奈米科技在食品上的應用

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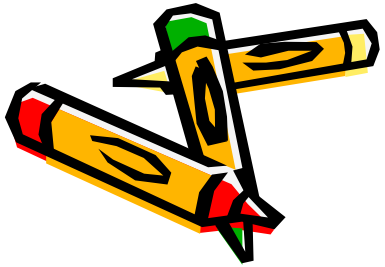
台灣大學食品科技研究所

奈米科技與生活 研討會

宜蘭大學

October 11, 2007

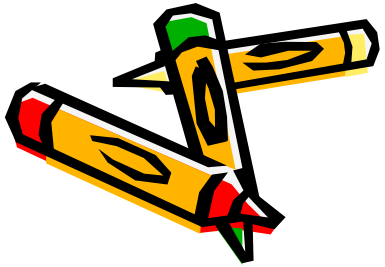


"There's Plenty of Room at the Bottom"

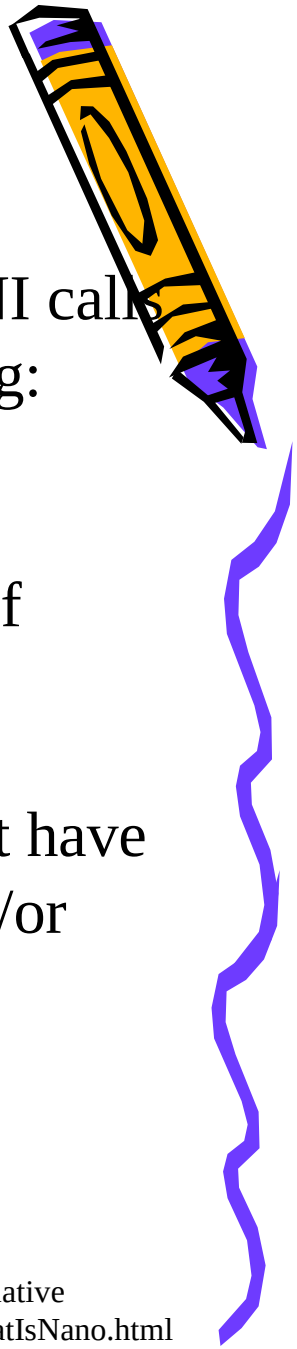
By Richard P. Feynman (著名物理學家 理查. 費曼)

The annual meeting of the American Physical Society at the California Institute of Technology on December 29, 1959

The speech was first published in the February 1960 issue of Caltech's Engineering and Science



What is Nanotechnology?



While many definitions for nanotechnology exist, the NNI calls it "nanotechnology" only if it involves all of the following:

1. Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range.

2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.

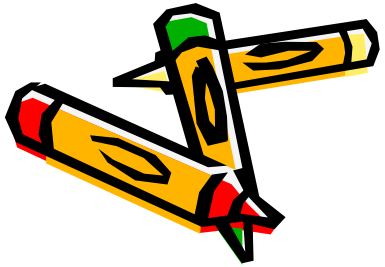
3. Ability to control or manipulate on the atomic scale.

National Nanotechnology Initiative
http://nano.gov/html/facts/whatIsNano.html

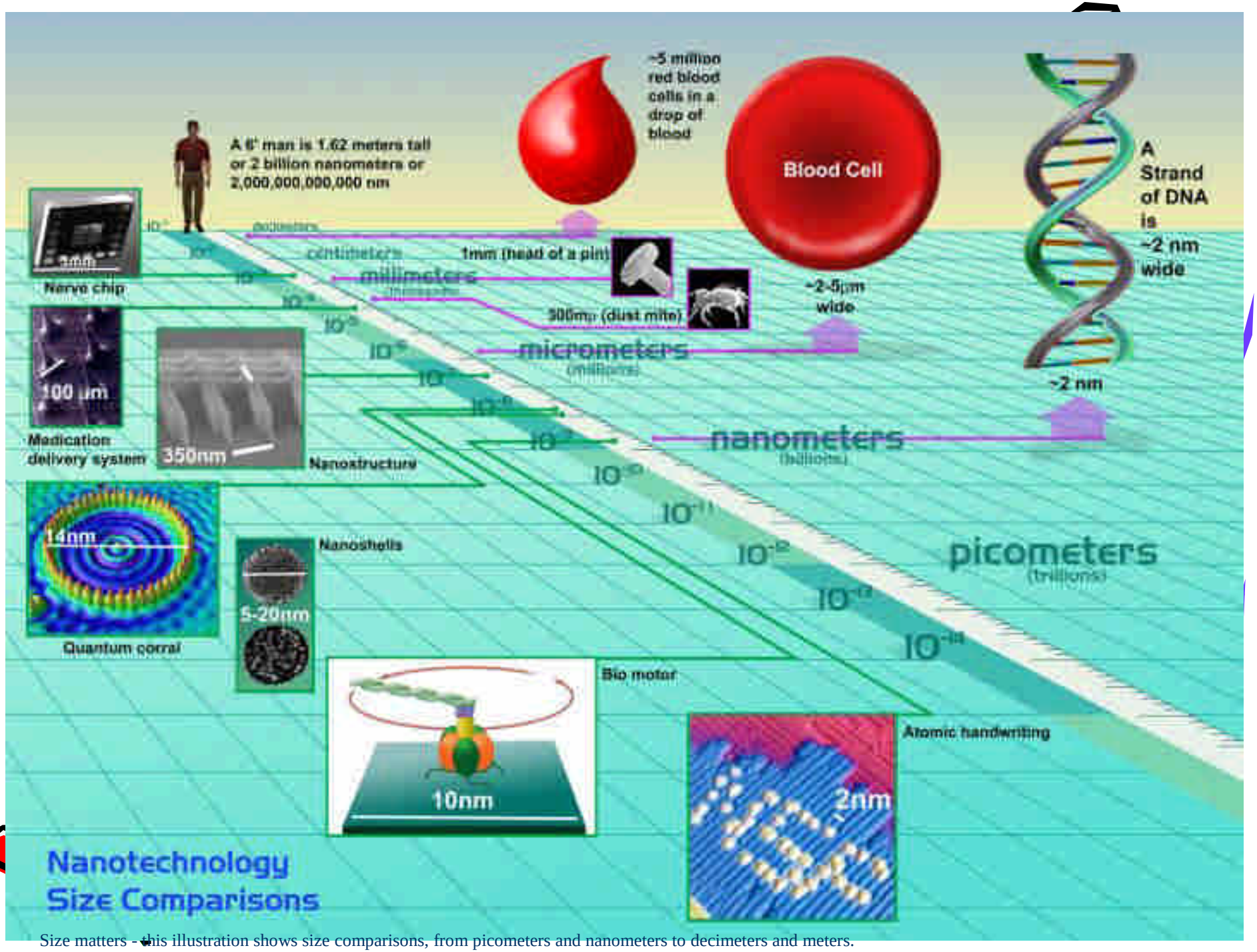
Definitions of Nanoscience and Nanotechnologies

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale.



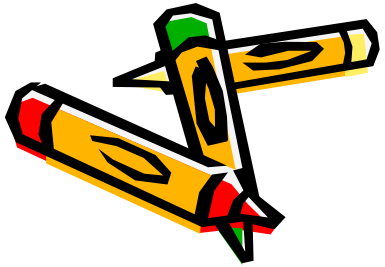
The Royal Society & The Royal Academy of Engineering
Nanoscience and nanotechnologies: opportunities and uncertainties| **July 2004**|p.5
http://www.nanotec.org.uk/report/chapter2.pdf



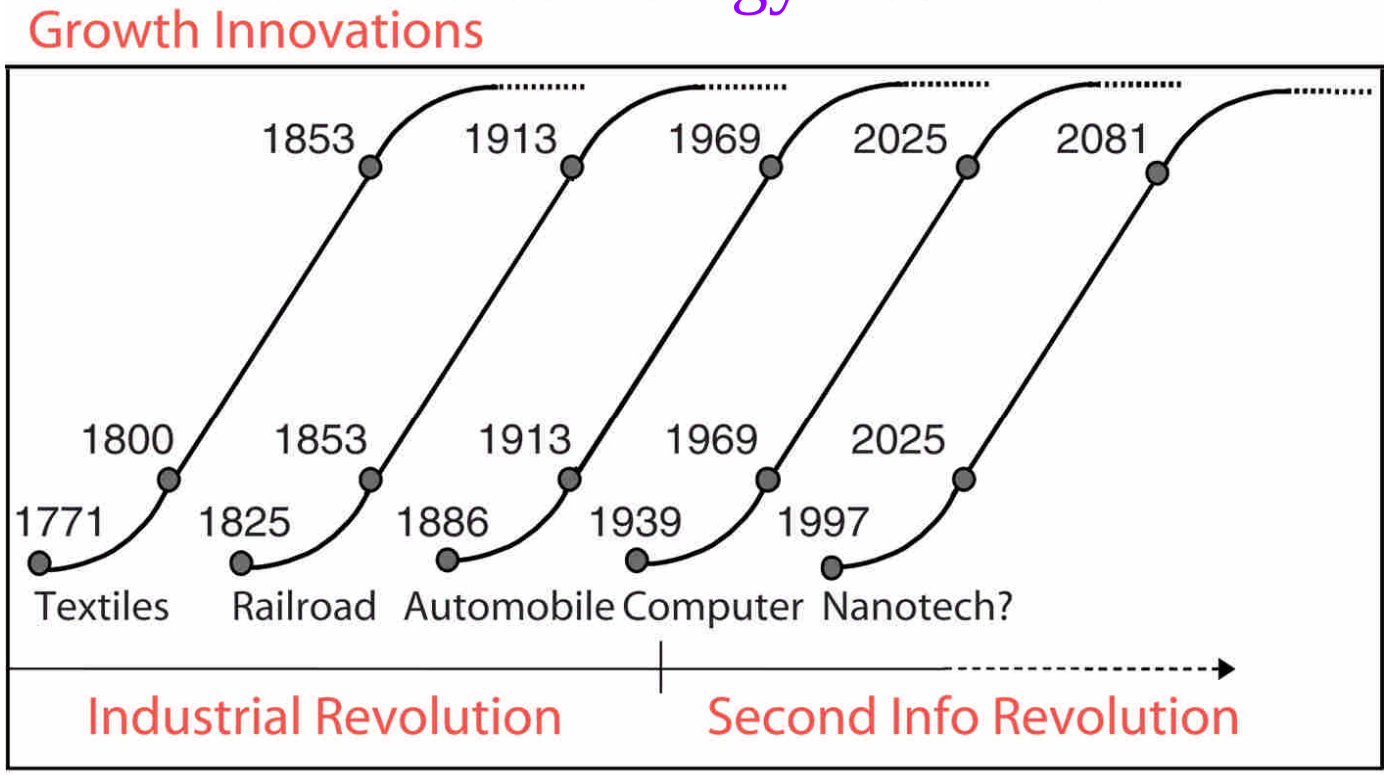
Size matters - this illustration shows size comparisons, from picometers and nanometers to decimeters and meters.

Prefixes that Describe the Sizes of Things

Prefix	Symbol	Power	Name
Exa	E	10^{18}	quintrillion
Peta	P	10^{15}	quartrillion
Tera	T	10^{12}	trillion
Giga	G	10^{9}	billion
Mega	M	10^{6}	million
Kilo	k	10^{3}	thousand
Unity		10^{0}	one
Centi	c	10^{-2}	hundredth
Milli	m	10^{-3}	thousandth
Micro	μ	10^{-6}	millionth
Nano	n	10^{-9}	billionth
Pico	p	10^{-12}	trillionth
Fento	f	10^{-15}	quartrillionth
Atto	a	10^{-18}	quintrillionth



The Nanotechnology Revolution

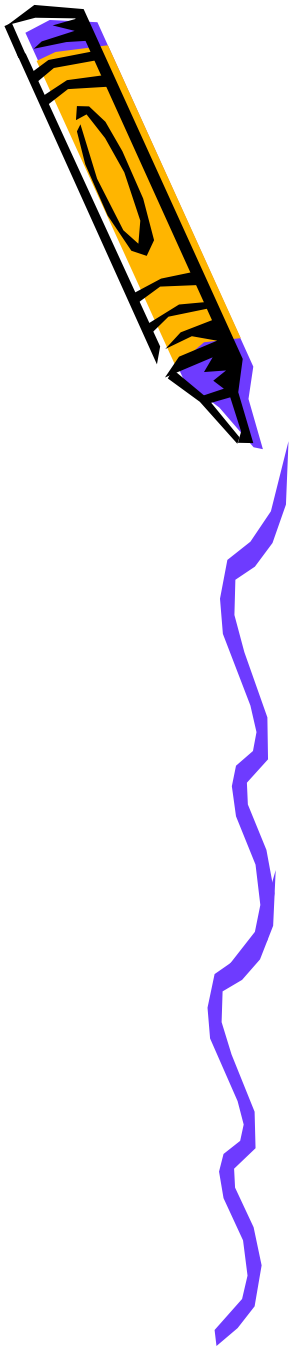


Sources: Norman Poire, Merrill Lynch

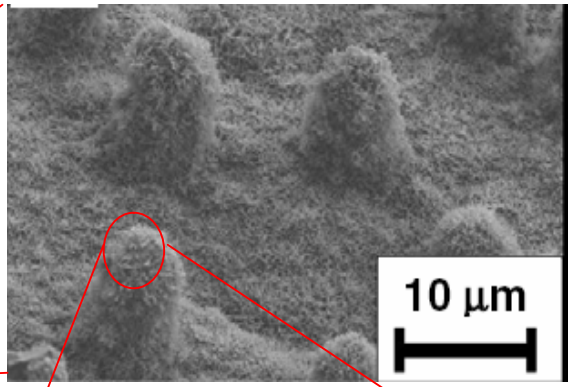
Nanotechnology is predicted to rival the development of the automobile and the introduction of the personal computer

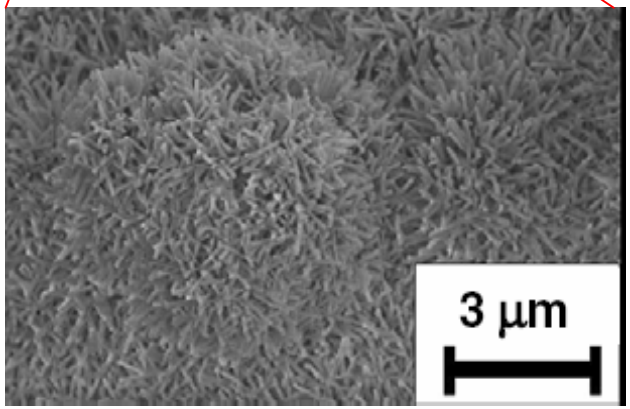
http://www.mrsec.wisc.edu/Edetc/SlideShow/index.htm

Introduction



蓮花效應（Lotus Effect）





Zyga, Lisa February 17, 2006
PhysOrg.com
Accessed on Dec. 7, 2006

Cheng et al., 2006
Nanotechnology 17:1359-1362.

永不褪色的衣服

奈米技術使衣服永遠亮麗如新

張迪愷 Feb. 11, 2007
世界週刊
專題報導 p. 10-17

不沾水的襯衫

在衣料上塗覆奈米顆粒可以防水、保暖、且不易髒污

張迪愷 Feb. 11, 2007
世界週刊
專題報導 p. 10-17

奈米化妝品：唇膏

將奈米技術應用於化妝品與保養品中，有益皮膚吸收、保濕，色彩更持久。

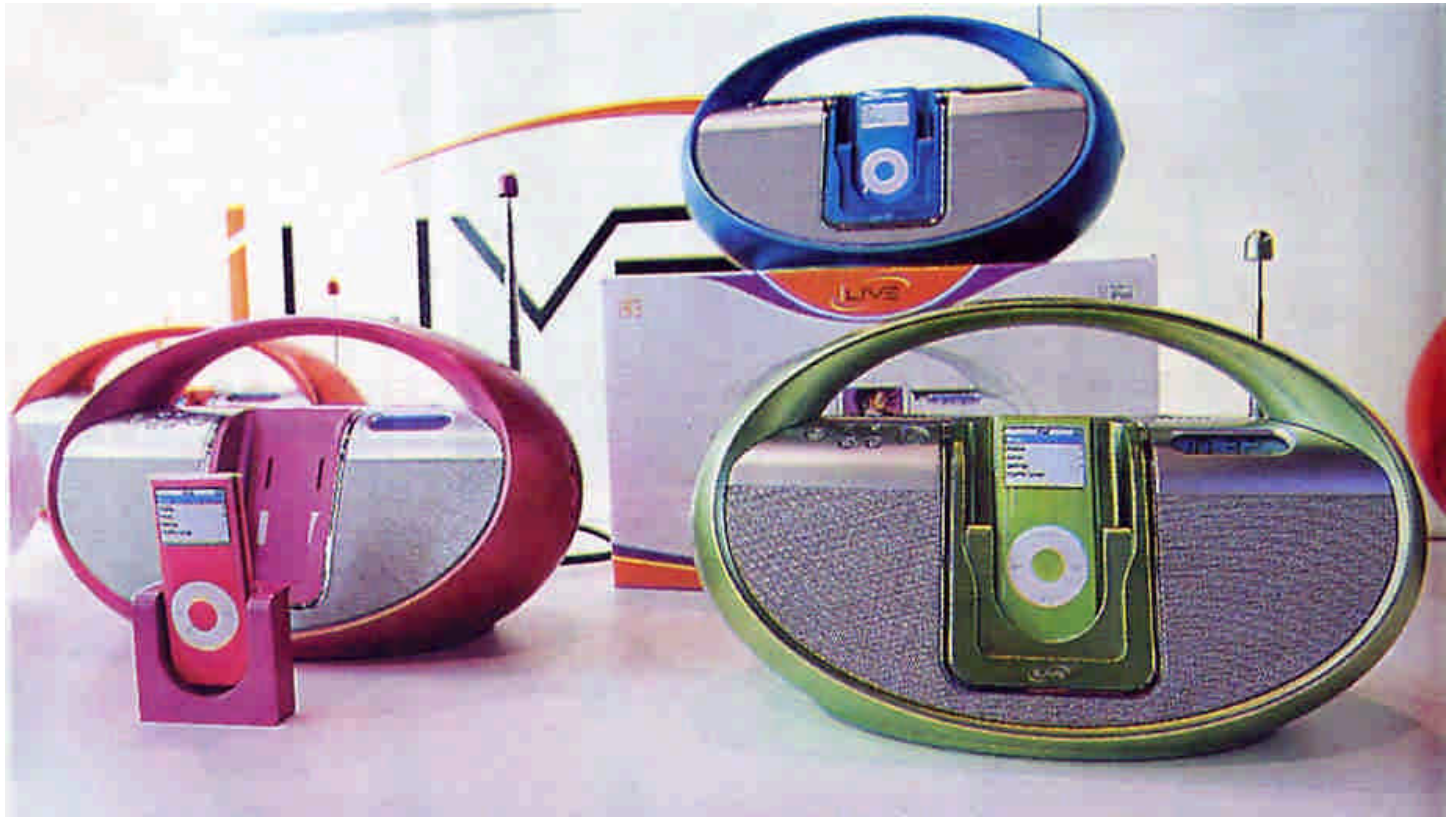
張迪愷 Feb. 11, 2007
世界週刊
專題報導 p. 10-17

不沾污的馬桶

經奈米表面處理，馬桶永遠亮晶晶。

張迪愷 Feb. 11, 2007
世界週刊
專題報導 p. 10-17

體積小、高記憶體的iPod MP3



音樂播放器，容量越來越大，最高可達80 GB，但體積會越來越小

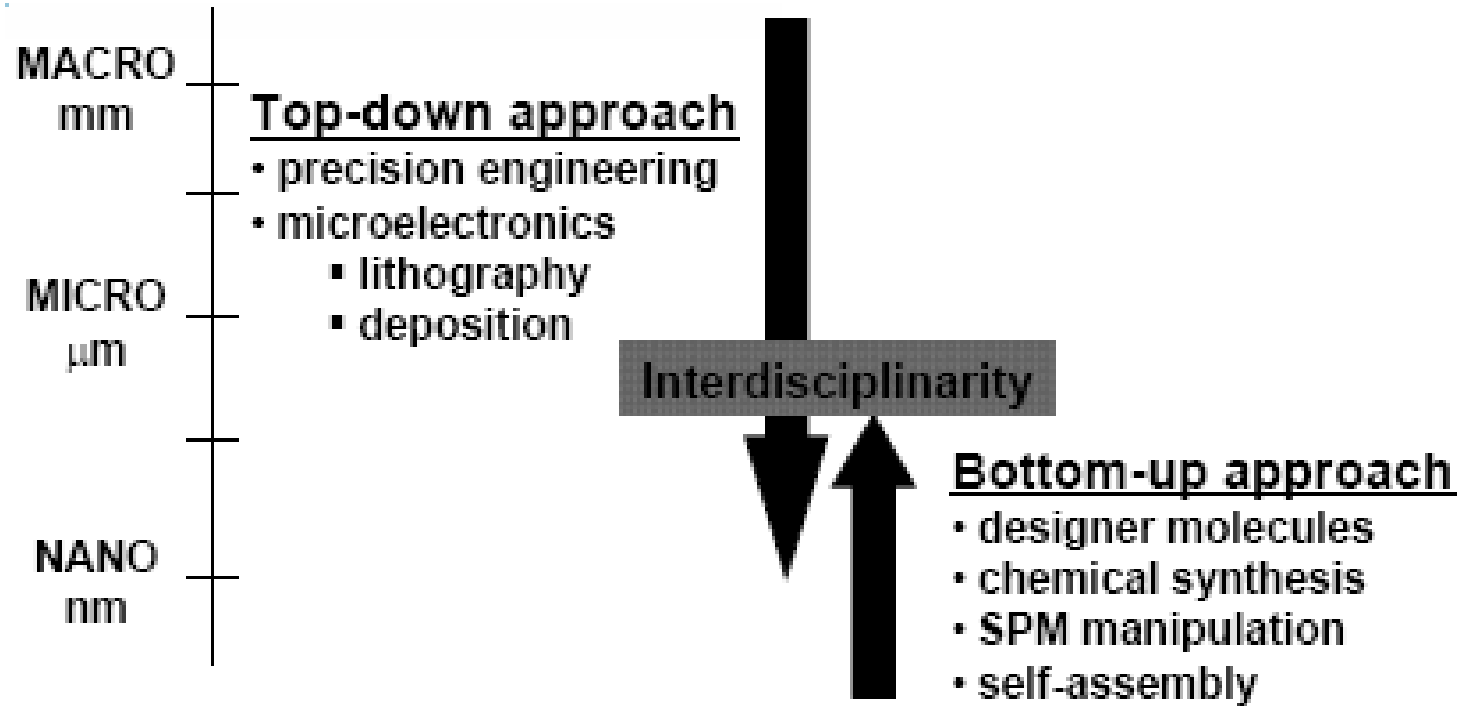
張迪愷 Feb. 11, 2007
世界週刊
專題報導 p. 10-17

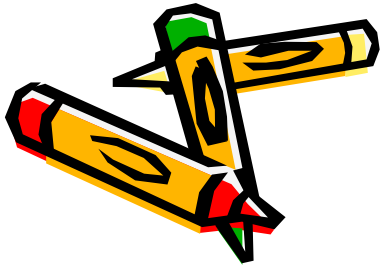
An Integrated and Responsible Approach

- **Nanotechnology requires action on several fronts**

Communication from the Commission COM (2004) 338
http://www.cordis.lu/nanotechnology
ftp://ftp.cordis.lu/pub/nanotechnology/docs/communication_presentation.pdf

Nano-Manufacturing





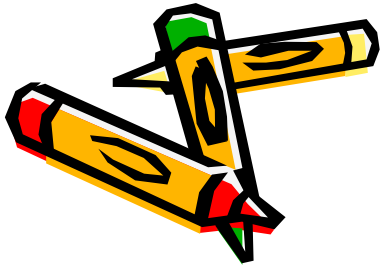
Communication from the Commission COM (2004) 338
http://www.cordis.lu/nanotechnology
ftp://ftp.cordis.lu/pub/nanotechnology/docs/communication_presentation.pdf

粒子奈米化

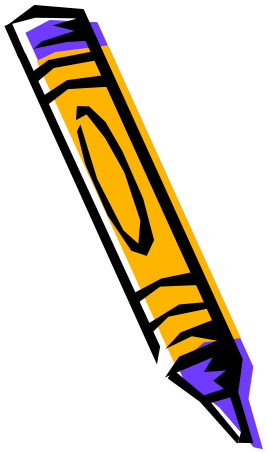
粒子數與表面積均增加

2克100奈米的鋁粒子，其總數可以平均分給地球上每人300,000顆，

700克10奈米的粒子（假設比重1.5）的表面積，可以覆蓋台北市。

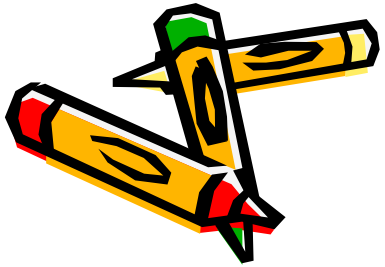


Coagulation Half-life



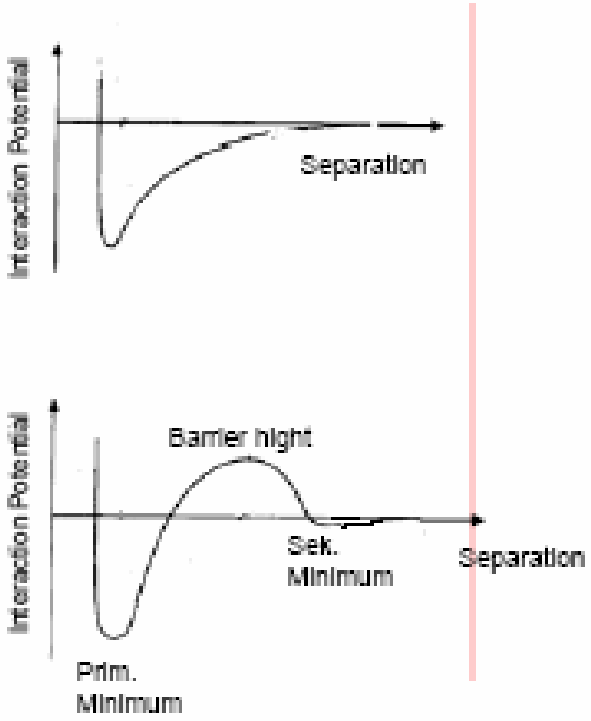
Particle diameter nm	Half life 1 g m^{-3}	1 mg m^{-3}	1 µg m^{-3}	1 ng m^{-3}
1	2.2 µs	2.20 ms	2.2 s	36.67 min
2	12 µs	12.00 ms	12 s	3.34 hrs
5	0.12 ms	0.12 s	2 min	33.34 hrs
10	0.7 ms	0.7 s	11.67 min	8.1 days
20	3.8 ms	3.8 s	63.34 min	43.98 days

1 m^3 = 1000 Liters



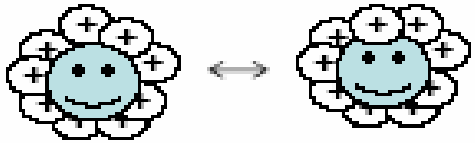
Aitken, Creely, Tran 2004
Institute of Occupational Medicine report 274
Nanoparticles: An occupational hygiene review p.19
(Preining 1998)

Particles Stability

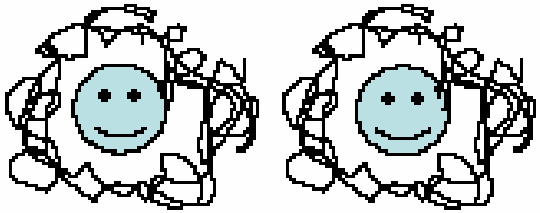


Stabilization methods:

- Electrostatic stabilization



Introduction of spatial constraints



液體-液體懸浮液的粒徑

乳化液

膠微粒

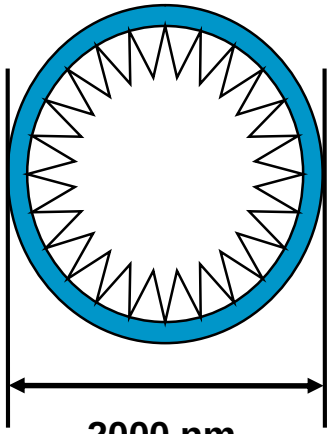
100 nm

一般均質

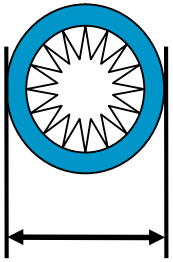
高壓均質

超乳化

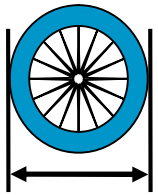
膠微粒



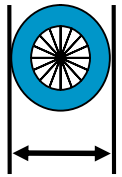
2000 nm



200 - 300 nm



30 - 50 nm



5 - 10 nm

乳白

藍白

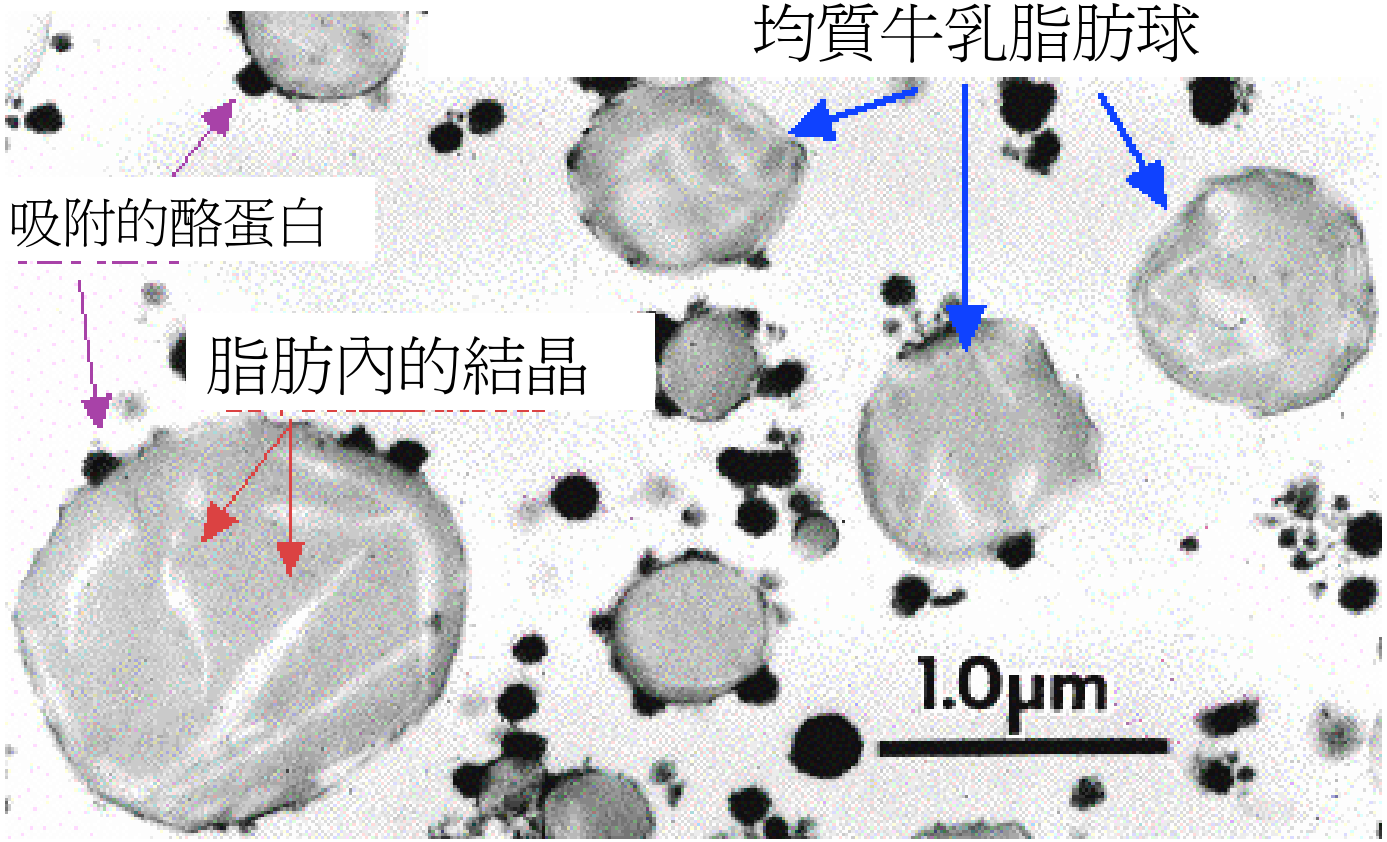
半透明

透明

乳化液容易分層與再聚集

可殺菌、穩定

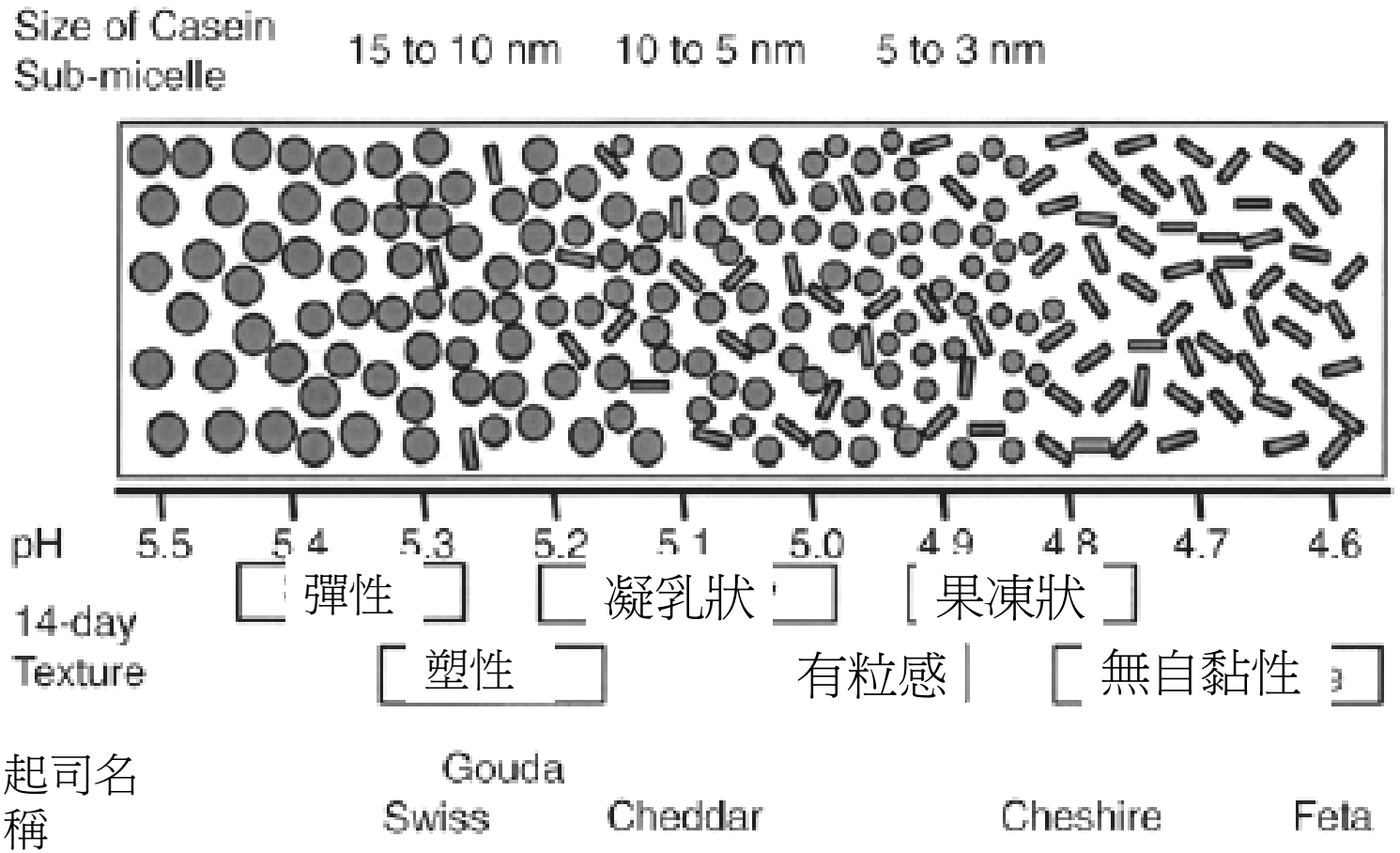
The Natural Nano-Particles



Electron Micrograph of Homogenized Milkfat Globules

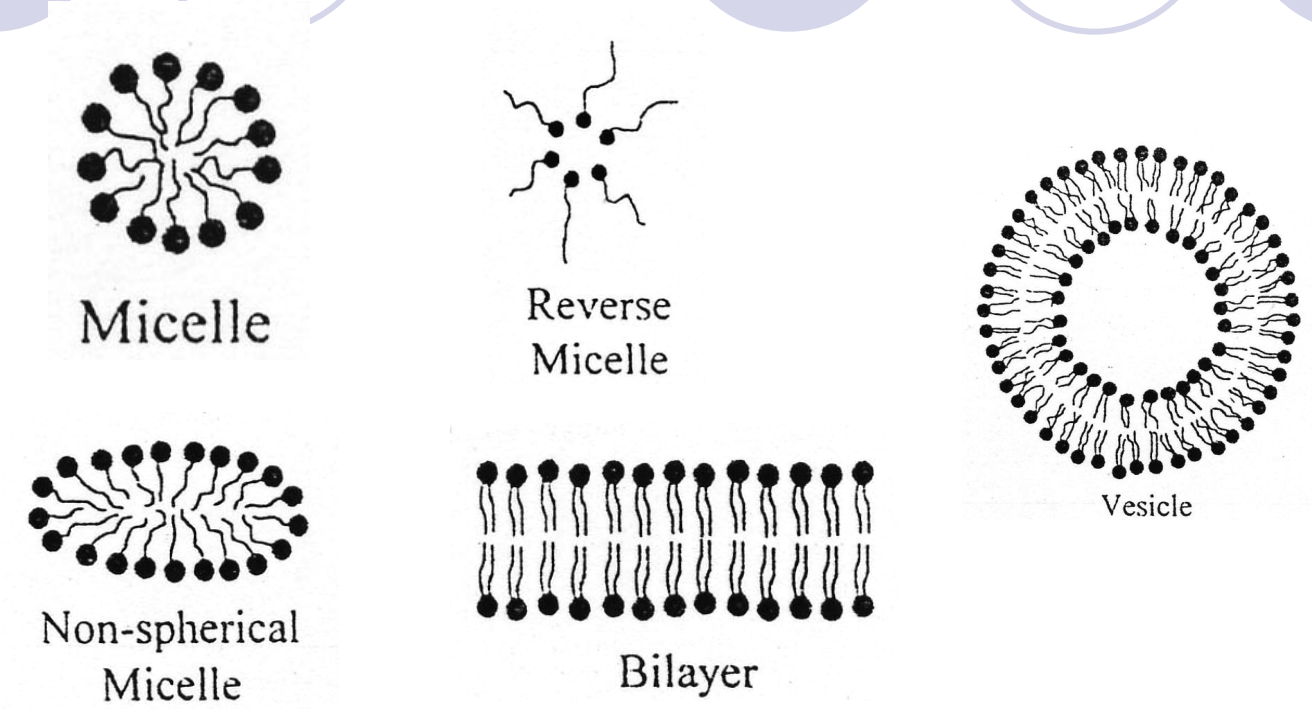
http://www.foodsci.uoguelph.ca/deicon/globule.html

Effect of pH on Cheese Texture



(Lawrence et al 1987)
J. Dairy Sci 70:1748

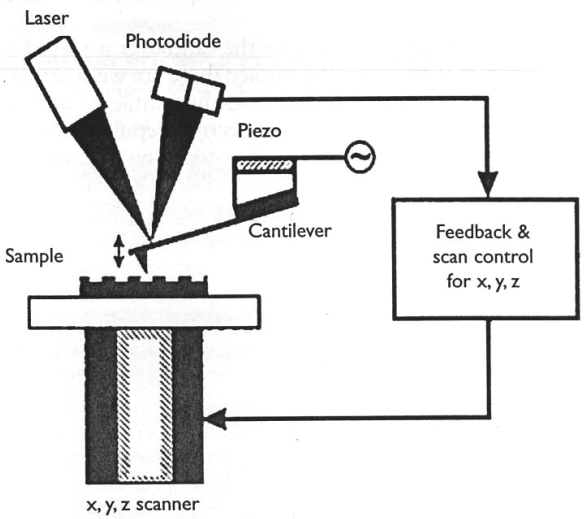
Small Particles have Already Existed

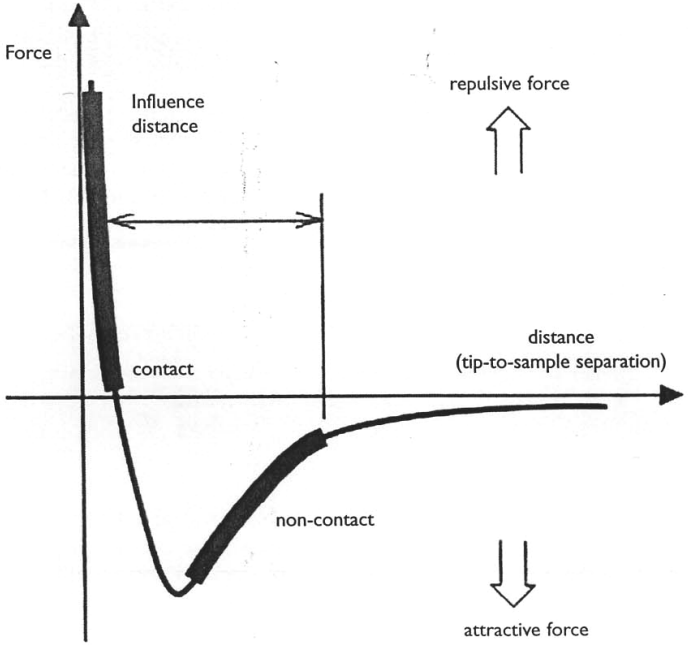


Some examples of surfactant association colloids (self-assembly structure) formed when a surfactant is dissolved in water

(Martin et al. 2003)
Special Publication Royal Society of Chemistry, vol. 284, 3-13

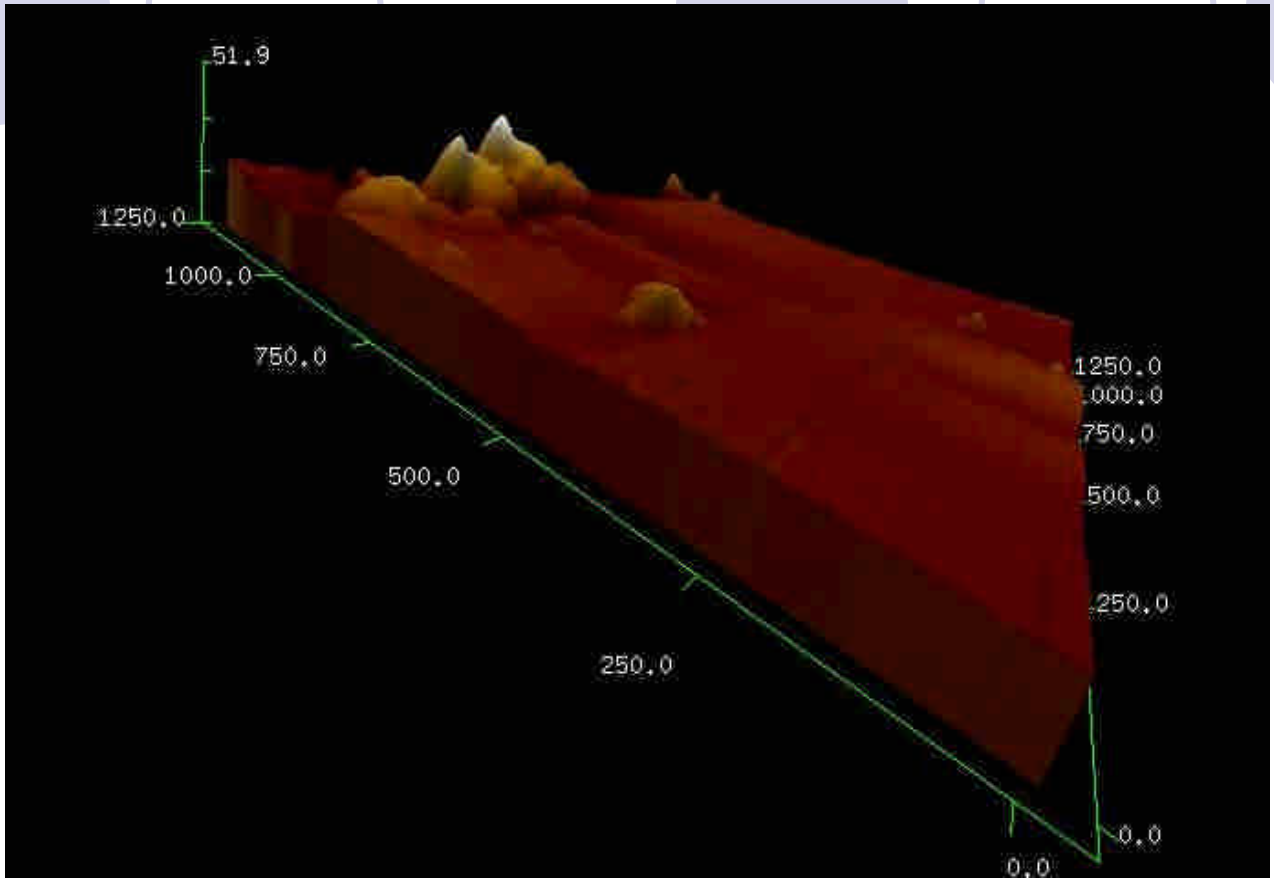
Atomic Force Microscope





Contact mode: the repulsive forces are measured as the sample cantilever pushes into the sample.
Non-Contact mode: the attractive van der Waals forces are measured by oscillating the cantilever with a small amplitude some 5 to 10 nm from the surface of the sample.

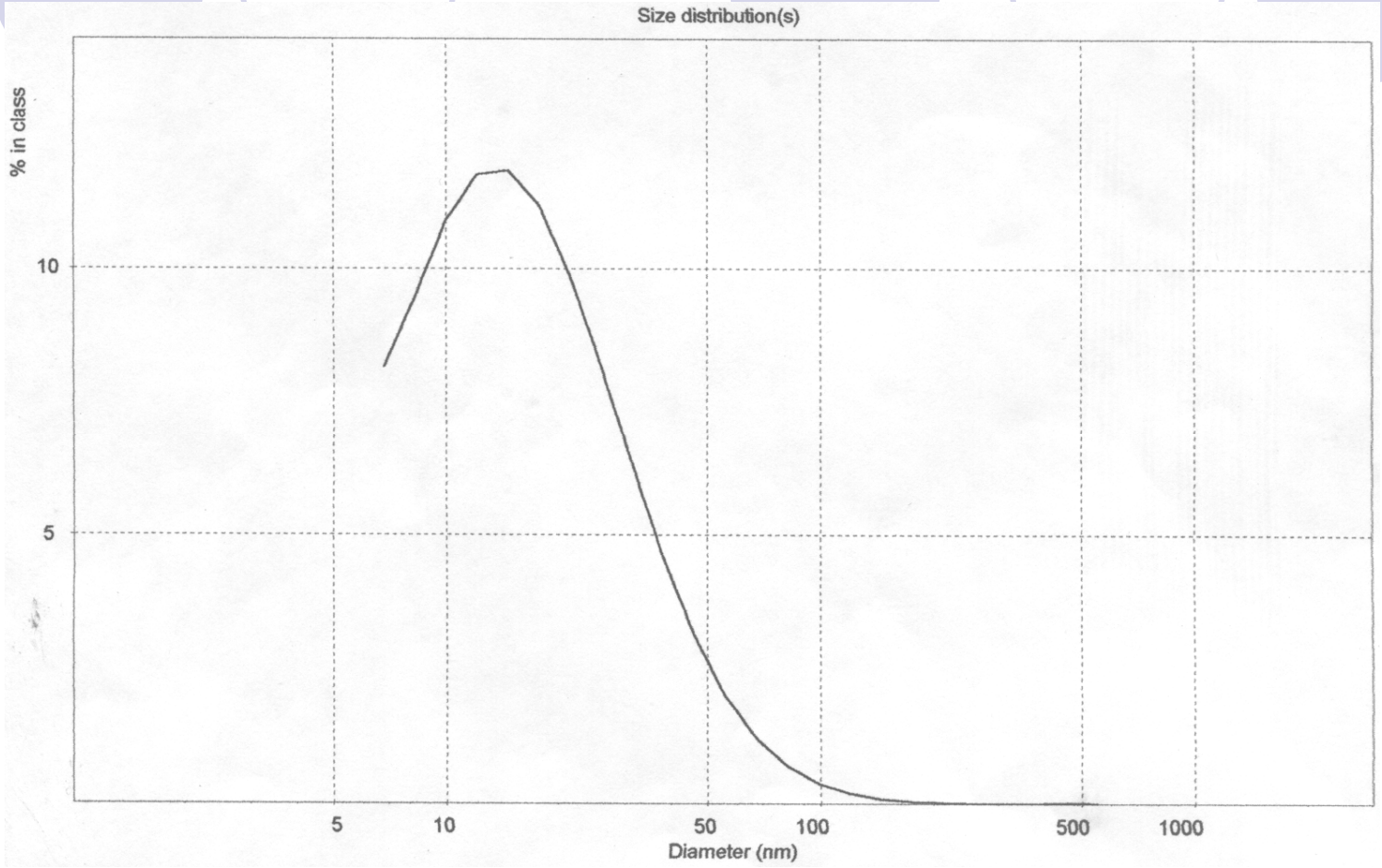
(Wilson et al. 2002)
Nanotechnology p. 37



AFM Photo of Cotton Cellulose after Milling

cellulose particle with length, width smaller than 100 nm, height lower than 50 nm

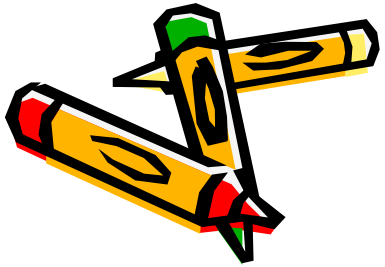
Particle Size Distribution of Nano-Starch

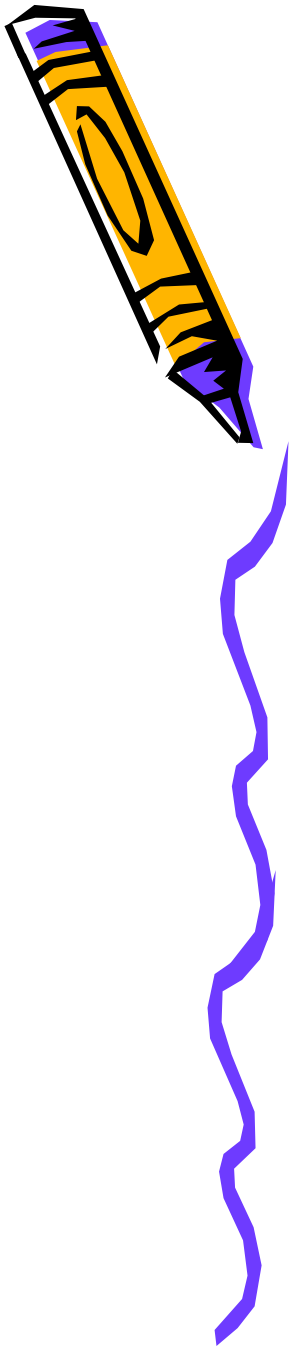


1 wt.% of starch, determined by Laser Light Scattering

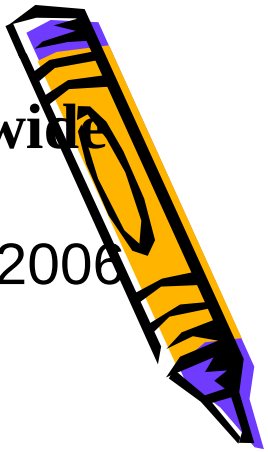
至茂企業股份有限公司提供

國外現況





Strong Increase in Nanofood Markets in 2005 Worldwide

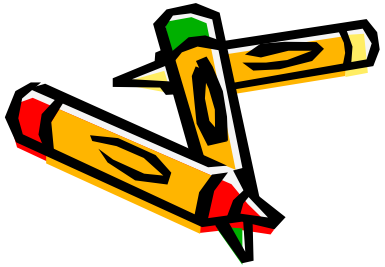


The nanofood market has been soaring from $410 million in 2006 to be worth $5.8 billion by 2012.

Nano-featured food packaging market will grow from US$ 1.1 bn. 2005 to US$ 3.7 bn up to 2010.

More than 400 Companies around the world are today active in research and development and production.. USA is the leader followed by Japan and China.

By 2010 Asia, with more than 50 percent of the world population, will become the biggest market for the Nanofood, with China in the leading position.

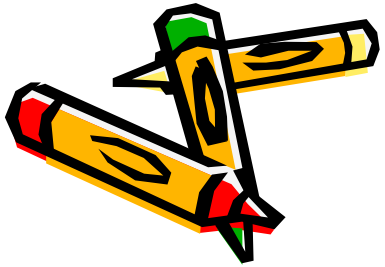


Svidinenko (Svidinenko) 2005.10.30
http://www.nanonewsnet.com/index.php?module=Pagesetter&func=viewpub&tid=2&pid=125
Accessed Oct. 30, 2005

美國農業部（USDA）建議研究領域 ：

1. 偵測系統（病原菌、污染物等）
2. 產品履歷與追蹤系統
3. 診治傳輸系統
4. 農產、食品加工系統整合
5. 分子、細胞生物之奈米裝置
6. 奈米材料科學與
7. 環保與廢棄物處理
8. 一般大眾教育

是食品與奈米技術結合的開始。



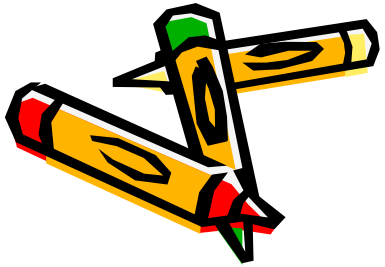
NATIONAL PLANNING WORKSHOP
November 18-19, 2002
Washington, DC

Trend of Development

2005年

歐盟報告(www.europa.eu.int/comm/reach):

健康、環境、糧食、加值型產品與提高生活品質相關，為奈米科技研發之四大主軸，期能開發新的生產技術，滿足消費者對於食品安全、新鮮度與品質的要求，奈米科技將是發展保健食品的關鍵技術。



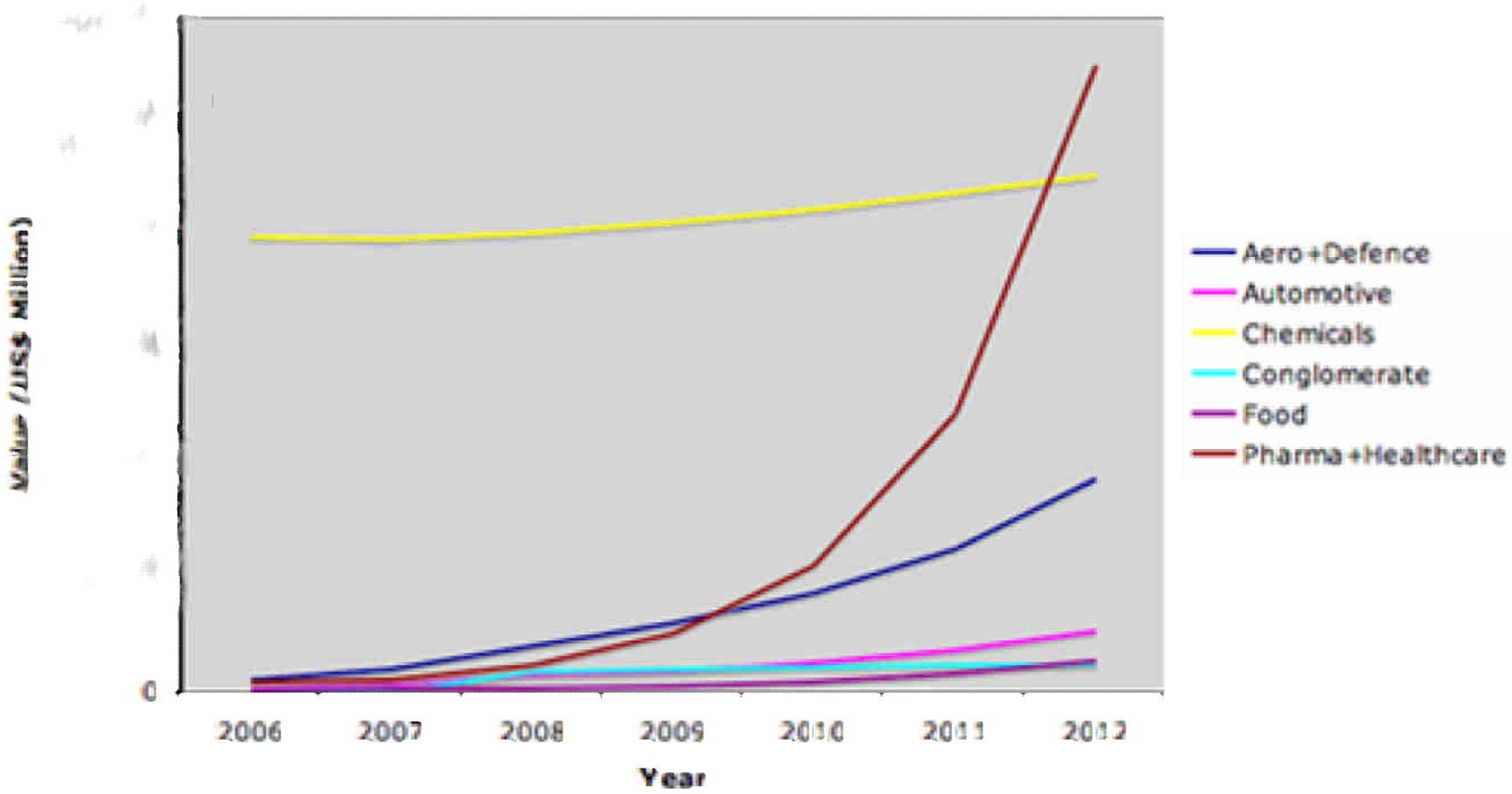
Trend of Development

2006年
IFT會議:國際食品奈米研討會
以改善食品安全、較佳營養輸送、推廣奈米教育、增進包材效能與改進食品加工為議題。

Nano4Food研討會(美國亞特蘭大)
以奈米技術在製備、安全、品質、健康與疾病預防之應用為議題，

Nano and Microtechnologies in the Food and HealthfoodIndustries (荷蘭阿姆斯特丹)
以安全規範，疾病偵測、健康與預防為議題。

可見奈米技術在食品工業之應用逐漸受產學研界所重視，並積極朝檢測、安全、製備、應用等領域發展。



Cientifica
http://www.cientifica.eu/index.php?option=com_virtuemart&Itemid=80&vmcchk=1
Accessed March 5, 2007

近年國外食品業於奈米技術的研究

領域	主題	公司
包裝	- 機智包裝	Kraft
	Imperm: 奈米複合屏障	Voridian
	- 奈米複合塑膠	Nanocor
偵測	- 電子鼻	Nanocor
	- 電子舌	Nanocor
	- 生物偵測器	Nanocor
	- 奈米條碼	Nanoplex
乳化	- 奈米粒子乳化	Nestlé & Unilever
輸送	-奈米包覆	Nestlé
	- 親油性粒子	NutraLease
過濾	- 過濾（利用形狀）	Kraft
	- 奈米陶瓷	OilFresh
新型產品	- 互動產品	Kraft

http://www.forbes.com/investmentnewsletters/2005/08/09/nanotechnology-kraft-hershey-cz_jw_0810soapbox_inl.html?partner=rss

Safer And Guilt-Free Nano Foods
Josh Wolfe, Forbes/Wolfe Nanotech Report, 08.10.05

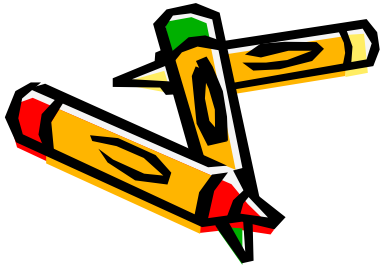
諾丁安食品奈米科技中心

（**The Nottingham Nanotechnology and Nanoscience Centre**）(NNNC) (€4.7 million) at the University of Nottingham

於2007 年 6月18日, 正式營運

四大領域：

1. 包裝材料：增進保存與品質
2. 食品安全偵測系統
3. 新式加工：創造新型產品
4. 新式添加物：提升產品品質



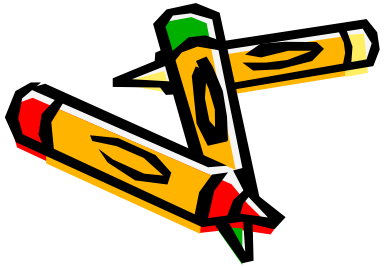
George Reynolds 6/18/2007
http://www.foodnavigator-usa.com/news/ng.asp?n=77439-nanotechnology-nanopackaging-shelf-life
Accessed on \June 24, 2007

Major Fields of Projects for Food Industry

Using nanomaterials to improve food **packaging** or to **detect** and, in some cases, **neutralize** substances that are the frequent cause of potentially fatal bouts of food poisoning.

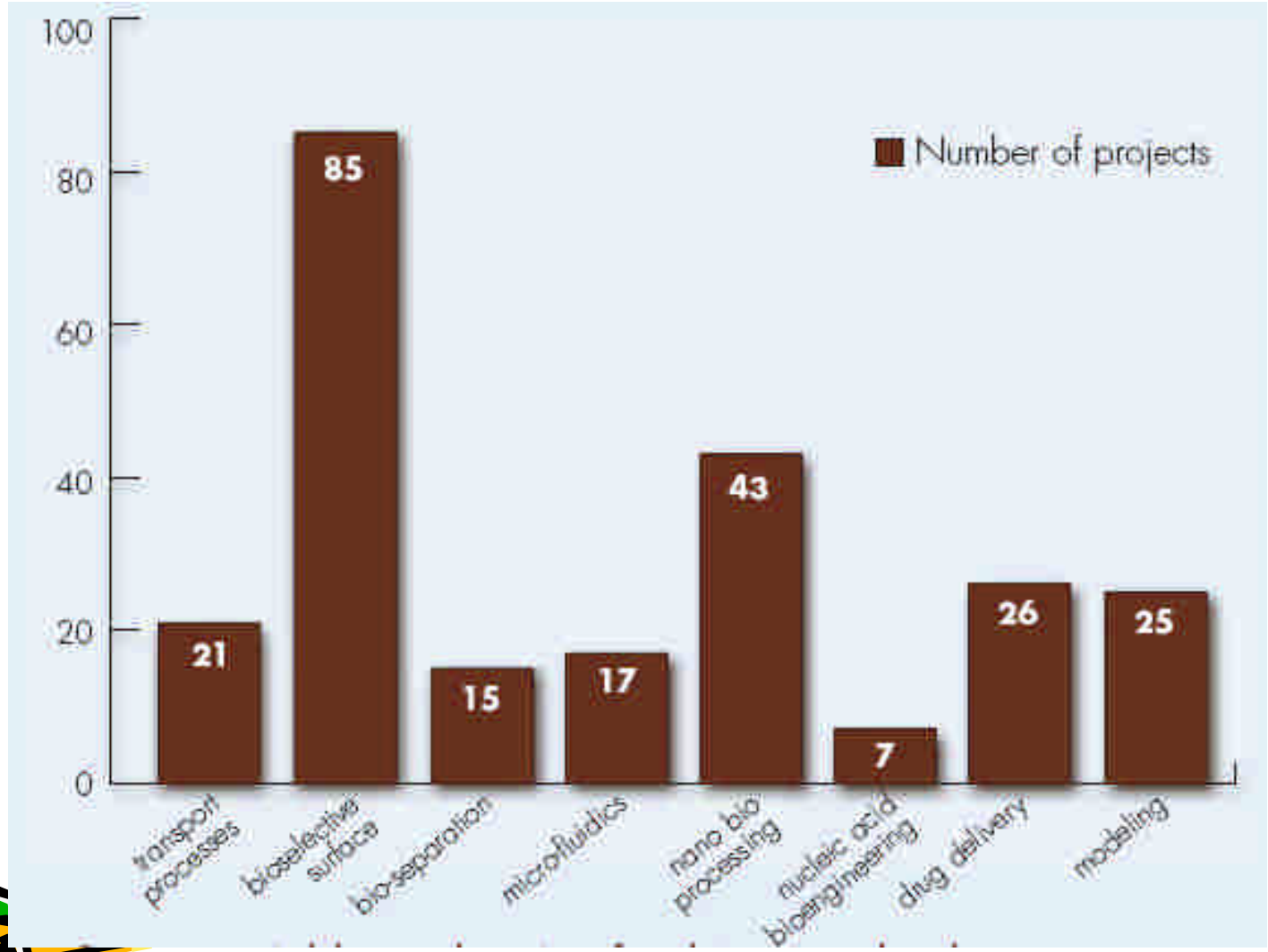
Using nanomaterials to **enhance the biological activity** of dietary supplements or “nutraceuticals.”

In fact, a recent inventory of nanotechnology-based products already on the market contains a dozen **dietary supplements**.



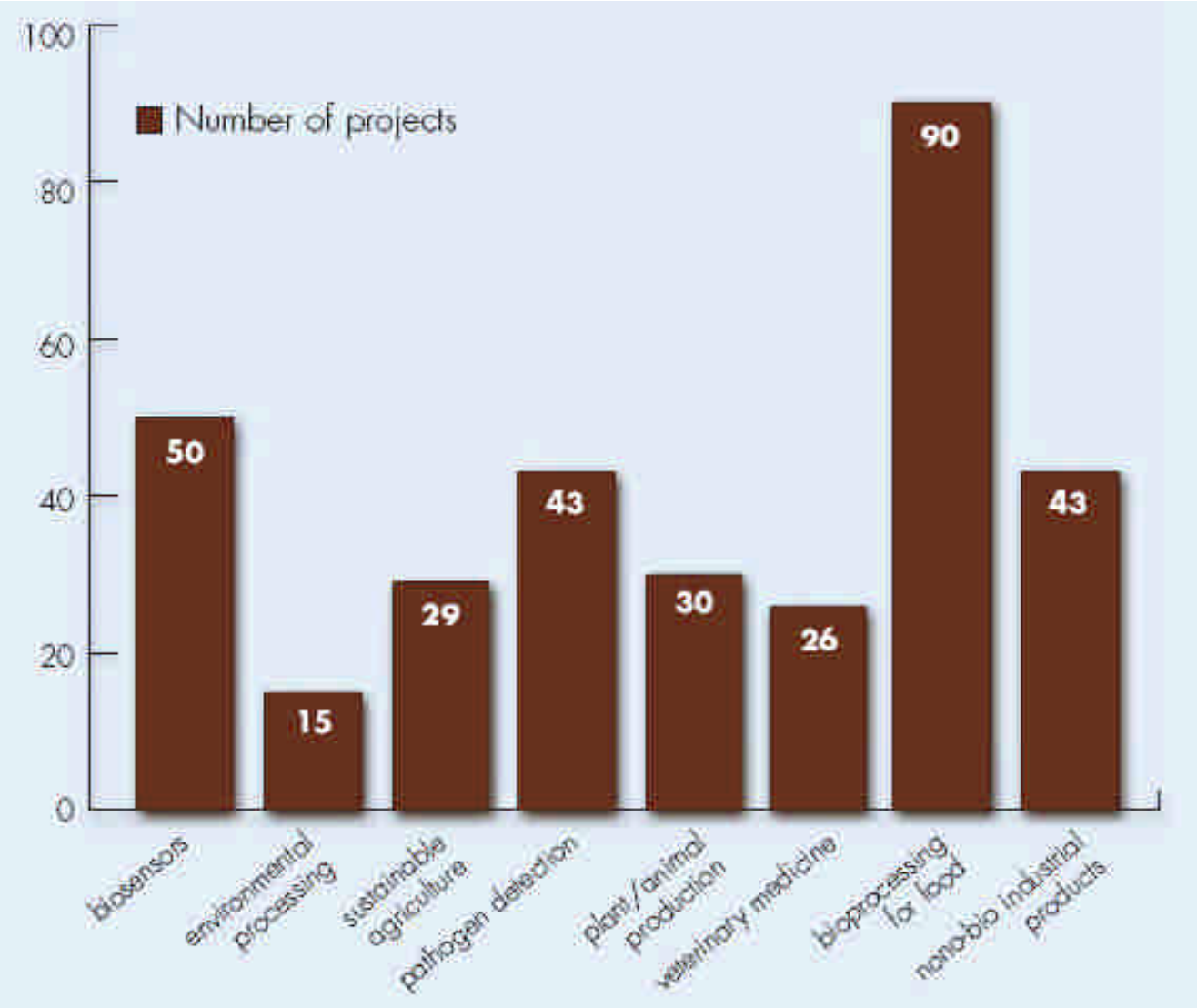
Kuzma & VerHage 4 September, 2006
NANOTECHNOLOGY IN AGRICULTURE
AND FOOD PRODUCTION:ANTICIPATED APPLICATIONS
http://www.nanotechproject.org/50 accessed March 17, 2007

Techniques Used in Agrifood Nanotechnology Projects



Kuzma & VerHage 4 September, 2006
NANOTECHNOLOGY IN AGRICULTURE
AND FOOD PRODUCTION:ANTICIPATED APPLICATIONS
http://www.nanotechproject.org/50 accessed March 17, 2007

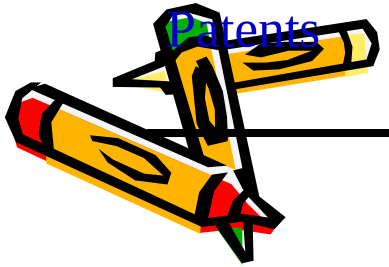
Topics Addressed in Agrifood Nanotechnology Projects



Kuzma & VerHage 4 September, 2006
NANOTECHNOLOGY IN AGRICULTURE
AND FOOD PRODUCTION:ANTICIPATED APPLICATIONS
http://www.nanotechproject.org/50 accessed March 17, 2007

National Competitiveness in Nanotechnology

Category	1	2	3
Public and private group invested 12.4 billions in 2006. Companies sold more than 50 billions worth of nano enabled products.			
Government spending	US (US$1.78 billions)	Japan (975 millions)	Germany (563 millions)
When lower costs of goods and services are considered, China is closing the lead, with 906 millions in 2006 (19% rise over 2005)			
Corporation spending	US (1.93 billions)	Japan (1.7 billions)	
When researchers considered price partly, China's corporate nanotech funding reached 165 millions (68% rise over 2005)			
Publication nano science & eng.	US (43,000 since 1995)	China (25,000)	
Patents	US (6,081)	Germany (773)	Total of 10,105 in 14 countries

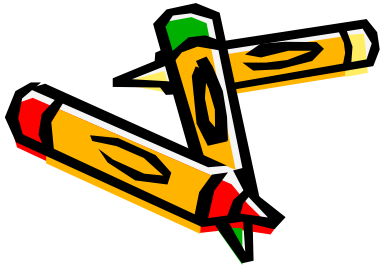


K.C. Jones (Lux Research) InformationWeek 9 2007
http://www.informationweek.com/news/showArticle.jhtml?articleID=197801614
Accessed on March 17, 2007

What We Should Know?

With millions of dollars being spent globally by both government and industry to apply nanotechnologies in areas such as food processing, food safety and packaging, and agricultural production, it is the right time to start asking a number of related questions:

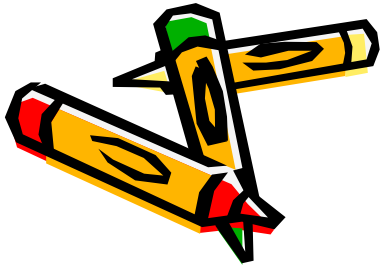
What nano-engineered food **products** will appear on the market over the next year or two?
What are the potential **benefits and risks**?
Who will be affected?
How can **consumers** become engaged early on?"



8 September 2006
http://nanotechweb.org/articles/news/5/9/7/1

access on March 16, 2007

Applications of Nanotechnology in Food in Taiwan



奈米標章

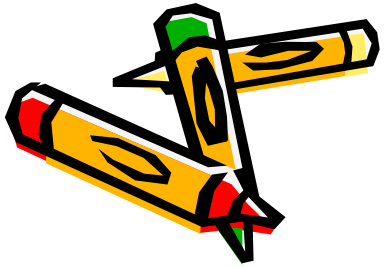
經濟部工業局

目前受理產品：奈米光觸媒及奈米塗料等相關產品，未來三年將陸續擴充項目可達二十項。

2004/11/12

國內概況

- 本領域爲新規劃之研究領域
- 國內食品業界之應用
- 學術研究之概況

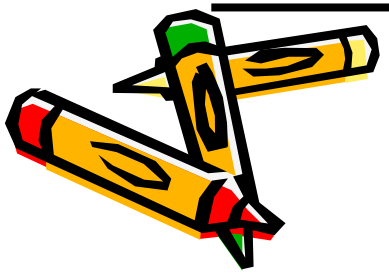


台灣食品業於奈米產品的應用

產品	特色	公司
礦物質		
硒 (Selenium)	增進生物活性 (20 – 60 nm)	統一集團
鈣（Calcium） 鐵（Iron）	營養傳輸系統（日本太陽公司超乳化技術）~ 33 nm 用於乳製品以增進吸收	統一集團 味全公司

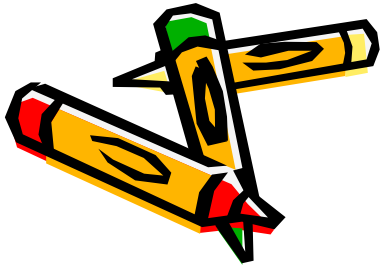
台灣食品業於奈米產品的應用

產品	特色	公司
中草藥		
靈芝	增加吸收性 (5~8 μm) (超微粉末)	九鼎公司
靈芝菌絲體	多醣、三帖 (100~300 nm)	台糖公司
冬蟲夏草	增加營養成分11% 之吸收 (500 ~ 700 nm)	台糖公司
綠茶 樟芝	增加吸收性 約爲 500 nm (高能量超微粉)	奈米高能量超微粉 國際研究中心



學術研究重點

- 中草藥
- 生理活性
- 製備方法
- 應用



學術研究計畫

中草藥

計畫名稱	學校
靈芝子實體之奈米粒子的製備與特性鑑定	國立台灣大學
幾丁聚醣紅麴奈米粒之製備及其特性之探討	國立台灣海洋大學
山藥-幾丁聚醣 奈米 粒之製備及其對皮膚纖維母細胞抗氧化性的影響	國立台灣海洋大學
微米級和奈米級茄紅素粉末抑制乳癌細胞生長、侵襲及轉移之研究	輔仁大學
丹參奈米化對其主要成分與生理活性之影響	虎尾科技大學

Data resource: Science & Technology Policy Research & Information Center
http://stinet.stic.gov.tw/sticweb/html/index.htm

生理活性

學術研究計畫

計畫名稱	學校
利用 奈米 技術改善果渣纖維理化性質和保健功能之研究	國立中興大學
細胞在含有特定 奈米 膠原纖維之生物基板上的生長與分化	國立陽明大學
奈米材料顆粒對小鼠肺臟功能及基因表現影響之研究	國立陽明大學
幾丁聚醣奈米顆粒在細胞穿透及藥物輸送之研究	大葉大學
以藥動學研究微米及 奈米 膠囊化茄紅素在[illegible]腸模擬系統之吸收	輔仁大學

製備方法

學術研究計畫

計畫名稱	學校
奈米食用纖維材料製備方法與產品性質之研究	國立台灣大學
利用奈微米技術開發多功能保健食品	國立中興大學
奈米蛋殼粉製備及其特性之研究	國立嘉義大學
幾丁聚醣奈米顆粒製造、特性分析及應用研究	大葉大學
奈米 膠原蛋白製備及其產品特性之研究	大葉大學
奈米微粒研磨製程最佳化之研究	雲林科技大學

應用

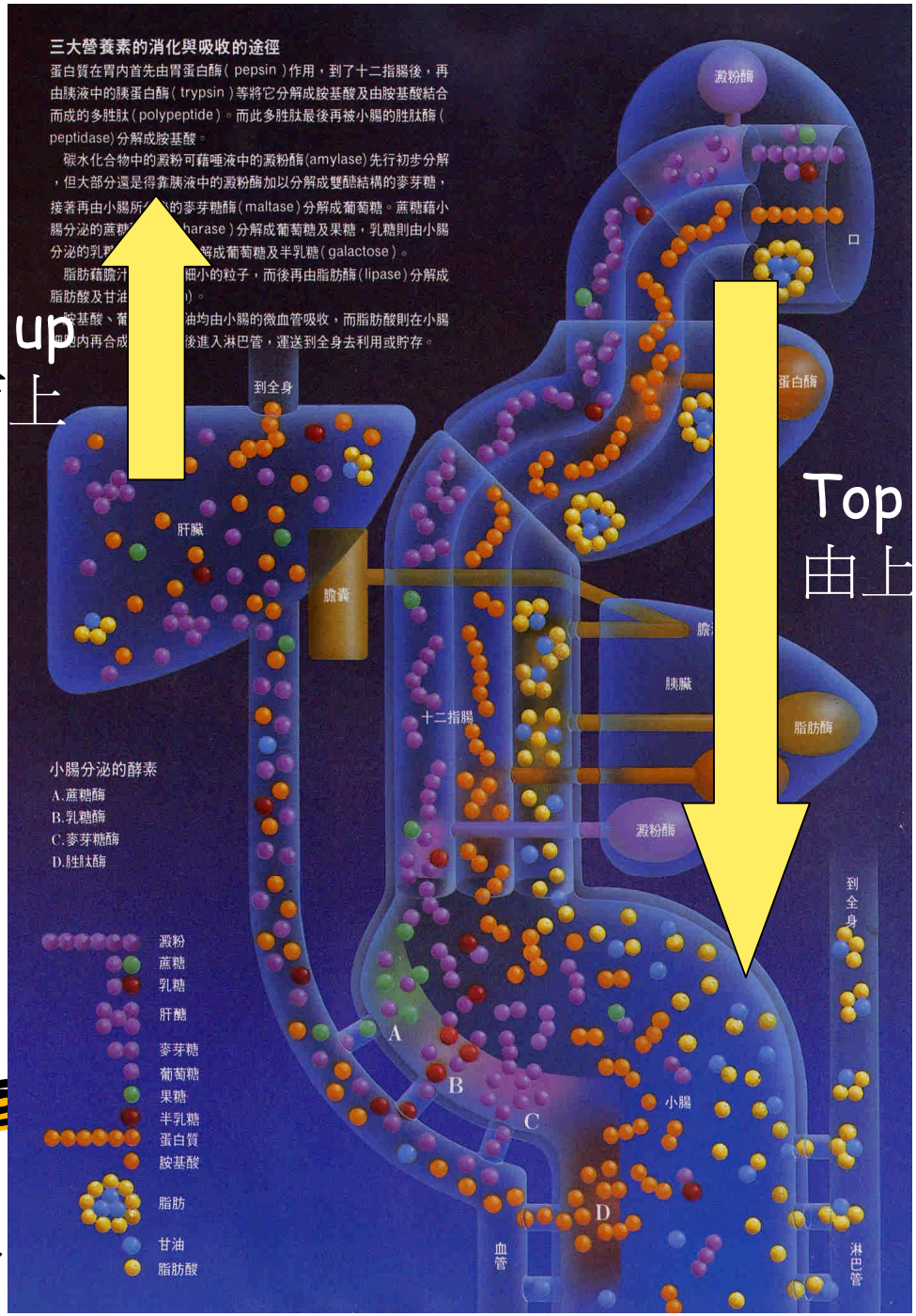
學術研究計畫

計畫名稱	學校
以奈米技術開發茶葉黑色素的新功能	國立交通大學
改善骨質疏鬆功能山藥酸乳酪之產製技術	國立台灣海洋大學
靈芝奈米膠囊化妝品之製造	靜宜大學
奈米幾丁聚醣於水果保鮮之開發與應用	元培科技學院
超順磁性 奈米 粒子的製備與表面修飾及其在酵素固定化與酵素分離之應用	南台技術學院
利用果膠酯抑制劑及 奈米 處理技術於降低水果釀造酒中甲醇含量及提高混濁安定性之研究	高雄海洋技術學院

人體內的消化吸收

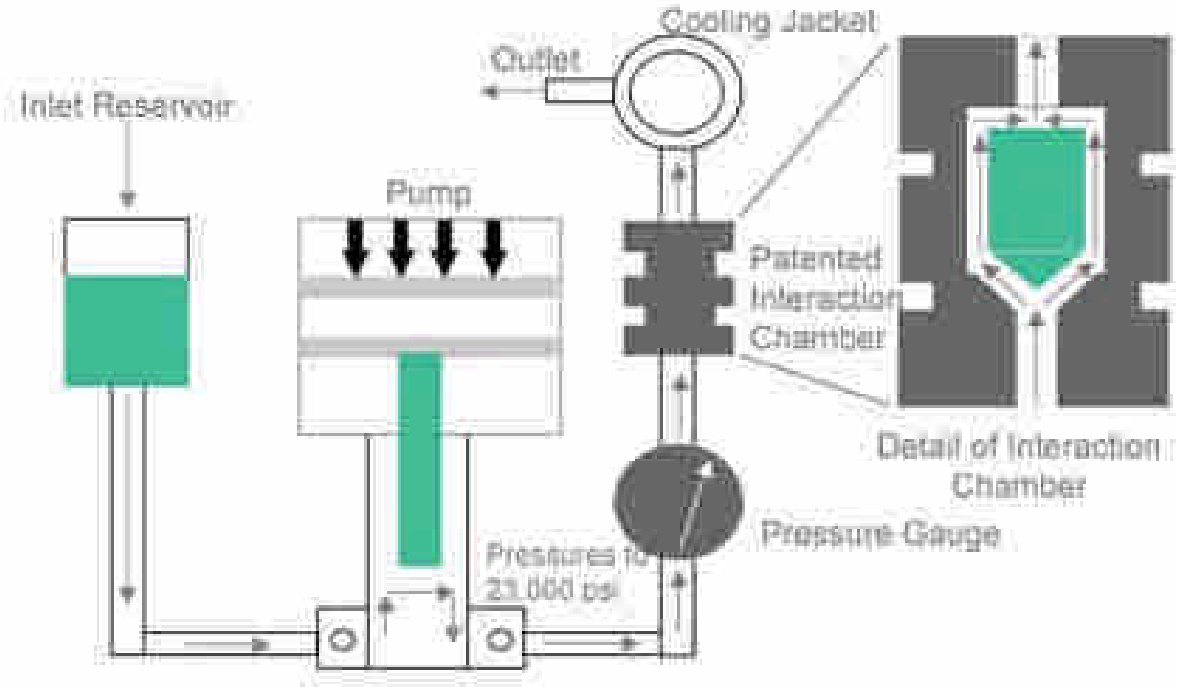
Bottom up
由下而上

Top Down
由上而下



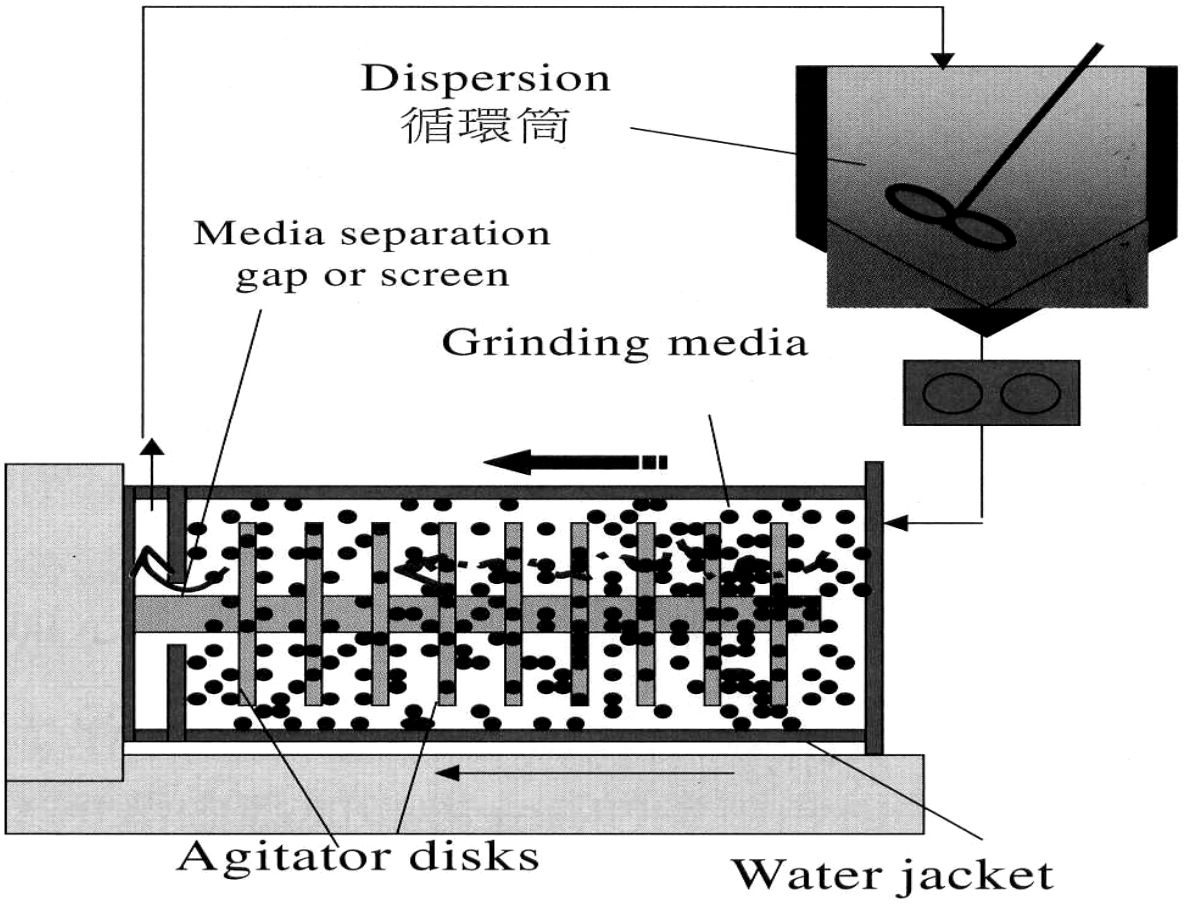
(Anonym 1985)
Newton 2(10):72

Basic Concepts of Single Pump Microfluidizer



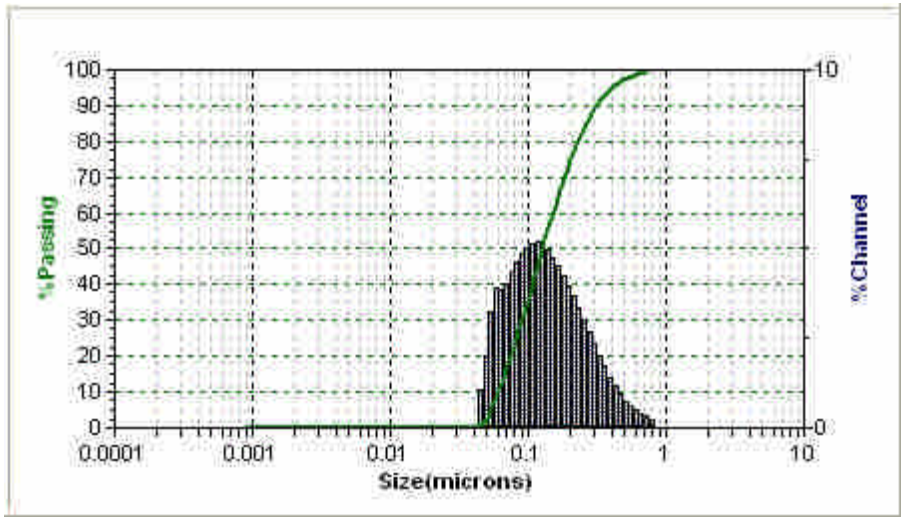
Irwin J. Gruverman, 2004, Jan 26-28
Ultraturbulent Reactuib Technology, Drug Delivery Partnerships, vol. 3,p.101
http://drugdeliverytech.com/cgi-bin/articles.cgi?idArticle=113

Media Milling

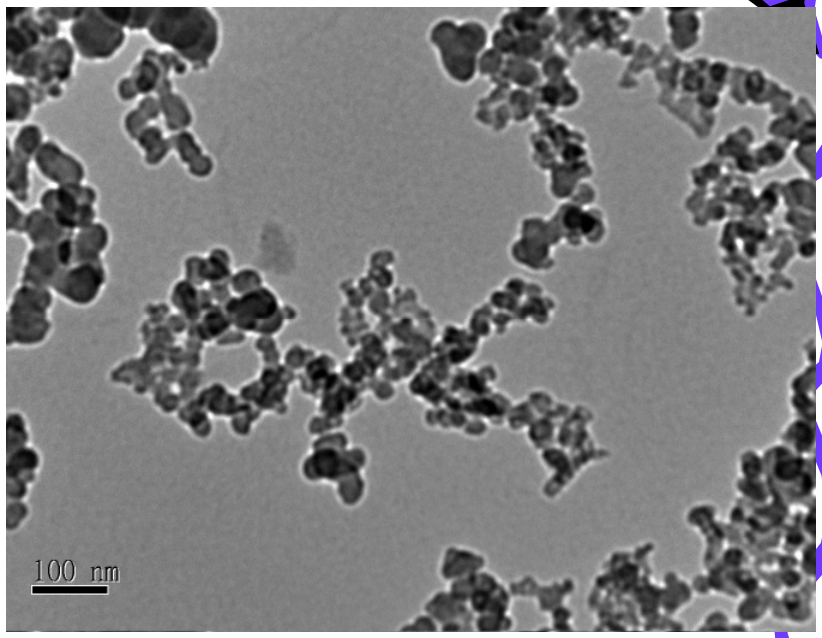


Media Milled *Ganoderma taugae*

Characterization of Medium Milled *Ganoderma taugae*

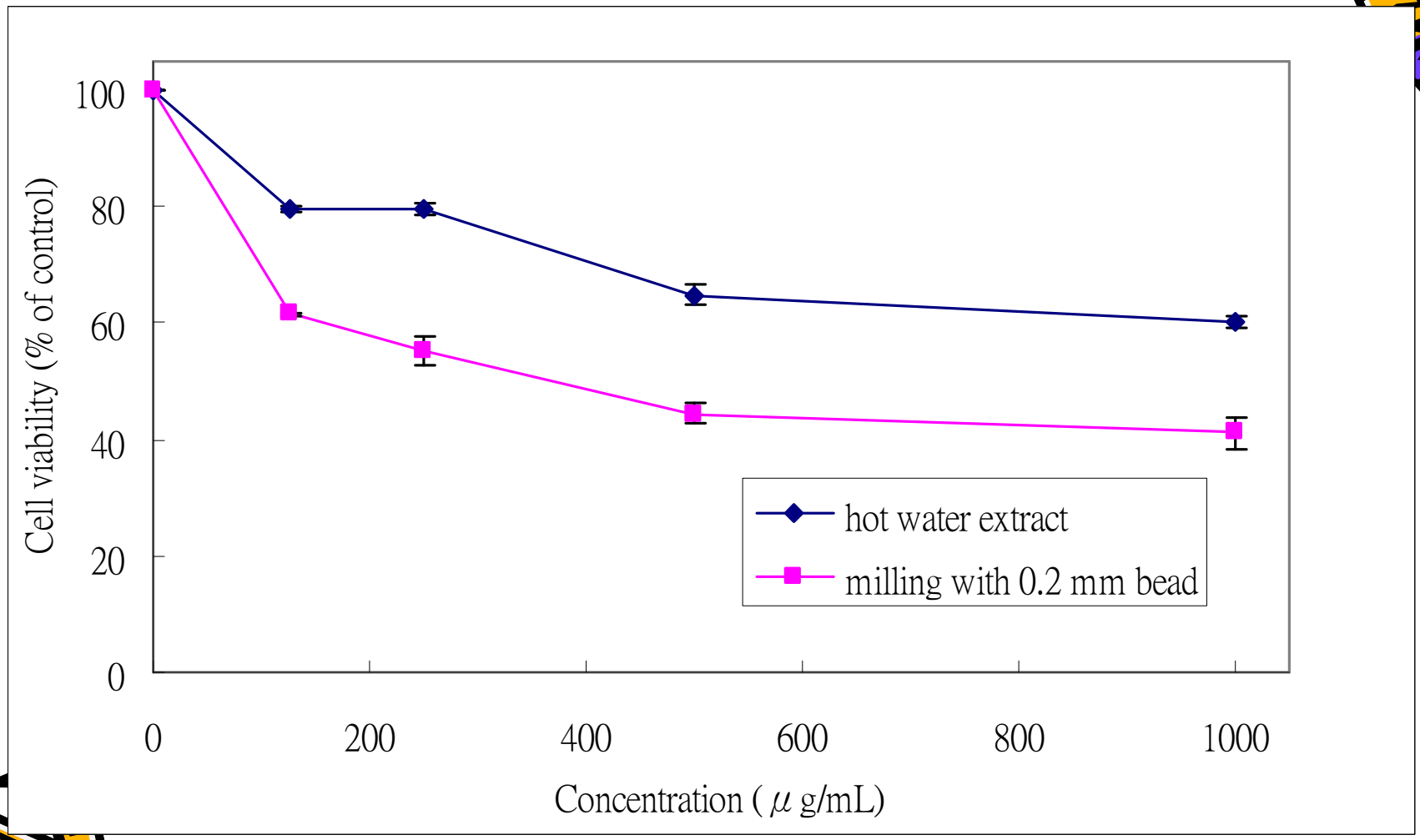


Particle size distribution



Nano Particle from *Ganoderma taugae*

Effects of Hot Water Extract and Milled Product from *Ganoderma* on Viability of Hep 3B hepatoma cells



Appearance of Media-Milled Cellulose

蛋糕類(Cake): 重奶油蛋糕Butter cake

奶油+牛奶 100% replaced
吃的感覺較乾燥及韌性強

Control group

麵包類(bread)奶油餐包Butter Roll

奶油 100% replaced
吃的感覺較乾燥及韌性強

Control group

餅乾類(cookies): 冰箱小西餅ice box

奶油 35%→15%
全蛋 100% replaced
吃的感覺較乾燥及不鬆脆

Control group

中式蒸類(Steam)甜饅頭Steam Bread

白油 100% replaced.
吃的感覺，較乾燥

Control group

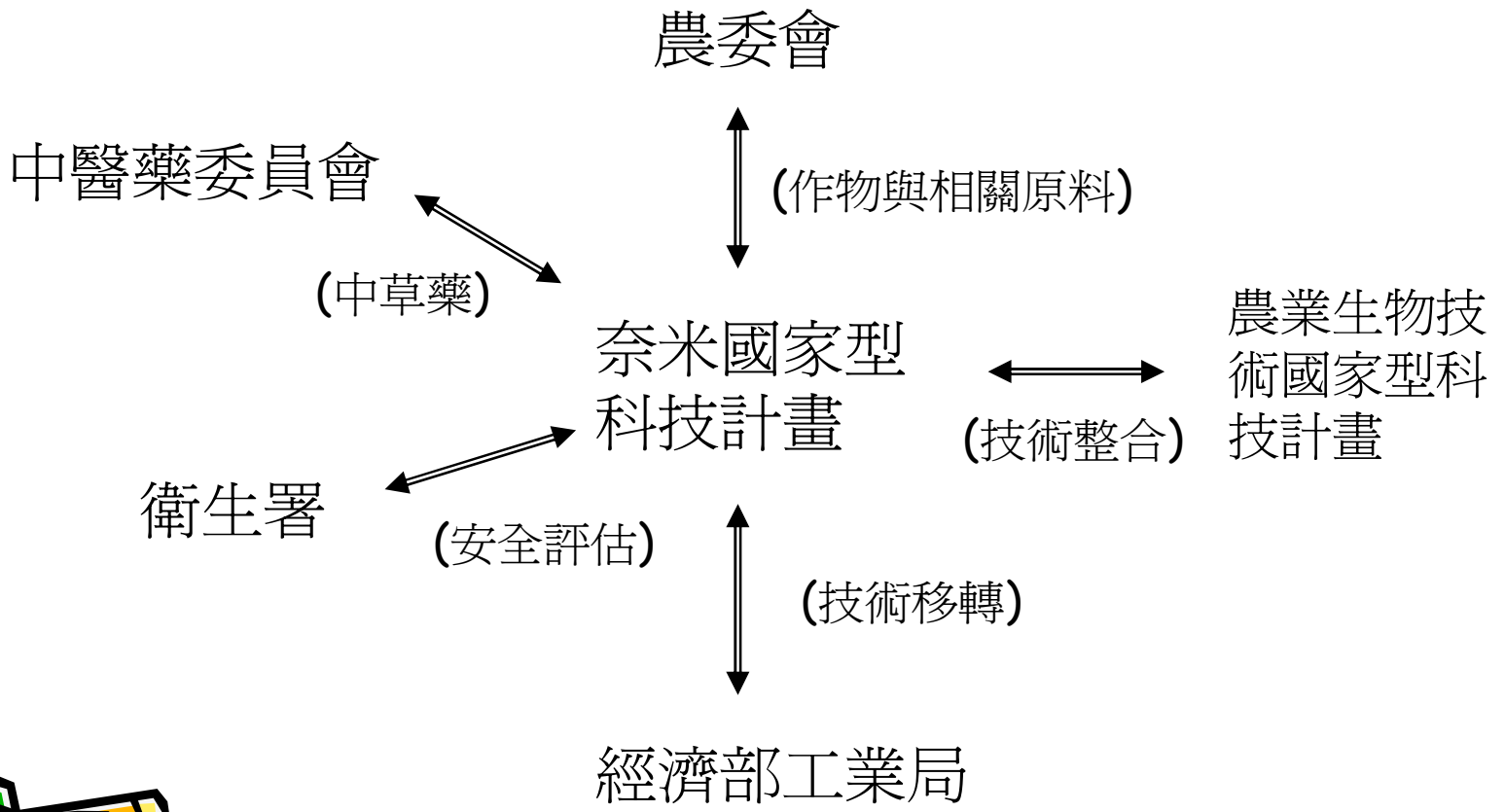
未來趨勢

- 以奈米材料改善包裝，增進保健食品的活性或可利用率。
- 以奈米偵測系統控管食品品質與防治污染，探測病原菌、污染物、營養物、生理活性成分等。
- 開發機智傳輸系統（藥物、殺蟲劑、營養分、益生菌、保健食品、可移植的細胞生物反應器等）。

建議研究方向

以國產之作物或廢棄物為原料，利用奈米/次微米之科學與技術，開發具高價值之產品（如保健食品、化妝品等），提供業者所需之關鍵技術，期能有助於業界拓展市場。

可能參與部會


農委會
中醫藥委員會
(作物與相關原料)
(中草藥)
奈米國家型
科技計畫
農業生物技
術國家型科
技計畫
(技術整合)
衛生署
(安全評估)
(技術移轉)
經濟部工業局

From Nano to Wellness

Birschbach, Fish, Henderson, and Willrett 2004
FOOD TECHNOLOGY 58(4) p.26


陳時欣、 林穎聖、 陳仲仁
姜瓏萱、 劉盈吟、 黃宜謹
詹雅婷、 黃仁毅、 于達元


Thanks for Your Attention