Emerging Issues: Nanotechnology and Artificial Intelligence

CARe Emerging Issues 1

Brooklyn

June 5, 2018

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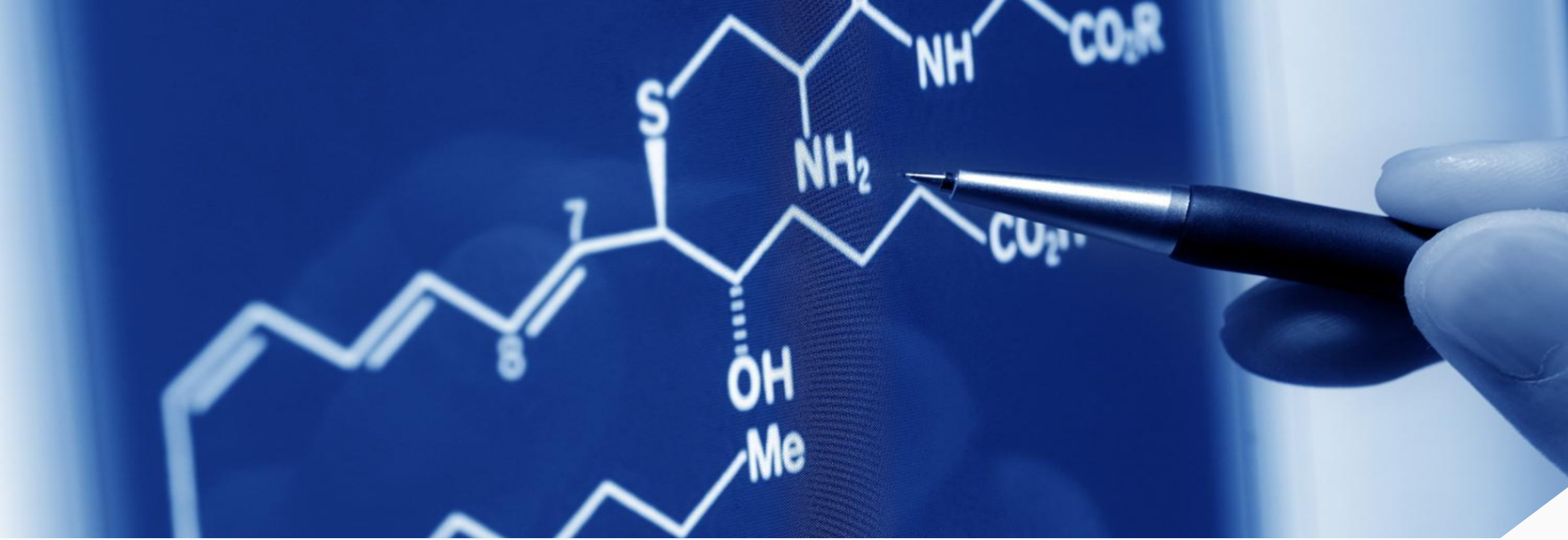

Nanotechnology
2018 CAS Seminar on Reinsurance
June 5, 2018
Brooklyn, NY

Gerry Finley, Senior Vice President,
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Underwriting Services
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Title

- Bullet Point 1
- Bullet Point 2
- Bullet Point 3
  - Sub-bullet point

Agenda

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- Definition
- Market - Key Technology of 21st Century
- Exposures/Loss Scenarios
- Legal and Regulatory Landscape
- Underwriting and Risk Management Considerations

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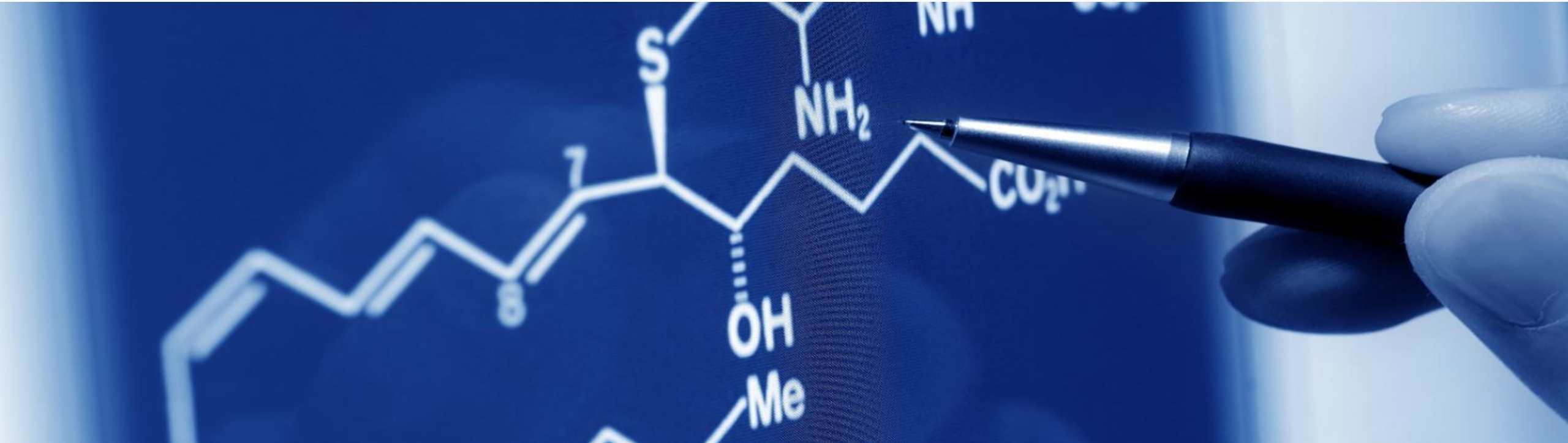
NANOTECHNOLOGY DEFINED



Nanotechnology
……Its Place in History

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Hunters and Gatherers – Nomadic; Unstructured

Agricultural Revolution – Provided the means to grow food; Basis for Societies and Civilizations

Industrial Revolution – Provided the means for producing material objects; mechanical systems; modern economy

Information Revolution – Provided the means to create, store, disseminate information and knowledge at increasing rates

Nanotechnology Revolution – Using all of the above will generate new means for producing material objects with quality and characteristics beyond prior capability

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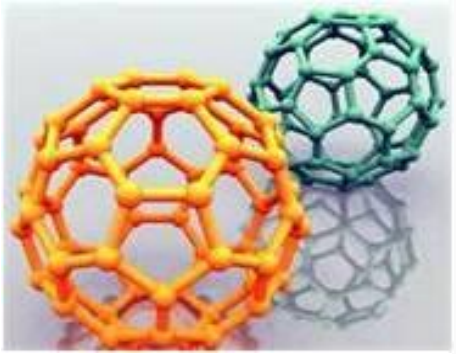
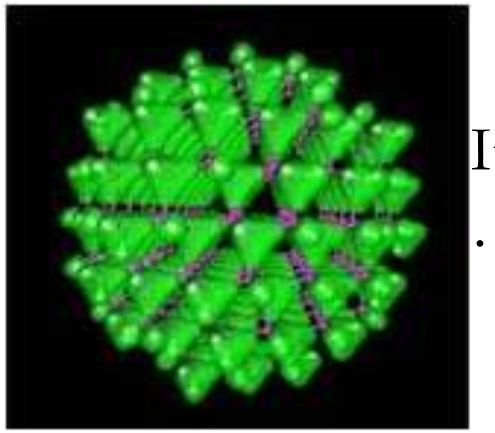
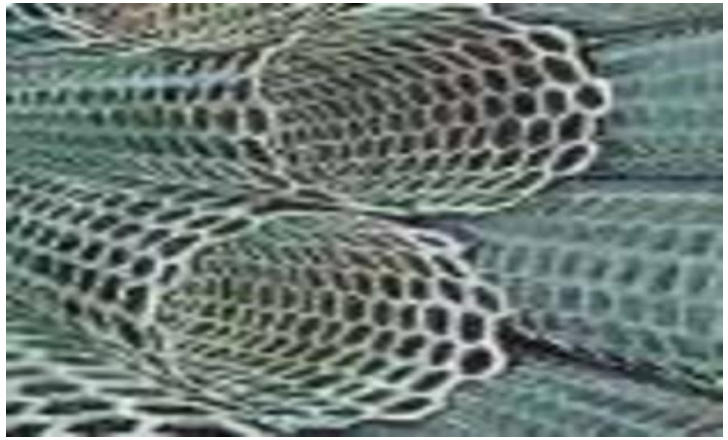
Nanotechnology …



Is the least discussed, most important Emerging Technology today.



It will redefine manufacturing ……
….and in the process touch every aspect of society…..



....for the most part making it better……
…...but not without risk

Image source: National Nanotechnology Initiative

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National Nanotechnology Initiative

- Nanotechnology is the understanding and control of matter at the nanoscale…..
  - at dimensions between approximately 1 and 100 nanometers (1 Billionth of a Meter),
  - where unique phenomena enable novel applications.

- Encompassing nanoscale science, engineering, and technology,
- Nanotechnology involves imaging, measuring, modeling and manipulating matter.

Image source: National Nanotechnology Initiative

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Comparative size chart

- A sheet of paper is about 100,000 nanometers thick
- Strand of human DNA is 2.5 nanometers in diameter
- 25,400,000 nanometers in one inch
- Human hair is about 80,000- 100,000 nanometers wide
- A single gold atom is about a third of a nanometer in diameter
- One nanometer is about as long as a fingernail or typical man's beard grows in one second

Source: NNI

What Does Smaller Mean

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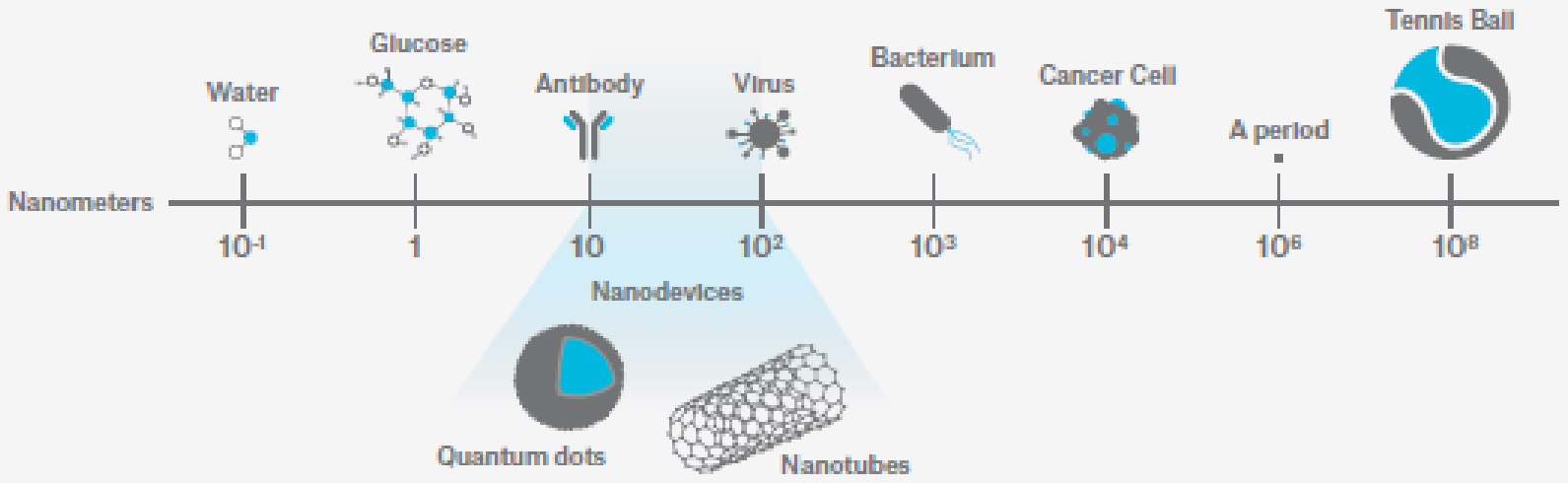
Enhances Existing Products…….Creates New Products

Nanoscale enables scientists to utilize the unique physical, chemical, mechanical, and optical properties of materials including :

Strength
Conductivity
Weight
Color
Durability
Capacity
Reactivity

Nano Scale



Source: nih.gov

Source: FDA 2013; nih.gov

Nanoparticle Categories

Categories	
Category 1	▪ Newly designed nanoparticles that are manmade rather than naturally-occurring ▪ e.g., polyacrylate
Category 2	▪ Nanoparticles that are manufactured industrially on the basis of time-proven manufacturing processes ▪ e.g., carbon black manufacture
Category 3	▪ Common vicariously created Nanoparticles (created by human activity and existing constantly and broadly) ▪ e.g., Automotive exhaust gas; domestic emissions, cigarette smoke
Category 4	▪ Naturally occurring nanoparticles ▪ e.g., smoke, volcanic ash

Using Chemistry, Biology, Physics, etc…

To Purposely
…..Create
..…Manipulate
…..Use
Nanomaterial…

To

Achieve Desired Outcomes..
…Create New Products…
…..Enhance Existing Products.

Understanding the Key Terms

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"Nanotechnology" = Totality of techniques used in the investigation, production, processing and use of …

"Nanomaterial" = Specific nano substance used in the manufacturing process leading to…

"Nanoproducts" = Products/Processes that contain knowingly manufactured or utilized functional nano components.

Nanotechnology Value Chain ……a Manufacturing Process

Nanomaterials	Nanotools	Nanoproducts
▪ Minimally processed ▪ Engineered nanostructures – e.g., quantum dots; silver; nanoparticles; nanotubes; polymers	▪ Intermediate products ▪ Incorporate nanomaterials or material constructed at a nanoscale	▪ Finished goods ▪ Incorporate nanomaterials or nanointermediates

Nanotechnology is a new industry that impacts many other industries…..
…… Making New Products Possible….and Existing Products Better

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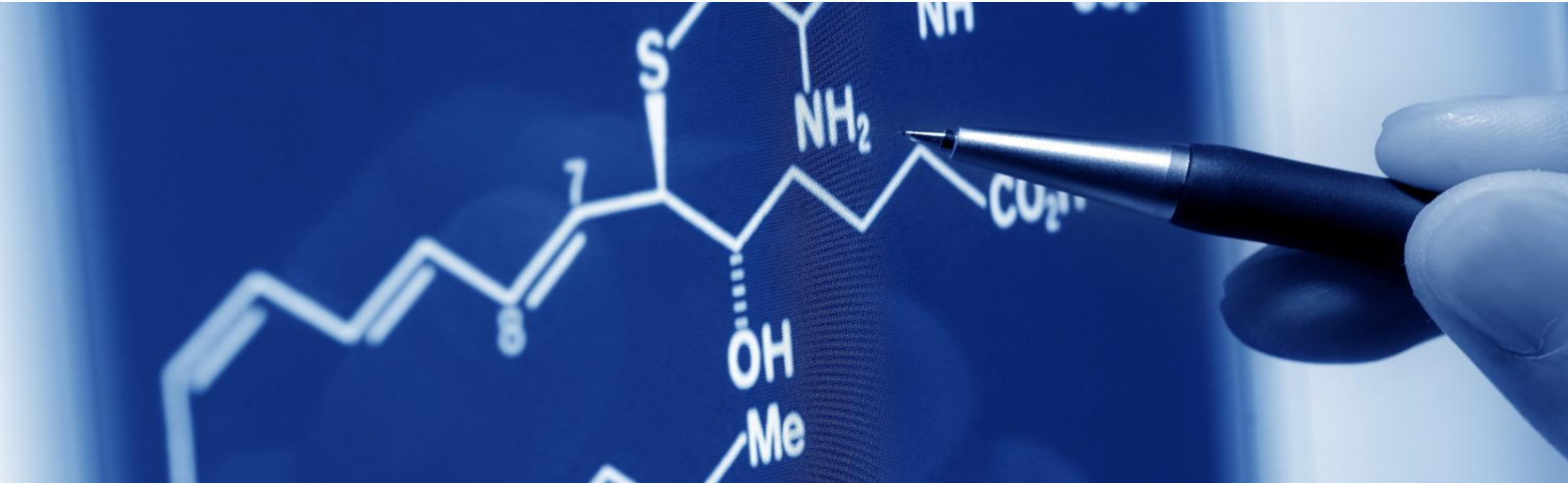
NANOTECHNOLOGY MARKET



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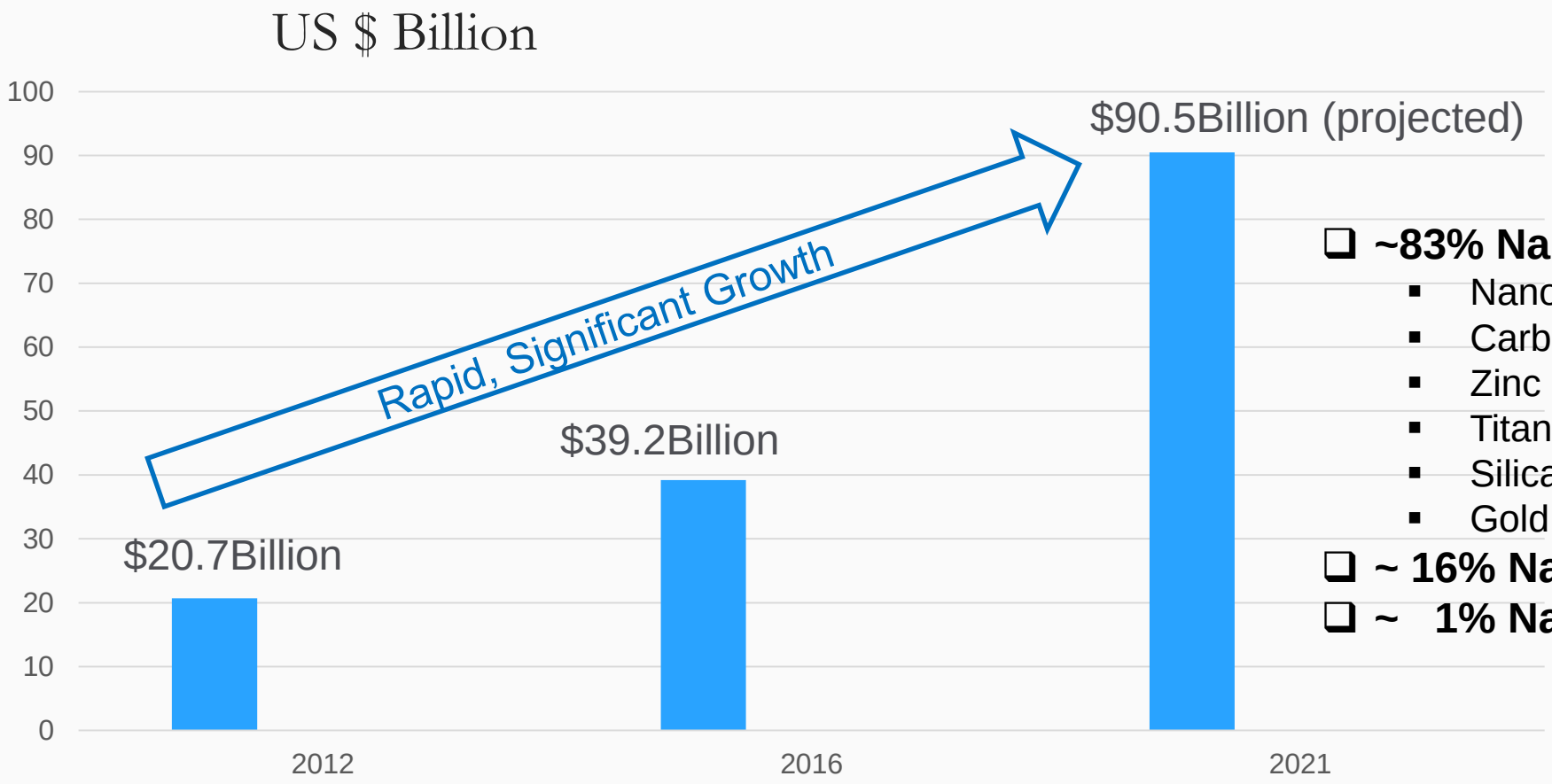
Global *Nanotechnology* Market, 2012-2021 (projected)



- ❑ **~83% Nanomaterials Manufacturing** :
  - Nano Silver
  - Carbon Nanotubes and Fullerenes
  - Zinc (incl. Zinc Oxide)
  - Titanium (incl. Titanium Dioxide)
  - Silica
  - Gold
- ❑ **~ 16% Nanotools**
- ❑ **~ 1% Nanodevises**

Source: BCC Research 1/17/17

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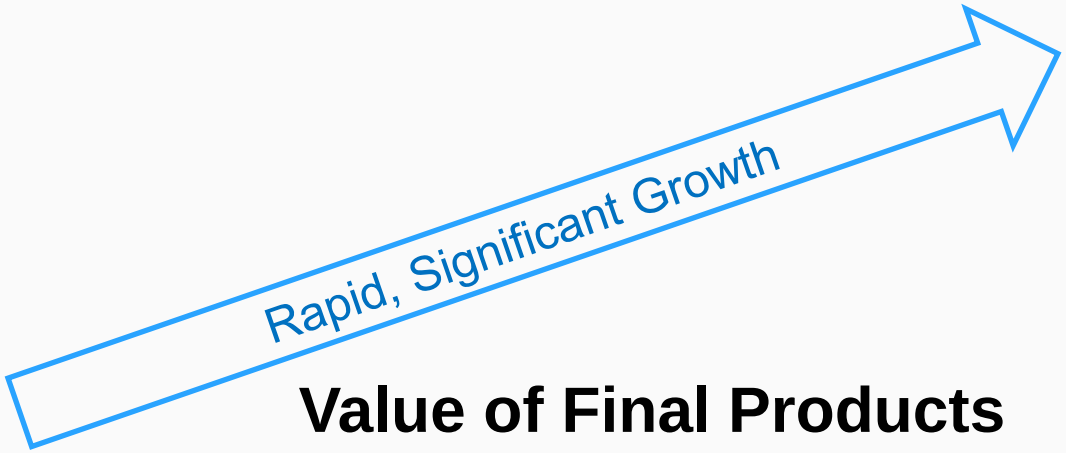
Nano-enhanced *Finished Products* 2012-2020 (Projected)



Value of Final Products
that include Nanotechnology

2012
$88 Billion

2020
$3.0 Trillion
Employ 2mm workers

(National Science Foundation)

Source: BCC Research

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Top 10 Countries: 2017 Nanotechnology Granted Patents With Growth From 2016

Rank	Country	Granted patents in USPTO	Granted patents in EPO	Growth of USPTO patents compared to 2016 (%)	Growth of EPO patents compared to 2016 (%)
1	USA	4725	669	9.48	15.94
2	South Korea	1044	166	14.22	58.10
3	Japan	733	265	-10.50	40.96
4	China	524	64	25.96	8.47
5	Taiwan	490	15	-4.67	-21.05
6	Germany	378	354	25.58	22.49
7	France	235	236	11.90	13.46
8	UK	144	89	17.07	9.88
9	Netherlands	122	69	-10.29	-2.82
10	Canada	119	29	12.26	31.82

USTPO:
US Trade & Patent Office

EPO:
European patent Office

http://statnano.com/news/62082

The Global Nature of Nanotechnology Intellectual Property

Nanotechnology Research Activity

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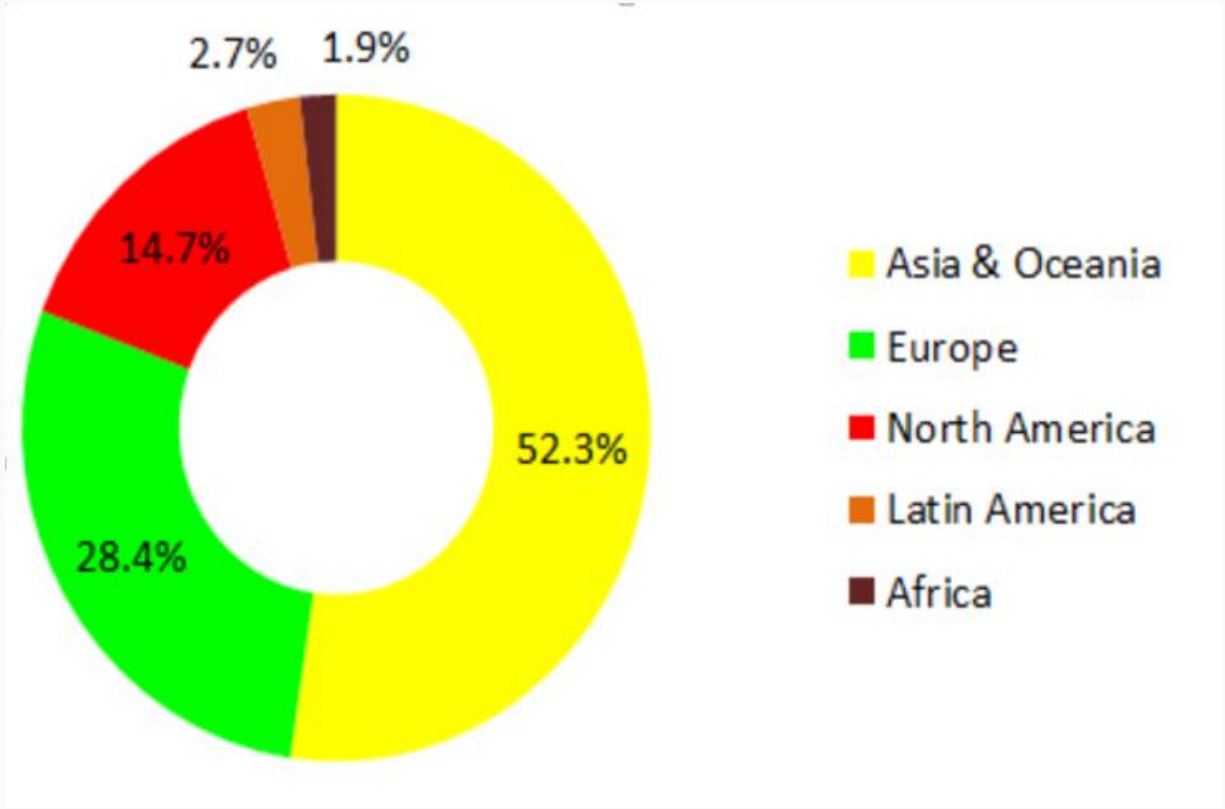
Top 15 Countries @2016
Based on Published Nano Research Papers

Rank	Country	Nano-articles	Share (%)
1	China	47,455	34.51
2	USA	22,337	16.25
3	India	11,066	8.05
4	South Korea	8,386	6.1
5	Germany	7,963	5.79
6	Iran	7,583	5.52
7	Japan	6,952	5.06
8	France	5,313	3.86
9	UK	5,038	3.66
10	Spain	4,178	3.04
11	Russia	4,124	3.0
12	Italy	3,901	2.84
13	Australia	3,406	2.48
14	Canada	3,018	2.19
15	Taiwan	2,831	2.06

Regional Distribution @2016
Of All Published Nano Research Papers



Source: http://statnano.com/news/57105

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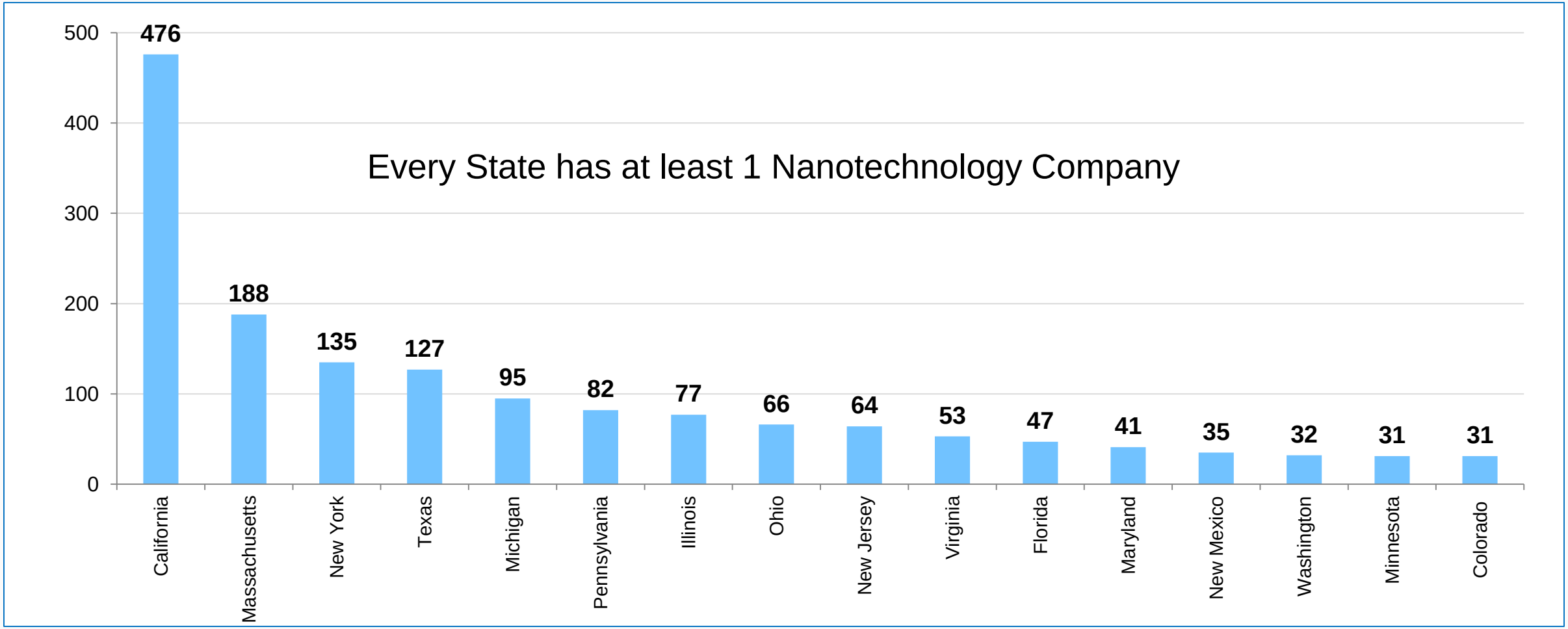
Top 15 states with Nanotechnology Companies - 2014



Source: Nano Science and Technology Institute - As of August 2014

Examples of Nanotechnology Use

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Current Specific Nano uses - A sample list (growing daily)

Automotive Lightweight construction; catalysts and painting, tire sensors, windshield and body coatings	**Chemical** Fillers for paints, composite materials, impregnation of papers, adhesives, magnetic fluids
Construction Materials, insulation, flame retardants, surface coatings, mortar	**Cosmetics** Sunscreen, lipsticks, skin creams, toothpaste
Electronics Displays, data memory, laser diodes, fiber optics, optical switches, filters, conductive and antistatic coatings	**Energy** Lighting, fuel cells, solar cells, batteries, capacitors
Engineering Protective coatings for tools and machines, lubricant-free bearings	**Environmental** Environmental monitoring, soil and ground water remediation, toxic exposure sensors, fuel changing catalysts, green chemistry
Food and Drink Packaging, storage life sensors, additives, juice clarifiers	**Household** Ceramic coatings for irons, odor removers, cleaners for glass, ceramics and metals
Medicine Drug delivery systems, contrast medium, rapid testing systems, prostheses and implants, antimicrobial agents, in-body diagnostic systems	**Sports** Ski wax, tennis rackets, golf clubs, tennis balls, antifouling coatings for boats, antifogging coatings for glasses and goggles
Textiles Surface coatings, "smart" clothes (anti-wrinkle, stain resistant, temperature controlled)	**Warfare** Neutralization materials for chemical weapons

Source: Project on Emerging Nanotechnologies in the Science and Technology Innovation Program at the Woodrow Wilson International Center for Scholars, in collaboration with the Virginia Tech Center for Sustainable Nanotechnology.

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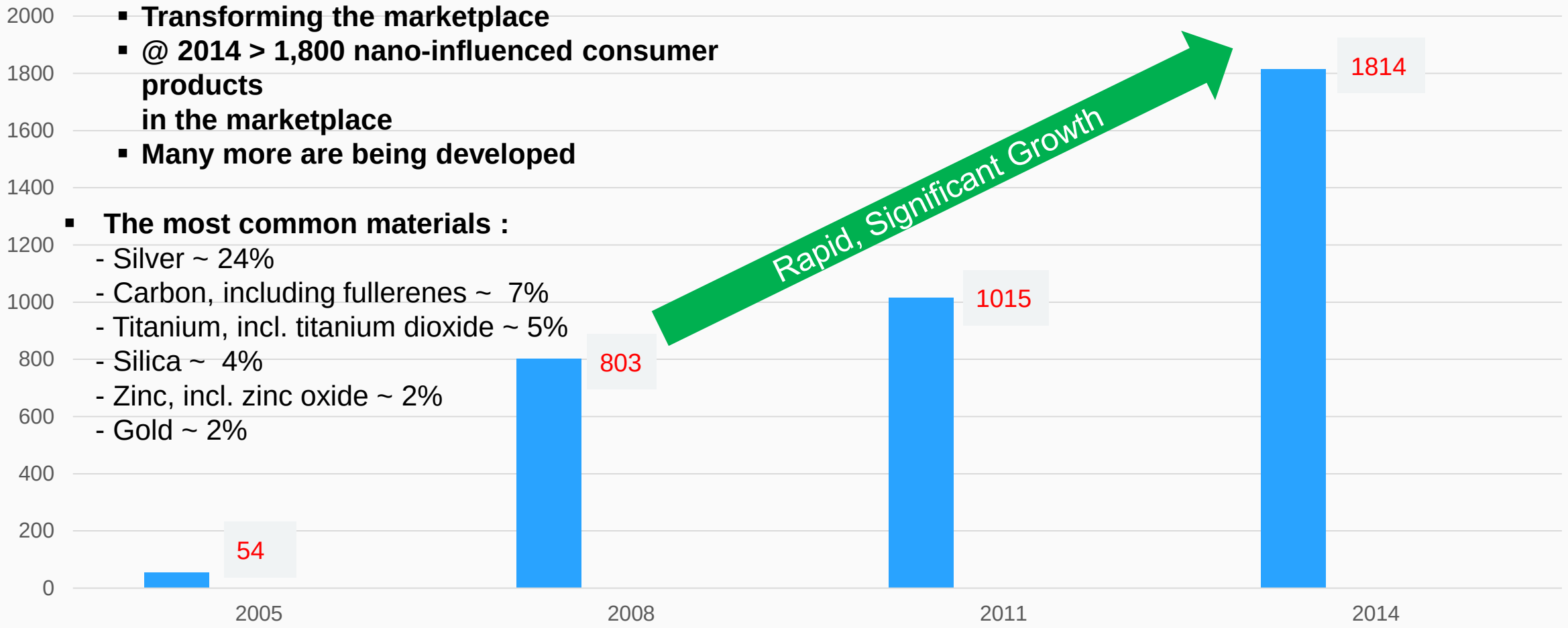
Market Scope : Consumer Products Growth (as of 2014)

- **Transforming the marketplace**
- **@ 2014 > 1,800 nano-influenced consumer products in the marketplace**
- **Many more are being developed**

- **The most common materials :**
  - Silver ~ 24%
  - Carbon, including fullerenes ~ 7%
  - Titanium, incl. titanium dioxide ~ 5%
  - Silica ~ 4%
  - Zinc, incl. zinc oxide ~ 2%
  - Gold ~ 2%



Beilstein Journal of Nanotechnology "Nanotechnology in the real world: Redeveloping the nanomaterial consumer products inventory" August, 2015

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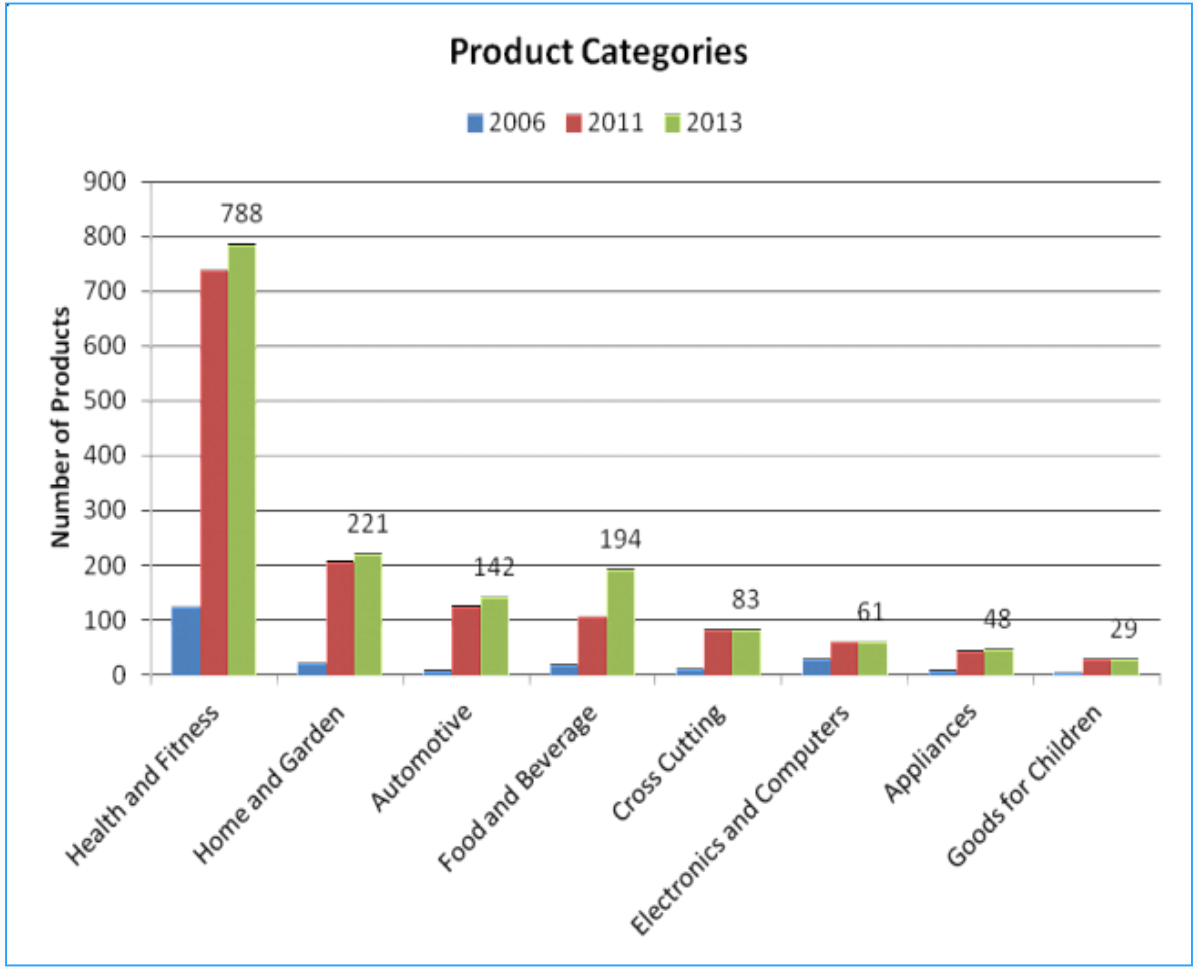
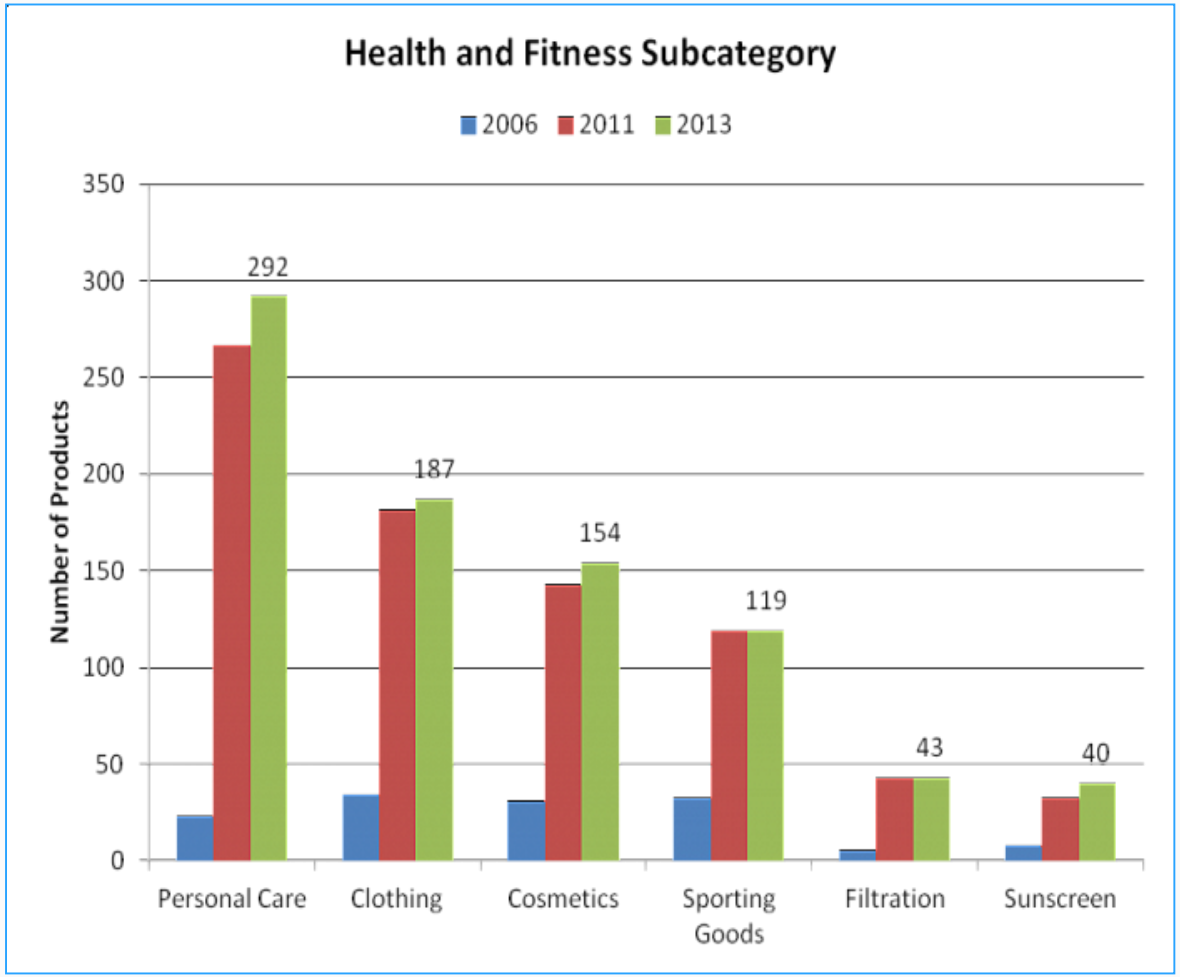
Health and Fitness Products (as of October, 2013)





Project for Emerging Technologies, October, 2013 (nanotechproject.org)

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Food and Beverage……Greatest Consumer Growth

- **Packaging Keeps Food Fresher Longer**
- **Make More Affordable**
- **Deliver/Protect Nutrients**
- **Detect Pathogens ….**

http://commons.wikimedia.org/wiki/File:Kool-Aid.svg

http://creativecommons.org/licenses/by-sa/3.0/

http://commons.wikimedia.org/wiki/File:Chocolate_cake_with_chocolate_frosting_topped_with_chocolate.jpg

http://commons.wikimedia.org/wiki/File:Plain-M%26Ms-Pile.jpg

http://commons.wikimedia.org/wiki/File:Rainbow-Jello-Cut-2004-Jul-30.jpg

Consumer Product
……An Example: Food

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Oh No……Burgers and Donuts too!!!!!!!

Titanium Dioxide
Commonly Used Additive

Major companies removing titanium Dioxide from their products include:

- Kraft-Heinz,
- McDonalds,
- Dunkin Donuts
- Mars Candy

Center for Food Safety *Wednesday Mar 7th, 2018*
https://www.indybay.org/newsitems/2018/03/07/18807226.php

http://commons.wikimedia.org/wiki/File:Custard_doughnut.jpg

Consumer Product
……An Example: Food

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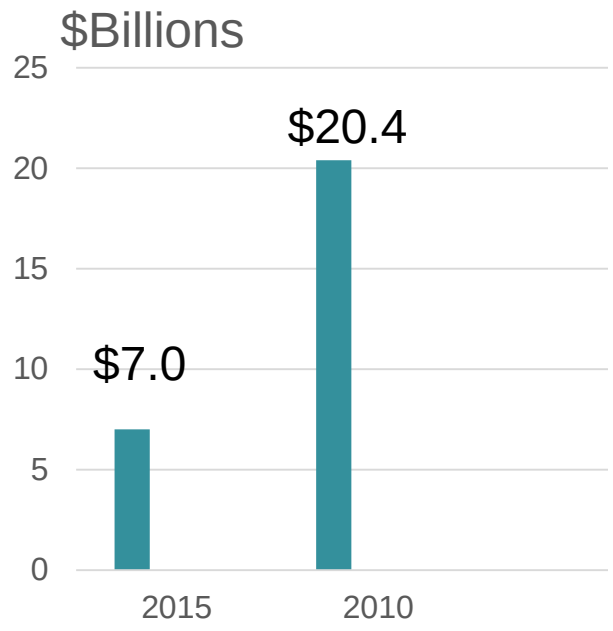
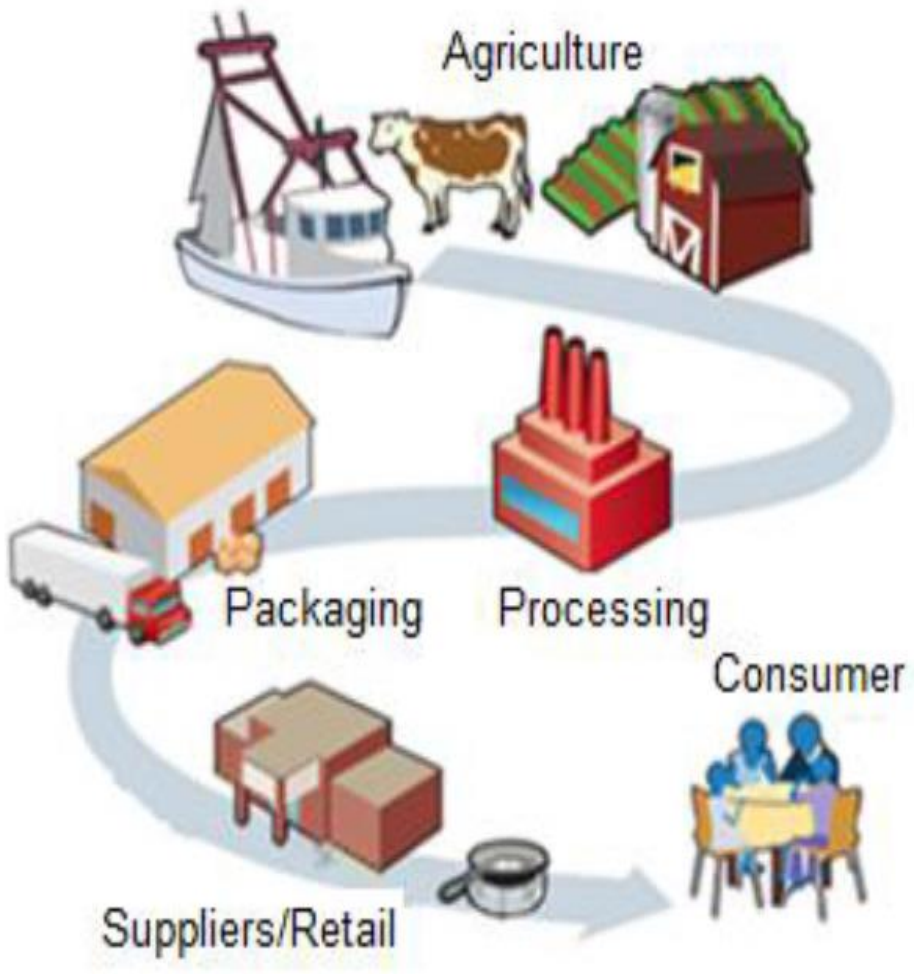
The Process

Nanotechnology Food Industry use….

….Expected to Triple:





AGRI

- Pesticide
- Fertiliser

FOOD

- Food additive
- Food contact material
- Novel food
- Flavouring
- Enzyme
- Supplement
- Food ingredient (not specified)

FEED

- Feed additive
- Enzyme
- Supplement

OTHER

- Veterinary drug
- Biocide

https://www.newfoodmagazine.com/article/42338/nanotechnology-food-industry-plenty-room-innovate/

Center for Food Safety *Wednesday Mar 7th, 2018* https://www.indybay.org/newsitems/2018/03/07/18807226.php

Commercial Products
……An Example: Construction

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Enhance Material Properties and Energy Conservation

Cement, Concrete, Steel

- ❑ Lighter,
- ❑ Stronger,
- ❑ More Durable,
- ❑ Self Healing,
- ❑ Air Purifying,
- ❑ Fire Resistive,
- ❑ Easy to Clean
- ❑ Nanotechnology in the Walls – Enhanced Insulation

Carbon Nanotubes and Diamond Taller Nano Threads ……
……Enable Taller Buildings that Dwarf current Skyscrapers

The Building Sector is responsible for 40% of global energy use and climate gas emissions.

Coatings

Prevent Graffiti

Glass/Windows

"Smart Windows": Multifunctional

- ❑ Energy Saving,
- ❑ Easy Cleaning,
- ❑ UV Controlling,
- ❑ Photovoltaic Solar Panels in Roof and Walls

Sustainable "Green" Construction
Nanotechnology: Essential in the bringing it to a broad-based reality

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Highly Efficient Solar Power Conversion Allowed By a Novel Composite Material

Composite thin film development improves solar cells' power conversion efficiency significantly

Québec, Canada | Posted on April 10th, 2018 Nanotechnology Now http://www.nanotech-now.com/news.cgi?story_id=55069

Commercial Products
…..An Example: Battery Technology

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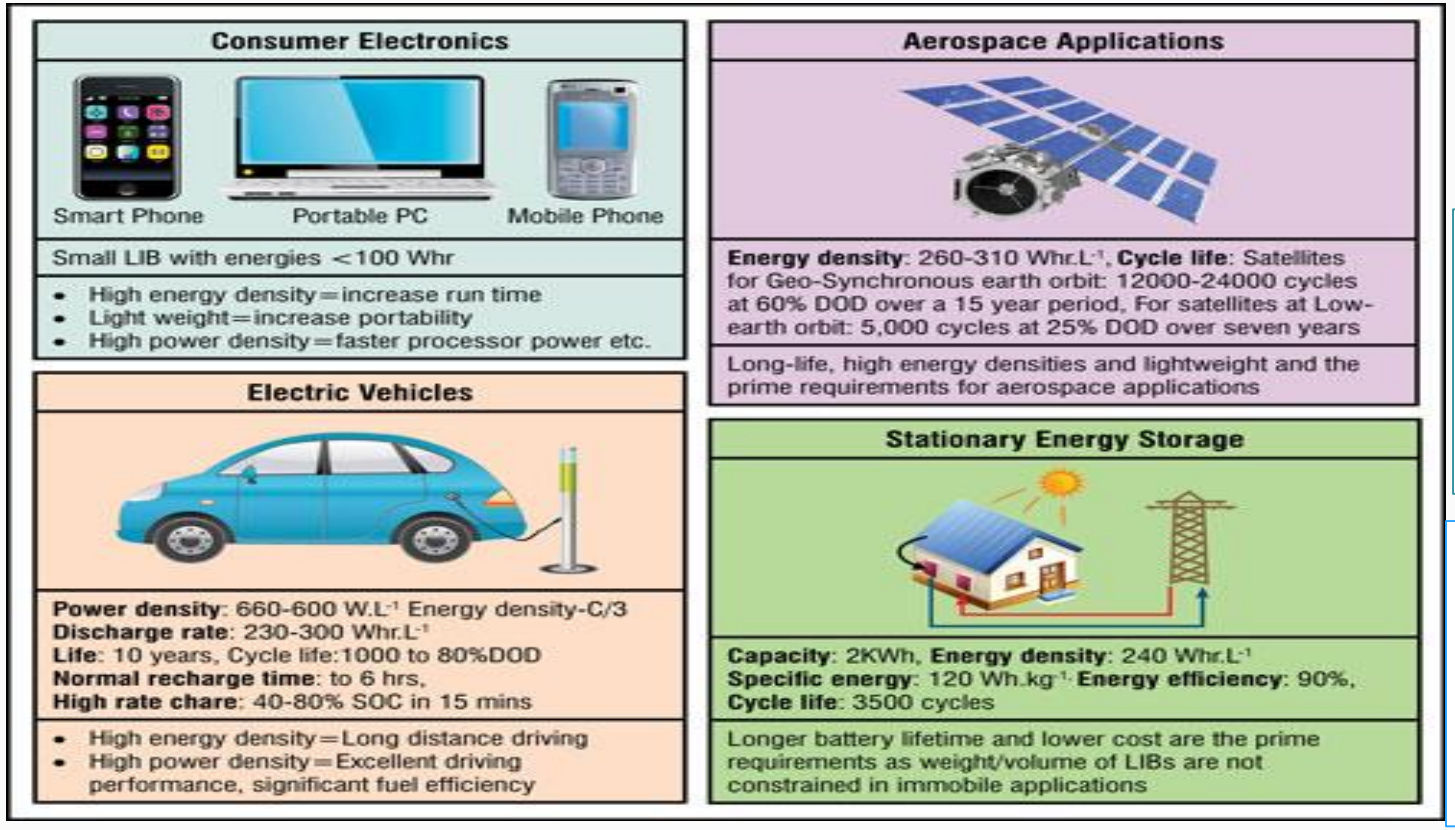
Lithium Ion Batteries: Despite some Risks and Past Problems (e.g., Hover Boards)



Lithium Ion batteries - Highest Ratio: Electrical Storage Capacity/Weight
(one unit of LIB can replace two nickel-hydrogen battery units).

LIBs used in many sectors:
- Consumer gadgets (e.g., Hover Boards),
- Electric cars,
- Medical devices,
- Space & Military (use LIBs as portable power sources)

Nanotechnology –enabled Battery Market…
….. Compound Annual Growth Rate 2018-2022
17.35%

Market Insights Reports – *Global Nanotechnology-enabled Battery Market 2018-2022*
https://theanalystfinancial.com/143435/nanotechnology-enabled-battery-market-to-grow-at-a-cagr-of-17-35-2018-to-2022/

LIBs suitable for applications requiring both high energy density and power density

Image credit: *Nanowerk Spotlight*) Posted: Jun 18, 2014
Basic LIB characteristics required for different applications 1,2 (DOD: Depth of Discharge, SOC: State of Charge). (click on image to enlarge)

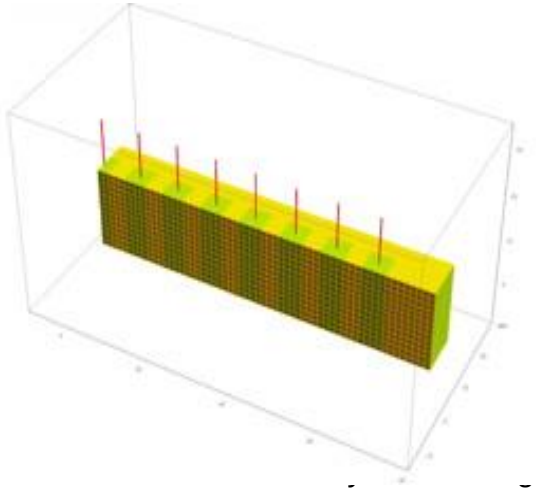
Commercial Products
…..An Example: 3D and 4D Printing

3D / 4D Printing has the potential to change the face of Manufacturing

……..“Personal/Customized” Manufacturing

…….Made possible by Nanotechnology.

Hybrid Material being Developed…potential for 4D Printed Adaptive Devices



December

$550b P/Y Economic Impact by 2025

(McKinsey Global Institute, Disruptive Technologies, 2013)

Picture Source: Wikimedia http://commons.wikimedia.org/wiki/File:3D_Model_Workshops.jpg

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Car Manufacturers: Using Nanotechnology to develop Selfdriving cars

."Selfdriving Cars Popular by Mid-century" as reported by NBC News, Jan, 2014

Source: US DOT

Current Vehicles Have Many

Autonomous Features

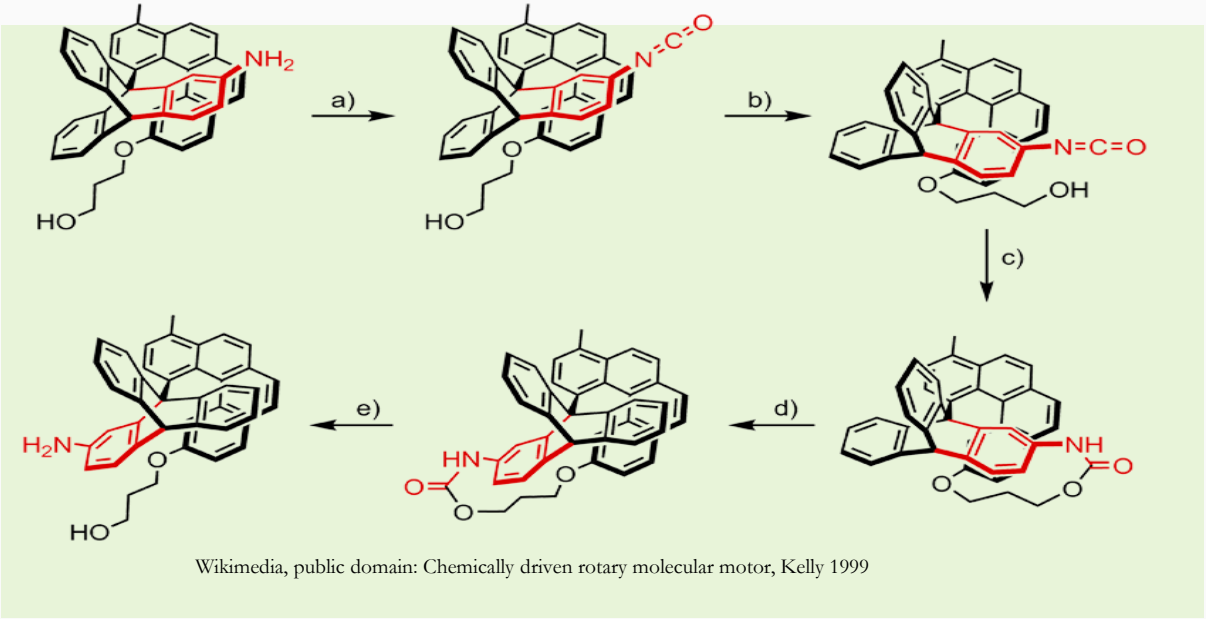
Becoming
More Autonomous
Every Year

Commercial Products
……An Example: Electric Motors

World's Smallest Electric Motor Made from a Single Molecule

ScienceDaily (Sep. 4, 2011)

"Chemists at Tufts University's School of Arts and Sciences have developed the ***world's first single molecule electric motor,*** *a development that may potentially* ***create a new class of devices that could be used in applications ranging from medicine to engineering."***



Wikimedia, public domain: Chemically driven rotary molecular motor, Kelly 1999

e.g., Sensing Medical Devises; Drug Delivery; Cell Phones, etc.

"In research published online Sept. 4 in Nature Nanotechnology, the Tufts team reports an electric motor that measures a mere 1 nanometer across, groundbreaking work considering that the current world record is a 200 nanometer motor."

Source: Tufts University. "World's smallest electric motor made from a single molecule." *ScienceDaily*, 4 Sep. 2011. Web. 16 Jul. 2012.

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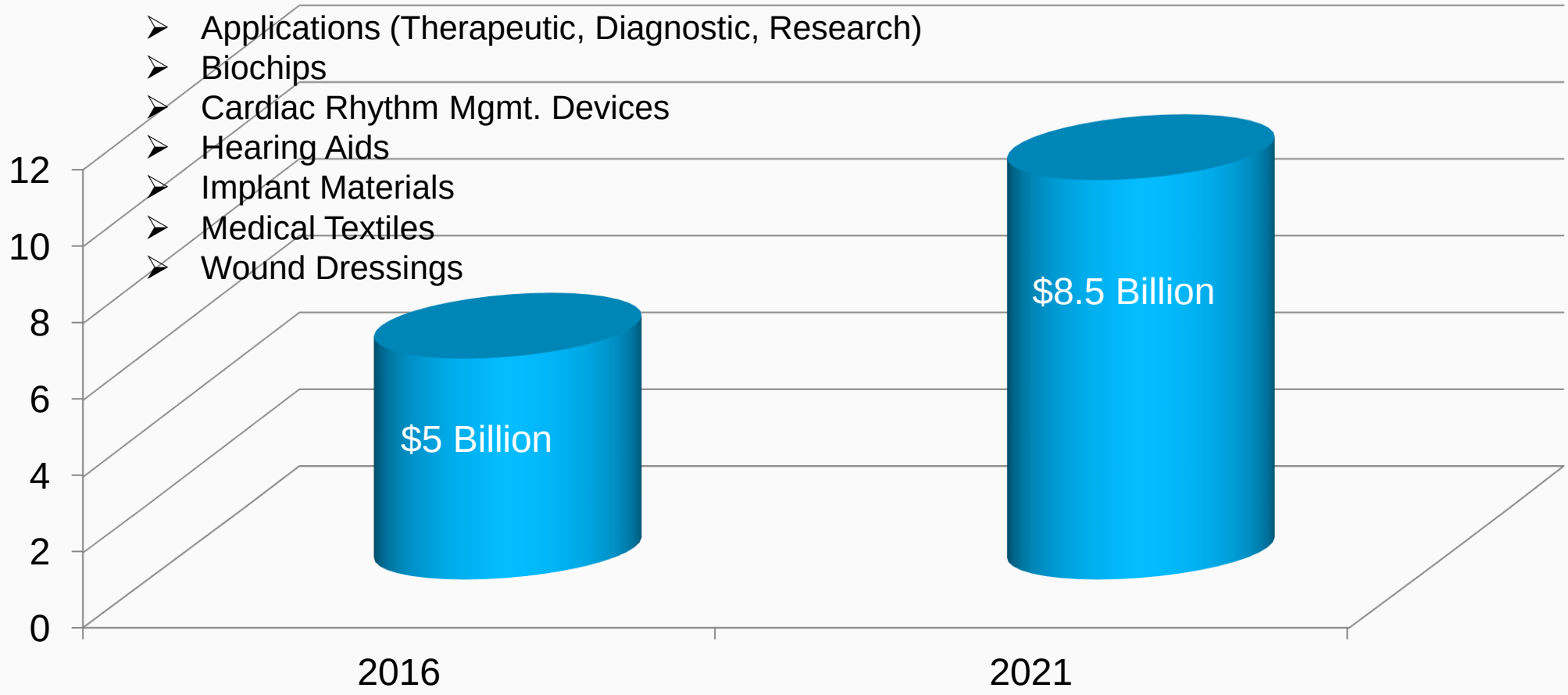
Nanotechnology in Medical Devices



https://www.marketdataforecast.com/market-reports/global-nanotechnology-in-medical-devices-market-325/

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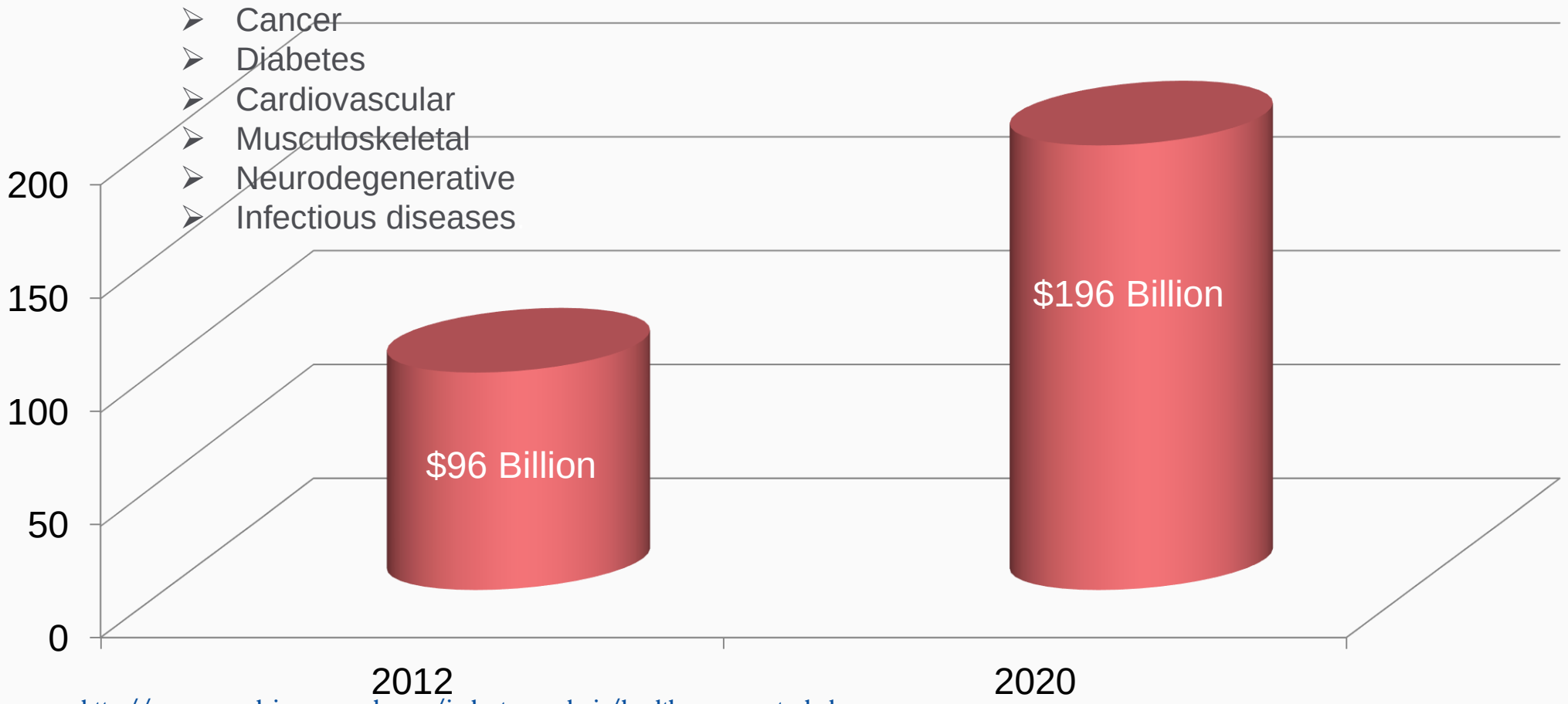
Healthcare Nanotechnology



http://www.grandviewresearch.com/industry-analysis/healthcare-nanotechology

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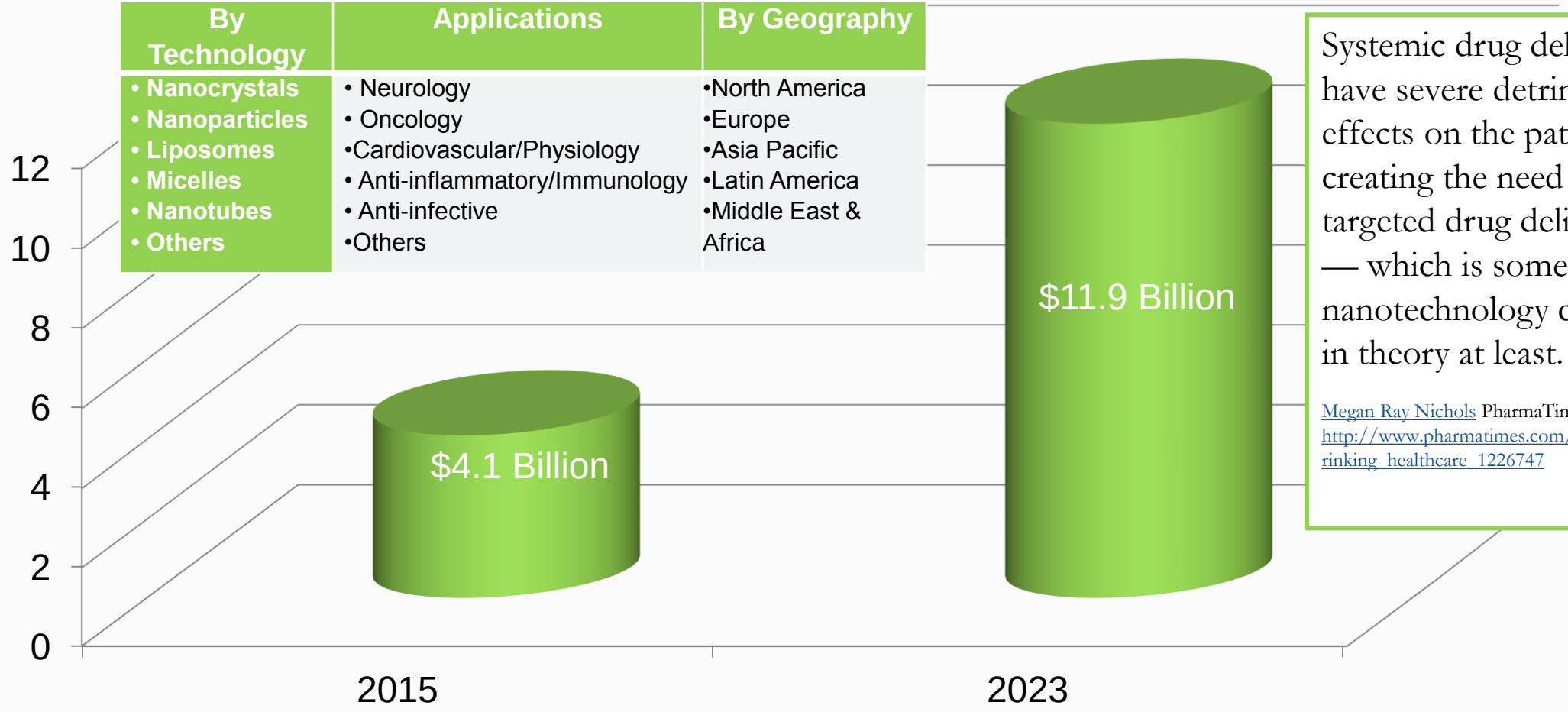
Nanotechnology Drug Delivery

By Technology	Applications	By Geography
• Nanocrystals • Nanoparticles • Liposomes • Micelles • Nanotubes • Others	• Neurology • Oncology •Cardiovascular/Physiology • Anti-inflammatory/Immunology • Anti-infective •Others	•North America •Europe •Asia Pacific •Latin America •Middle East & Africa



Systemic drug delivery can have severe detrimental effects on the patient, creating the need for targeted drug delivery — which is something nanotechnology can deliver, in theory at least.

Megan Ray Nichols PharmaTimes
http://www.pharmatimes.com/web_exclusives/shrinking_healthcare_1226747

https://www.transparencymarketresearch.com/nanotechnology-drug-delivery.html

The Future
…..Some Recent Headlines – Nano Medical

- "First Step to Help Preserve Organs Survive Deep Freeze" (Associated Press 3/2/17)
- "Nanotechnology delivers chemotherapy to prostate cancer cells" (Cancer News 1/10/12)
- "How Nanotechnology Can Help Detect Disease Earlier" (ScienceDaily 5/22/12)
- "Delivering Drugs via Skin Moisturizers" (Science Blog 7/3/12)
- "Researchers use nanotech to make cancer 3mm times more detectable" (Computerworld [illegible])
- "Nanotechnology Shows Potential in Fighting Mesothelioma" (PRWEB, November 19, 2013 usa.gov/1gJGL8A)
- "Researchers Developing New Nanotechnology for Medical Use" (Digital Journal/Technology, October, 13, 2013)
- "New Nanotechnology Application for Difficult to Treat Cancers" (Nanowerl News 5/10/17)
- "Nanotechnology May Provide faster Way of Diagnosing Type 1 Diabetes" (Diabetes in Control.com, Stanford University, 7/25/14)
- "Nanotechnology…Possible …Delivery Solution for Multiple Sclerosis (Health care Professionals Network , USC 8/2/14
- "Exploring Nanotechnology in HIV Drug (Specialty" Pharmacy Times 10/28/16)
- "Nanotechnology & Math Deliver 2 in 1 punch for Cancer Therapy Resistance" (ACS Nanorecnology Journal 6/3/16)
- "Nanotechnology Can be a Powerful Treatment for Brain Tumors…(EDT Science World Report 5/25/16)
- "New Skin patch Dissolves Love Handles and Boosts Metabolism (Pulse Headlines 9/16/17)
- Nanotechnology takes steps towards artificial retinas (https://www.nanowerk.com/spotlight/spotid=49959.php)

Medical Nanotechnology…..
…….3 Areas of Research

- Heart Disease
- Fertility
- Cancer

(Investing News Network January 17, 2016)

The Future
…..Some Recent Headlines …..Nano Medical

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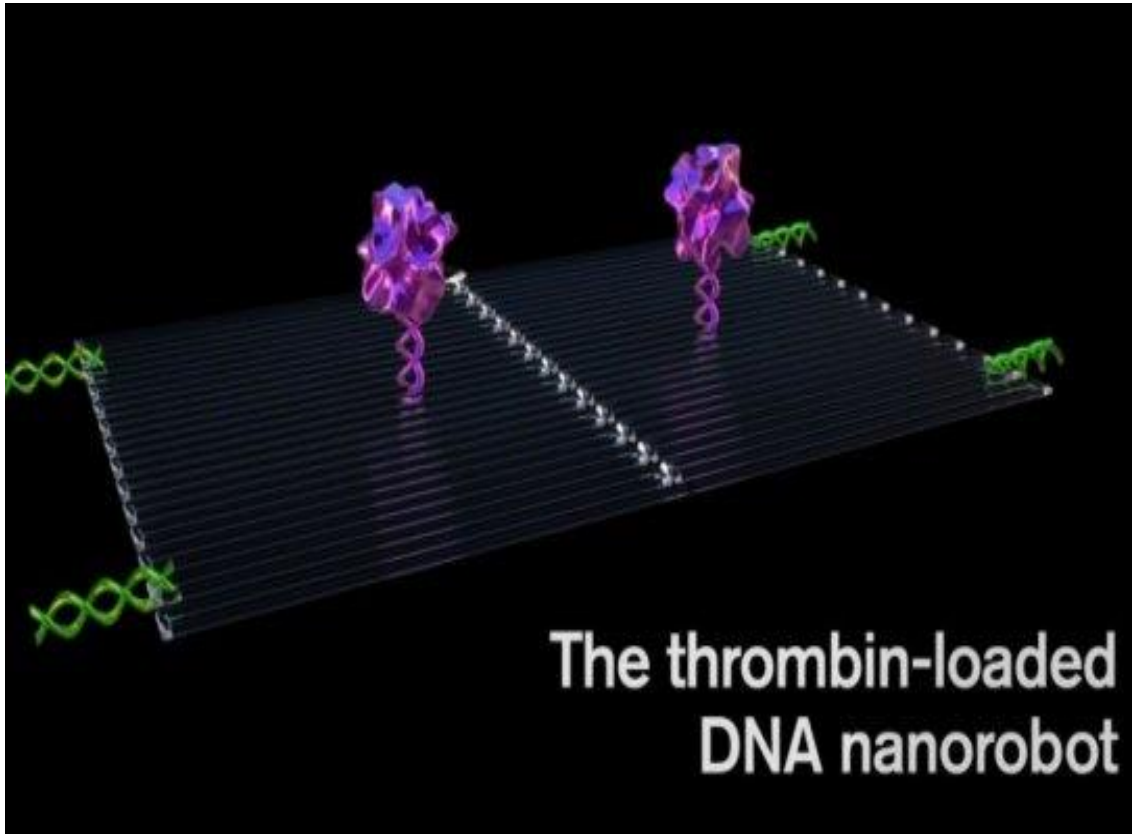
Major Advancement in Cancer Treatment .

Nanorobots successfully programmed to shrink Cancer tumors by cutting off their blood supply.

(February 12, 2018 Science Daily ttps://www.sciencedaily.com/releases/2018/02/180212112000.htm)



Clothing Treated with Nanoech will Treat Eczema

Embedded in clothes nano-capsules release oils when they contact bacteria that causes skin infections.

(https://phys.org/news/2017-07-intertwined-nanotech-eczema.html)

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Nanotechnology Improves Alzheimer's Disease Drug Delivery.

/

PEG Nanoparticles And Memantine

- ✓ Advancements in biomaterials and regenerative medicine technologies offer new ways of improving drug delivery to affected regions of the brain with a controlled release of drugs.
- ✓ Nanoparticle combined with Mematine acts as a vehicle for drug delivery – with drug encapsulated within it – to Pass through the blood-brain barrier, entering the brain.
- ✓ Positive Test Results on Mice including the reduction of amyloid-beta plaques and associated neuroinflammation common to Alzheimer's disease brains show that with improved and effective administration of Alzheimer's disease drugs it is possible to provide a positive disease reduction effect.

University of Barcelona https://reliawire.com/nanotechnology-memantine-delivery/

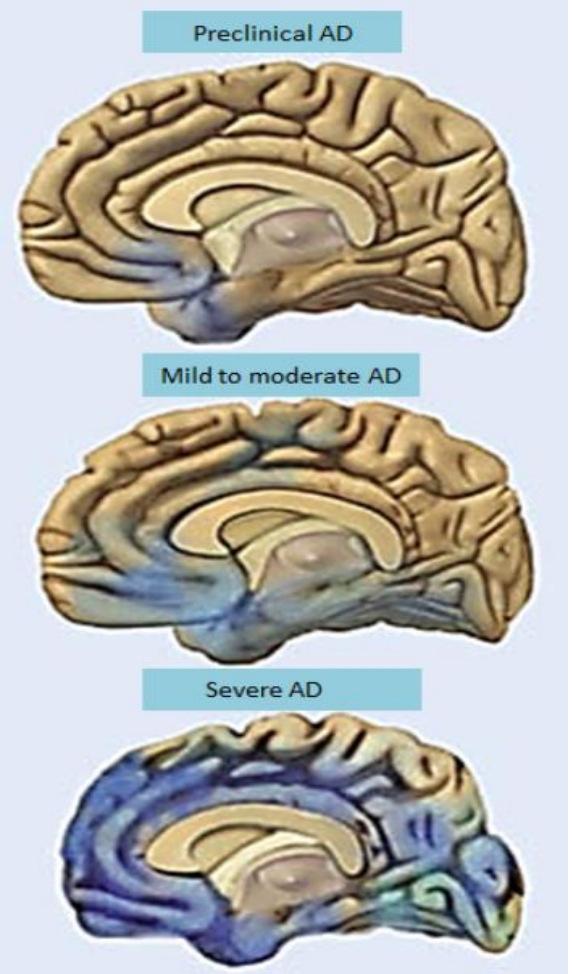

Image: By National Institute on Aging - http://www.nia.nih.gov/alzheimers/topics/alzheimers-basics, Public Domain, https://commons.wikimedia.org/w/index.php?curid=25039741

The Future
…..Some Recent Headlines …..More “Stuff”

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- “New ‘Power Felt’ could charge your phone with body heat” (techland.time.com 2/23/12)
- “Nanotechnology Providing Tools to Clean up Oil Spills” (Nanowerk News 101/11/16)
- “Nanotechnology Increases Solar Panel Efficiency” (Green Technologies AfricanBrains 5/16/16)
- “Nanotechnology Boosts Batrter Storage by 50%” - Nano-Nouvelle (NewsMikeWheeler 12/14/16
- “LG TVs Offer Better Color 4K Experience with Nanotechnology” (Jai Mobile & Apps 1/4/17)
- “Nanotechnology T-Shirt to replace batteries?” Towards wearable energy storage (NanoWerks 8/29/13)
- “Nanotech Breakthrough Promises Super-Accurate Hand held Bomb Detectors”
- “How nanotechnology can improve paint and detect structural flaws” (Daily Commercial News 3/9/12)
- “Strongest Fabrics are man-Made, backed by Nanotechnology” (Chicago Daily Herald 2/19/18)
- “Nanotech Breakthrough Promises Super-Accurate Hand held Bomb Detectors” (Nature Nanotechnology, UC Berkeley, 7/21/14)
- “How nanotechnology Can Help Us Grow More Food Using Less Energy and water” (Huffington Post 5/26/16)
- “New Silicon Chip for helping Build Quantum Computers and Securing Information” (Nanotechnology Now 2/18/18)

“6 Amazing Inventions Made Possible by Nanotechnology” (Inhabitant 3/21/12)

- Water Purifying Teabags
- Artificial Muscles to propel nanobots through the body
- Self Heating Roads
- Improving methane energy output by 20X
- Catalytic Clothing improves air quality
- Solar Panel Clothing

The Nanotechnology Market

Image credit: Argonne National Laboratory

Promise ⟷ Risk

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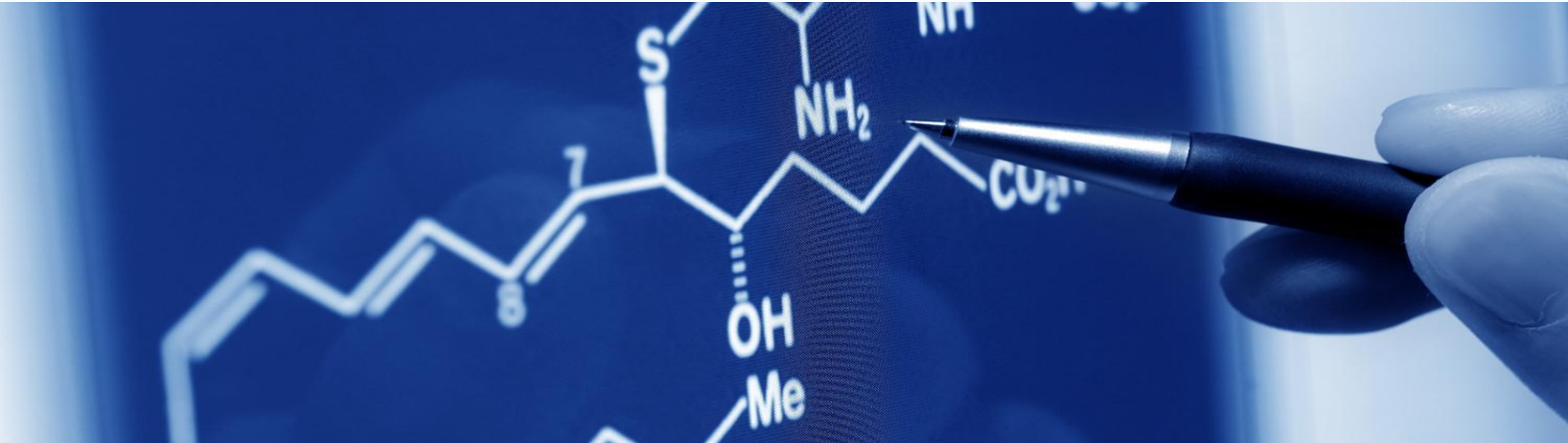
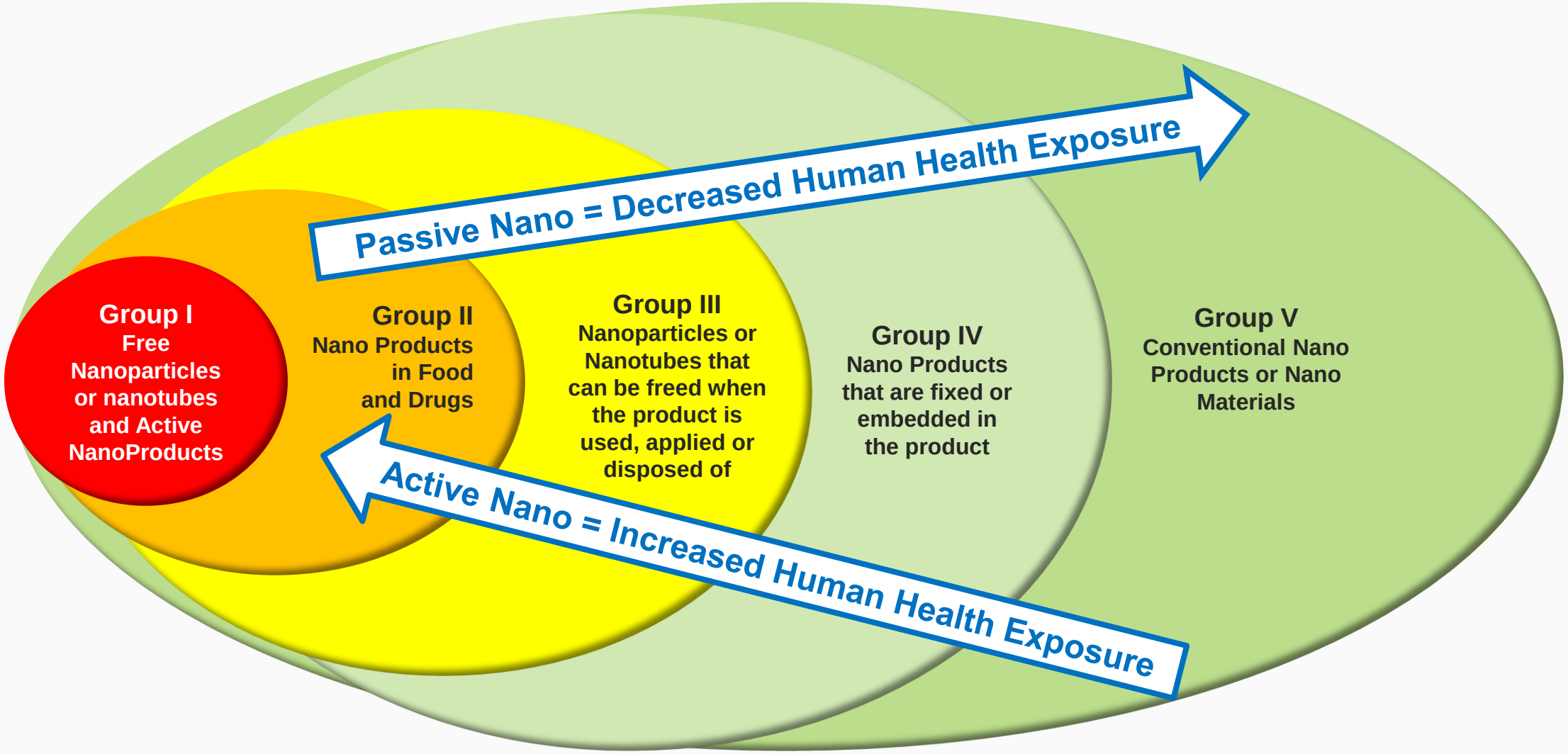
NANOTECHNOLOGY

RISK/ EXPOSURES/LOSS SCENARIOS



Nanotechnology Exposures



CRO Briefing - Emerging Risks Initiative Position paper (November 2010)

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Active Nano Particles and Health Exposure

Group I Free Nanoparticles or NanoTubes; and Active NanoProducts

Extensive Mobility Character: can reach sensitive organs (e.g.,bone marrow, lymph nodes, heart brain)

Small Size: 3 Ways to Enter the Body:

1. Crossing the Blood-brain barrier (Ingestion): accumulate in the brain, lungs or other internal organs – ultimate effect is unknown

2. Crossing the Skin-blood barrier (Dermatological) : penetrate and accumulate through absorption by contact – ultimate effect not clear

3. Crossing the Blood-air barrier (Respiratory) : accumulate directly in the lungs – lungs and all affected organs can be severely damaged.

Extensive global research is ongoing. Initial indications are that nanotubes can penetrate the walls of the lungs, damaging lung tissue.

CRO Briefing - Emerging Risks Initiative Position paper (November 2010)

Major Risk Categories

Major Potential Risk Categories	
Workers	▪ Most prominent health exposure to date ▪ Manufacturing and processing ▪ Disposal and recycling (including incineration) ▪ Firefighting/first responders
Consumers / Products Liability	▪ Long Term Product Quality???? ▪ Lack of awareness makes choice & “intelligent consumption” difficult ▪ e.g., potential skin absorption – clothing, cosmetics, skin creams, etc.
Healthcare recipients	▪ Most prominent “consumer” exposure ▪ Release/escape of nanoparticles used in medical applications ▪ e.g. – dental fillings,
Environmental	▪ Production process handling by-product release into the air or water ▪ Waste disposal ▪ May lead to health effects (drinking water or agriculture contamination)

Less exposure

Nanofilms and lateral nanostructures, e.g., computer and electronics

Nanocomposites , e.g., sporting goods or other solid bodies that contain nanoparticles

Nanoparticles and nanofibres, e.g., cosmetics, clothing

Free particles or nanodispersens, e.g., sprays

Greater exposure

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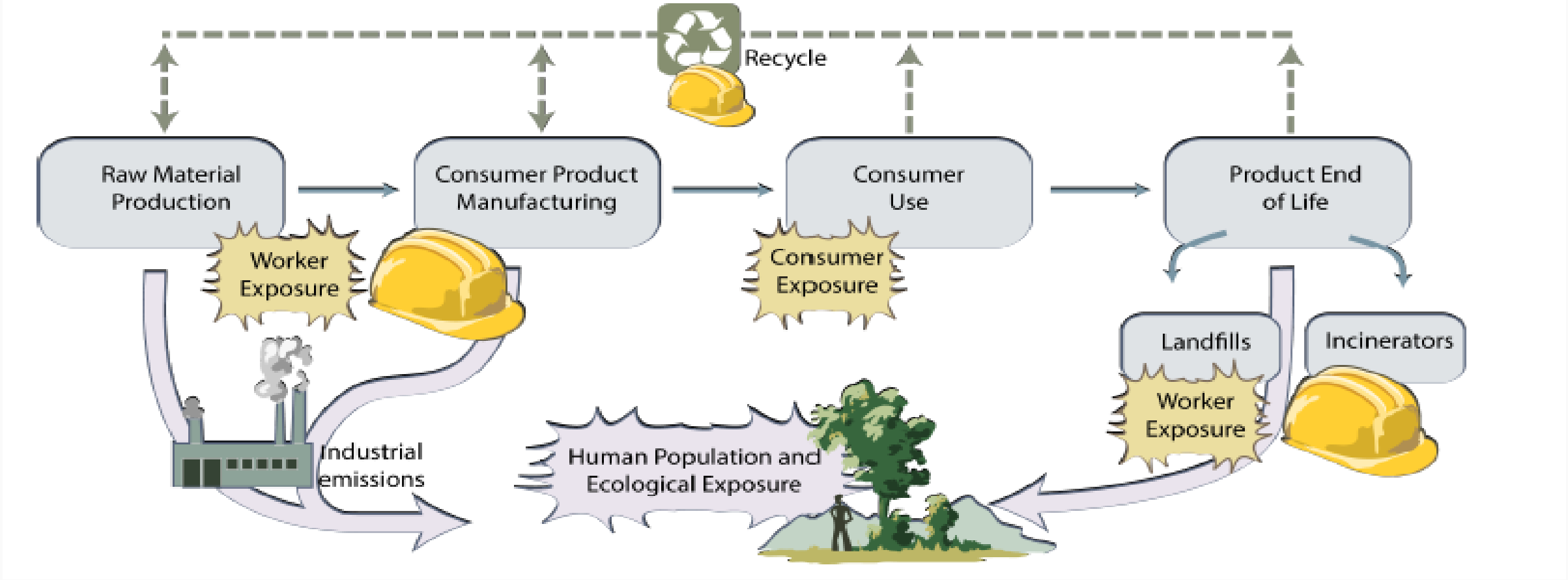
Active Nano Particles - Health and Environmental Exposure



Source: 2014 NNI Strategic Plan *[94], adapted from [93].)*

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Center For Food Safety (US) / Friends of The Earth (AUS) Report (nanowerk 10/9/15):

- Nanomaterials can be found in 300 food products and food contact products
- Titanium Dioxide (whitening) and Silica (anti-caking agent) are common
- 2020 Projected Value: $20.4bb…300% increase from 2017
- >1,000 Companies researching Nano-enhanced Food Products
- Examples:
  - Candy (M&Ms, Skittles)
  - Baby Bottles
  - Plastic Storage Containers
  - Processed Cheese
  - Chewing Gum
  - Etc.

https://www.fooddive.com/news/what-is-the-future-of-nanotechnology-in-food/446173/

2017: USDA

Announces $4.6 Million for Nanotechnology Research

https://nifa.usda.gov/funding-opportunity/afri-foundational-agriculture-systems-and-technology

Website with a list of almost 300 Food Products

http://www.centerforfoodsafety.org/press-releases/4075/new-database-shows-nanotechnology-in-common-food-products

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Dental Materials:
Different ways Nanotechnology is used in Dentistry (Source: Cell Press)

- **Nano-composite Resins** (silica and zirconia nanoparticles) - White Cavity Fillings resemble teeth better than their metal alternatives; less likely to come loose or fracture teeth. **(Used for over a Decade)**
- **Antimicrobial Adhesives** (carbon nanotubes) – **Type of wearable toothpaste**
- **Quantum Dots combined with cancer-specific antibodies** - applied inside the mouth to detect troublesome cells.
- **Potential** – Research using nanoparticles incorporated in dental materials may **prevent and/or control oral diseases** through their long-term release and action."

Are some nanomaterials toxic to healthy cells?
New nanomaterials used for dentistry should have formal pre-clinical and clinical trials before they can receive approval….Are They?

Image: Amauri Jardim de Paula and nelson Duran, et.al.

Boeing 787
…..The Dreamliner

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Extensively Uses Composite and High Tech Materials and Equipment

Grounding of all Dreamliners
…..2013 Grounding Due to internal Fire

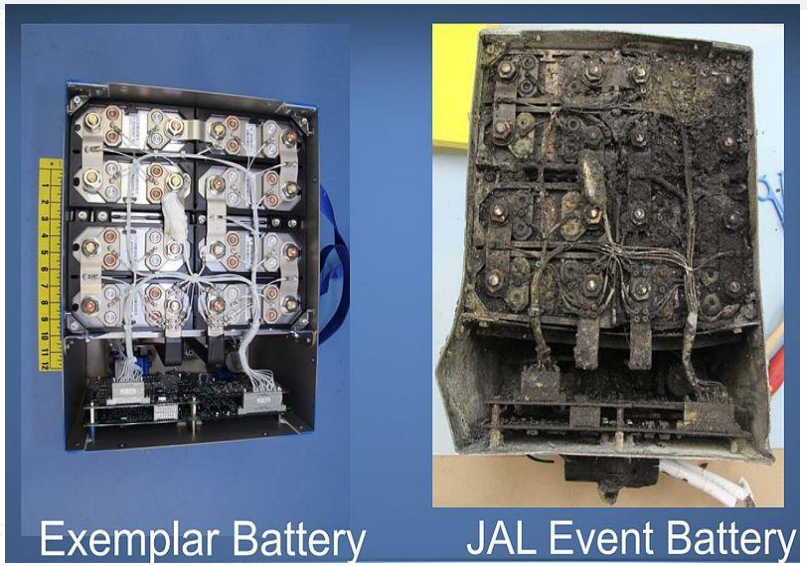
Japanese airlines ground Dreamliners after emergency landing

Empfehlen 922 Personen empfehlen das.

By Mayumi Negishi and Tim Kelly
TOKYO | Wed Jan 16, 2013 11:04am EST

(Reuters) - Japan's two leading airlines grounded

Also suspected in a 2013 fire in Ethiopian Airlines Boeing 787

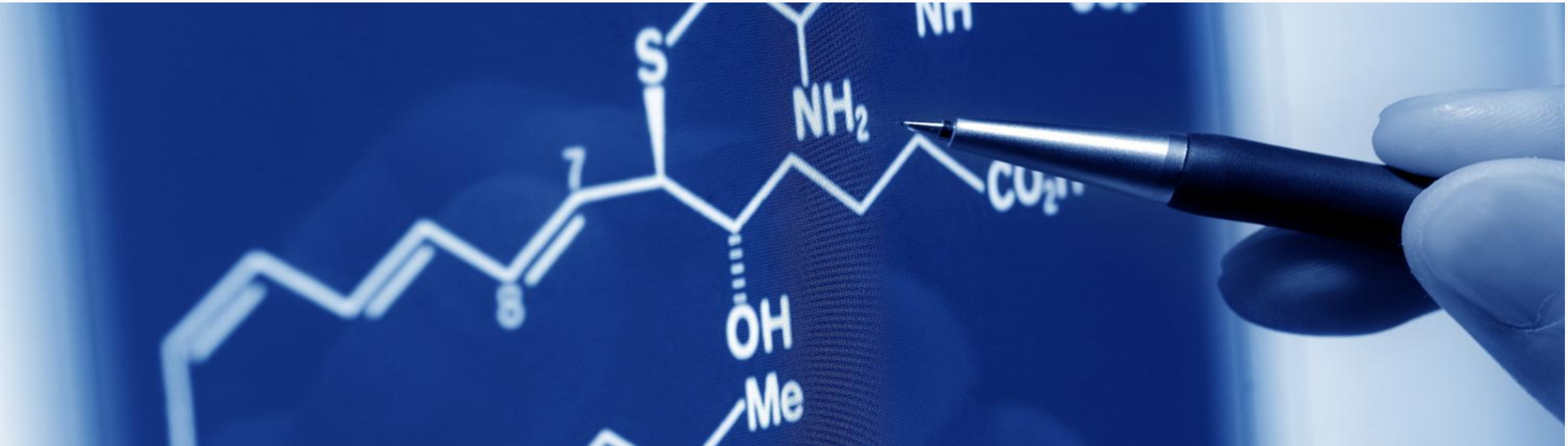


Japan Airlines says will ground all its Boeing 787s on Thursday

Production of lithium cobalt oxide batteries using a nanotechnological process (liquid-feed flame spray pyrolysis)

The nanotechnically produced nanoparticles, the battery's design and the high charge density make spontaneous self-ignition possible (as in fact occurred)

LEGAL AND REGULATORY LANDSCAPE



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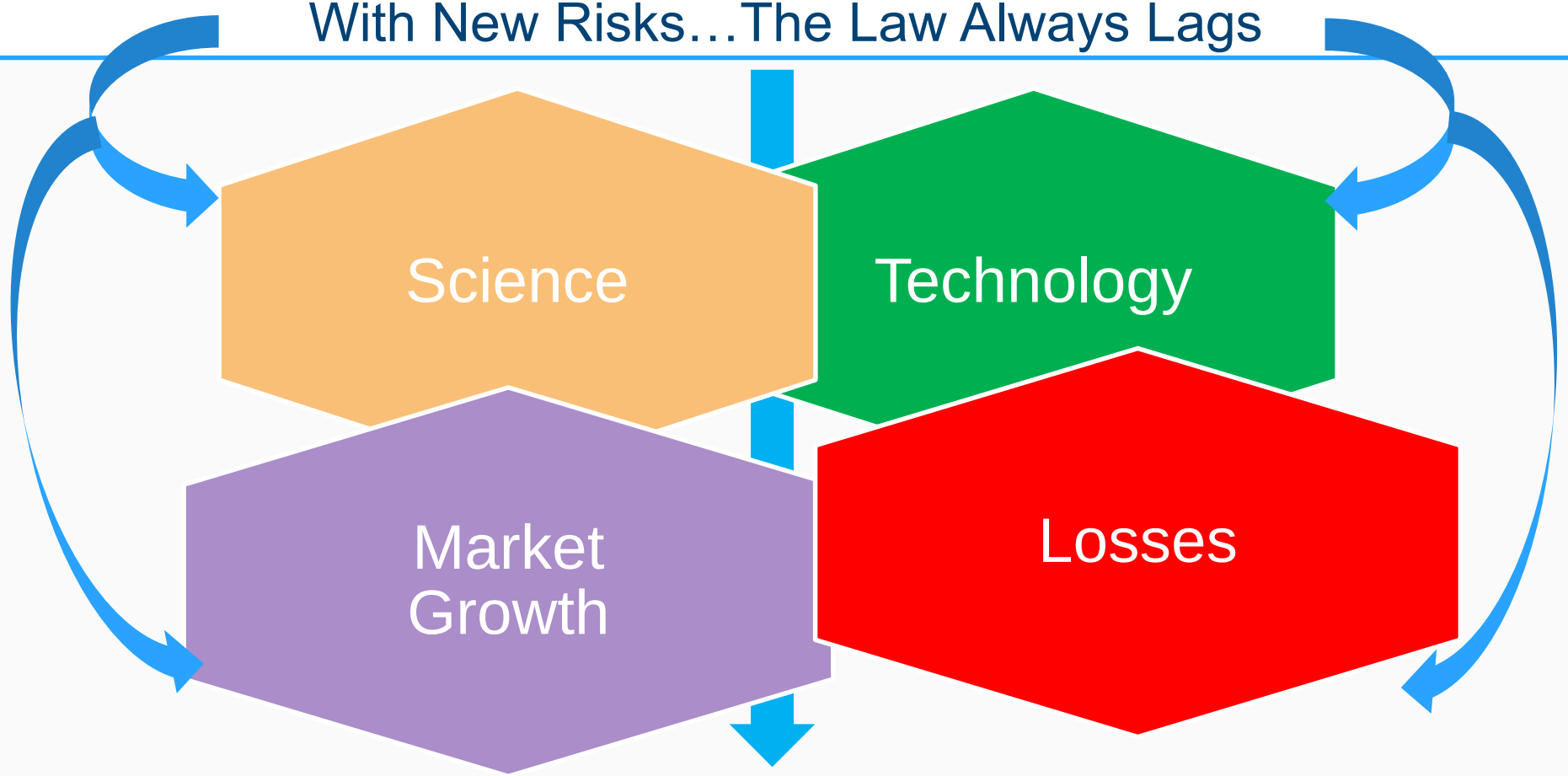
Common Theme…Especially for Technology Driven Risks

With New Risks…The Law Always Lags



Increased Judicial Risk

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Causation Premise

- **TYPE - Some, but not all, types** of engineered nanoscale material may cause harm or damage to the environment, peoples health/wellbeing or property

- **USE - Some, but not all, uses** of engineered nanoscale material or uses of nanoscale material may cause harm to the environment, health

The Challenge: Separating the Good the Bad and the Ugly

Liability Premise

Manufacturer held to a high standard…..

…The more potentially harmful the product…the higher the standard, and.....

……The lower the bar to prove liability…..Inherently harmful??? = ”Strict Liability”

Wood v. Phillips petroleum Co., 119 S.W. 3rd (TX App.2003)

“manufacturer is held to the knowledge and skill of an expert . . . it must not only keep abreast of scientific knowledge, discoveries, and advances, but, more importantly, test and inspect its product . . . This duty to research and experiment is commensurate with the dangers involved. . . . A manufacturer may not rely unquestioningly on others to raise concerns about its product, but must instead show that its own conduct was proportionate to the scope of its duty."

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Minimal Litigation To Date…

International Center for Technology Assessment, et al
v.
Margaret A. Hamburg, M.D

- Administrative Procedure Act case seeking declaratory & injunctive relief. Filed 2011
- **Demands that the FDA respond to petition that the plaintiffs filed with the FDA (2006) that claimed: 1] there was scientific evidence of nanomaterial risks; and, 2] requested the FDA take regulatory action**.
- FDA has formally responded to the Plaintiffs and the Suit has been dropped.

Suit Filed July, 2015…..
Center for Food Safety
v.
Environmental Protection Agency (EPA)

Filed: Ninth Circuit Court of Appeals

- **Seeks to block EPA's allowance of a nanosilver pesticide product** "NSPW-L30SS" on the market without the legally required analysis on its effects on humans, wildlife, and the environment.
- **EPA admits potential exposure to workers, consumers, and the environment,** including potentially harmful effects on workers and consumers who contact or breathe the chemical and toxic effects on animals exposed to the chemical.
- **Despite this risk, EPA is allowing NSPW-L30SS** on the market over the next four years while its manufacturer (Nanosilva LLC of Newnan, GA) **generates the required data to determine its effects on public health and the environment.**

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…Significant Future Litigation Potential

Future Mass Tort Potential…
…fueled by:

Science Uncertainty
+ Public Fear
+ Past Mass Torts

- "**Nanophobia":** Warnings (often speculative) about nanotechnology risks have been publicized by various interest groups & even some governmental agencies …sets the stage…feeds public and political perception

- **Plaintiff Bar Infrastructure**: Even with uncertainties about the actual health/environmental risks…the legal industry (plaintiffs bar) has established an infrastructure geared to extensive litigation of new exposures

At a minimum, defense costs will be high initially

Regulatory Challenges

1

Too little =
Public harm

How much regulation?

Too much =
Progress stalled

2

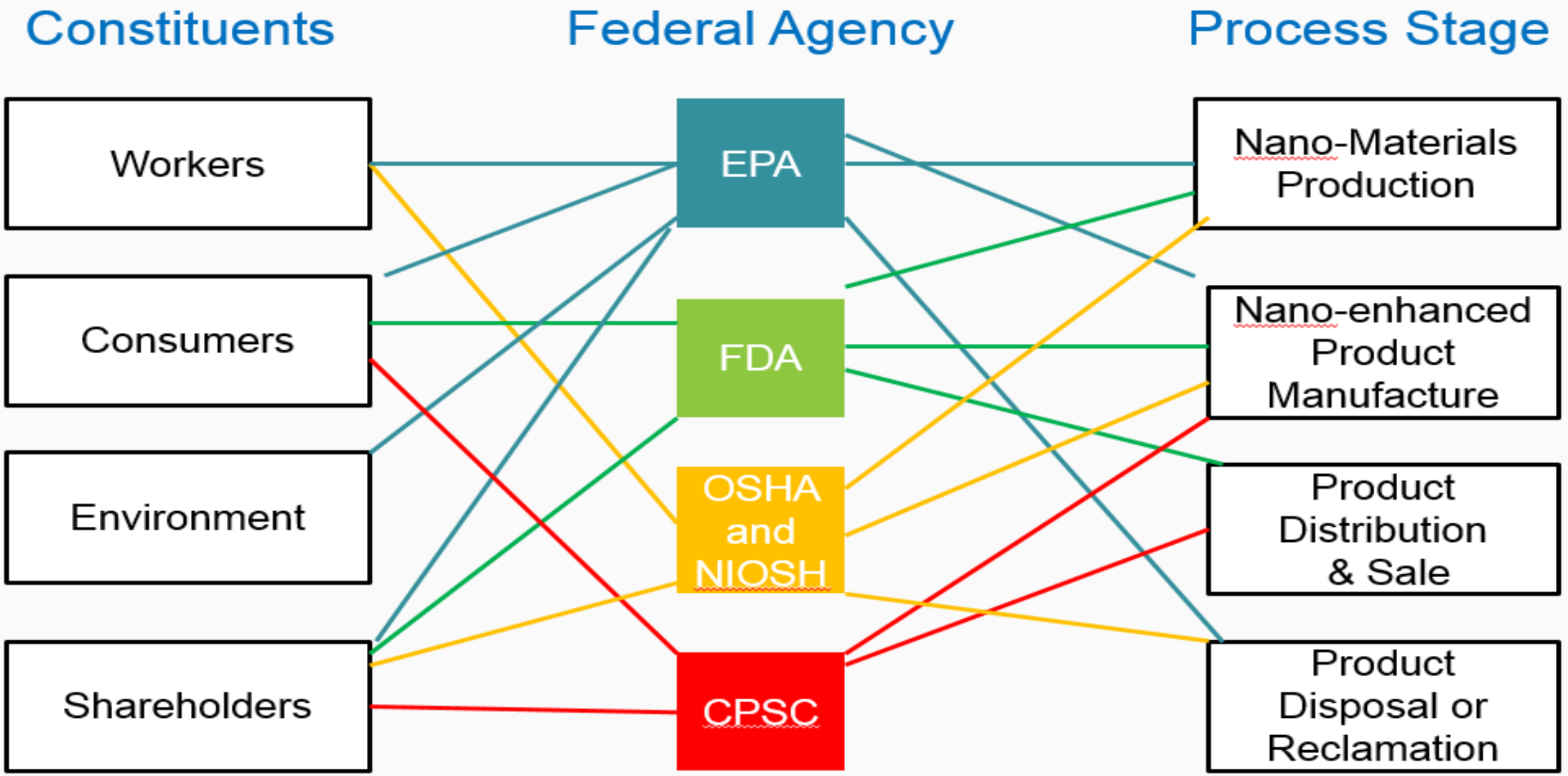
Multiple agencies involved: coordination is critical

Federal Regulation

Federal : Who is regulating (educating about) nanotechnology?	
FDA	▪ **Regulates specific Food and Drug related products (Mfg. must inform FDA of the existence of nano)** ▪ 2007 – FDA nanotechnology task Force Report issued ▪ Since 2011 – Various General Guidance for Industry released (Cosmetics and Food ingredient mfg.; Nano Safety Program; Cosmetics; Food (Humans/Animals); ▪ 2014 - Final Guidance on Nano Products including Cosmetics and Food Substances ▪ 2015 - Nano Standards introduced; Noted that Product Specific Guidance would be issued as appropriate. ▪ 2017 Draft Guidance on Nano-enhanced Drug and Biological Products
EPA	▪ **Regulates the environmental safety** ▪ Views carbon nanotube as a new chemical ▪ Regulates nano-based pesticides ▪ Clean Air Act, Clean Water Act, Toxic Substance Control Act and Superfund Laws apply to nanomaterial
OSHA	▪ **Regulates Worker Safety**
NIOSH	▪ **Part of the Centers for Disease Control – provides Research for OSHA** ▪ April 2013 Report recommends limiting worker exposure to Nano-Titanium Dioxide ▪ 2018 Issued 4 Documents recommending how to Minimize Worker Nanotechnology exposures
CPSC	▪ **Regulates Consumer Product Safety;** ▪ 2018 Announced they would establish 3 collaborations to research nanotechnology in consumer products
NTP	▪ **Part of the Department of Health and Human Services focused on Toxicology** ▪ Examines the potential health effects of nano-influenced products.

Note: There is some individual State regulation, but Federal regulation is more efficacious due to the nature of nanotechnology

Federal Regulation
…..Silo Effect



National Nanotechnology Initiative (NNI)
(The 21st Century Nanotechnology Research and Development Act)

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What it is

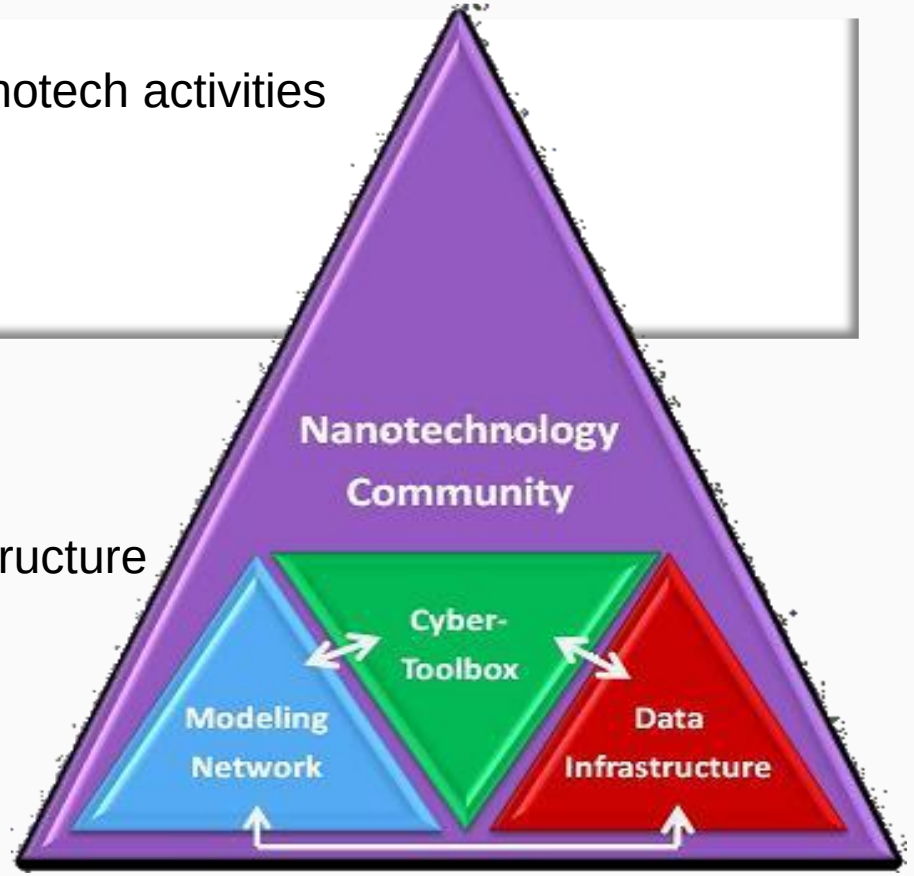
- Coordinating arm for various federal agencies that are involved in nanotechnology regulation and research
- 25 participating agencies

What it does

- Allocates funds for various federal agencies nanotech activities
- Shares information
- Educates
- Develops protocols for the Industry

Stated goals

1. Advance world class R&D
2. Develop and sustain nanotechnology education, workforce & infrastructure
3. Foster the transfer of new technologies into beneficial products
4. Support responsible development of nanotechnology for the future



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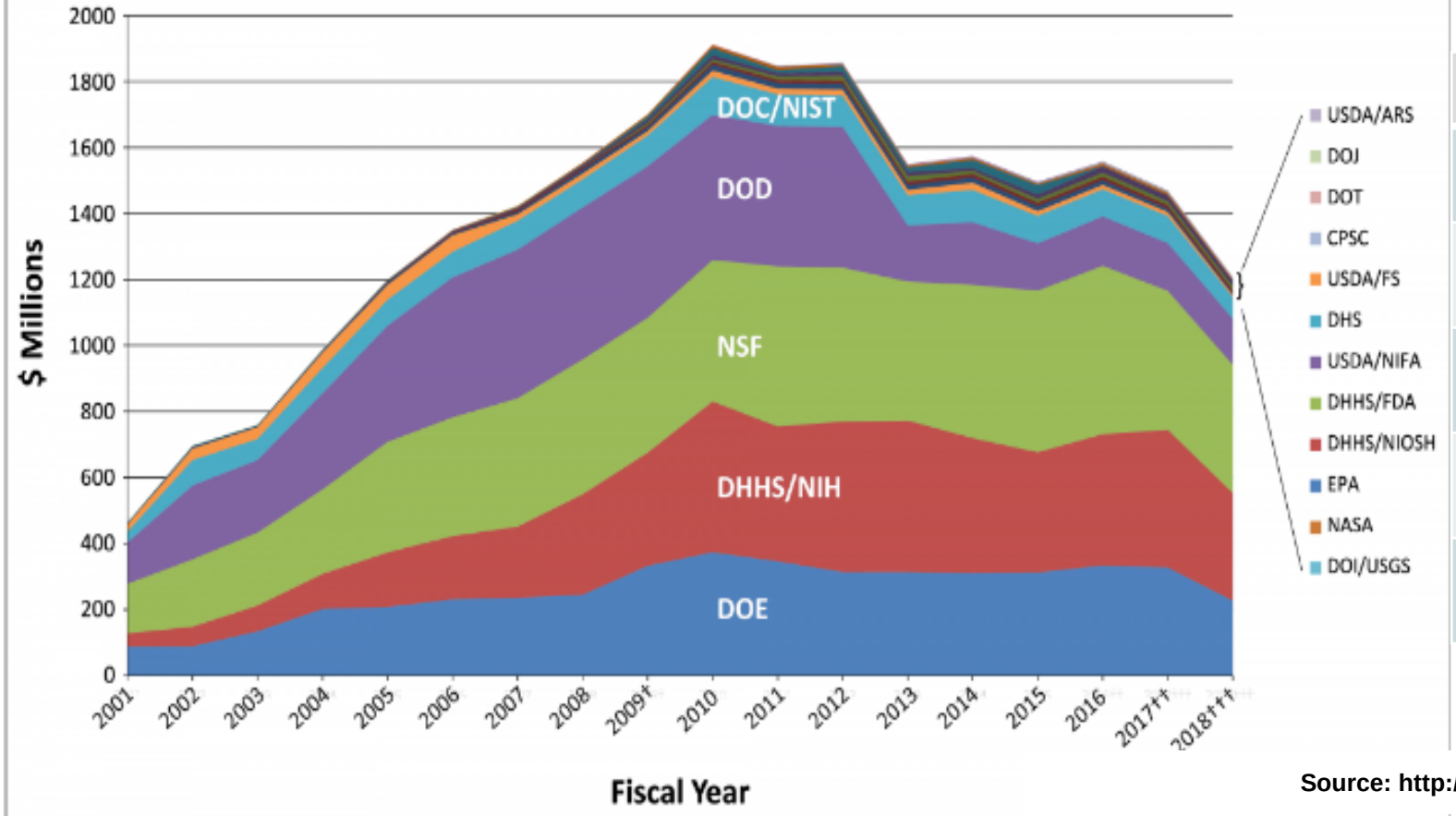
Four Areas Get the Bulk of the Allocated Funds

By Department Fiscal year 2018



2018 Funding: Top 4	
TOTAL	**$1.208 bb**
NSF (National Science Foundation)	32%
NIH (National Institute of Health)	27%
DOE (Department of Energy)	19%
DOD (Department of Defense)	12%

Source: http://www.nano.gov/2018BudgetSupplement

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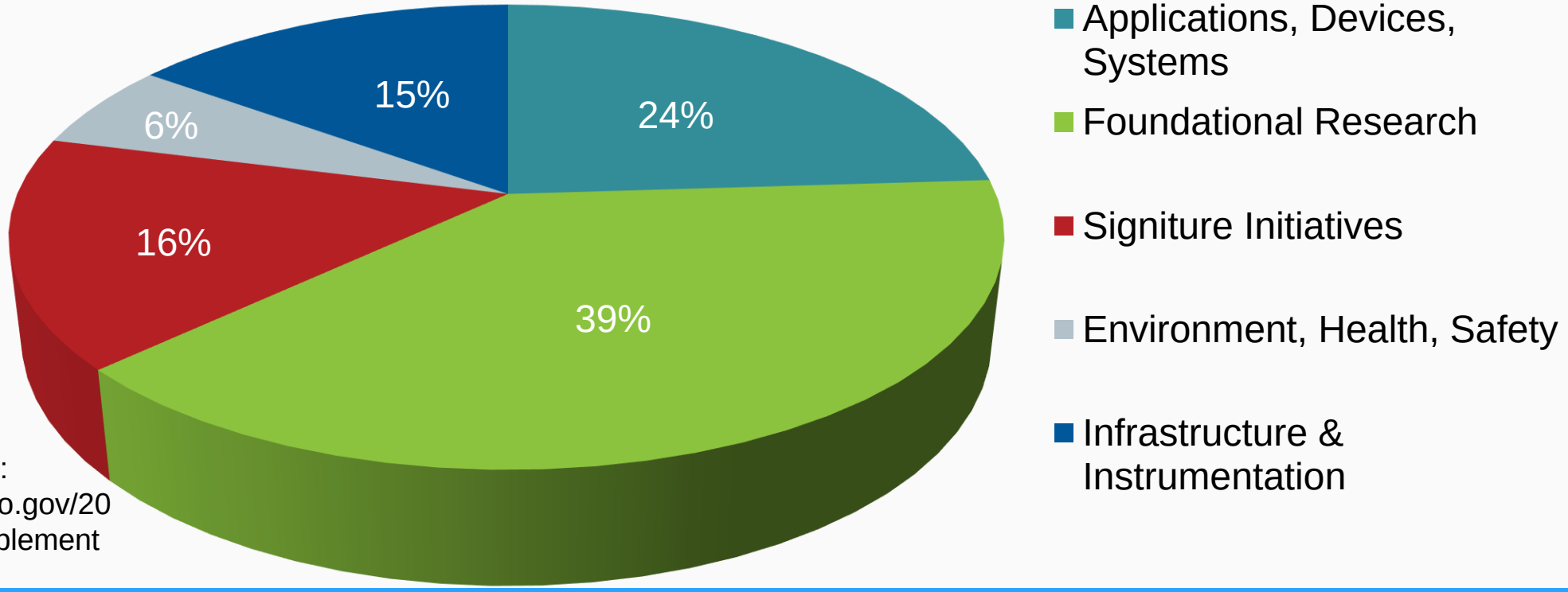
2018 President Budget: NNI Holding Steady at ~ $1.2bb ….Cumulative Funding since 2001 inception ~ $25bb

2018 NNI Investments by Program Componants Area



Source: http://www.nano.gov/2018BudgetSupplement

(Focus: Cleaner Energy; Human Welfare; National Security; Next Generation Workforce)

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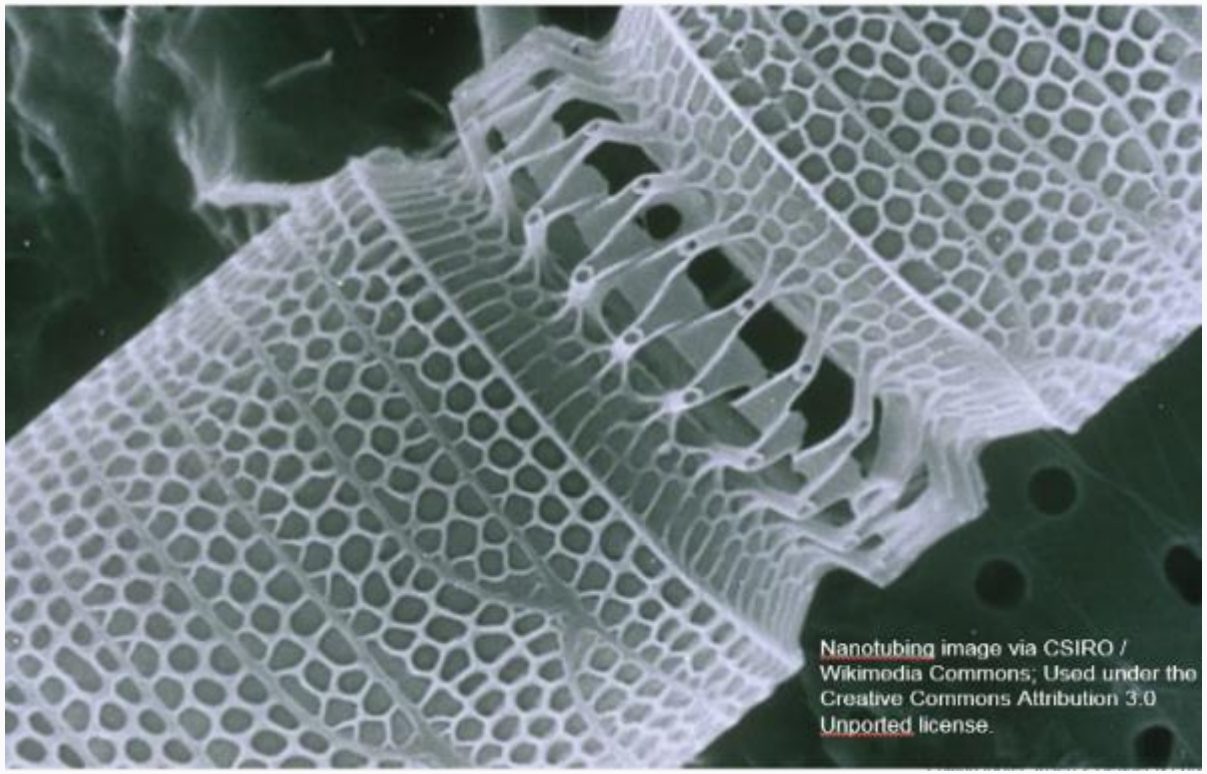
Independent 3rd Party Testing of Nano Products is essential …For:

- Regulation,
- Manage Product Liability
- Corporate Responsibility
- Good Product Stewardship
- Insurability
- Product Marketing



……

FDA and other Federal Agencies Need to be More Proactive

….Testing, Labeling, etc.

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US and EU Scientists and Nano Practitioners

Platform to Develop and Share Protocols and Methodology

Goal: Bridge Nano EHS Research Efforts

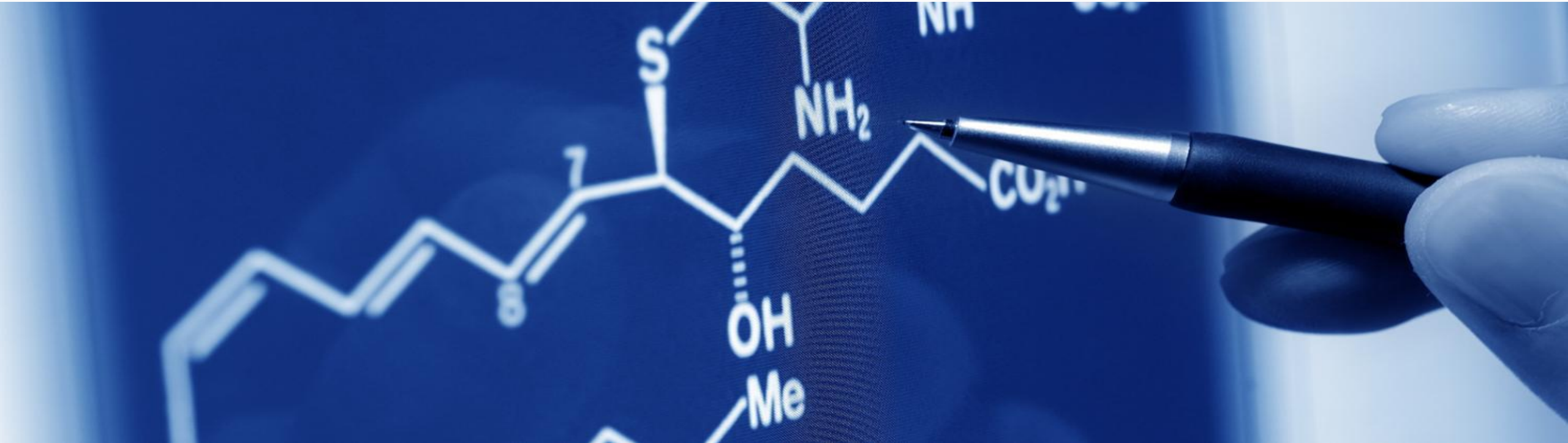
Advance Nanotechnology While Optimally Managing Environmental and Health Safety Risks Associated with Nanomaterial

Self-run Private Organization – Administratively supported by the EC and US National Nanotechnology Coordinating Office

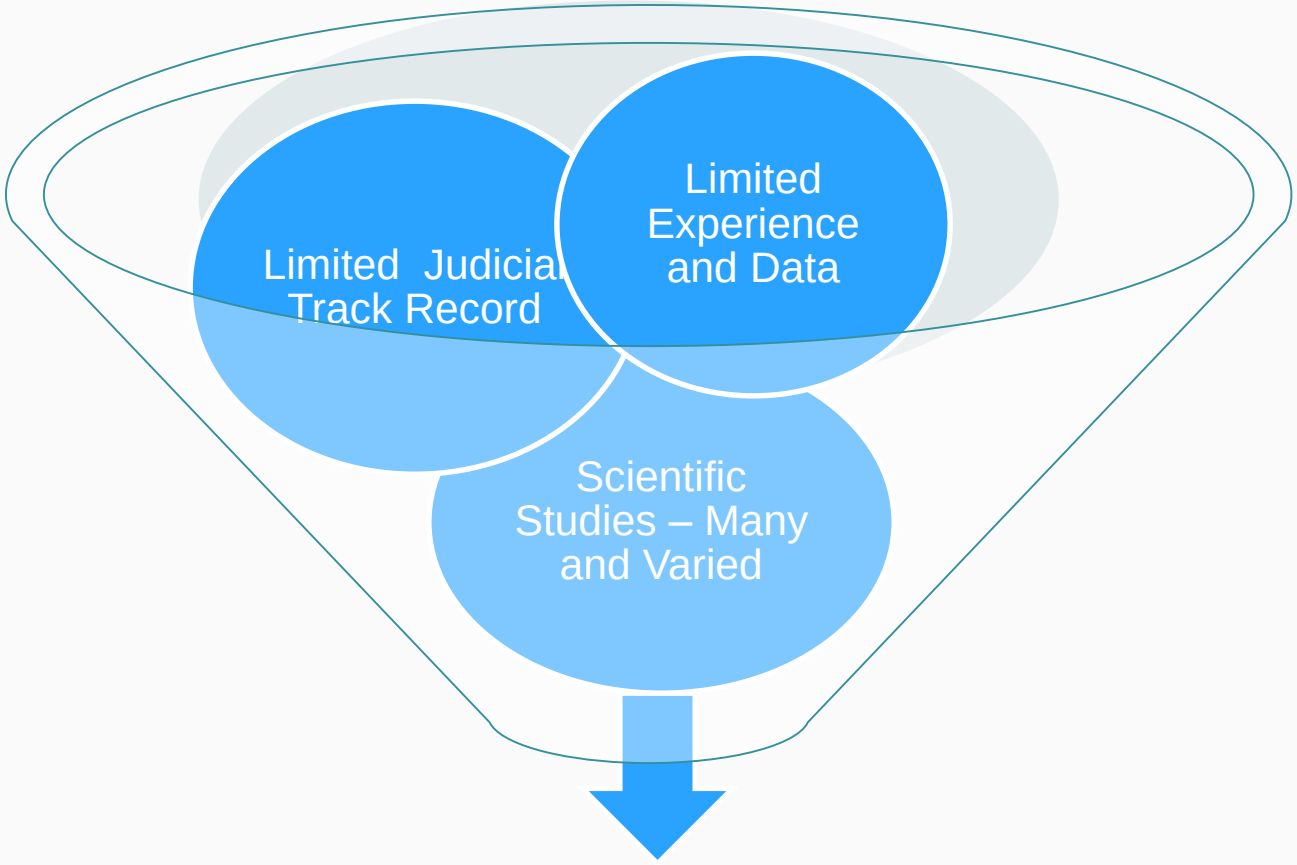
Source: us-eu.org

INSURANCE IMPACT…

UNDERWRITING AND RISK MANAGEMENT CONSIDERATIONS



Insurance Challenges
More Qualitative than Quantitative



How best to Identify, Measure, Classify, Price Risks

No Established/Credible Way

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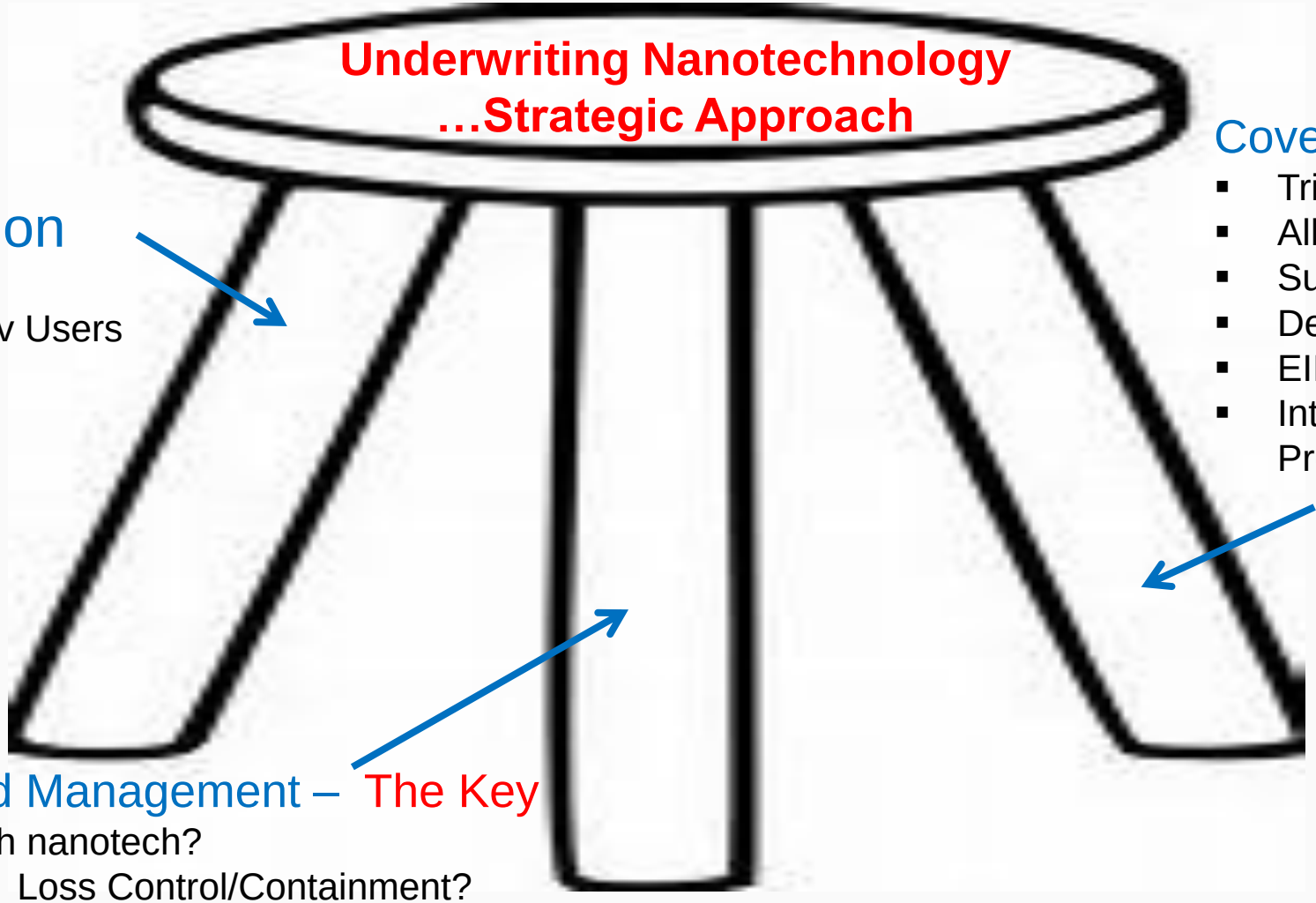

Class Selection

- Manufacturing?
- Nanotech Mfg. v Users of Nanotech ?

Coverage - Exposed Risks

- Trigger - Claims Made ?
- All Risk or Named Peril?
- Sub-limits?
- Defense Containment?
- EIL Coverage or Exclusion?
- Intellectual Property, D&O, Product Recall, etc???

Risk Selection and Management – The Key

- How and how much nanotech?
- Risk Assessment - Loss Control/Containment?
- Creation and Disposal, including Waste?
- Government Inspection/Certifications – Process and Products?

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Loss Scenarios – Possible Examples

Health risks	▪ Workers and consumers ▪ Lungs, digestive tract, skin
Environmental Risks	▪ Toxic nanoparticle byproducts, waste or accidentally released ▪ Contaminated air, water, and agricultural
New or increased existing risks	▪ Products Liability/Recall ▪ Terrorism – smaller more powerful bombs ▪ Cyber – development of quantum computers making current computer data encoding methods less effective and cyber crime easier or more effective

Lines of Business Exposed

Prominent Lines Exposed	Additional Lines Possibly Exposed
Workers Compensation	Medical Malpractice (Drugs, Devices, etc)
Environmental Liability	Cyber /Internet Liability
GL, Products, Product Recall (Umbrella)	Intellectual Property
	Directors and Officers

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Standard CGL / Umbrella (Products Liability) Challenges

Trigger / Timing of Loss

- Latency Exposure
- "Occurrence" Trigger
- Uncertain Court Application

Defense

- Potentially Unlimited
- Untested - Emerging Nature of Claims

Scope of Coverage

- "All Risk" Coverage
- Exclusions are Critical

Nanotechnology Exclusions????

Already Covered under CGL and Umbrella (Unknowingly?)

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Challenges with an Exclusion

- "Nanotechnology" itself is a process, not a product or a "thing"
- "Nanotechnology" is a process applied to and/or embedded in thousands of other products
- Other than an operation that actually manufactures or distributes "nanomaterial", nanotechnology has no function other than to enhance or create other products.

Exclusion would have to apply to either:

- Specific Product…or….
- Specific Nano material

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Nanotechnology and ISO/NCCI	
ISO General Liability Classification	▪ Introduced in 2011 ▪ Code 13208: Nanomaterial distributors – risks that sell nanomaterials to others ▪ Code 53953: Nanomaterial manufacturing – risks that manufacture or engineer nanomaterial for others
ISO Exclusions	▪ ISO does not have a Nanotechnology Exclusion, nor do they have plans to develop one. ▪ They feel the Pollution and Designated Products Exclusions are adequate …*Not Court Tested in a Nano case yet*
WC - NCCI	▪ NCCI does not have separate Class Codes for Nanotechnology ▪ They feel it is absorbed by the Governing Class of the business……*??????*

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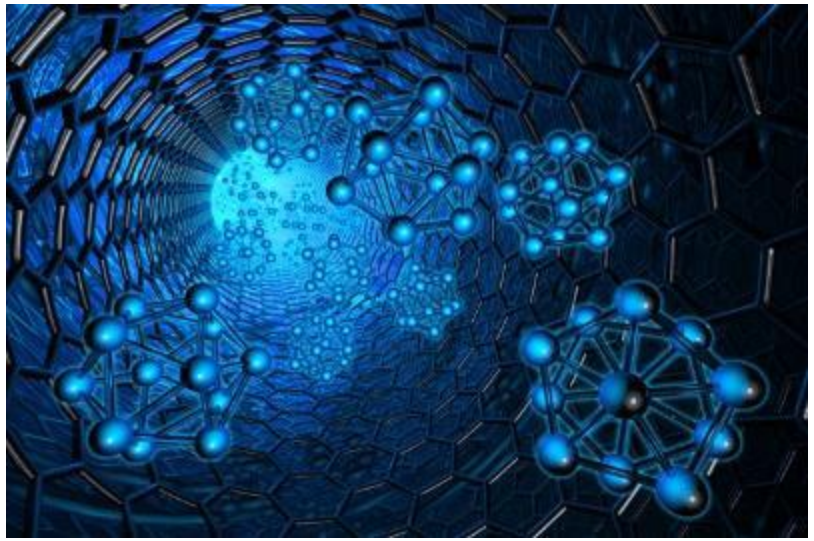
Nanotechnologies : Broad Spectrum of Applications

New / High Tech Products/Technology

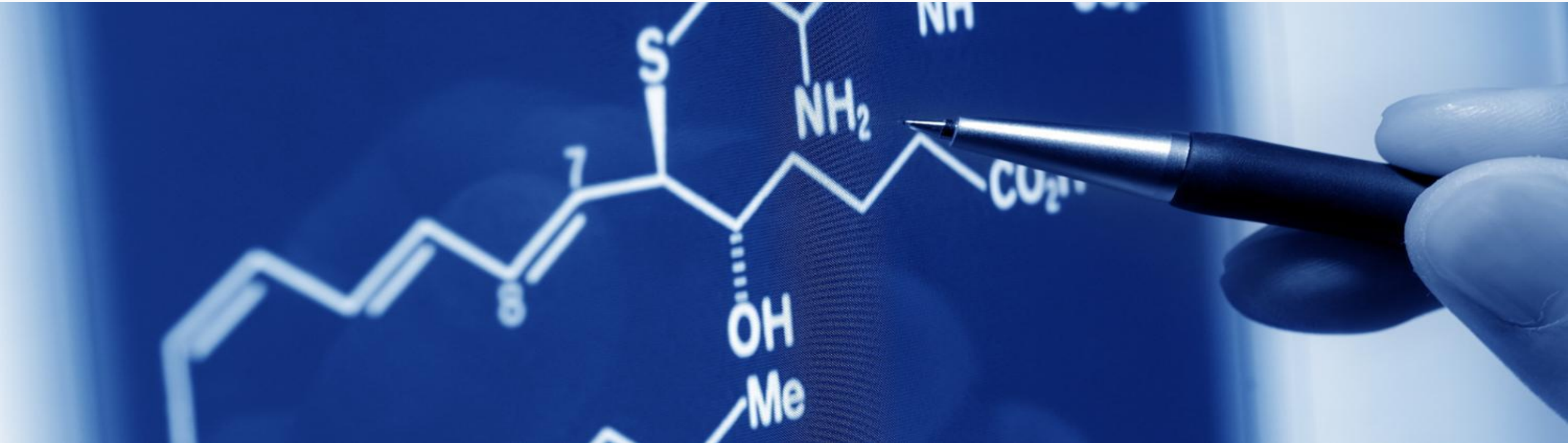
Enhanced Traditional Products/Technology

Challenges

- Rapidly Evolving State of the Science
  - State of The Art and Defense Issues
  - Expensive Litigation
- Lack of Labeling/Warnings
- Regulation slowly evolving
- CGL …All Risk, Occurrence, Defense O/S Limit
- Lack of Judicial Track Record
- Latent Accumulation Potential



SOME CLOSING THOUGHTS



The Future of Nanotechnology: Broad and Significant Growth Projected

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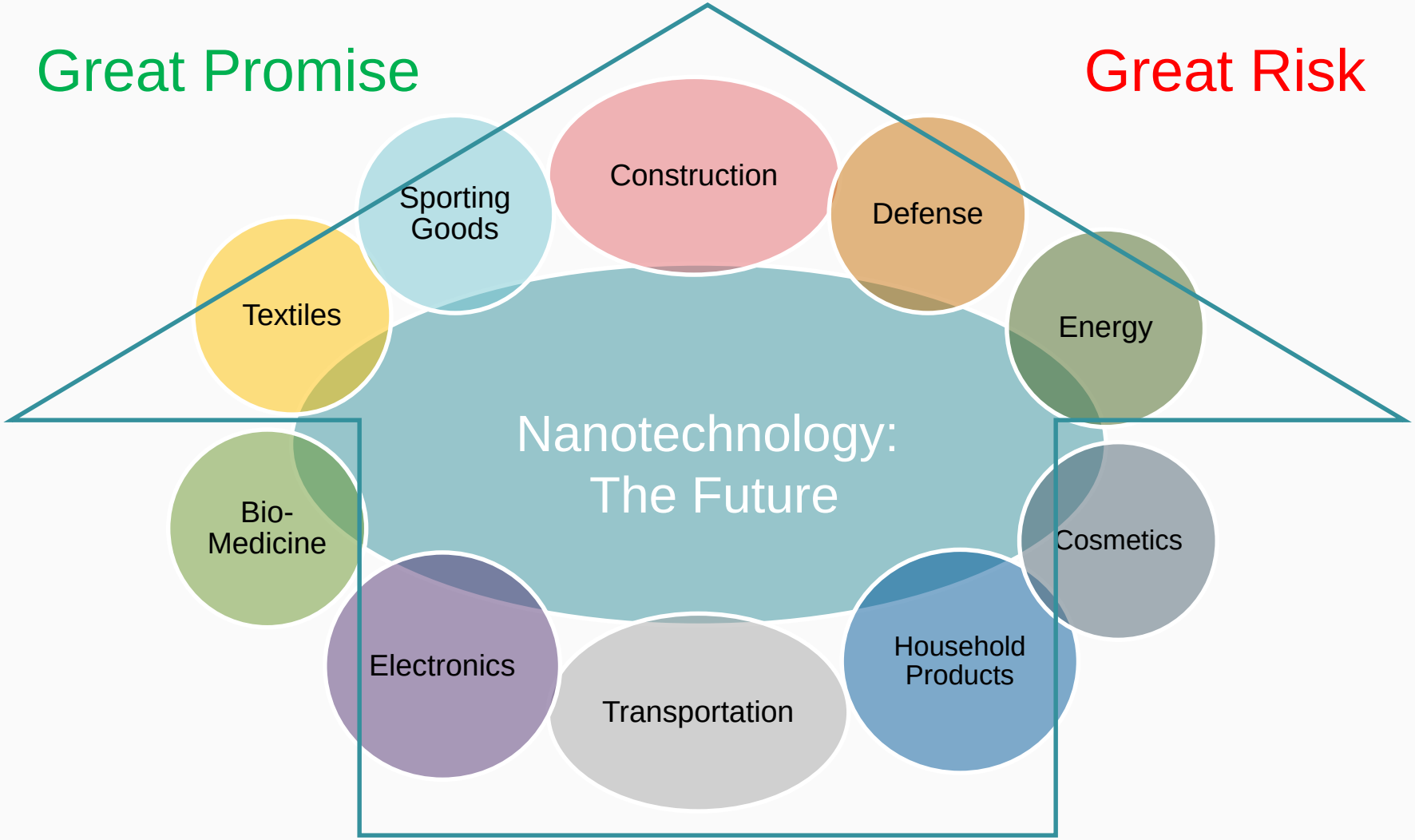

Image credit: Argonne National Laboratory

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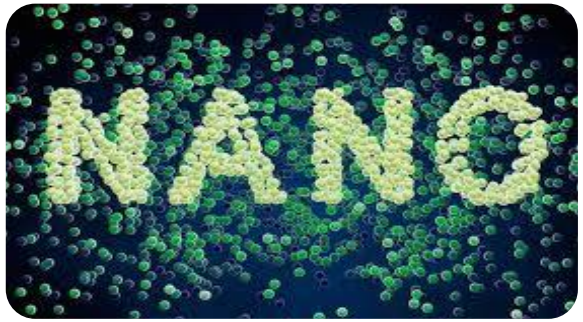
Nanotechnology Risks - still emerging…but include

1. Elements behave differently at the nano-scale than in bulk form--effect may not be fully understood.
2. Potential toxicity of some nano-particles to vital organs (limited evidence to date)
3. Lack of product labeling
4. Ethical concerns, especially in medicine – how is the nanotechnology used
5. Dramatic Growth of Nanotechnology
6. Unknown economic and environmental impacts
7. Minimal ability to model risk.
8. Regulatory and Legal landscape not yet fully developed nanotechnology exposure and risk.



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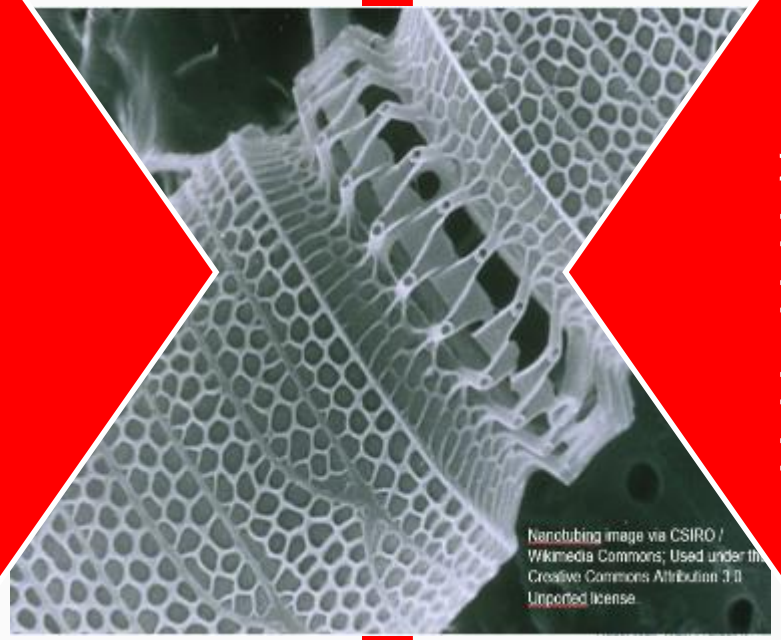
Unknown Long Term Product Quality /Health Effects

Little Data Currently Available about the Long Term Health Impact of Exposure to Nanomaterial in clothing, medical food, environmental waste, etc

BOTTOM LINE



Broad Insurance Coverage and Exposure

> Product Liability,
> Workers Compensation,
> Environmental Liability
> Medical Malpractice;
> Directors & Officers

Long Latency / Broad Accumulation Potential

Nanotechnology Information Sources

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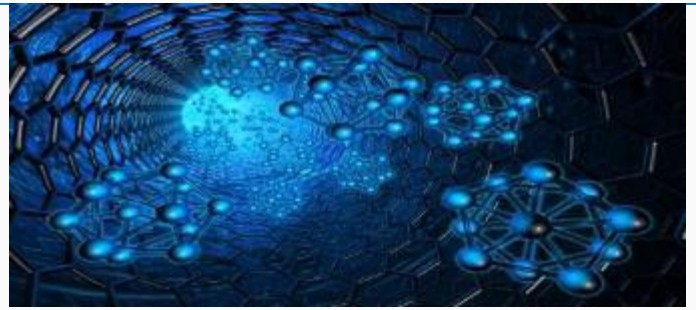
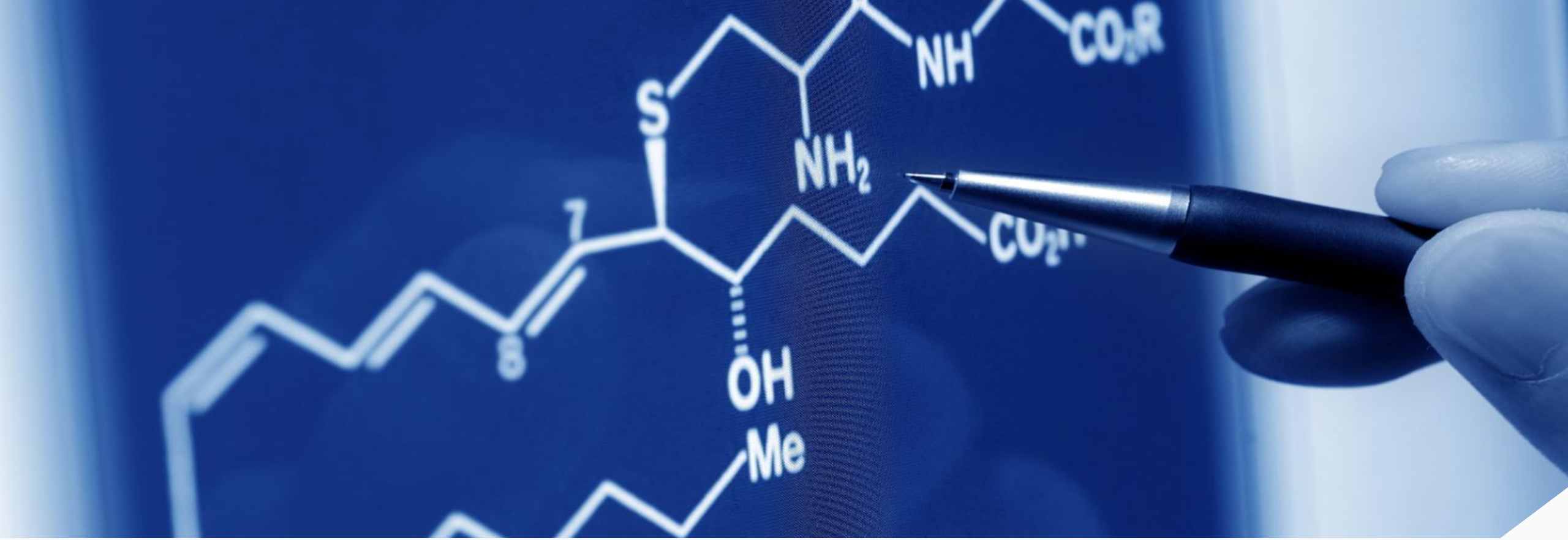
US Government Resources

National Nanotechnology Initiative
NNI is a federal R&D program established to coordinate the multiagency efforts in nanoscale science, engineering, and technology.
http://www.cdc.gov/niosh/topics/nanotech/other.html
The National Nanotechnology Initiative Strategy for Nanotechnology-Related Environmental, Health and Safety Research
This document prioritizes the research needs for nanotechnology environmental, health and safety issues.
National Cancer Institute - Office of Technology and Industrial Relations - Nanotechnology in treating cancer
U.S. Environmental Protection Agency (EPA)
U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) - Safety and health topic page
U.S. Food and Drug Administration (FDA) - Provides insight on how nanotechnology products are regulated by FDA.
National Institute of Standards and Technology (NIST)
Center for Nanoscale Science and Technology
Center for Neutron Research
The U.S. Government Accountability Office (GAO)
Nanomanufacturing: Emergence and Implications for U.S. Competitiveness, the Environment, and Human Health (GAO-14-181SP)



Non-Government Resources

World Health Organization (WHO) Guidelines on Nanomaterials and Worker's Health
International Council On Nanotechnology (ICON)
A partnership for Nanotechnology stewardship and sustainability. GoodNanoGuide
A collaboration platform designed to enhance the ability of experts to exchange ideas on how best to handle nanomaterials in an occupational setting
Virginia Tech and the Woodrow Wilson International Center for Scholars
The partnership have sponsored the Project on Emerging Technologies Consumer Products Inventory, an inventory of nanotechnology-based consumer products introduced on the market.
Safe Nano - U.K.'s premier independent resource for nanotechnology hazard & risk
Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) links about Nanotechnology
IRSST is a private, non-profit scientific research organization based in Quebec.
Center for Biological and Environmental Nanotechnology (CBEN), Rice University - CBEN focuses on research at the interface between "dry" nanomaterials and aqueous media such as biology and the environment.
Nanomaterials in the Workplace: Policy and Planning Workshop on Occupational Safety and Health. A report by the RAND Corporation for NIOSH
Nanotechnology and Nanoscience. A joint study between the Royal Society and Royal Academy of Engineering
Nanoparticles: An Occupational Hygiene Review
Health and Safety Executive (HSE) report that provides information on routes, sources, and and levels of nanoparticle exposure, control measures, trends, more...
Nano&Me - Funded in part by the UK department of Business, Innovation and Skills (BIS) and developed by the Responsible Nano Forum , Nano & Me is aimed at providing clear and balanced information on an emerging technology.
NanoImpactNet - European network on the Health and Environmental Impact of nanomaterials
Nanowerk - Nanotechnologies and emerging technologies news
http://www.nsti.org Nano Science and Technology Institute http://www.us-eu.org



Thank You

Munich RE

Artificial intelligence and the insurance industry

Gerald Deneen, CARe Seminar, June 5, 2018

Swiss Re

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1. Defining artificial intelligence
2. Insurance loss exposures created by artificial intelligence
3. Underwriter and claim handler artificial intelligence issues
4. More artificial intelligence fictitious claim examples

Defining artificial intelligence

Definition

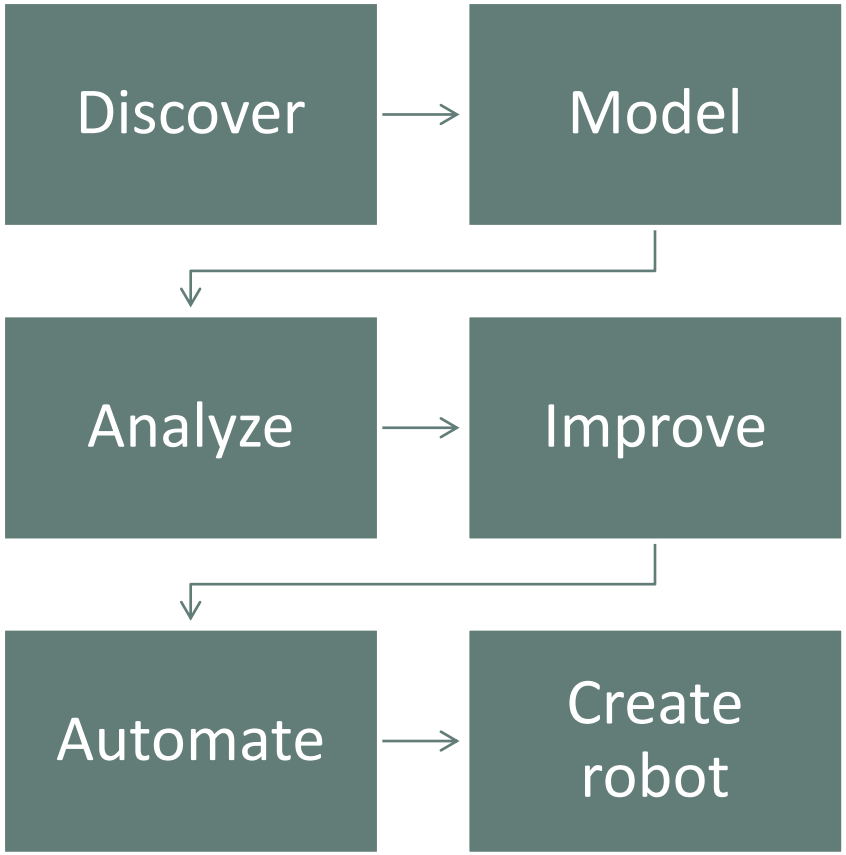
What is artificial intelligence?

Simplest definition: Having a computer do things that we thought only humans could do

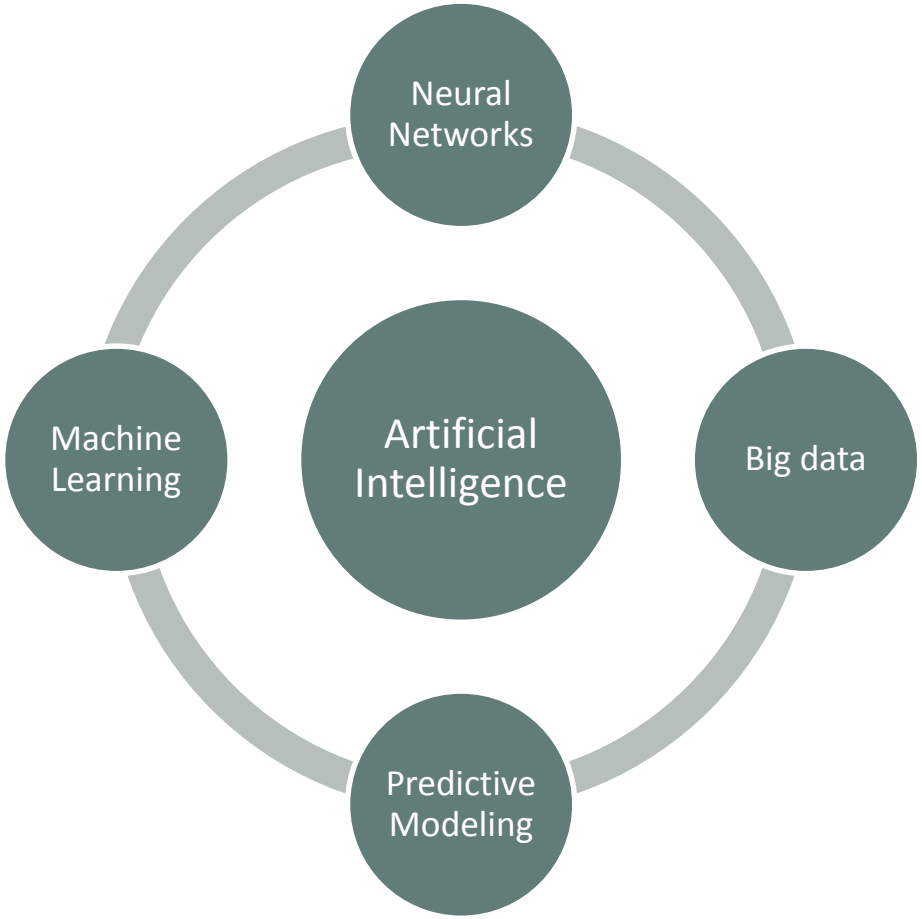
Smart Home

Business process management

"Business Process Management" is the term that has been adopted to identify the discipline of operations management. It uses specific methods to:



Artificial Intelligence – many names, facets and causes

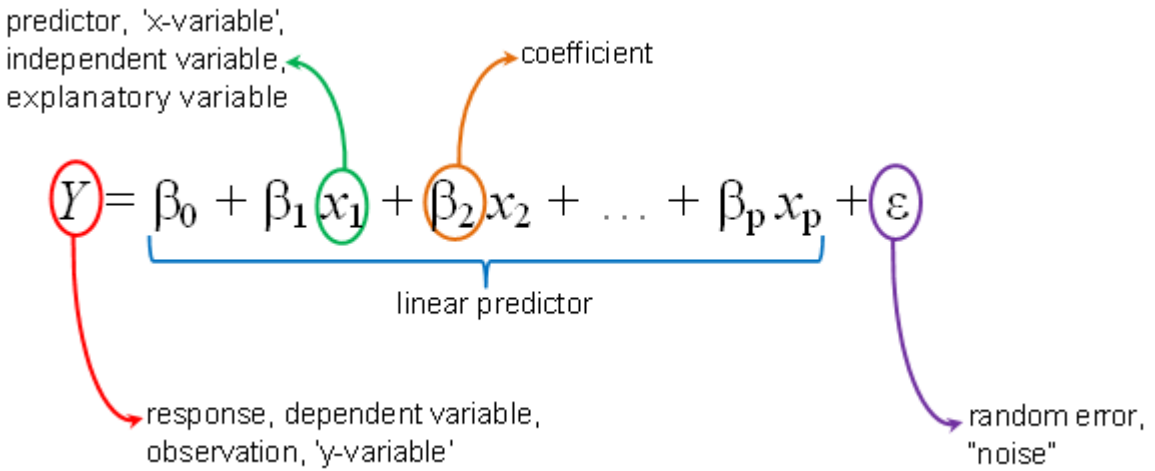


- Artificial Intelligence combines many recent hardware developments, programming breakthroughs, and in some underwriting applications, access to EXTREMELY granular social and financial information about an individual or a household (e.g., pre-fill information) to create a final product

Machine learning caveats

Concerns with data-up approach (machine learning)

- This means starting from the data itself with no preconceived notions of what you'll find or what results to expect.
  - Correlation does not mean causation
    - Causation is needed to determine if a person organization is liable for discriminatory or illegal behavior
      - Disparate impact exception
    - All insurance rating that uses classifications in its rating is discriminatory; the question is if it is ***unfairly discriminatory***



Fictitious examples of issues with machine learning

What if "data up" approach finds these correlations and uses them in their decision making:

- Hiring software for a fast food restaurant chain discovers that based on their data that teenage employees that come from a home with a household income 3 or more times the national average have been the most reliable in terms of showing up on time and lasting longer with the same franchise
  - it programs that only teenagers from these households are interviewed for jobs (company in photo did not do this)
- Sub-prime auto loan application using pre-fill software discovers that religious affiliation from a specific denomination has a pretty strong impact in certain zip codes in whether a loan is going default or not
  - it factors religious affiliation heavily in the interest rate charged the borrower
- Owner, franchisor and software developer will probably all be sued for discrimination
  - Should insurers start offering coverage for this exposure?

Insurance loss exposures created by artificial intelligence

Artificial intelligence – third party software causes physical injury

Insurance risk needs to distinguish "robots" or artificial intelligence devices that can cause bodily injury or property damage from hybrid companies who create software used by third party persons or organization and such third parties can cause bodily injury or property damage from using the software, e.g., Uber of Lyft

- For example, Transportation Network Companies (TNC) like Uber or Lyft whose software couples their "customers" with their "drivers"
  - Really unknown if the TNC companies are liable in a specific state or not until a court decides
    - 2014 California Case Sofia Liu vs Uber, both parties agreed to a settlement with undisclosed terms in 2015
    - Are drivers independent contractors and are TNC common carriers?
      - Many states passed legislation that declares drivers independent contractors and that TNC's are not common carriers

With new technologies, problem is laws weren't developed based on these technologies, but who is liable and why is still based on existing laws when "commerce" was done much differently

Artificial intelligence – devices with software and hardware created by same manufacturer that cause bodily injury or property damage

Insurance risk needs to distinguish "robots" or artificial intelligence devices that can cause bodily injury or property damage; i.e., bodily injury or property damage is caused by both hardware and software

- Autonomous car
- irobot Roomba vacuum cleaner
- Relay by Savioke
  - http://www.savioke.com/hospitality-1

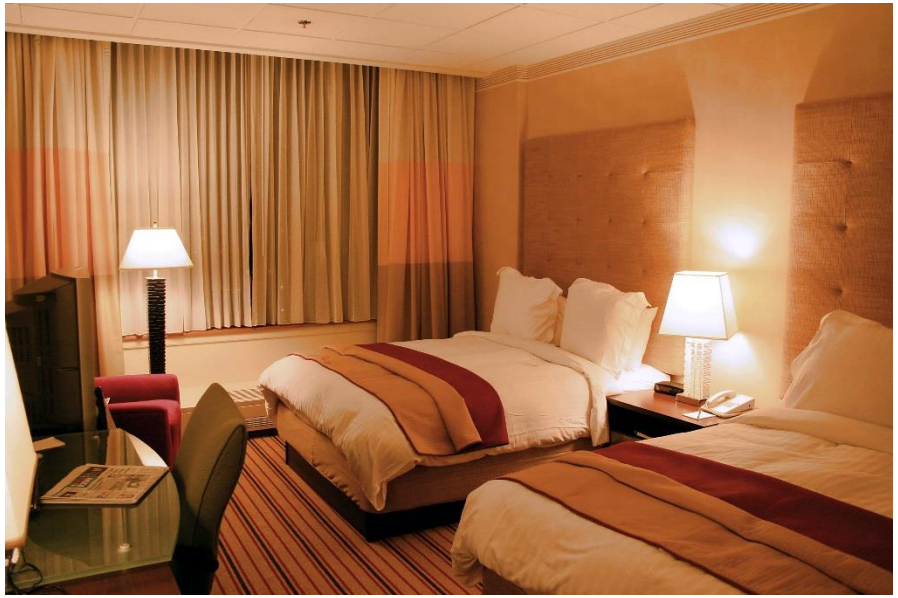
Artificial Intelligence – hotel robot analysis

Liability risk for hotels who use robot

- Small child runs into robot and suffers a concussion
- Child hurts hand or fingers pulling package out or putting package in robot
- Lithium ion batteries overheat that causes a fire that kills customers
- Senior citizen trips over robot, breaks hip and dies soon after
- What do you charge for exposure and how do you know they have one if application doesn't ask about it?

Property risk for hotels who use robot

- Lithium ion batteries overheat that cause a fire
- Someone steals the robot
  - ACV, replacement cost value are question marks
- Someone steals a package for the customer from the robot
- Does application even ask if hotel has a robot?



Artificial intelligence – software that creates a professional liability exposure

Insurance risk needs to distinguish predictive analytic software developed to make decisions that create a professional liability (usually discrimination) and/or errors and omissions risk

What if software doesn't deliver the results or efficiencies that were indicated?

For example, current AI software assists lawyers in the many phases of contract review: contract creation, contract analysis, and contract due diligence

- Do mistakes in software make it much easier to create class action lawsuits?
- How to apportion liability between the lawyer, law firm and software developer may lead to costly litigation
- How do insurers avoid paying multiple coverage limits for the same loss. For example, general liability and professional liability

Underwriter and claim handler artificial intelligence issues

Underwriter Issues

Are questions about use of artificial intelligence going to be needed in application and incorporated in underwriting guidelines

For risks that create or use robots and risk with exposures with internet of things, will underwriters need to know cyber exposures and professional liability exposures in addition to property and casualty?

- Can one underwriter realistically know all this information to effectively underwrite

Importance of contractual risk transfer, hold harmless agreements and additional insured endorsements

Technology so new

- No credible rates to cover these exposures

Claim handler issues

Will claim processing algorithms be exploited for fraud?

Will algorithm be discoverable in the event of a bad faith claim?

How effective will algorithm be in detecting fraud?

- "Touchless" auto physical damage claim applications

Will property appraisal applications from a third party vendor that are sold to multiple insurers lead to "collusion" lawsuits?

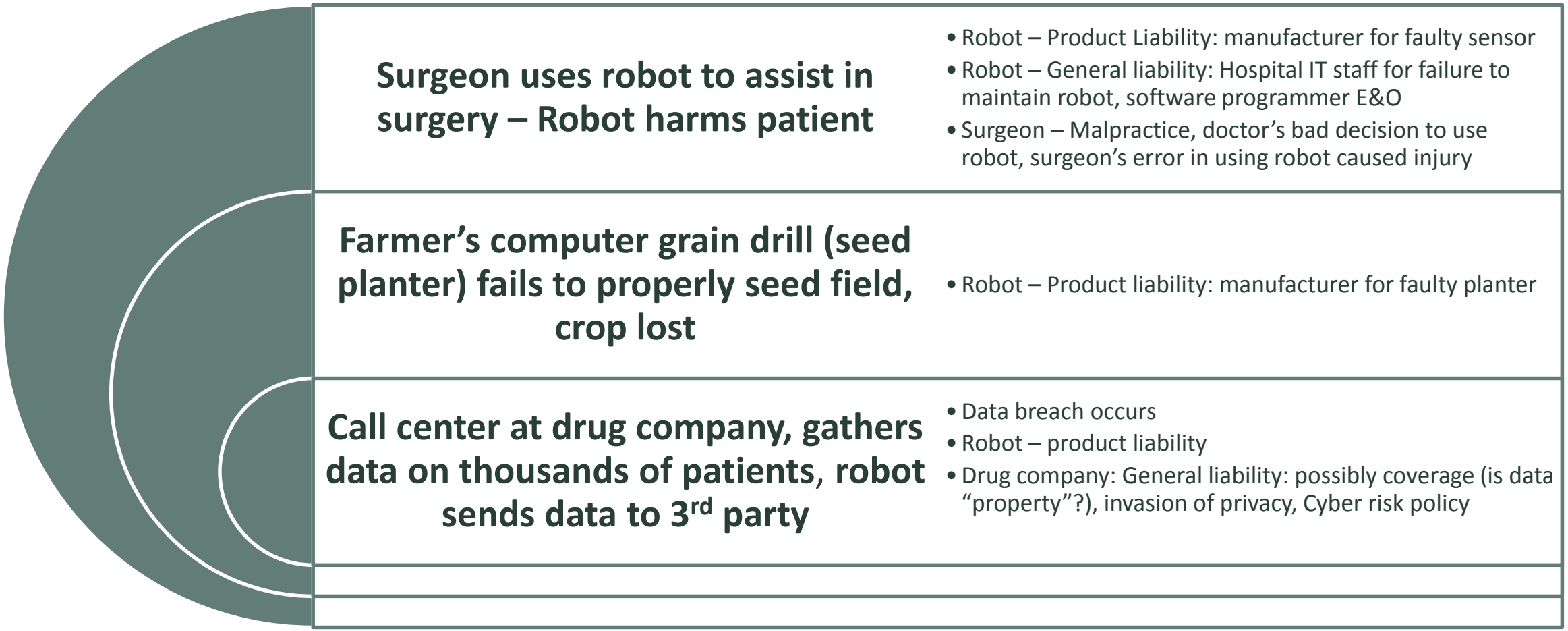
- What happens if insurer appraisal application differs from appraisal applications developed for auto body shops?
  - How is this difference of bias, or at least the perception of bias, resolved

More artificial intelligence fictitious claim examples

Current insurance for users and robot acts

General Liability	E&O	Product Liability
Personal injury, BI & PD	Operator Error	Product Malfunction BI & PD
Invasion of Privacy	Programmer Error	Business interruption
Copyright infringement	Bad investment advice	
Defamation	Bad insurance advice	
	Medical malpractice	
	Professional liability	

Today: Insurance coverage v. robot acts – examples



Today: Insurance coverage v. robot acts – examples

Hackers take over self-driving car, cause accident	• Product liability: manufacturer for product malfunction • E&O: programmer error for opening that allows hackers in • Product recall • Will property damage liability be excluded because of cyber exclusion? • Will manufacturer's product liability policy respond or third party software developer's E&O policy?

Robotic technology for screening job applicants	• Selects applicants based on impermissible categories (race, gender, age, etc.)
	  • Robot - Product liability: programmer error
	  • Employer – Employment practices liability, discrimination
	  • Robot manufacturer and software provider: Professional liability – Negligent legal advice

Computer aided investment advice, auto-cash movement, error causes financial losses investors	• Robot – Product liability, but may not apply because no bodily injury or property damage liability • Investment firm: E&O, responsible for bad advice

Future: Robots with Artificial Intelligence

The next frontier: next 20 to 40 years, computers will be trillions of times more powerful than they are today

Cognitive computing: simulation of human thought processes, self-learning systems, mimic the way the human brain works.

Crossing the border:

- Robots evolve into self-thinking and self-acting beings
- Act separately from their human creators
- Robots beget robots, create and program one another
- Robots become capable of having intent to commit an act
  - Earlier versions had no such capability, now can decide to act and do act
- **Will robots be subject to direct liability, separate from human creators!**

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Questions and Discussion