

# **NANOTECHNOLOGY FOR TRANSPORTATION ENGINEERS**

Presented by  
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# Outline

**Introduction and Background**

**Concept and Definition**

**Nano-Materials and Processing**

**Nano-Electronics and Instrumentation**

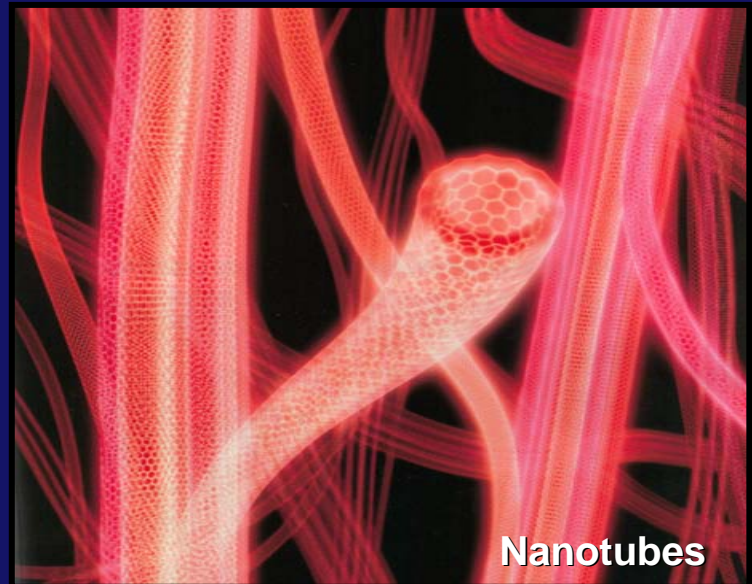
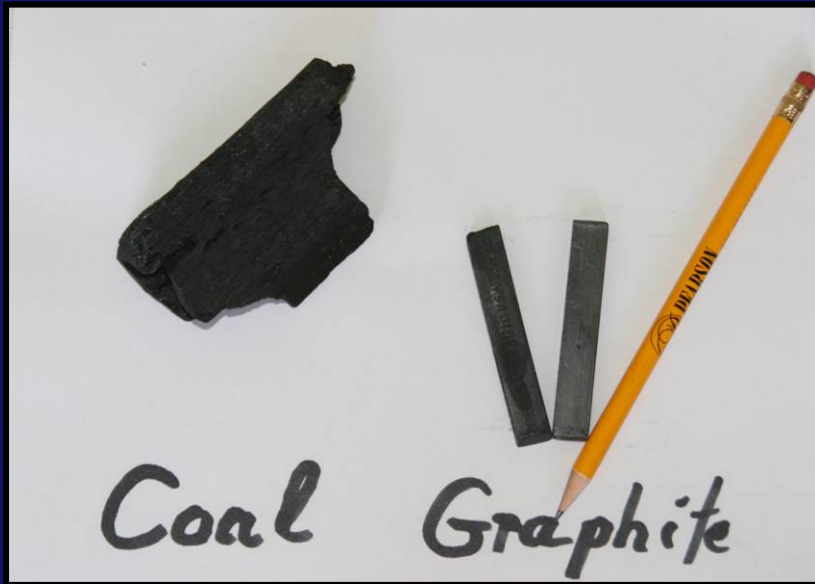
**Opportunities and Outlook for**

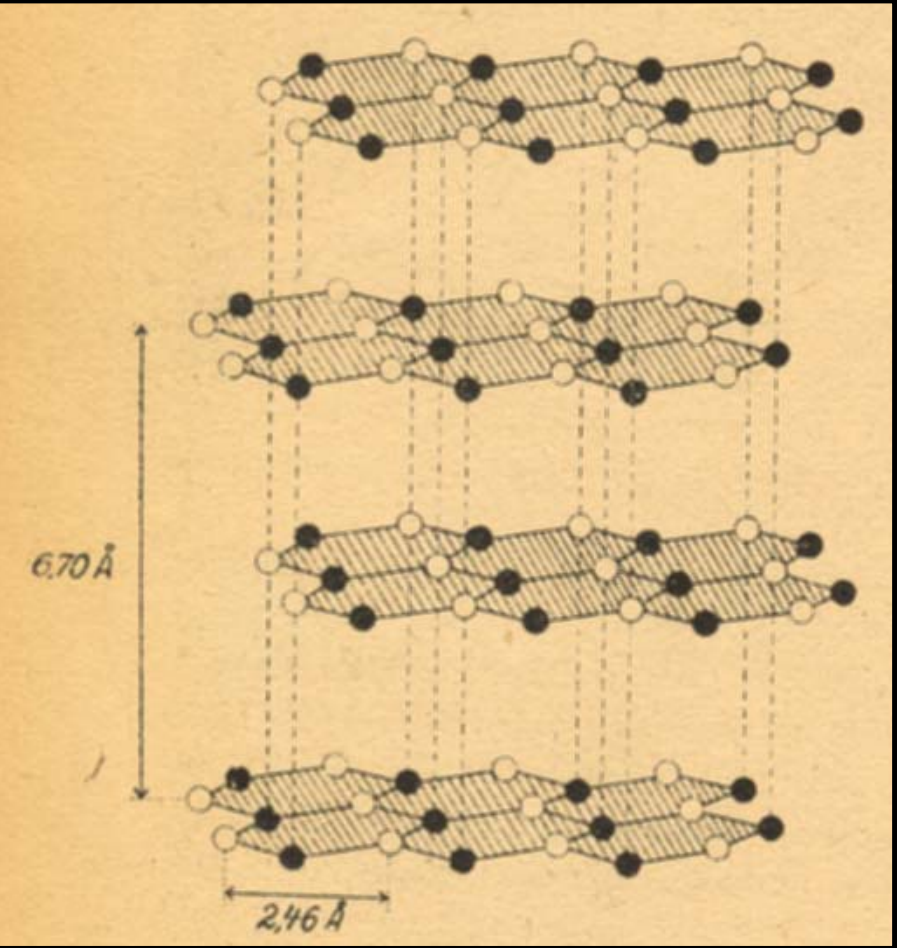
**Transportation Engineering**

**Conclusions and Recommendations**

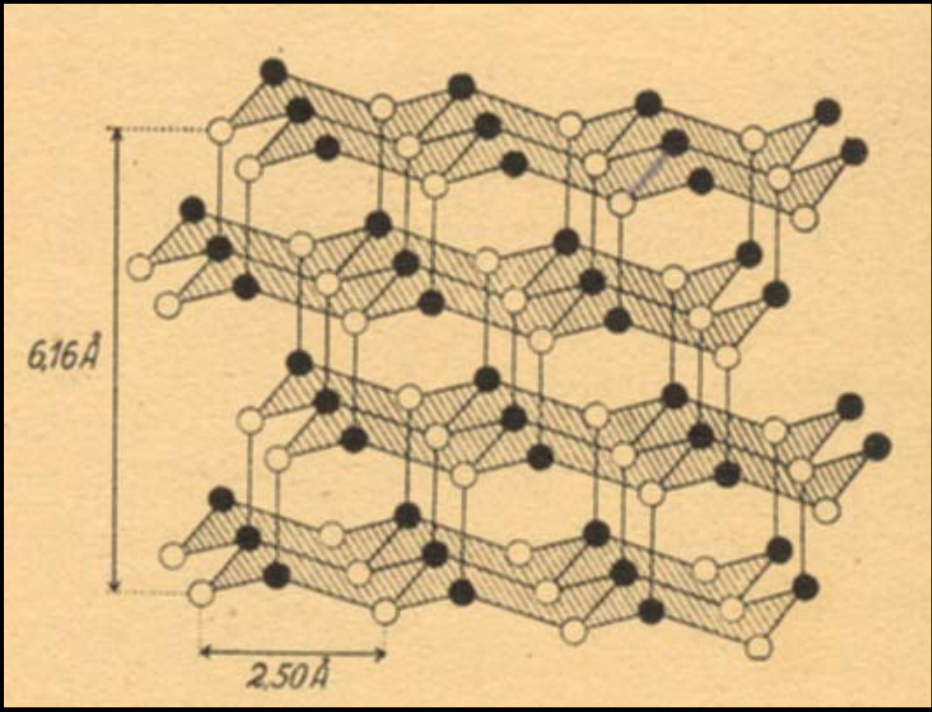
# Introduction and Background

- **Inter-Disciplinary Science**
- **Imagination** *“Imagination is more important than knowledge”*  
**Albert Einstein**
- **Examples:** coal > diamond, emulsified asphalt
- **Impact on Engineering:** challenging, competitive, and revolutionizing
- **Purpose and Goals:**
  - ✓ introduce basic concepts and definitions
  - ✓ describe nano-materials and processing
  - ✓ illustrate nano-electronics and instrumentation
  - ✓ elaborate on opportunities in transportation
  - ✓ suggest future direction





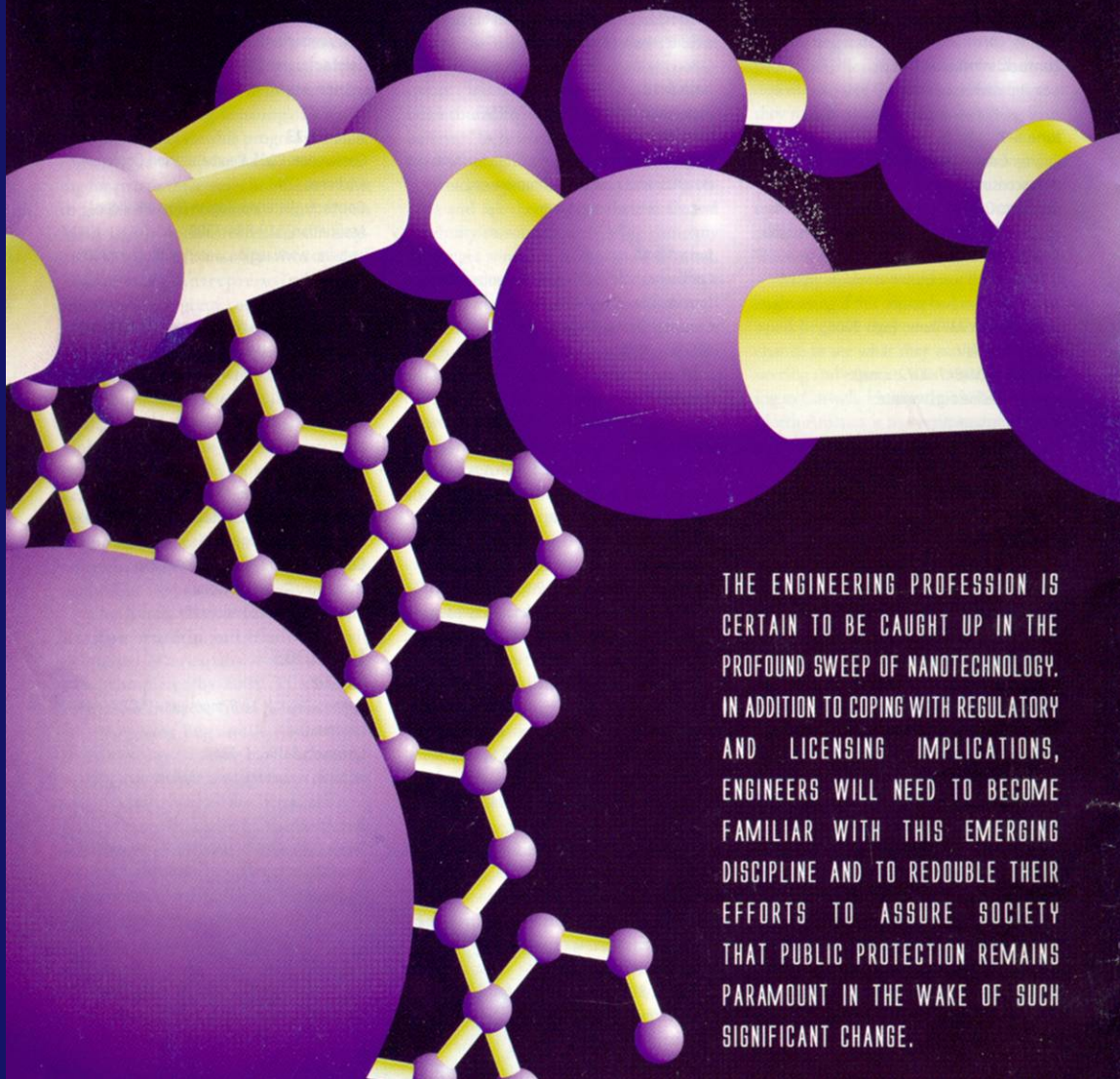
Kristallgitter des Graphits



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# NANOTECHNOLOGY: BRACING FOR A WHOLE NEW WAY



THE ENGINEERING PROFESSION IS CERTAIN TO BE CAUGHT UP IN THE PROFOUND SWEEP OF NANOTECHNOLOGY. IN ADDITION TO COPING WITH REGULATORY AND LICENSING IMPLICATIONS, ENGINEERS WILL NEED TO BECOME FAMILIAR WITH THIS EMERGING DISCIPLINE AND TO REDOUBLE THEIR EFFORTS TO ASSURE SOCIETY THAT PUBLIC PROTECTION REMAINS PARAMOUNT IN THE WAKE OF SUCH SIGNIFICANT CHANGE.

- **Impact on Engineering: challenging, competitive, and revolutionizing**

1. **Research groups and initiatives**

- ✓ **National Institute for Nanotechnology (NINT)**  
*[www.http://nint-innt.ncr-cnrc](http://nint-innt.ncr-cnrc)*
- ✓ **National Nanotechnology Initiative (NNI)**  
*[www.nano.gov](http://www.nano.gov)*
- ✓ **CANSMART, “Materials and Structures Group”**  
*[www.cansmart.com](http://www.cansmart.com)*
- ✓ **Nano-Ontario, initiative of Toronto, Waterloo and McMaster Universities**

- **Impact on Engineering: challenging, competitive, and revolutionizing**

## 2. References

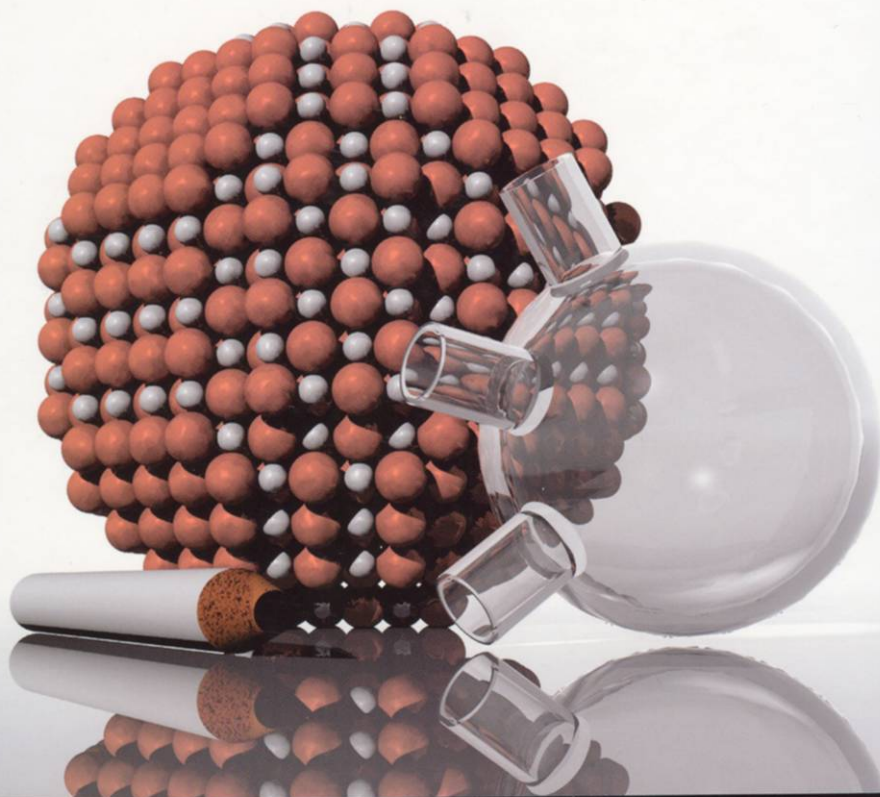
- ✓ Better Roads, “Small science will bring big changes” , July 2004, page 20
- ✓ Better Roads, “Road Science – Smart Structures” Dec. 2003, page 32
- ✓ University of Bonn, “Lotus Effect”,  
[www.Botanik.uni.bonn.de/system/hionik\\_en.html](http://www.Botanik.uni.bonn.de/system/hionik_en.html)
- ✓ Free Trade Publication, “Nanotechnology Now: Your Gateway to Everything Nanotech”,  
[www.nanotech-now.com](http://www.nanotech-now.com)
- ✓ Ozin, G.A. and Arsenault, A., “Nanotechemistry: A Chemical Approach to Nanomaterials”,  
textbook by RSC 2005
- ✓ National Geographic, June 2006



# NANOCHEMISTRY

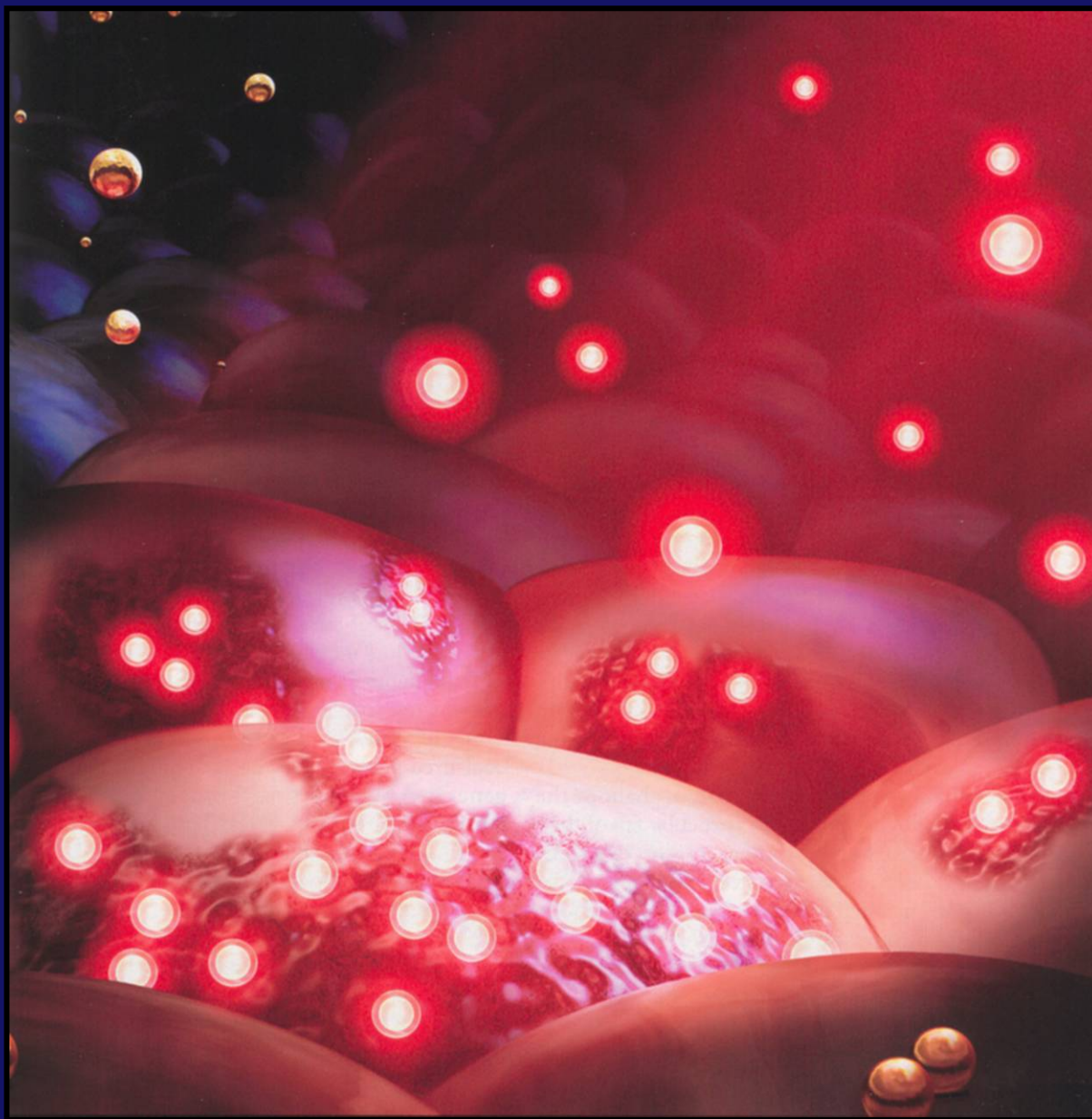
A Chemical Approach to Nanomaterials

Geoffrey A Ozin & André C Arsenault



RSC Publishing

# Killing Cancer Cells



# Concepts and Definitions

## 1. Concepts

- **Quantum size effect**
- From large to small
- Science and technology combine to shape society
- Developing new material properties and processes
- Extend of application and benefits:
  - ✓ New and improved material properties
  - ✓ Greater precision in manufacturing
  - ✓ Lighter, stronger and more durable materials
  - ✓ Sensing changes and deficiencies
  - ✓ Initiating self-repair
  - ✓ Material self-assembly

# 1. Concepts cont'd.

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  - ✓ Etc.

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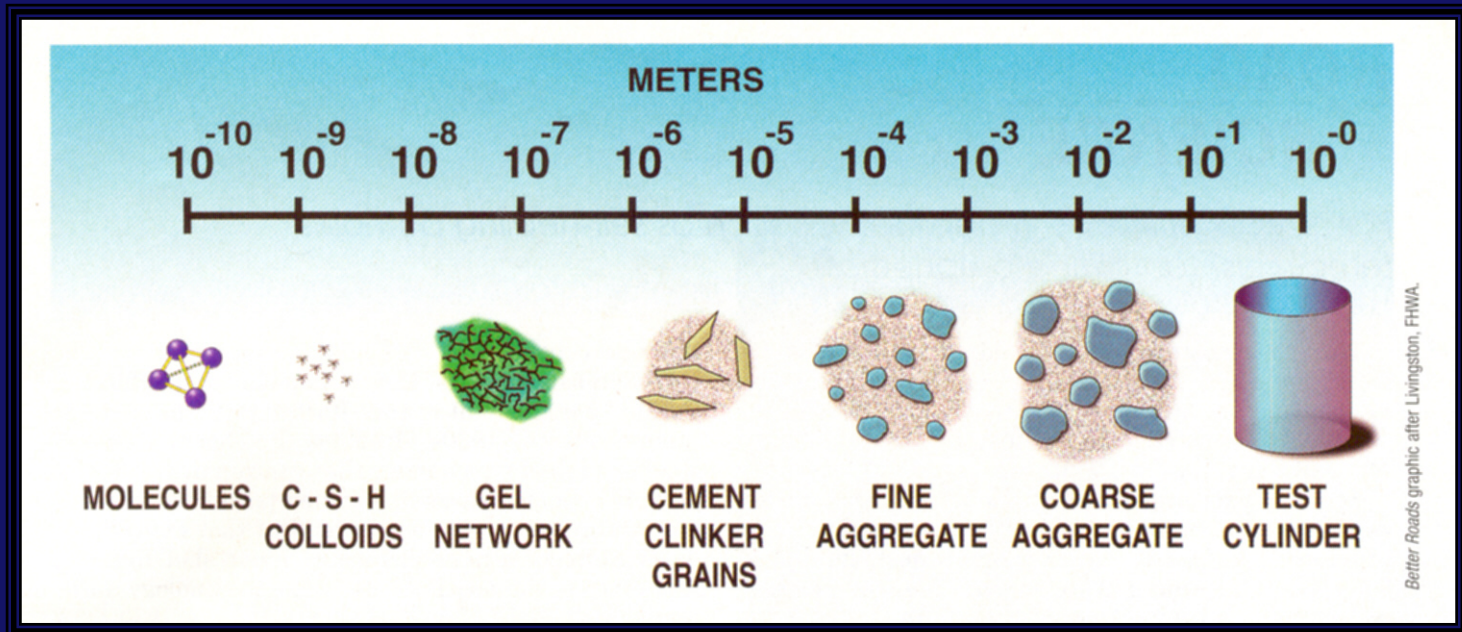
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  - ✓ Etc.

# Concepts and Definitions cont'd.

## 2. Definitions

- “Nano” from *nanos* = dwarf (Greek) denotes the prefix for the factor  $10^{-9}$



## 2. Definitions cont'd.

- “Nano” from *nanos* = dwarf (Greek) denotes the prefix for the factor  $10^{-9}$
- Derived terms: *nanosecond*; *nanometer*; *nanoscience* and *nanotechnology*
- CCPE nanotechnology research areas
  - ✓ nano-materials and processing
  - ✓ nano-electronics and instruments
  - ✓ software and computing
  - ✓ nano-biotechnology medial products
  - ✓ environment (water purification, renewable fuel)

# Nano-Materials and Processing

- **Pavement crack repair with self-healing polymers**
  - ✓ **microencapsulated healing agent with catalytic chemical trigger within epoxy matrix**
  - ✓ **releasing healing agent into crack plane through capillary action**
  - ✓ **bonding upon contact with embedded catalyst**
  - ✓ **similar process with micro-sized hollow fibers containing crack sealant (for bridge piers)**



# Nano-Electronics and Instrumentation

- Smart structures for highway bridge
  - ✓ wireless maturity meter imbedded into pavement
  - ✓ meter provides immediate and continuous data collection



- ✓ other sensors are being developed to access the loading condition, structural responses, and changes in material properties

# **Nano-Electronics and Instrumentation** cont'd.

- **Smart aggregates and MEMS (MicroElectroMechanical Systems)**
  - ✓ **wireless sensor feasibility of cyberliths and their radio communication properties is studied**
  - ✓ **electromagnetic finite element models are used**
  - ✓ **to determine range and spatial (area) resolution of sensors embedded in concrete or soil**
  - ✓ **Wireless sensor to monitor corrosion have been developed**
  - ✓ **Golden Gate Bridge has 200 small MEMS, also called motes**

# Opportunity and Outlook for Transportation Engineering

- fundamental research in nano-materials, processing and sensors over the last decade has opened the doors for applied research
- opportunities for pavement and transportation application are excellent, eg.
  - ✓ mechanistic and science based composition and structure design
  - ✓ improved performance, incl. long lasting, durability, cost, maintenance, etc.
  - ✓ “smart roads” for network wide automated data collection as input for asset management and decision making
- opportunities for innovative technology related to safety, environment, recycling and rehabilitation
- predicted by need and opportunities, the outlook is also excellent

# Conclusions and Recommendation

- **Traditional macro-approach of transportation engineering must be and will be replaced by nanotechnology**
- **For many aspects a multi-disciplinary research approach will be required**
- **This emerging discipline requires a good deal of dedication, funding and training**
- **Nanotechnology development has high priority in CPATT's research program**

# Nanointro

