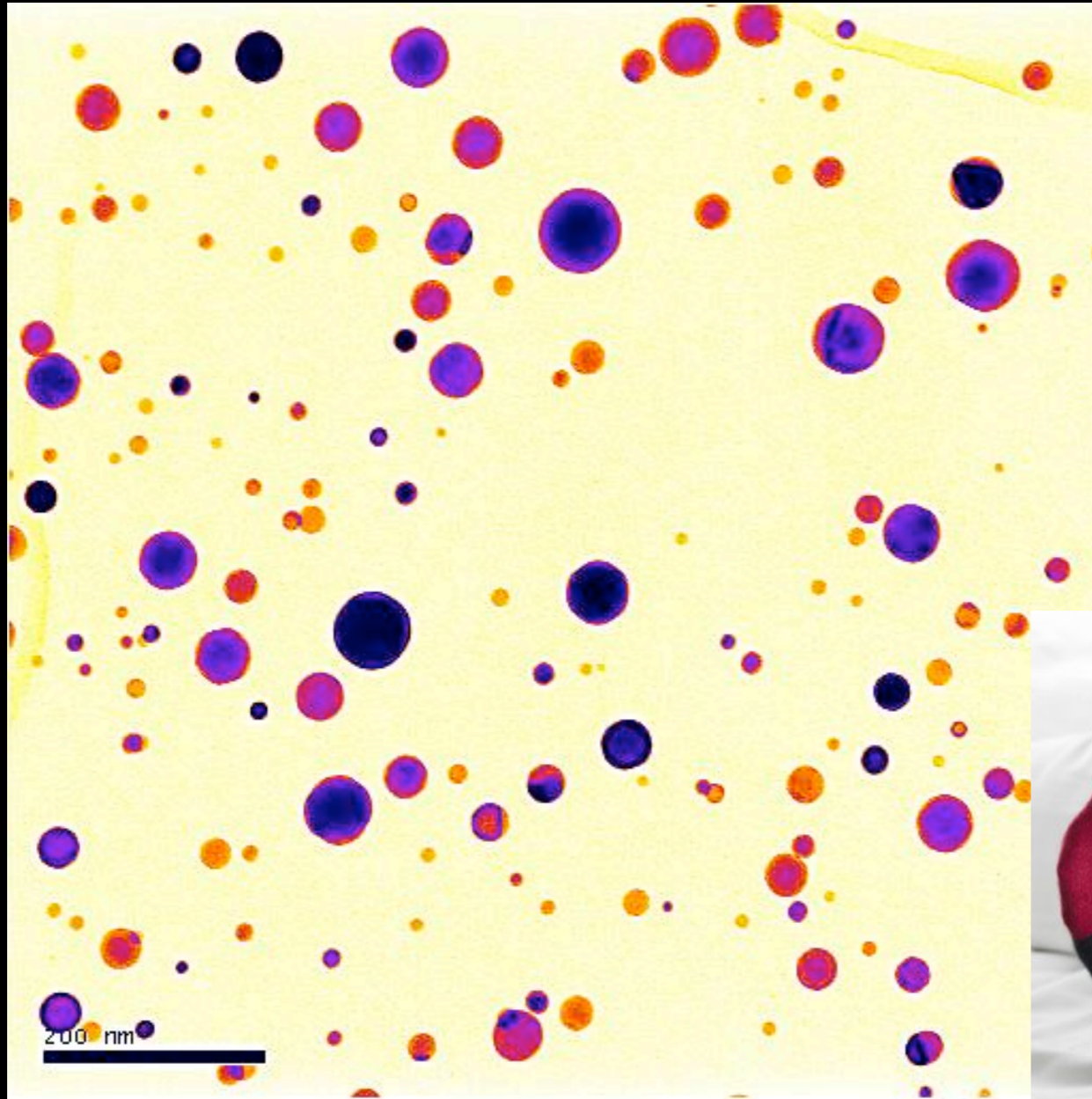
# Smallness



Gets you to new places



# Smallness



Silver

Small

*Suffocated bugs*

**Sweet feet**



Gets you to new places



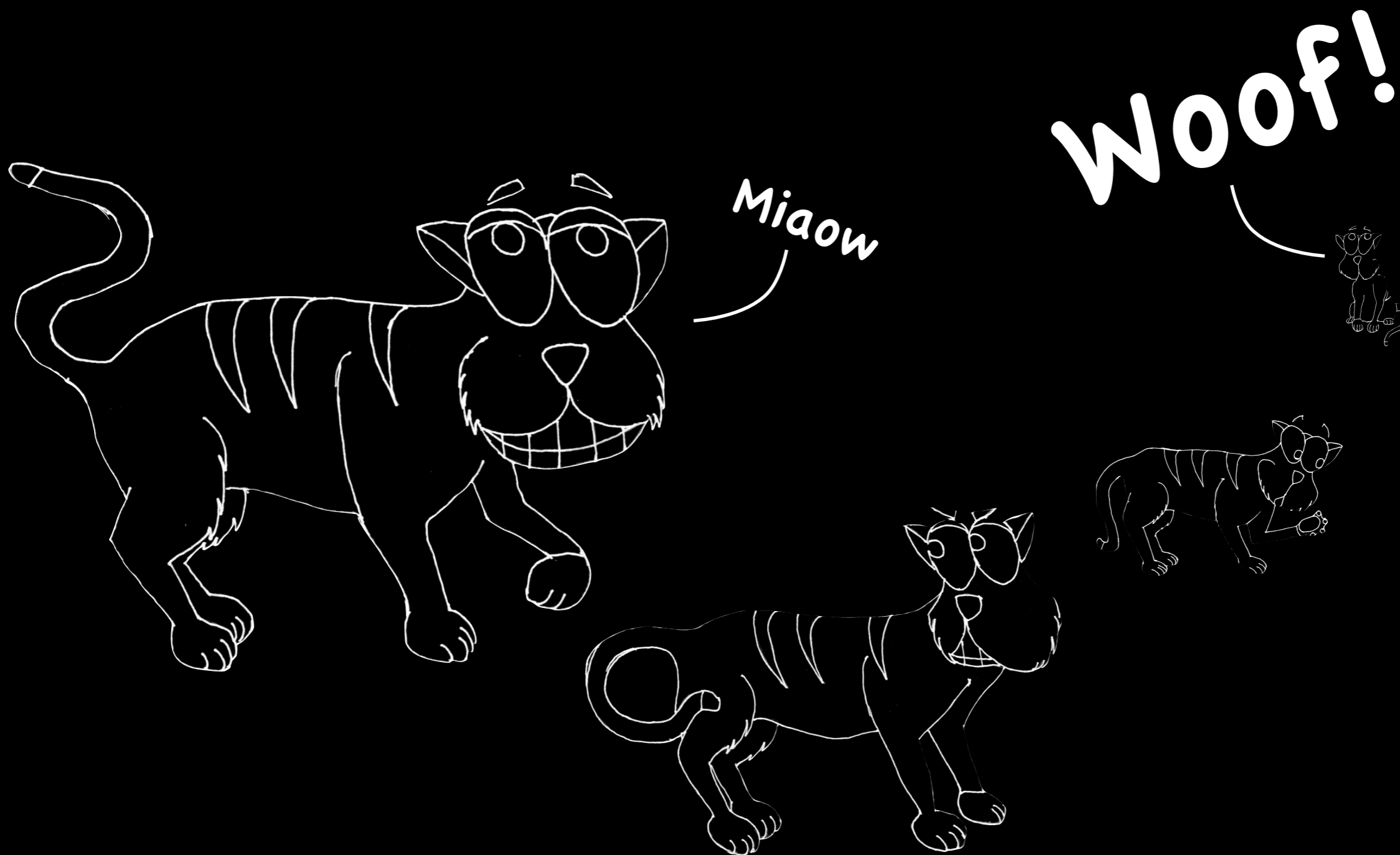
# The Great Nano Mentos Experiment



[http://www.youtube.com/watch?v=oPG7UXaAB\\_g](http://www.youtube.com/watch?v=oPG7UXaAB_g)



# Strangeness



Behaves in unexpected ways

# Strangeness



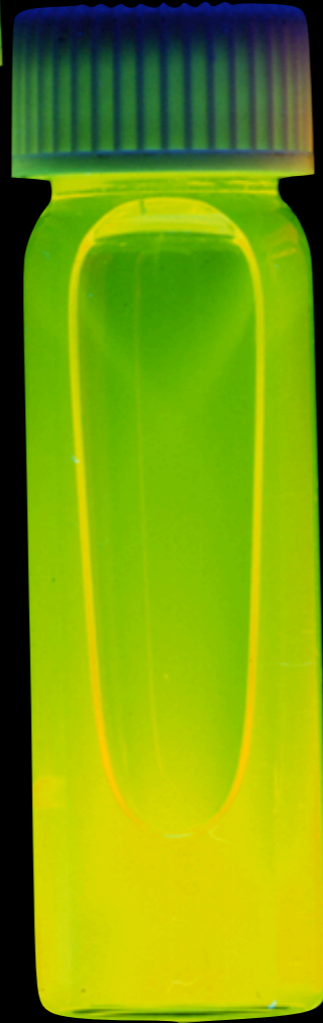
Lycurgus Cup



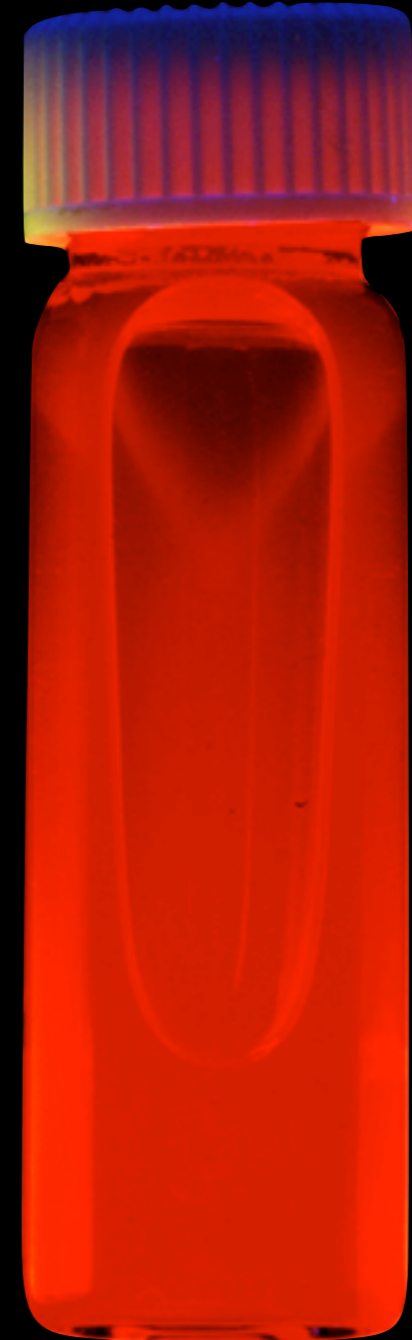
Behaves in unexpected ways



*Smallest*



*Largest*



*Cadmium Selenide  
"Quantum Dots"*

©Felice Frankel



# Sophistication



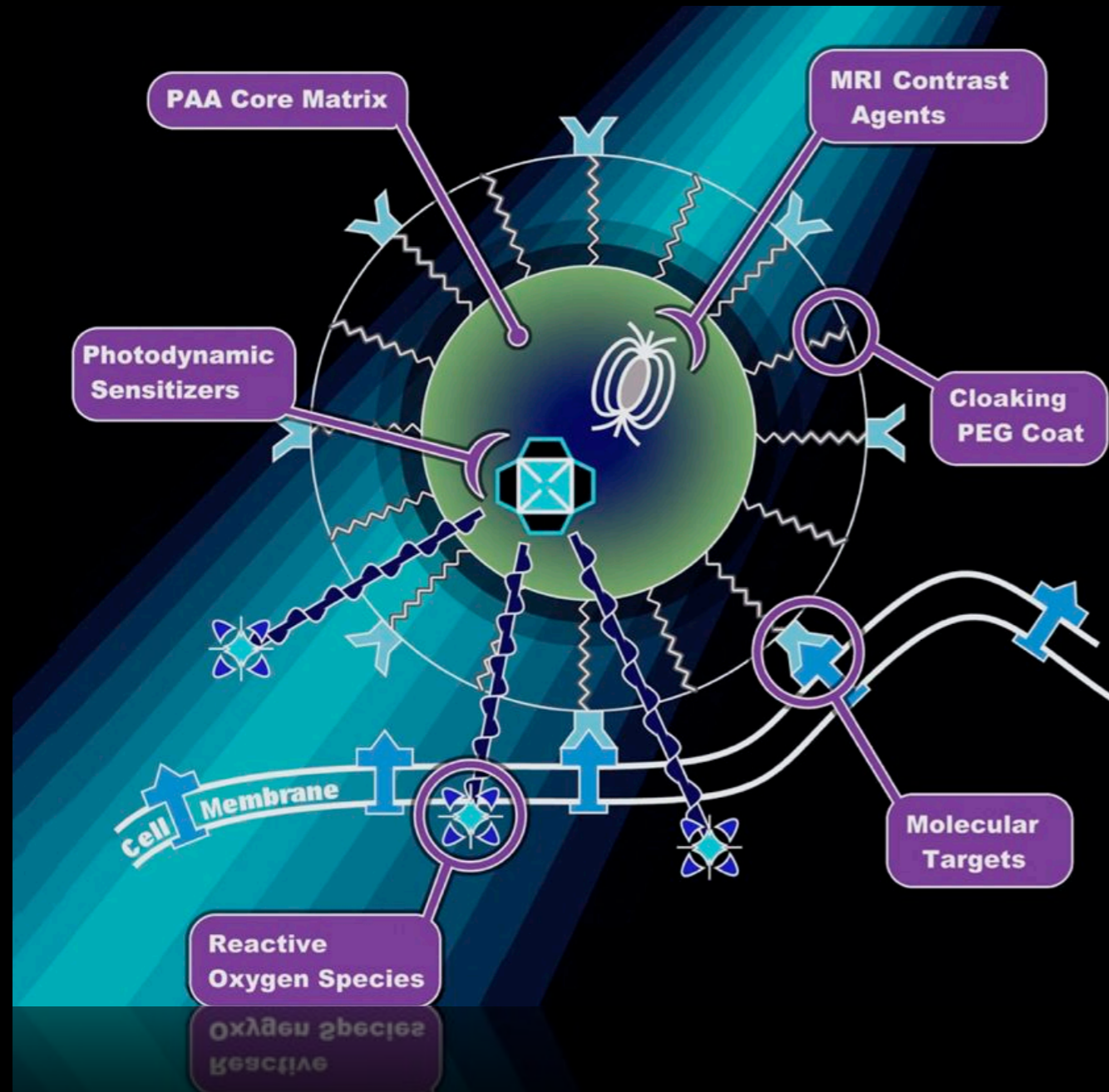
Nathan Sawaya

Increasingly complex



# Sophistication

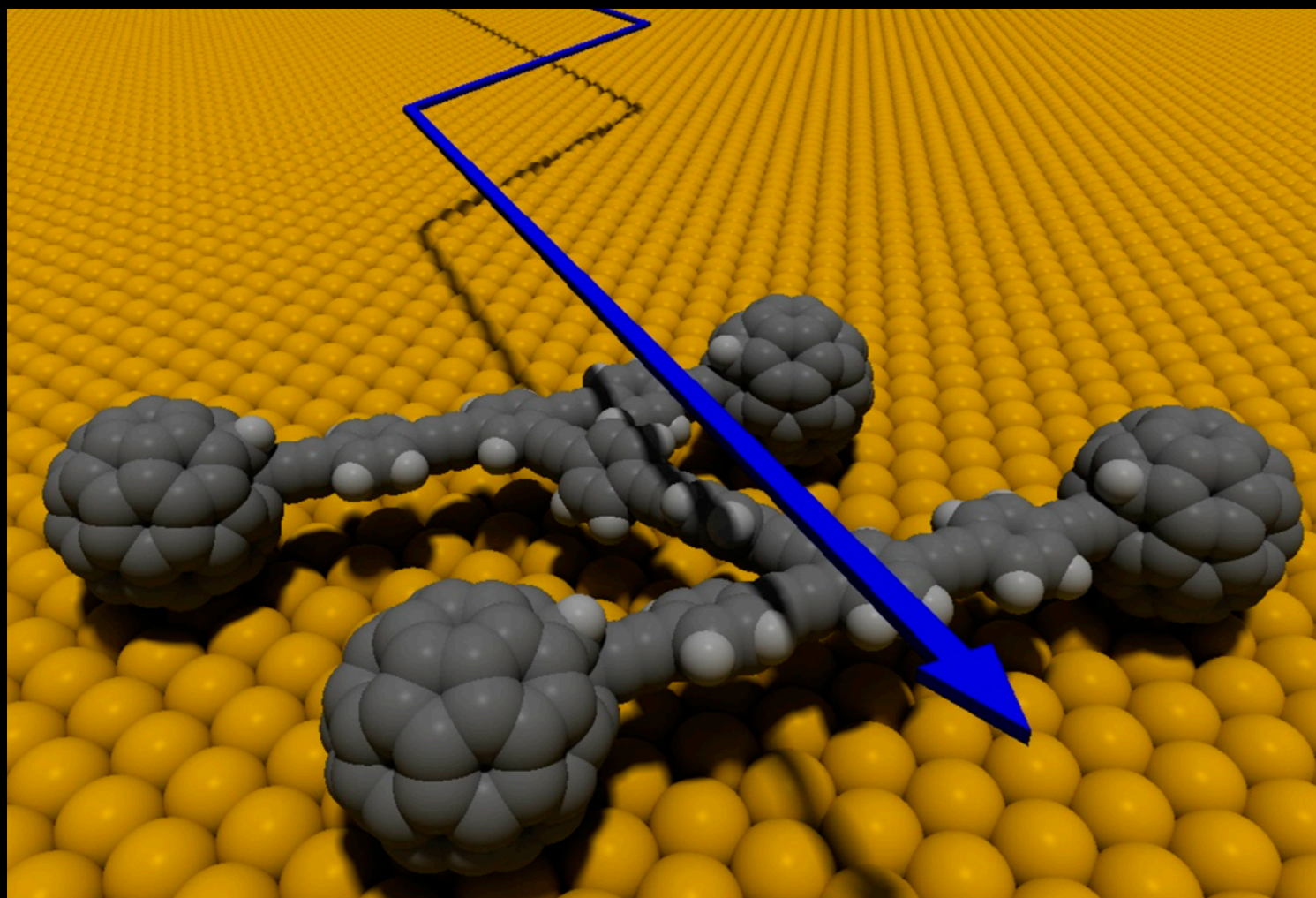
*Smart Drugs*



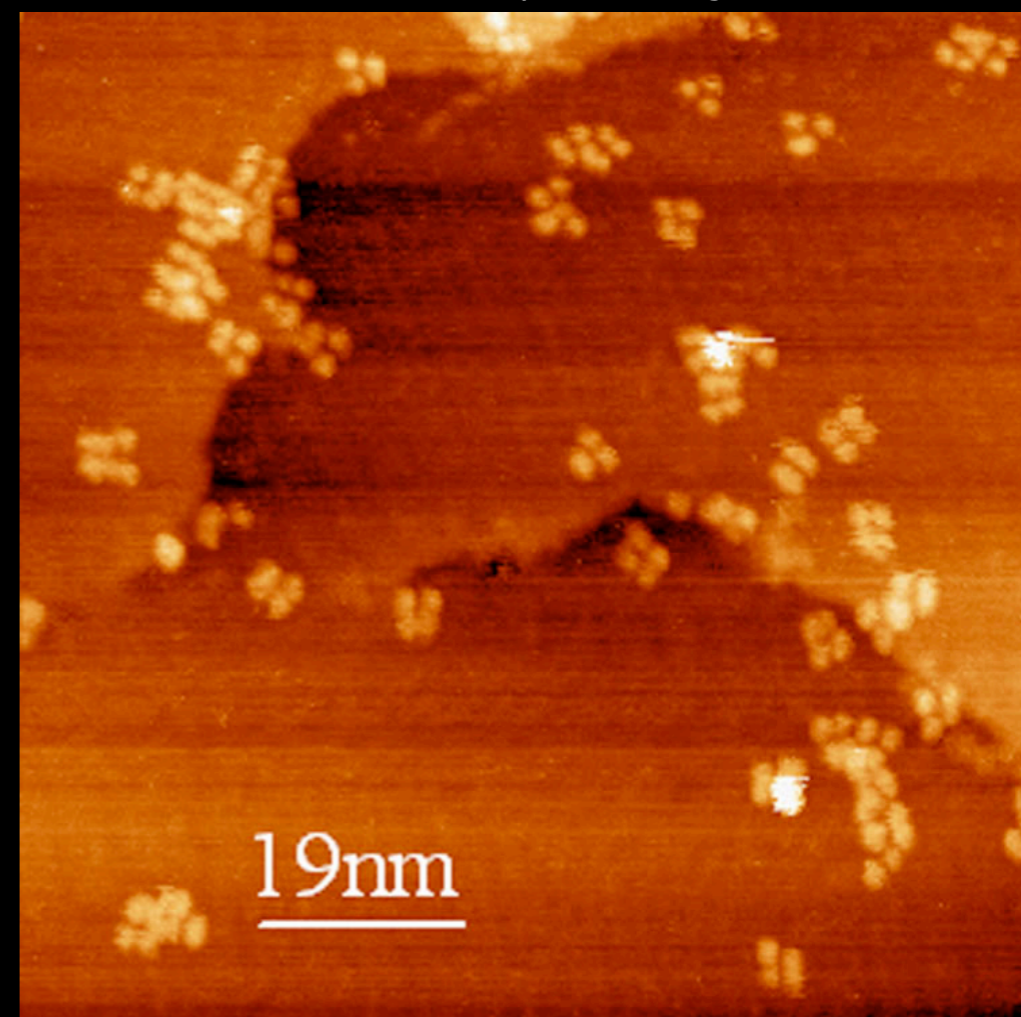
Increasingly complex



Y. Shirai/Rice University

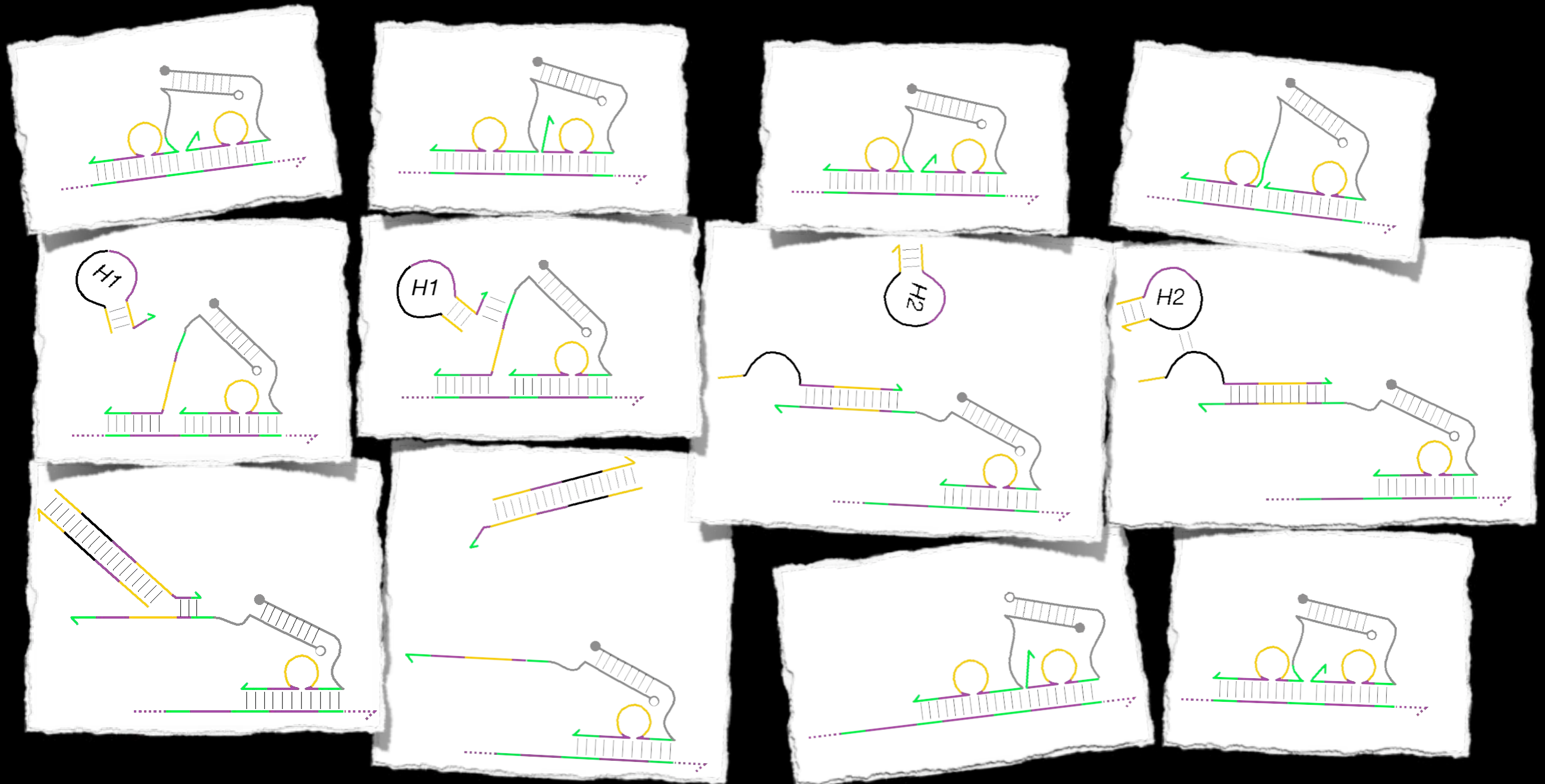


K. Kelly and A. Osgood/Rice University



Shirai, Y., A. J. Osgood, Y. Zhao, K. F. Kelly and J. M. Tour (2005). Directional Control in Thermally Driven Single-Molecule Nanocars. *Nano Lett.* 5(11): 2330-2334.

## A synthetic molecular motor



**Smallness**

**Strangeness**

**Sophistication**



# Nanoscale control:

Adding value to products

*I wish* my sunscreen wasn't so unsightly



*I wish* my socks didn't smell so much!



*I wish* my tennis racquet was lighter and stronger



*I wish* I could keep leftovers for longer, before they go off



*I wish* spilt red wine would run off my pants without staining



*I wish* I could get more songs on my iPod



Over 800 listed manufacturer-identified nanotech consumer products:  
[www.nanotechproject.org/consumerproducts](http://www.nanotechproject.org/consumerproducts)



# Solar Rx

SPF 30+ Nano-Zinc Oxide  
Therapeutic  
Sunblock

Chemical-Free  
Skin Health

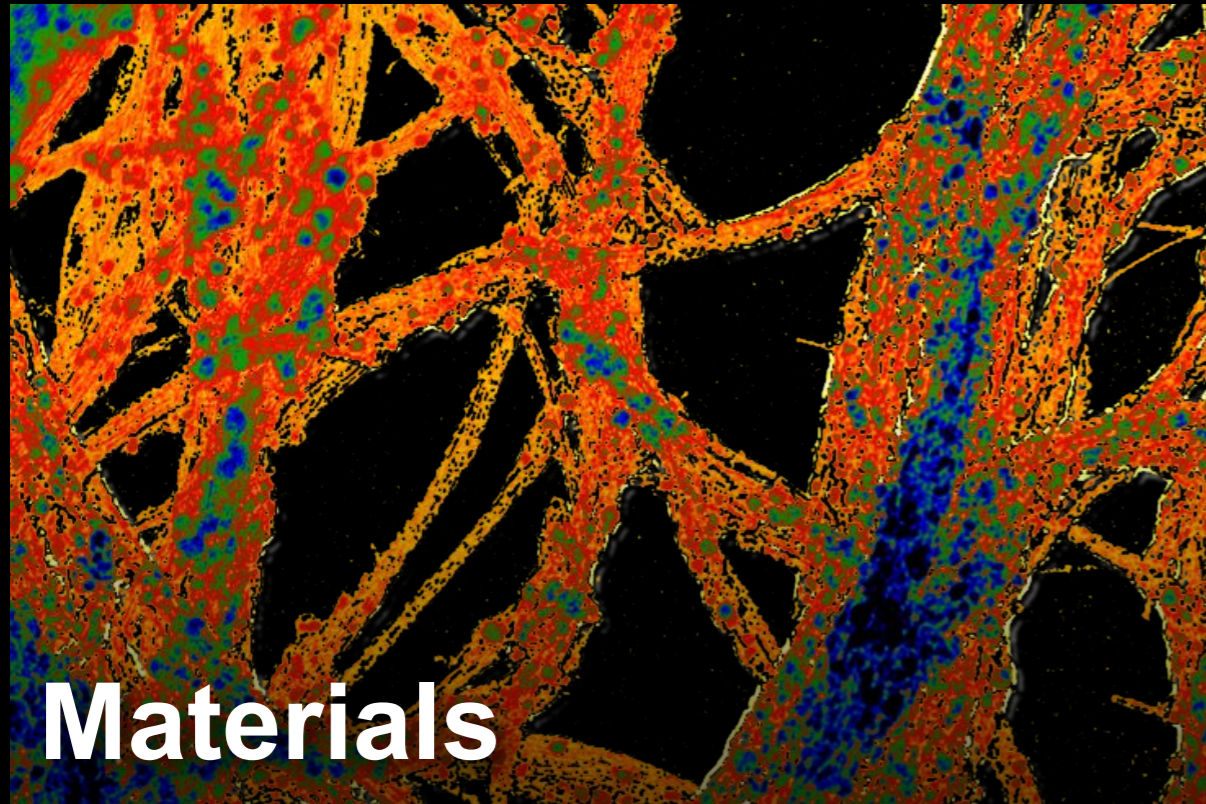
Net Contents 100 ml





# Nanoscale control:

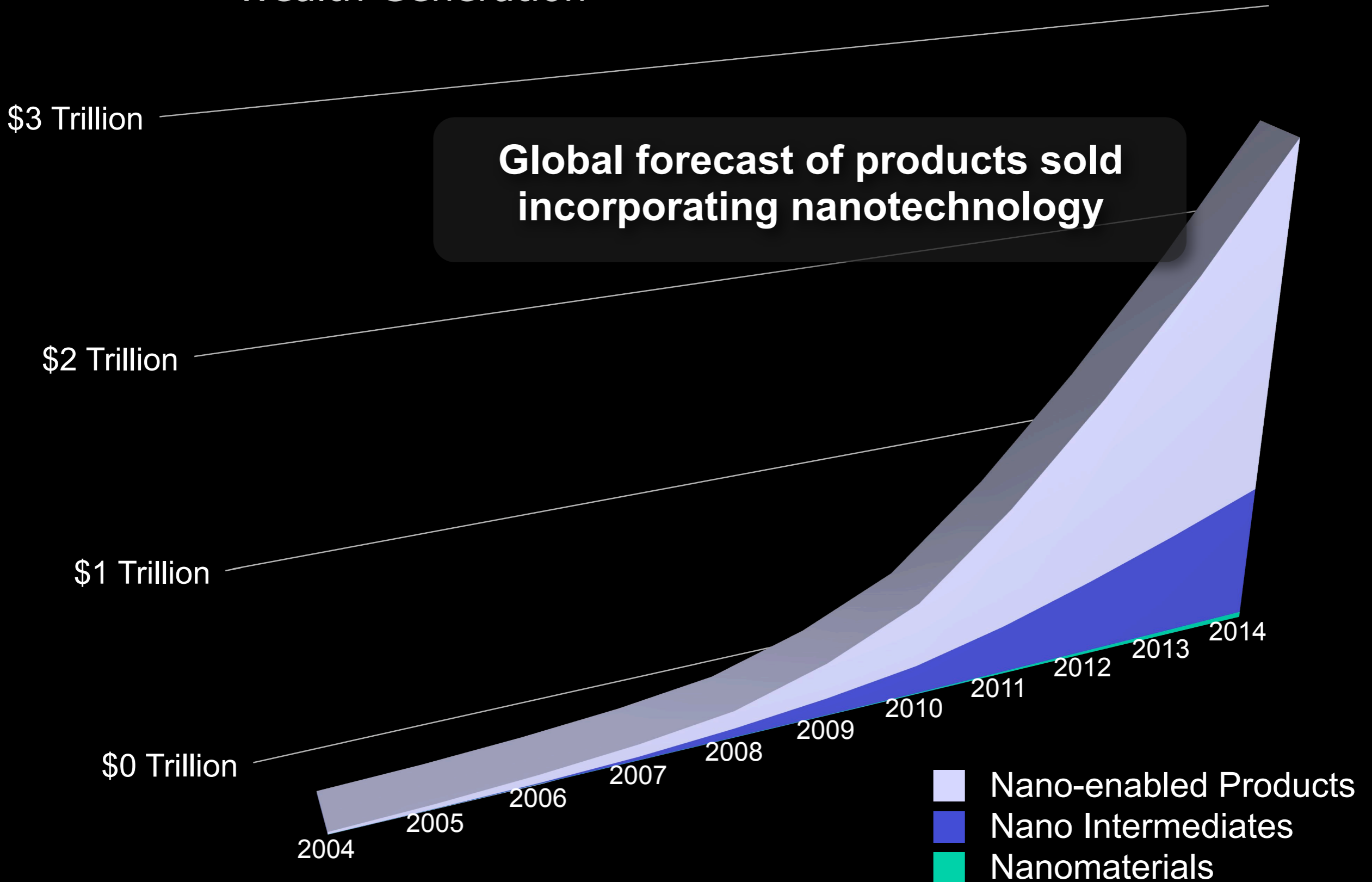
Solutions to problems





# Nanoscale control:

Wealth Generation

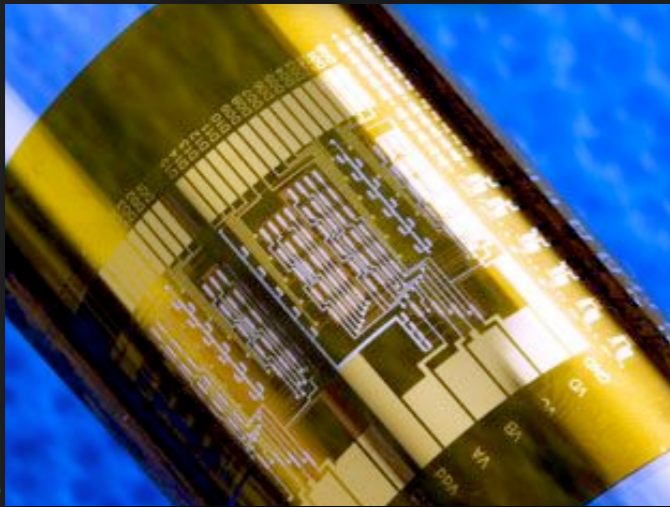


Source: 2004 Lux Research Report: "Sizing nanotechnology's value chain"



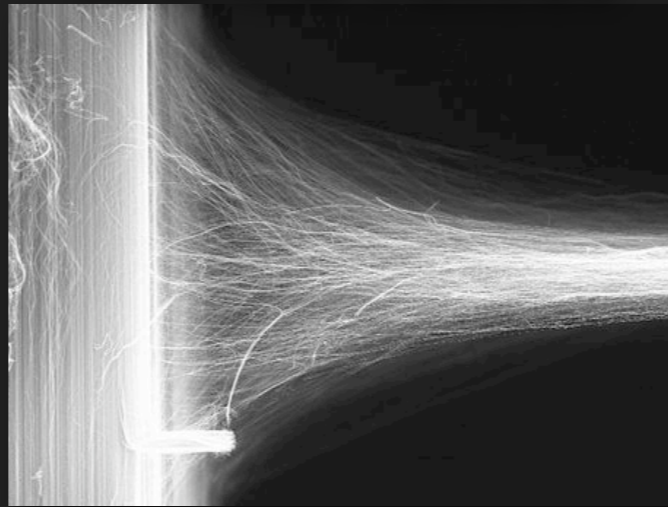
# Electronics

© Beckman Institute



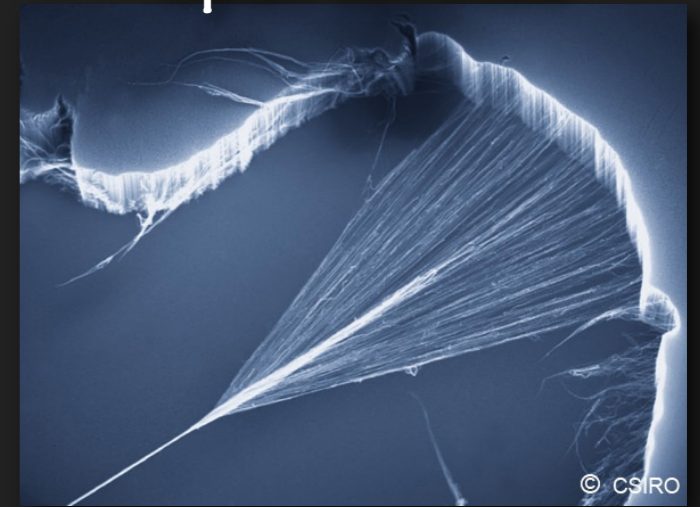
# Artificial muscles

blog.wired.com



# Spun textiles

© CSIRO



# Medicine

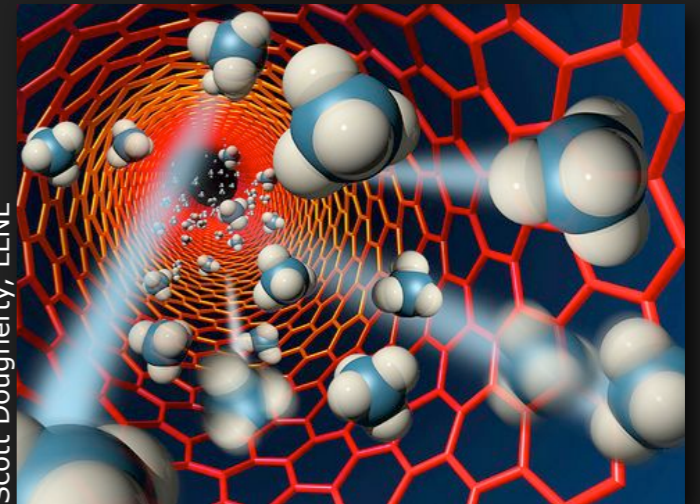
JPL



Chris Ewels, [www.ewels.info](http://www.ewels.info)

# Desalination

Scott Dougherty, LLNL



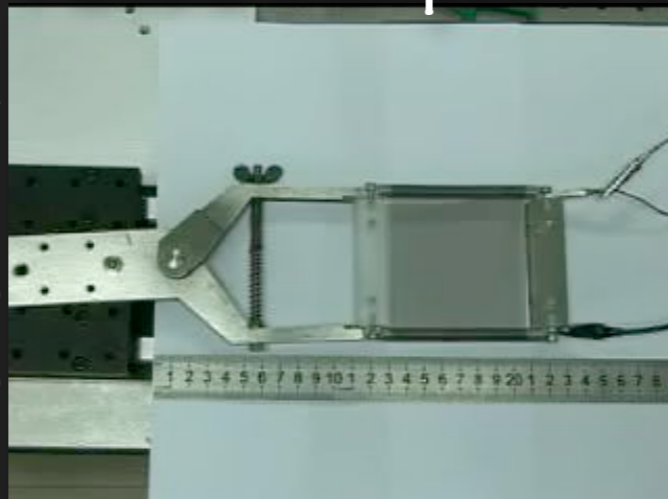
# Strong materials

Easton



# Flexible loudspeakers

Kaili Jiang, Tsinghua University



# Space elevator

NASA



*...but is nano*  
**SAFE?**



*...a nano interlude...*



**The  
TWINKIE  
Guide to Nanotechnology**

**Andrew D. Maynard**

**Chief Science Advisor**

**Project on Emerging Nanotechnologies**

Woodrow Wilson International Center for Scholars






**#1**

**The whole is more than  
the sum of the parts**





**Mono and Diglycerides**  
**Flour**  
**Sodium Stearoyl Lactylate**  
**Baking Soda**  
**Sodium and Calcium Caseinate**

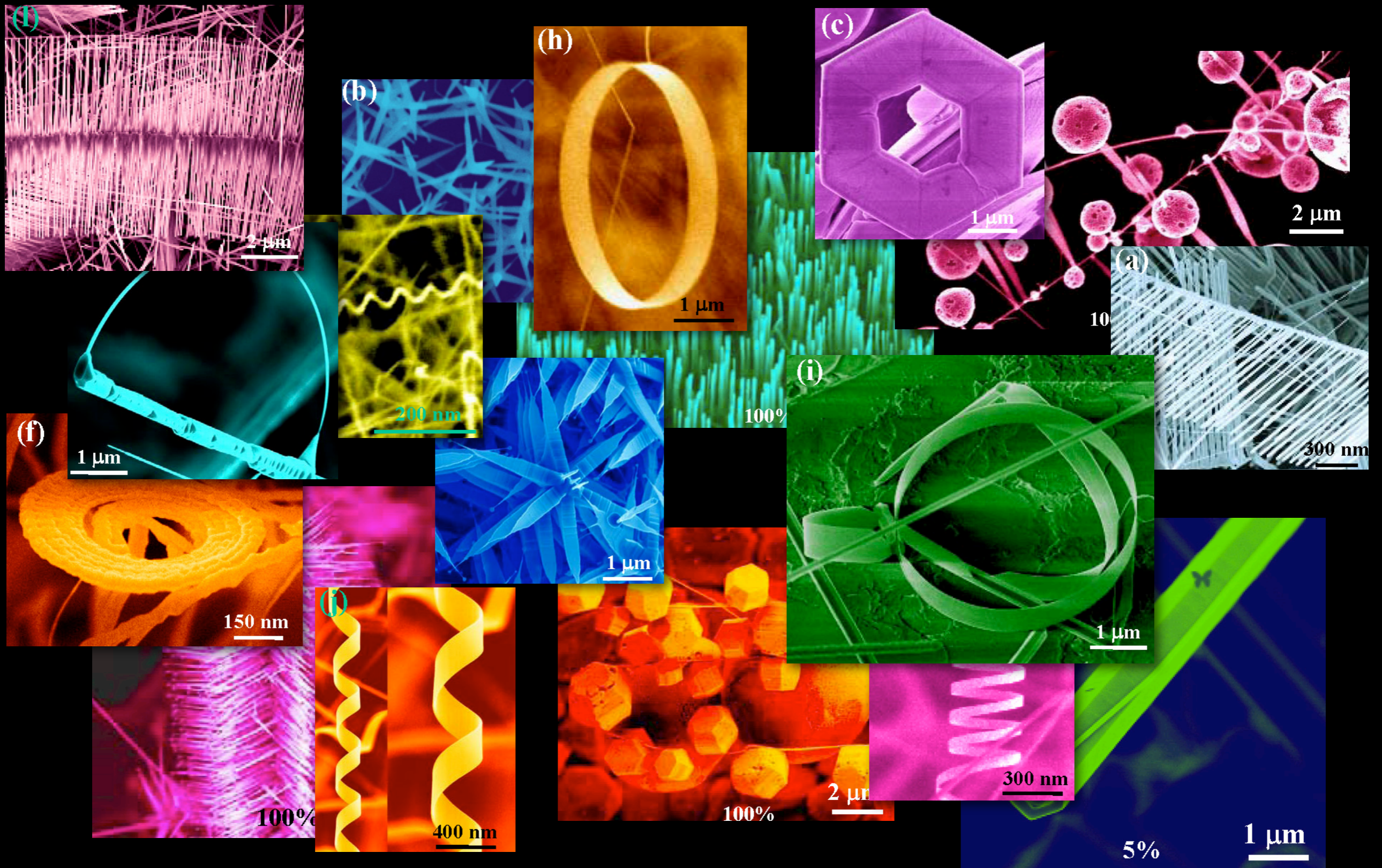
**Leavening**  
**Corn Thickeners**  
**Phosphates**  
**Salt**  
**Eggs**  
**Soda**  
**Soy Cellulose Gum**

**Sweeteners**  
**Polysorbate 60**  
**Whey**

**Water**  
**Food Coloring**  
**Calcium Sulfate**  
**Corn**  
**Sugar**

**Natural and Artificial Flavors**  
**Sorbic Acid**

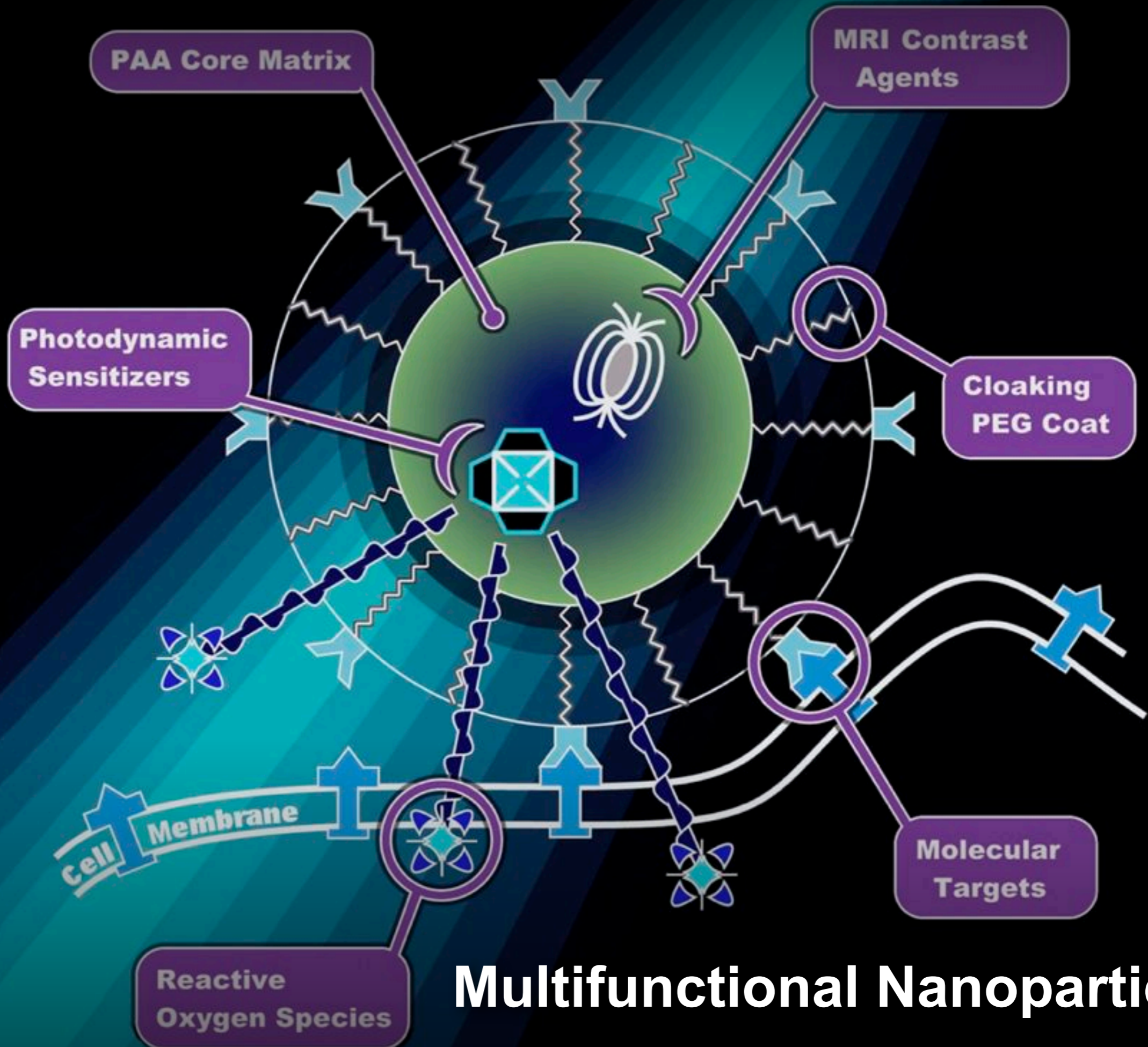




# Nano-ZnO

Courtney of Prof. Z.L. Wang, Georgia Tech





# Multifunctional Nanoparticles



**#2**

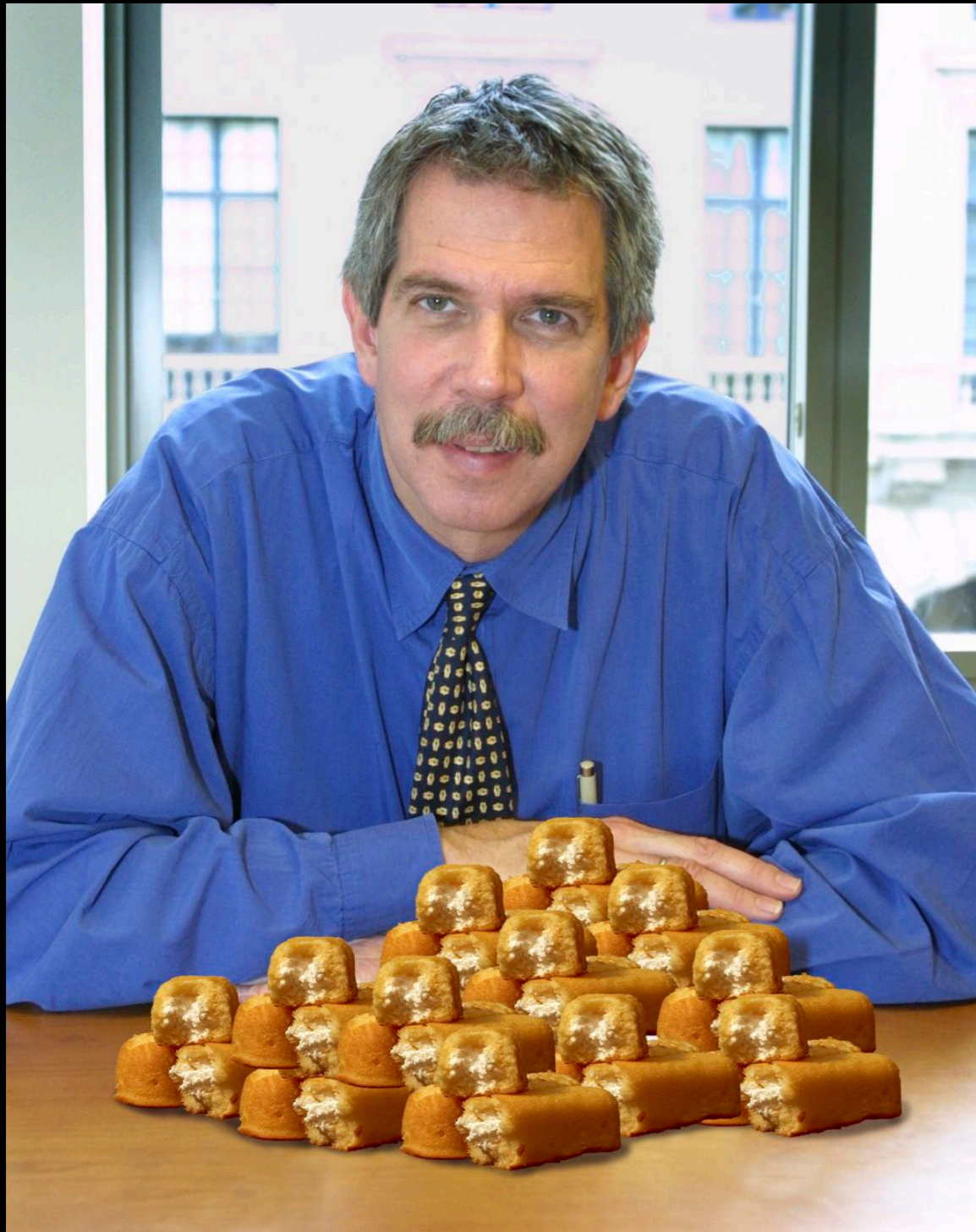
**Carpe Diem**





# David Rejeski

Director, Project on Emerging Nanotechnologies



**“I used to  
really love  
those things”**



# Nanoscale control:

Adding value to products

*I wish* my sunscreen wasn't so unsightly



*I wish* my socks didn't smell so much!



*I wish* my tennis racquet was lighter and stronger



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# Combating Radiation Sickness

Using carbon nanotubes

“More than half of those who suffer acute radiation injury die within 30 days, not from the initial radioactive particles themselves but from the devastation they cause in the immune system, the gastrointestinal tract and other parts of the body. Ideally, we’d like to develop a drug that can be administered within 12 hours of exposure and prevent deaths from what are currently fatal exposure doses of ionizing radiation...”

**Jim Tour**

Rice University

*Science Daily, Jan 29 2008*

<http://www.sciencedaily.com/releases/2008/01/080128084415.htm>



**#3**

**Too much of a  
good thing  
isn't always  
for the best**



# *Nano***RISK**

...potential for causing harm to  
humans and the environment



Size-specific behavior  
leads to the possibility  
for scale-unique  
risks

# Nanoparticles:

Getting to the places other particles cannot reach

*Nanoscale particles  
end up in the brain*



*Conventional particles  
end up in the lungs*



**#4**

**If it doesn't look good, it  
won't sell!**







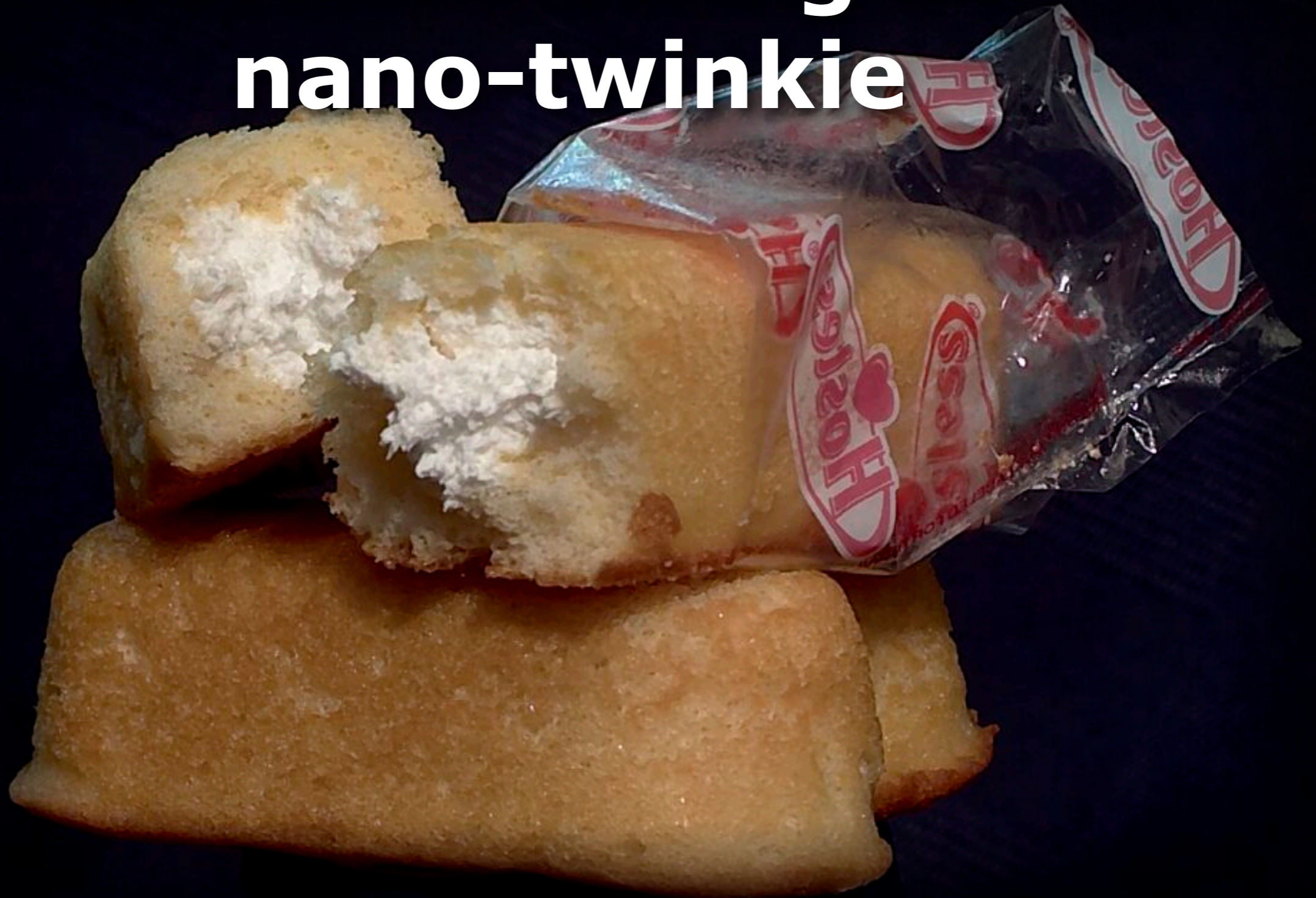
[www.chicagothong.org](http://www.chicagothong.org)

Topless Humans Organized for Natural Genetics (THONG)



**#5**

**Deconstructing the  
nano-twinkie**





# INGREDIENTS







**PROCESSING**





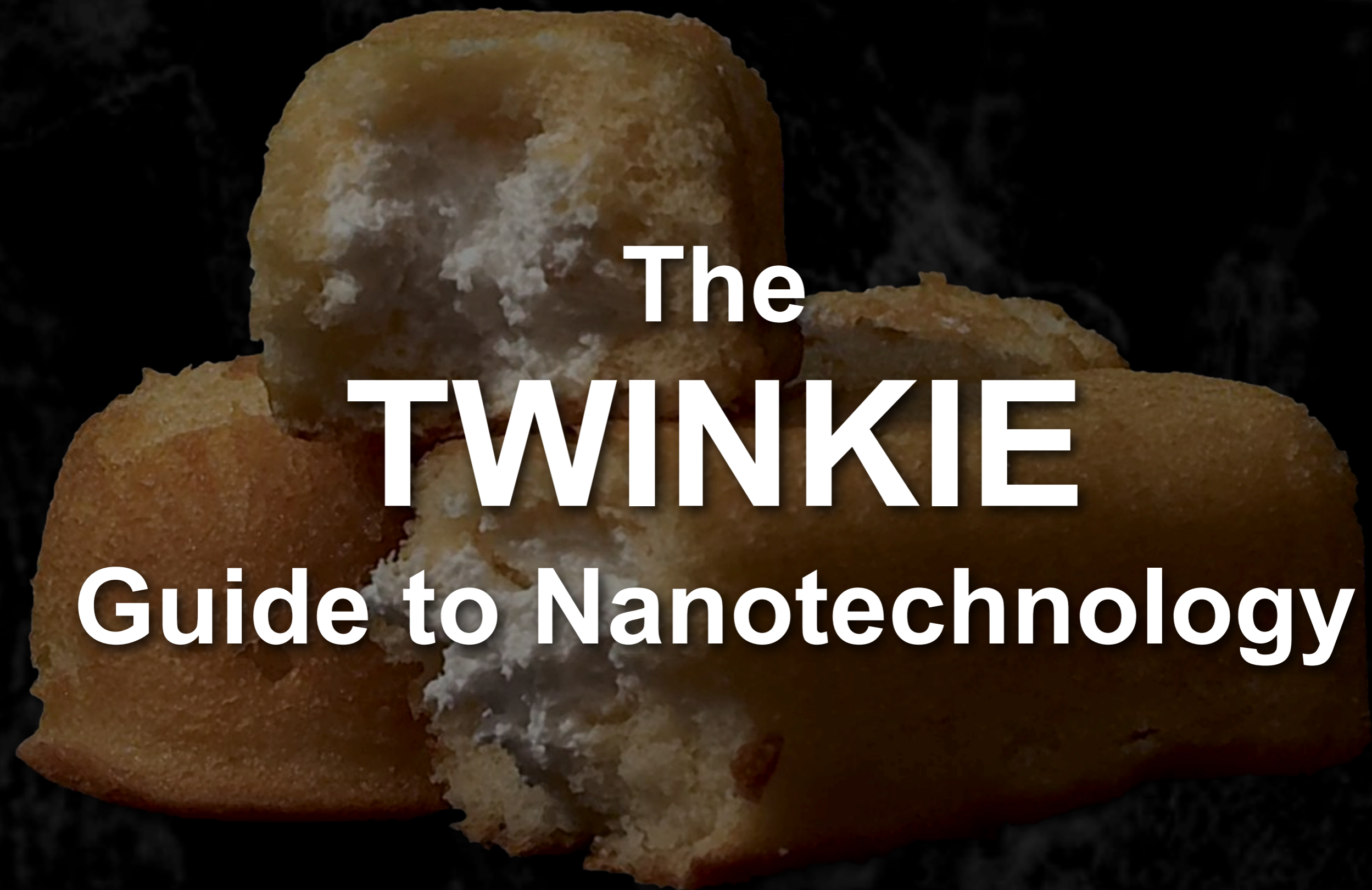
**SECURITY**



# PACKAGING







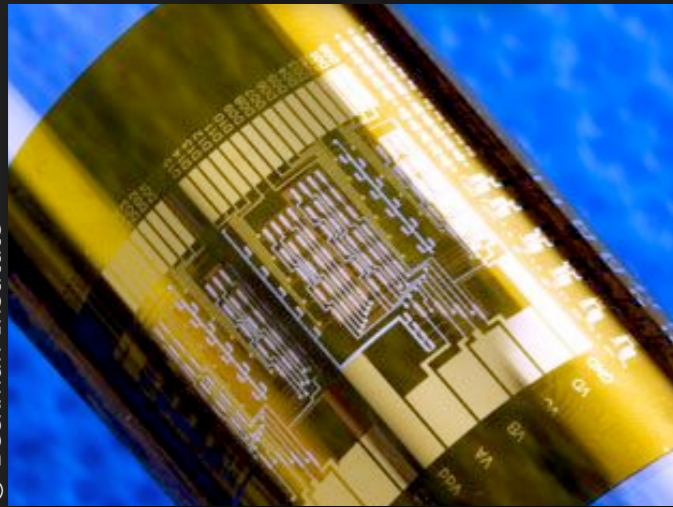
The

**TWINKIE**

**Guide to Nanotechnology**

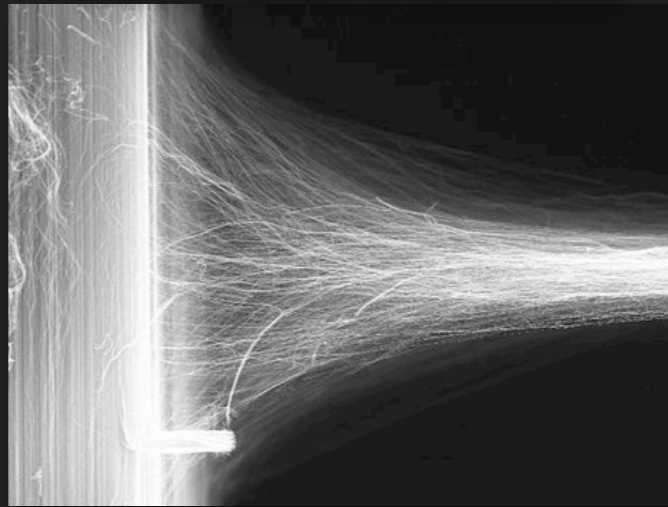


Electronics



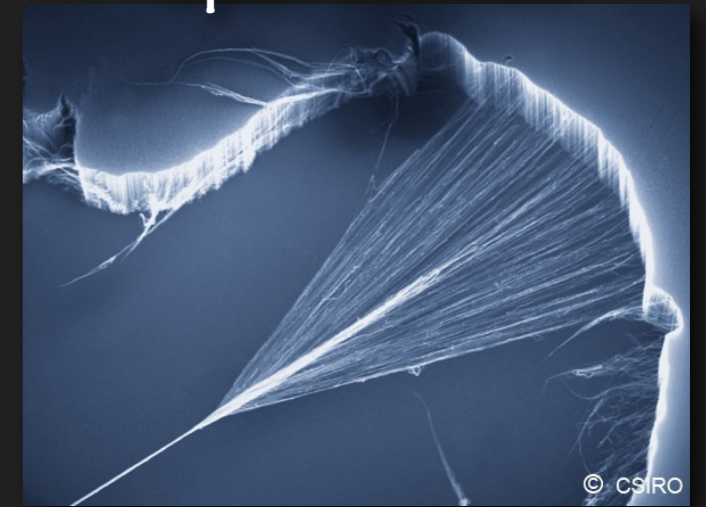
© Beckman Institute

Artificial muscles



blog.wired.com

Spun textiles



© CSIRO

Medicine



JPL

Ch



Desalination



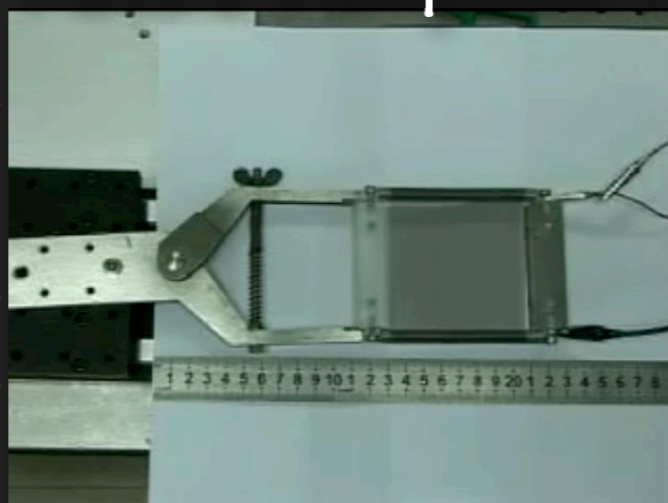
Scott

Strong materials



Easton

Flexible loudspeakers



Kaili Jiang, Tsinghua University

Space elevator



NASA

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Web: [www.nanotechproject.org](http://www.nanotechproject.org)

*Writing on emerging technologies at:*

*<http://2020science.org>*