



NANO IS TOO BIG NANO MEDICINE: THE FUTURE OF PHARMACOLOGY AND MEDICINE

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DOBŘÉ ODPOLEDNE

- JAK SE VŠICHNI MÁTE (HOW ARE YOU ALL)
- OMLouvám se, omlouvám se (MY APOLOGIES)
- NEUMÍM MLUVIT ČESKY (I CANNOT SPEAK CZHECHIA LANGUAGE)
- DOUFÁM, ŽE ROZUMÍTE MÉ ANGLIČTINĚ A ŽE SE MŮŽETE KDYKOLIV BĚHEM PŘEDNÁŠKY NA NĚCO ZEPTAT (HOPE YOU WILL UNDERSTAND MY ENGLISH, YOU CAN ASK ME QUESTIONS ANYTIME DURING THE LECTURE)
- DÍKUJI GOOGLE PŘEKLADAČI (THANKS TO GOOGLE TRANSLATOR)

BRNO MILUJI

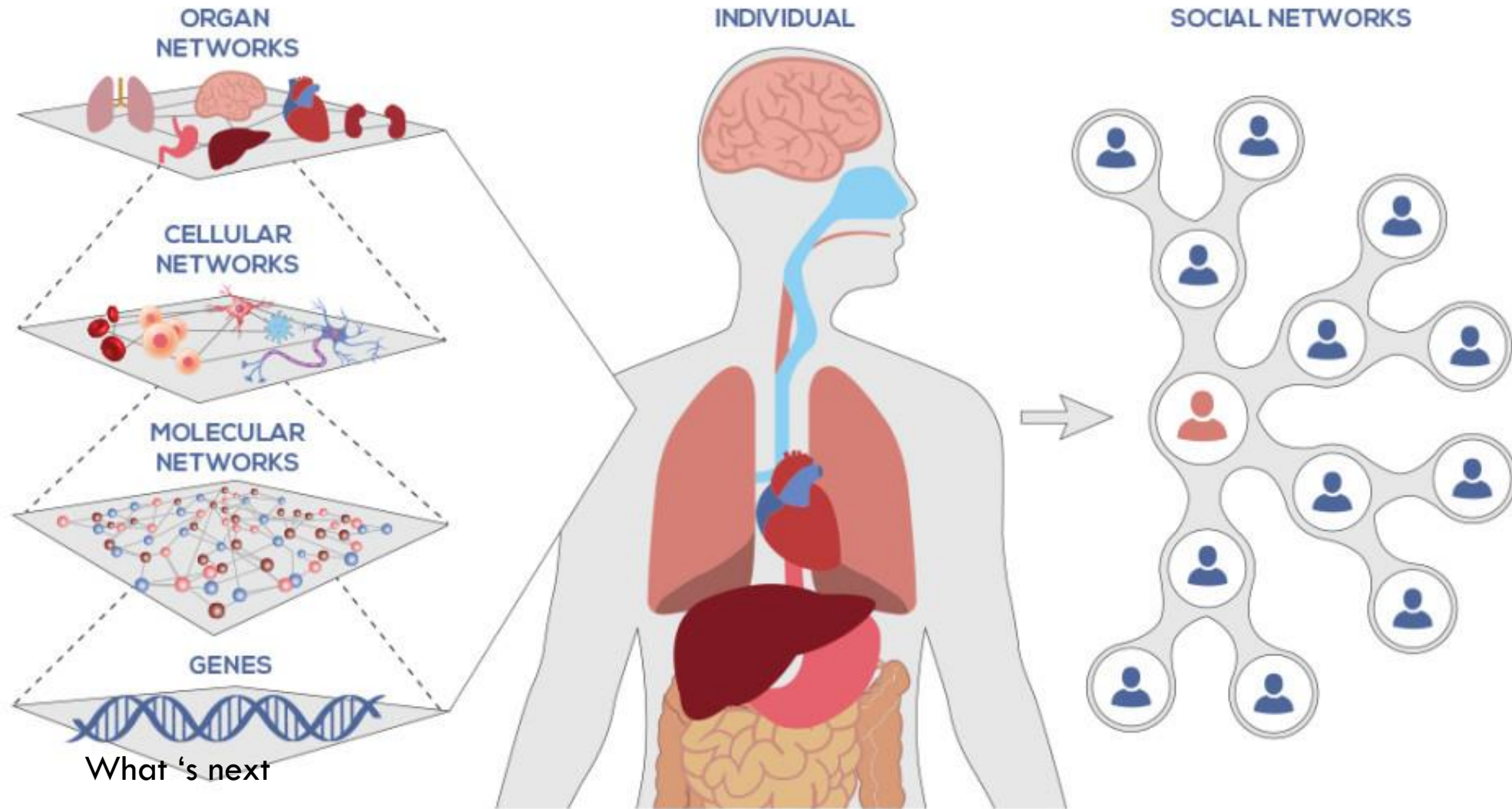
- BEAUTIFUL CITY
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- GREAT FOOD
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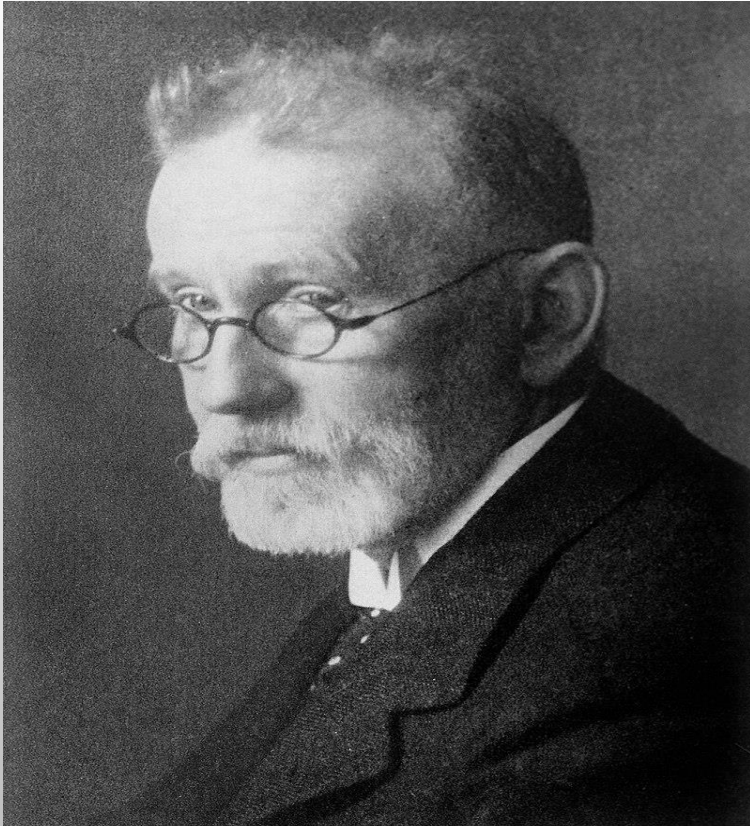
HUMAN BODY IS NETWORK OF NETWORKS

- ORGAN LEVEL
- TISSUE LEVEL
- CELLULAR LEVEL
- MOLECULAR LEVEL
- GENETIC LEVEL
- ???????? (WHAT IS THE NEXT LEVEL??)

NETWORKS OF NETWORK IN HUMAN BODY



MAGIC BULLET



German Biochemist Paul Ehrlich (1854-1915) developed a chemical theory to explain body's immune response and did important work in chemotherapy, coining a term MAGIC BULLET. Ehrlich received Noble Prize in Physiology-Medicine in 1908

WHAT IS NANO MEDICINE?

- THE EARLY GENESIS OF THE CONCEPT OF NANO MEDICINE SPRANG FROM THE VISIONARY IDEA THAT TINY NANO BULLETS AND NANO ROBOTS AND RELATED MACHINES COULD BE DESIGNED, MANUFACTURED, AND INTRODUCED INTO THE HUMAN BODY TO PERFORM CELLULAR REPAIRS AT THE MOLECULAR LEVEL.
- NANO MEDICINE TODAY HAS BRANCHED OUT IN HUNDREDS OF DIFFERENT DIRECTIONS, EACH OF THEM EMBODYING THE KEY INSIGHT THAT THE ABILITY TO STRUCTURE MATERIALS AND DEVICES AT THE MOLECULAR SCALE CAN BRING ENORMOUS IMMEDIATE BENEFITS IN THE RESEARCH AND PRACTICE OF MEDICINE.
- **WHO IS THE GREATEST SCIENTIST IN NANOTECHNOLOGY?**
- WHAT IS NANOMEDICINE? ROBERT A FREITAS, NANOMEDICINE , NANOTECHNOLOGY, BIOLOGY AND MEDICINE, VOL 1, 2-9, 2005

REGULATING INNOVATION

POLICY

Nano Risks Worry Scientists

A little risky business

Nanotechnology and the Media

The Inside Story

Is media coverage of nanotechnology's potential risks growing? If so, who or what is driving articles in national newspapers and newswires, environmental and consumer organizations, scientists, law makers, or industrial and financial groups? How do broadcast journalists decide to cover a nanotechnology story, especially one about possible risk-benefit tradeoffs? Do radio and television correspondents face special challenges reporting on a technology which most Americans do not know about and which is on a scale invisible to the human eye?

WHAT IS NANOTECHNOLOGY?

Nanotechnology is the ability to measure, see, manipulate and manufacture things usually between 1 and 100 nanometers. A nanometer is one billionth of a meter; a human hair is roughly 100,000 nanometers wide. By 2014, Lux Research projects that \$2.6 trillion in manufactured goods will incorporate nanotechnology, or about 15 percent of total global output.

and United Kingdom, research she does in collaboration with Brenda P. Egolf of Lehigh University.

National Public Radio host Nell Greenfield-boyce and Lehigh University professor Sharon M. Friedman will discuss these and other questions at an event at the Woodrow Wilson Center. Ms. Greenfield-boyce, who is heard regularly on *Morning Edition* and *All Things Considered*, will offer insights about covering nanotechnology — from government oversight to nano-cosmetics.

Professor Friedman will present her latest results from tracking seven years of newspaper and wire service reporting of nanotechnology risks in the United States

of the tiny

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News Column

Nanotechnology Used in Production of Cotton-based Goods

November 26, 2013

technology Used in Production of Cotton-based Goods -->

TEHRAN (FNA)- Iranian researchers from Islamic Azad University, Ardebil Branch, in association with their colleagues from Amir Kabir University of Technology presented a new and simple method for the completion of the process of production of cotton-based goods by using nanobiotechnology.

The method enables the production of cotton fibers with antibacterial and antifungal properties, and the clothes do not cause any side effect on human's body due to their very low toxicity. The aim of the research was to present a new and simple method for the completion of textile products by using biotechnology and nanotechnology at the same time. To this end, enzymes such as cellulase, laccase and their mixture in

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发高烧怎么办？可否吃虾或运动？

特训护理护士为癌患解疑虑



特训护理护士陈美玲体会到，在医疗人员看来的小问题，对病患来说却是大问题，需要护士一步步引导和鼓励。（国立癌症中心提供）

罗妙婷 报道
miaoteng@sph.com.sg

发烧38度须到紧急部门吗？第二期化疗发长出，是因为化疗不奏效吗？可以吃虾或运动吗？

特训护理护士向本的最大体会，是病患面对未知感到茫然，会发出许多小疑问，需要护士一步步引导和鼓励。

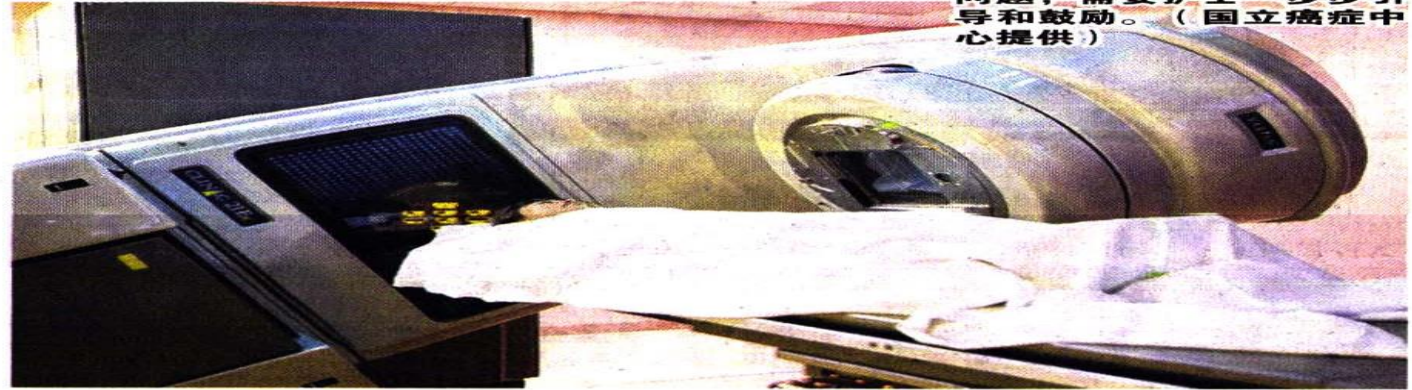
“本报星期三（28日）报道，新保集团杜克一国大乳腺中心（Singhealth Duke-NUS Breast Centre，简称SDBC）推出乳腺癌术前程序（Preoperative Breast Cancer Programme，简称PBCP）。

国立癌症中心参与该程序的特训护理护士（Advanced Practice Nurse）陈美玲（46岁）接受本报专访，分享照顾癌症病人一年来的体会。

陈美玲说，病患常会提出一些看似简单的小疑问，包括“发烧38度，是不是要去急诊室？”、“做完化疗，我可以去看电影吗？”、“我可以吃虾，可以去运动吗？”。

她说，病患接受治疗前，一般都先接受基础教育，如发烧超过摄氏38度会有生命危险，必须马上到中央医院急诊室去吊抗生素。

“但当真的发烧时，许多病患或家属都



在乳腺癌术前程序中，医疗人员会为病患安排及预约治疗时间，省去病患不少麻烦。（国立癌症中心提供）

会犹豫不决，需要再次确认。”

她说，也曾教育病患，化疗副作用之一是脱发，而一名病患接受第二阶段化疗时，发现已脱落的头发再次长

出，以为药物对她没产生作用。

她指出，不少病患也会上网阅读有关癌症的资料，结果越看越怕，因此当护士给予正确教导，病患才不会产

生不必要的隐忧。

她从中体会到，其实医疗人员看来的小问题，对病患来说却是大问题。“我们及时给予引导和帮助，能让他们感到比较踏实。”

提供24小时手机热线服务

病患可随时求助

提供24小时手机热线服务，确保癌症病人随时求助都有护士回应。

陈美玲说，病患有时可能三周才见一次医生，所以护士提供的24小时咨询服务，能即时化解病患的疑虑，并给予贴心鼓励和指导。

他们将公司提供的手机号码给病患，因此若放假或休班，手机仍全天候开着，由值班护士接手。

“我们是一个团队，对病患的进展与问题，我们也会沟通。因此，即便把病患交由另一个同事处理，也同样能提供及时帮助。”

问及是否曾有病患深夜来电，她表示曾教育病患，要他们好好休息，因此至今还没凌晨时分接听来电。

“最迟是晚上11点多打来，最早清晨5点左右发来简讯。”

说明书 联络号码 假发...

患病教师 少了恐惧 多了安心

双语说明书、护士联络号码、甚至假发在治疗前送到病患手上，让60岁女教师少了恐惧，多了安心。

本报联系上接受该疗程的一名病患，这名不愿具名的60岁小学女教师说，该疗程非常透明化，有任何疑问医疗人员都耐心回答，无

论医疗费用、药物副作用、医疗程序等，院方都会一一解释。

每个阶段 细心引导

“在治疗前医生还给了我双语说明书，假发等。这样透明化的处理方式，让我觉得比较安心。”

她表示，护士非常用心，除提供24小时咨询，也主动来电慰问，并传简讯提醒复诊与治疗的预约时间。

“整个过程没有想象中的痛苦，护士也会在每个阶段细心引导，所有预约也是医疗人员协助安排，非常方便，省去不少麻烦。”

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Audrey Tan

Nano missile fights cancer with green tea

A*Star institute's tiny drug carrier made of green tea ingredient, which itself can kill cancer cells

It is used in cosmetics for its supposed anti-ageing properties, and incorporated into "teatox" drinks to help users shed pounds.

But for green tea to work its anti-cancer magic, between two and five litres of it must be consumed every day, studies have shown.

Patients may soon be able to tap the benefits of the popular drink in a more realistic way.

Scientists here have developed a drug-delivery system using epigallocatechin gallate (EGCG), a key ingredient in green tea, that can kill cancer cells more effectively than traditional cancer treatments.

This new drug delivery system is essentially a drug nanocarrier made using EGCG extracts. It works like a tiny missile – zipping through the body's blood vessels to take cancer-destroying drugs to tumour sites.

And because the nanocarrier is itself made from an anti-cancer material, it delivers a double punch, boosting the rate at which cancer cells are killed.

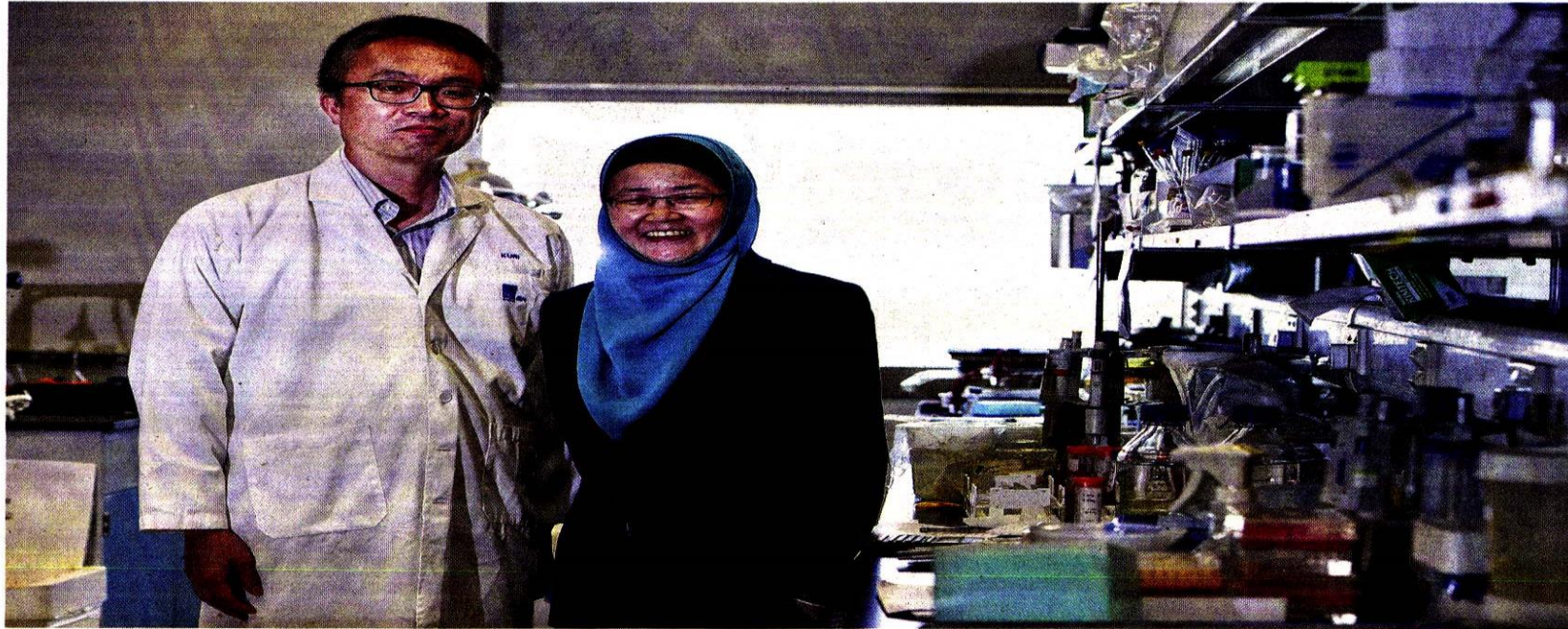
The discovery, published this month in the prestigious journal *Nature Nanotechnology*, is the latest cancer breakthrough developed by the brains at the Institute of Bioengineering and Nanotechnology (IBN), a unit under the Agency for Science, Technology and Research (A*Star).

Since IBN was established in 2003, research into cancer, a major killer here, has been an important focus for its scientists.

IBN executive director Jackie Ying said the institute approaches cancer research differently.

"Many researchers and medical doctors do research on cancer biology, while IBN develops new devices and systems for diagnosis, drug screening, in-vitro toxicology and drug delivery," she explained.

In July this year, for instance, the institute, working with the Singapore General Hospital (SGH) and National Cancer Centre Singapore (NCCS), developed a molecular test kit that can predict treatment and survival outcomes in kidney cancer patients.



Dr Motoichi Kurisawa, team leader and principal research scientist, and Professor Jackie Ying, executive director, at the Institute of Bioengineering and Nanotechnology (IBN). Dr Kurisawa says his eureka moment stemmed from his own love of green tea.

ST PHOTO: CAROLINE CHIA

The technology has been validated at SGH and the NCCS, and the institute is now seeking partners to develop and commercialise it.

And last October, researchers developed a non-toxic hydrogel that is capable of shrinking breast cancer tumours more rapidly than existing therapies.

The hydrogel was tested on tumour-bearing mice, and tumours shrank 77 per cent over 28 days. Since then, more research has been carried out on mouse models and data on these will be published soon, said IBN.

To date, IBN has published more than 970 papers and holds 500 active patents and patent applications. Approximately 10 per cent of

these patents and papers are related to cancer research.

IBN's principal research scientist and team leader, Dr Motoichi Kurisawa, who is from Hokkaido in Japan, made the latest discovery.

He said his eureka moment stemmed from his own love of green tea, which led him to wonder whether the health benefits of green tea could be one reason the Japanese have long life expectancies.

"From there, we had the idea to develop new biomaterials from green tea, which could be used as drug carriers for difficult-to-cure diseases such as cancer," he said.

Using EGCG to manufacture a drug nanocarrier has two main benefits.

First, it reduces damage to healthy cells, which are often killed during traditional chemotherapy.

The nanocarrier cannot squeeze into the tiny pores of healthy blood vessels, which are only about two to three nanometres wide. A nanometre is a billionth of a metre.

Pores at tumour sites, however, are over 100 times larger, so the EGCG missiles can easily slip through to deposit their payload of tumour-killing drugs, while themselves killing off more harmful cells.

In tests on mice, toxic anti-cancer drugs, which typically damage the liver and kidney, were lowered by up to 70 per cent in these organs when delivered through this method, he noted.

IBN has filed a patent on the green tea nanocarrier and is developing the technology for use in patients.

Plans to continue the research on large animals are in the pipeline, and the institute is also in discussions with companies to commercialise the technology.

Said Professor Ying: "Our green tea nanocarrier not only delivers protein drugs more effectively to the cancer cells, but the combination of carrier and drug also dramatically reduced tumour growth compared with the drug alone."

"This is an exciting breakthrough in nanomedicine."

✉ audreyt@sph.com.sg

IBN milestones

March 2003

■ The Institute of Bioengineering and Nanotechnology (IBN) is established under the Agency for Science, Technology and Research (A*Star) as the world's first bioengineering and nanotechnology research institute. It conducts research across scientific, engineering and medical fields to improve health care and quality of life.

October 2003

■ IBN initiates a Youth Research Programme to introduce students and teachers to scientific research through activities such as open houses, workshops, science camps and research attachments.

■ Since then, the programme has reached out to almost 70,000 students and teachers.

September 2004

■ IBN organises its first International Conference on Bioengineering and Nanotechnology in Singapore with the American Institute of Chemical Engineers' Society for Biological Engineers.

September 2006

■ IBN publishes its first paper in the prestigious science journal *Nature Materials*, on nanoparticles that can kill tumours with drugs and DNA. Since 2003, the institute has published more than 970 papers in leading scientific journals.

2008

■ IBN executive director Jackie Ying becomes editor-in-chief of the *Nano Today* journal. From a relative obscure journal then, it has risen to one of the most highly ranked nanoscience and nanotechnology journals today.

■ IBN forms its first spin-off company, *Curioux Biosystems*, which develops innovations based on its expertise in surface chemistry and engineering.

December 2012

■ IBN establishes its most recent spin-off company, *Invitrocue*, to commercialise its technology used for drug screening. In total, the institute has spun off seven companies.

EVERYDAY USES OF NANOTECHNOLOGY

National Nanotechnology Day (Oct. 9) is a yearly event in the U.S. to celebrate the tiny tech. Here, we take a look at various consumer products that utilize nanotechnology and the chemistry behind them.

WHAT IS NANOTECHNOLOGY?



SALT GRAIN = 100,000 nm



NANOPARTICLES = 1-100 nm

Nanotechnology involves the applications of nanoparticles, which are collections of atoms or molecules less than 100 nm across. Because of their small size, the particles have properties that can differ from those of larger amounts of the same material.

ANTIMICROBIAL USES



Products such as bandages, soaps, and surgical implements use silver nanoparticles for their antimicrobial effects. However, the particles' effectiveness in some applications has been questioned, and the materials may cause environmental problems.

SUNSCREENS



ZnO

MAINTAINS
BLOCKS
UV-A

TiO₂

MAINTAINS
BLOCKS
UV-B



UV-A 320-400 nm

UV-B 290-320 nm

Many sunscreens contain titanium dioxide and/or zinc oxide nanoparticles because the materials can absorb UV radiation. Titanium dioxide also finds use in some foodstuffs as a whitening agent.

CLOTHES



SILVER

ANTIMICROBIAL

SILICA

WATER-REPELLENT



TiO₂/ZnO

UV-ABSORBING

ANTIMONY-DOPED
TITANIUM DIOXIDE

ANTISTATIC

UV-absorbing titanium oxide and zinc oxide nanoparticles can be incorporated into clothes to prevent sunburn and sometimes to act as antistatic agents. Silicon dioxide nanoparticles can prevent stains and help clothing repel water.

SPORTS EQUIPMENT



CARBON NANOTUBES

100 TIMES AS
STRONG AS
STEEL

ONE-SIXTH THE
WEIGHT OF STEEL

AS STIFF AS DIAMOND

Sports equipment such as tennis rackets and bicycles are sometimes built using nanomaterials including carbon nanotubes. The nanotubes improve strength and durability and decrease weight. Titanium nanoparticles can also be used.

QUANTUM DOTS

2-10 nm



● CADMIUM SELENIDE
● ZINC SULFIDE
● VARIOUS LIGANDS

BLUE LIGHT



Quantum dots, which are nanoparticles of semiconductors such as cadmium selenide, absorb light of one color, such as blue light, and emit it as another depending on particle size. The particles are more energy-efficient than light-emitting diodes.

Spinning nano into gold

Economic developers looking favorably on GSO's joint school

BY MATT EVANS THE BUSINESS JOURNAL

GREENSBORO — State legislators may not know a fullerene from a nanopore, but apparently they appreciate the potential economic benefit of supporting those who do.

The Joint School of Nanoscience and Nanoengineering, a shared project of UNC-Greensboro and N.C. A&T State University, was the only request related to economic development made by the university system during this year's budget process to actually receive an allocation from a penny-pinching General Assembly.

JSNN received a nonrecurring allocation of \$1 million for staffing and equipment, while requests for similar funding for the N.C. Research Campus at Kannapolis, the N.C. State College of Engineering and the East Carolina State University School of Aviation among others received nothing.

The \$1 million is just a fraction of the money the state has invested in the JSNN, including about \$50 million for its 88,000-square-foot building currently under construction at Gateway University Research Park. That building is expected to open next year.

The JSNN is at the top of the list of funding priorities of area economic developers because they see it as a boon in several ways: The school boosts the region's cre-

PLEASE SEE JSNN, PAGE 25



JULIE KNIGHT/THE BUSINESS JOURNAL
Christopher Kopley, Ph.D., associate professor at the Joint School of Nanoscience and Nanoengineering, demonstrates use of the Zeiss helium ion microscope.

Honda highlights need for more aviation training

BY OWEN COVINGTON THE BUSINESS JOURNAL

GREENSBORO — While Honda Aircraft Co.'s proposed 400-job expansion would make the Triad more visible as an aviation center, local business leaders believe filling the jobs needed to fuel such growth will take the continued expansion of training and educational efforts.

Guilford Technical Community College has been working with Honda Aircraft, Timco Aviation Services and others in the sector to train workers, but companies continue to have to look outside the area to fill many vacant positions, with competition for workers only expected to increase.

"The more manufacturing jobs we get, the more emphasis that's put on the education system in our area to get a skill set," said Matt Edwards, human resources director for Ma-

PLEASE SEE AVIATION JOBS, PAGE 25

Triad aviation firms seek skilled workers

KERNERSVILLE — Honda Aviation isn't alone in seeking skilled workers. Piedmont Aviation Component Services, a Kernersville-based company that overhauls and repairs auxiliary power units for aircraft and landing gears for regional airlines, plans to add 20 workers to its staff of 105 within the next three months.

Starting hourly wages at Piedmont Aviation will be \$11 to \$13 based upon experience, said Dean Hall, chief operating officer.

Machine Specialties Inc. of Whitsett, which mills and turns precision metal parts for the aviation industry as well as other sectors, is ramping up its night shift. The company has 130 workers covering its day shifts and is looking to add to the 30 night-shift workers, though there's no set goal for the addition, said Human Resources Manager Matt Edwards. Starting hourly wages are between \$12 and \$18 based upon experience.

The largest regional additions in the near future will likely come from Greensboro-based Timco Aviation Services as it ramps up its aircraft seat facility in Davidson County. The company has already hired 115 workers and will add 42 employees at the Wallburg facility by mid-September.

The plant will eventually employ 500, the company has said. Most new workers will have average salaries in the low- to mid-\$40,000 range, said Timco CEO Kevin Carter.

— Owen Covington

Region to pitch sites for solar farms



TRIAD TALK
JUSTIN
CATANOSO

The effort to help accommodate a start-up Florida-based solar farm developer has spread across the Triad as economic developers in several counties scout for available sites that might be suitable for the green-energy project.

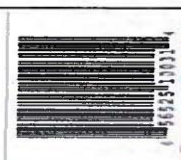
It's fair to say, though, that because the project lacks two critically important elements to local officials, it is not a priority for anyone. Those elements? Jobs and tax base. Solar farms create virtually no permanent jobs, and because of North Carolina law, so-called "solar electric systems" — the panels and equipment that comprise most of the

value of a solar farm — receive an 80 percent discount on local property taxes.

Still, as Bonnie Renfro, the lead economic developer for Randolph County, says, "Potentially, all of us benefit if we increase the amount of renewable energy in our state. Plus, if there is idle land that is restricted from other types of development, a solar farm could generate some taxes and give some options to a willing land owner."

Last week, four representatives from National Solar Power in Florida met at the

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UP CLOSE:
Helping make today's youth more productive and caring.

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MONEY MATTERS:
Publication honors Triad's top CFOs.
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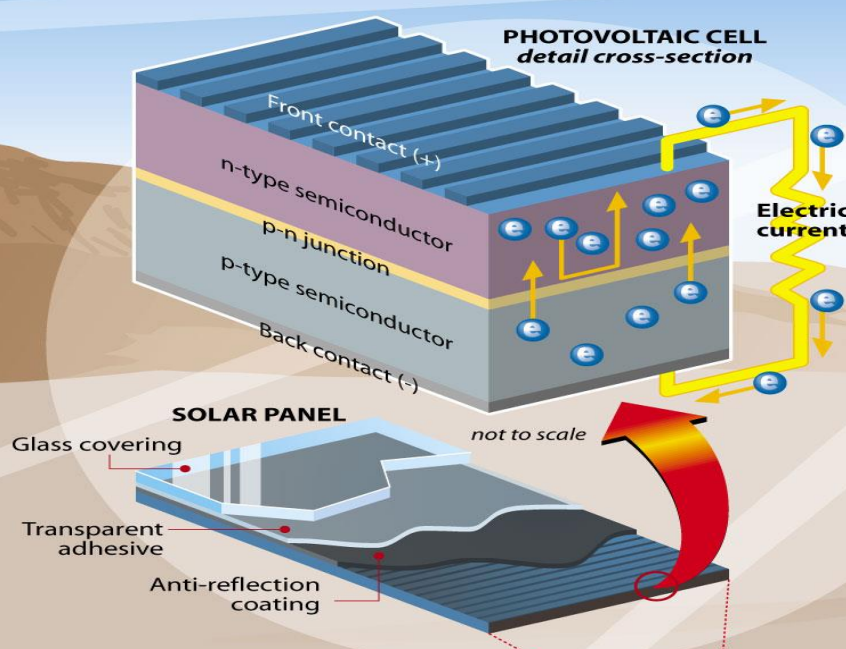
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Tapping the Sun's Energy

Solar panels, or photovoltaic cells, harness energy from the sun. The cells are made of a semiconductive material that is specially treated so that the sun's rays help create a flow of electrons, which can be used to power your home.

The sun gives off about 400 trillion trillion watts of power

A lot of the sun's energy is reflected back into space or absorbed by the Earth's atmosphere. An average of 1,000 watts hits each square meter of the Earth's surface during peak times, more energy per hour than the global population uses in a year.



PV cell at a glance

A photovoltaic (or PV) cell is a specially treated wafer of silicon, sandwiched between two thin contact plates. The top contact is positively charged and the back contact is negatively charged, making it a semiconductor.

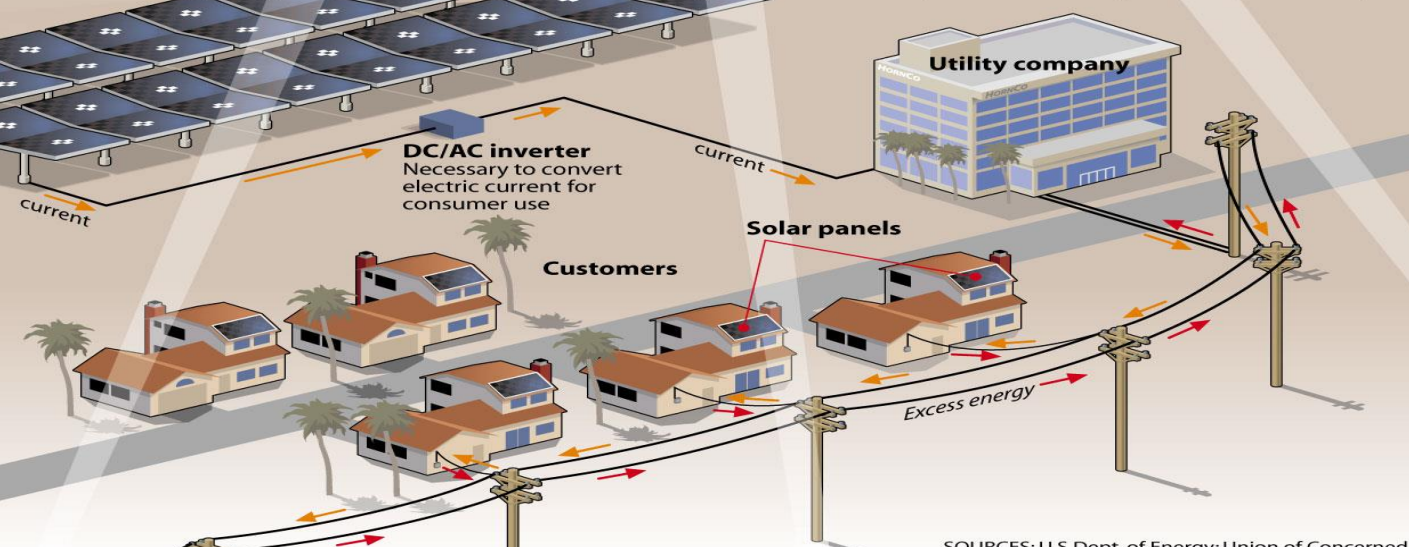
- ▶ The **n-type semiconductor** has an abundance of electrons, giving it a negative charge, while the **p-type semiconductor** is positively charged.
- ▶ Electron movement at the **p-n junction** produces an electric field that allows only electrons to flow from the p-type layer to the n-type layer.
- ▶ When sunlight hits the solar cell, its energy knocks electrons loose from the atoms in the semiconductor.
- ▶ When the electrons hit the electrical field, they're shuttled to the top contact plate and become a usable electric current.

Solar panel farm
How much energy a solar panel can make depends on how efficiently it converts the sun's energy. An average solar panel around a square meter in size can generate about 100 watts. Commercial panels are up to 17% efficient, and are getting better every day.



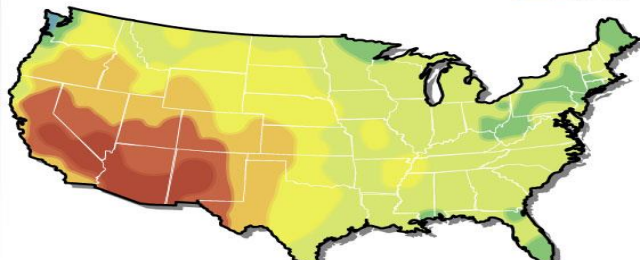
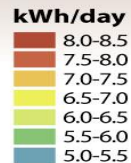
Feeding the grid

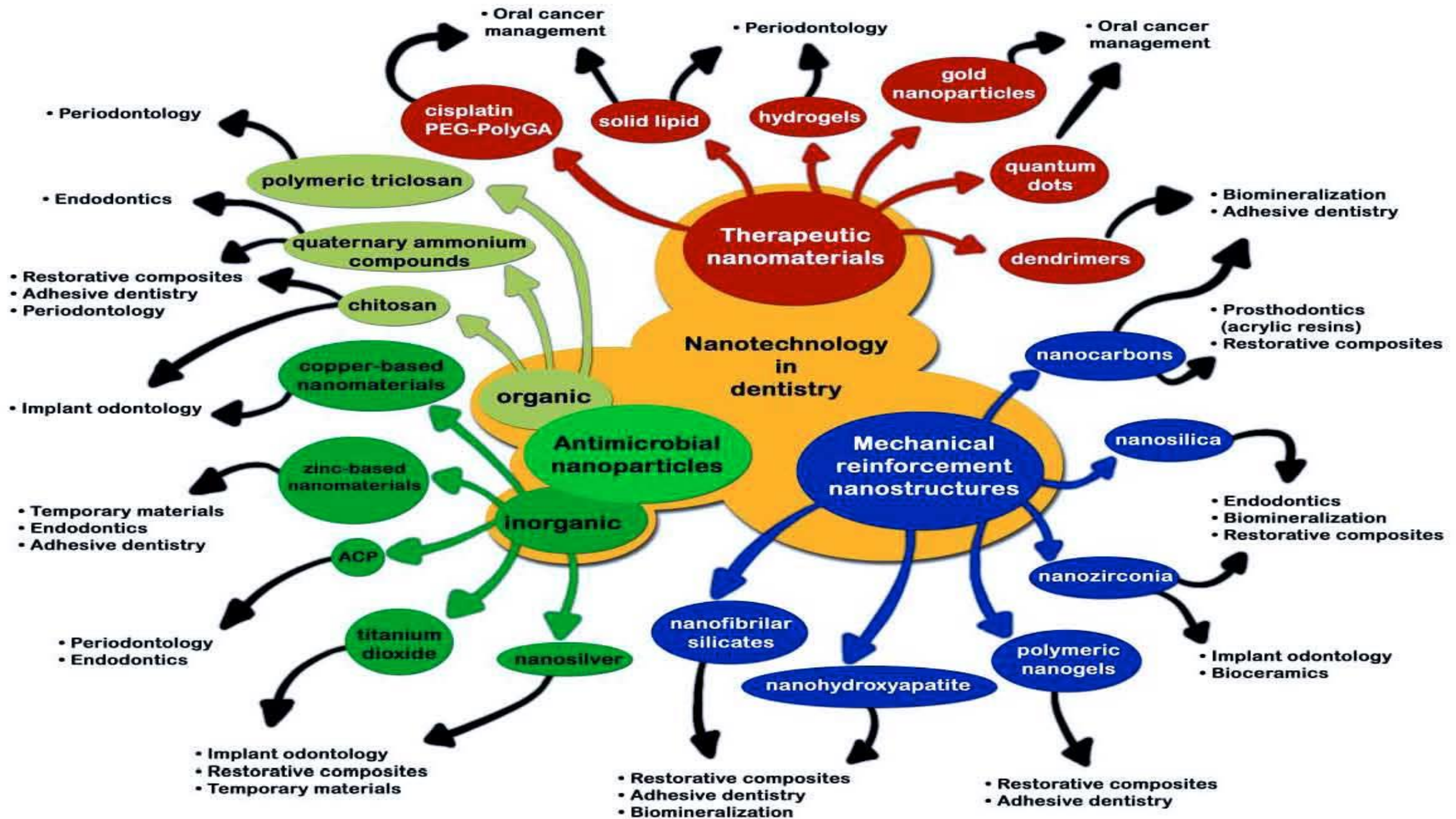
Excess energy from the solar array is fed into the power grid. It helps provide extra electricity to the community, especially during peak daytime hours. More than 35 U.S. states have laws that require net metering, which means that solar panel owners get to subtract the amount of energy produced by their solar panels from the energy they draw from the grid on their monthly bill.

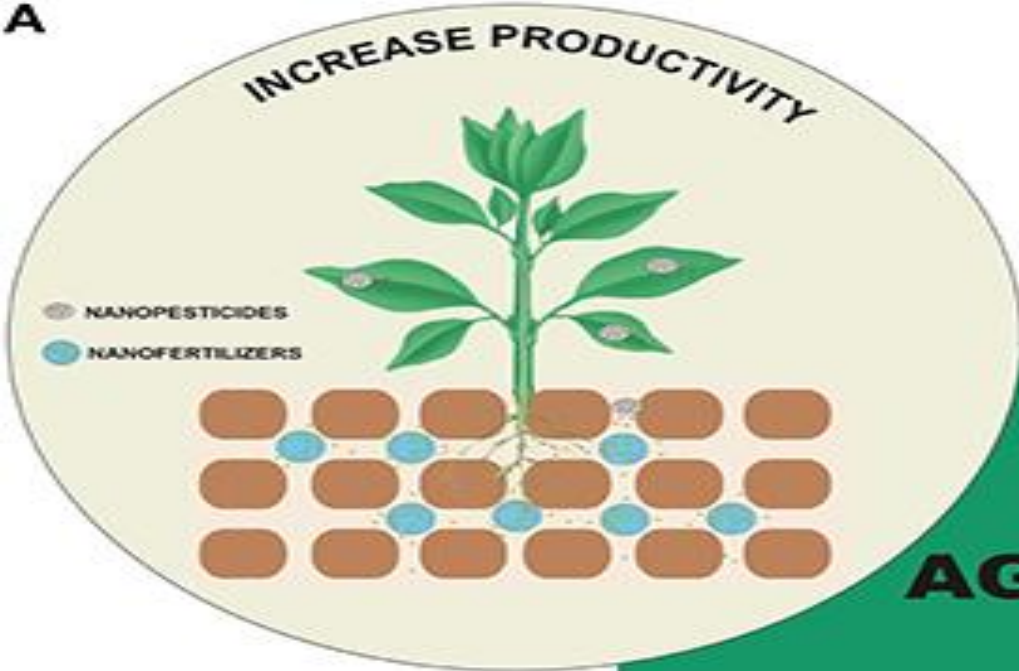
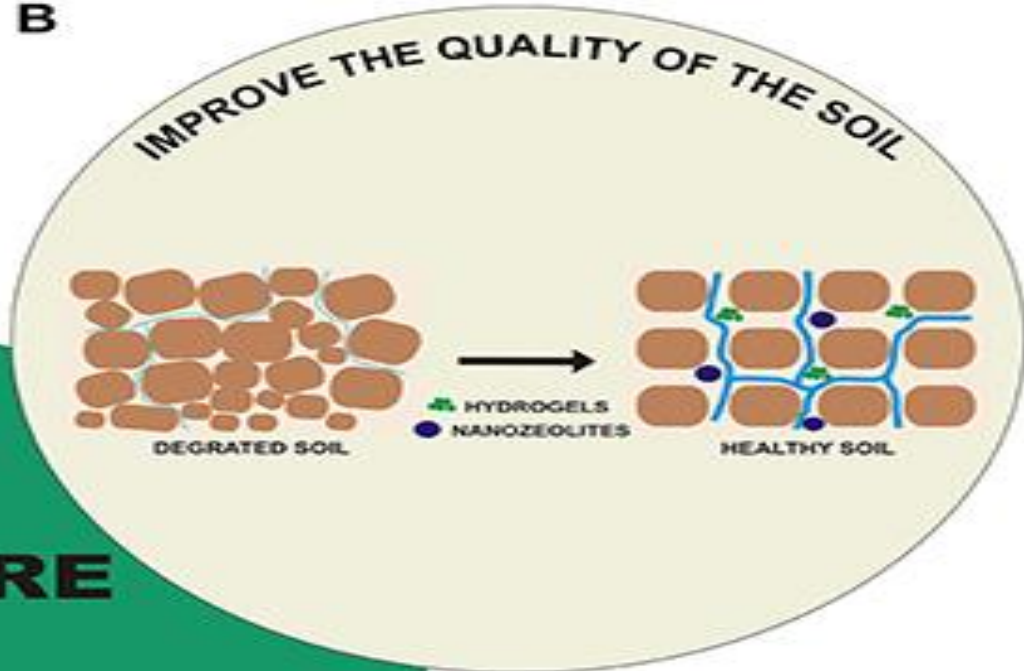


Solar potential in the U.S.

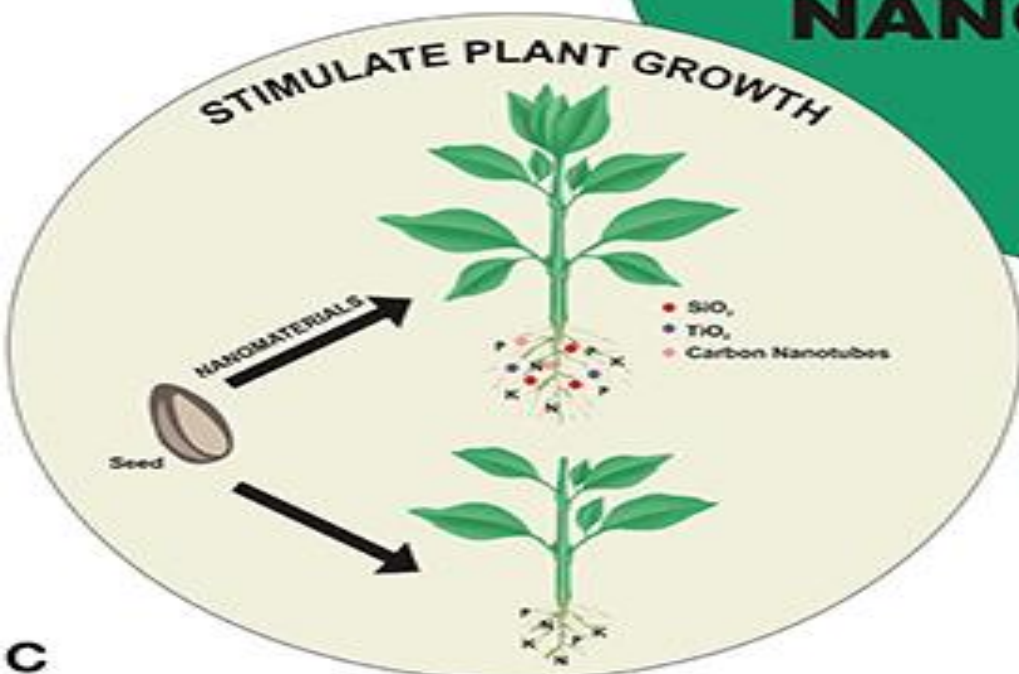
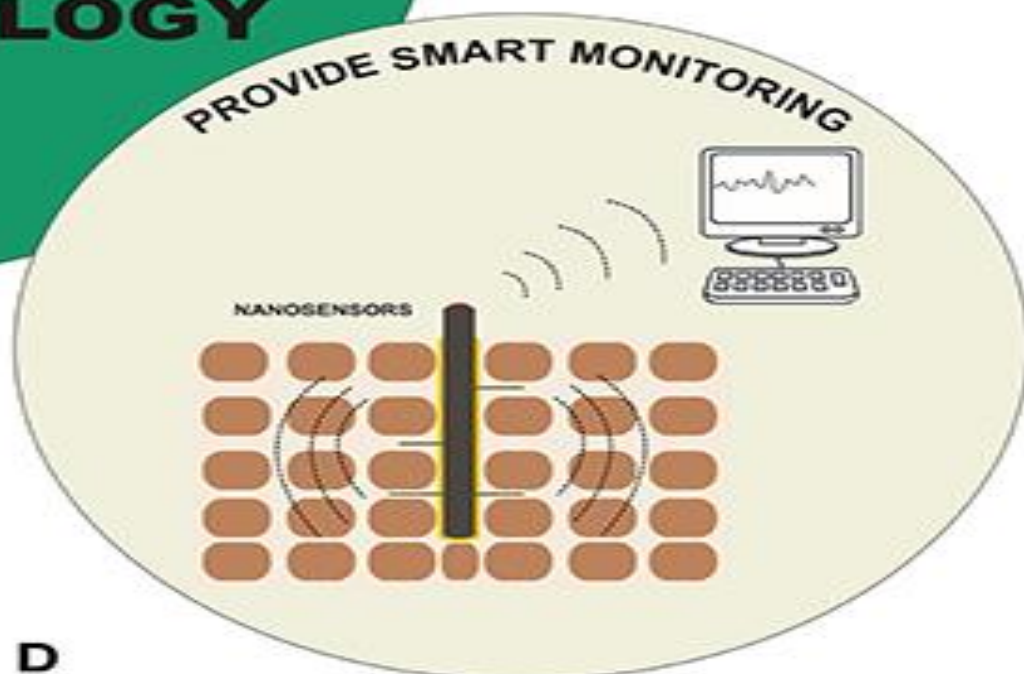
The amount of energy striking almost any part of the Earth is vast, regardless of region, season, time of day, climate and air pollution. Shown is the average radiation received on a horizontal surface across the continental United States in the month of June.





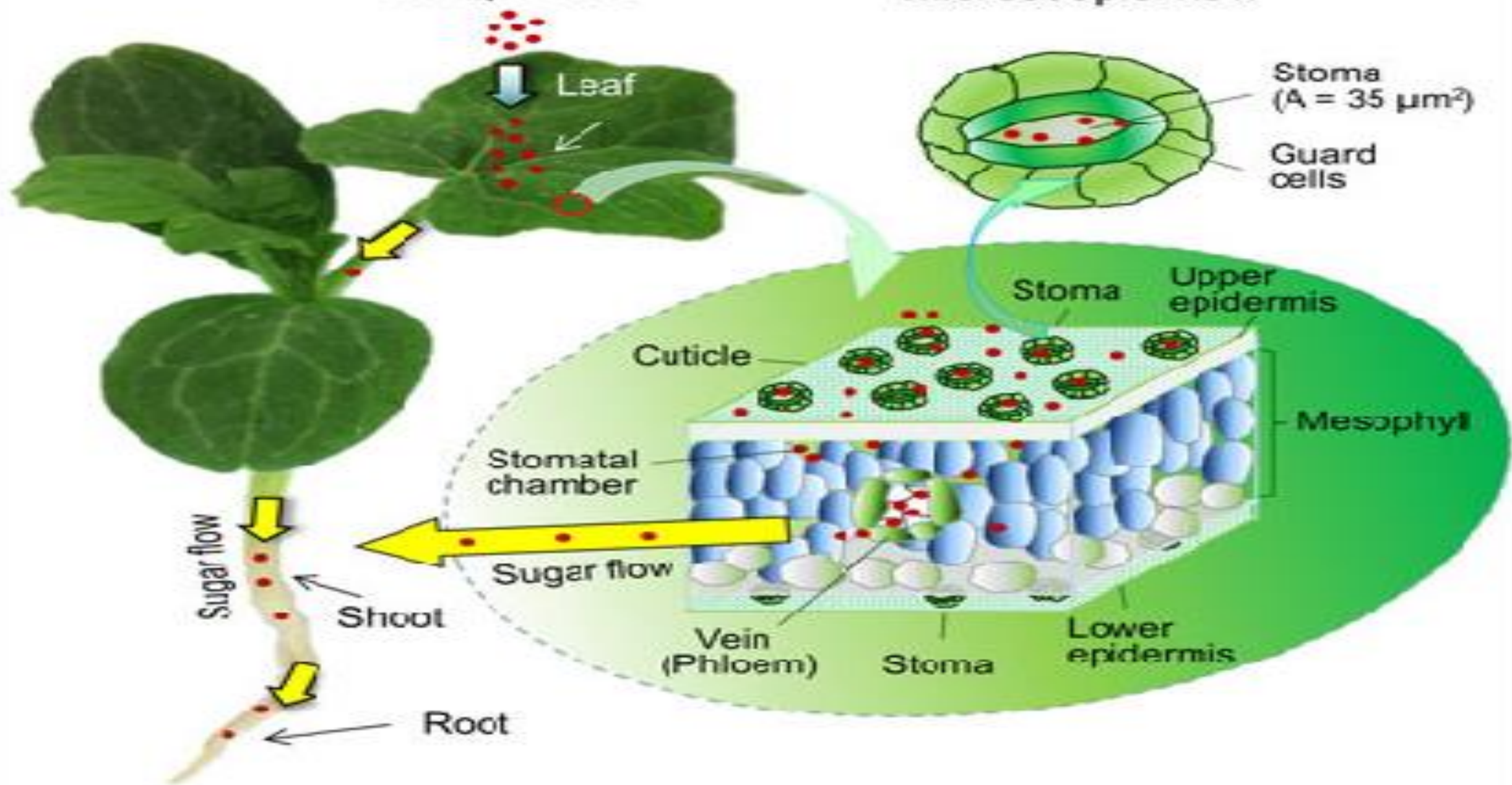
A**B**

**AGRICULTURE
AND
NANOTECHNOLOGY**

C**D**

Nanoparticles

Microscopic view





NEW TRENDS IN DRUG DELIVERY TECHNOLOGIES



- THE RECENT BURST OF INNOVATION AND CREATIVITY IN PHARMACEUTICAL INDUSTRY LED TO OVER 4500 ACTIVE TECHNOLOGIES WHICH CAN BE UTILIZED TO DELIVER A DRUG IN THE BODY BY MANY DIFFERENT ROUTES OF ADMINISTRATION
- THE NEW TECHNOLOGIES ARE GIVING TECHNOLOGICAL ADVANTAGES TO THE INDUSTRY AND ALSO HELPING TO REPOSITION THE FDA APPROVED DRUGS WHICH ARE ALREADY IN THE MARKET
- NEW PRODUCTS USING THESE TECHNOLOGIES ALSO HELP THE INDUSTRY TO EXPLORE NEW THERAPEUTIC INDICATIONS

Figure taken from Don't Accelerate Innovation – Burst it

by Mike Shipulski <https://www.innovationexcellence.com/blog/2018/06/11/dont-accelerate-innovation-burst-it/>

- 
- **WHICH IS THE MOST POPULAR ROUTE OF ADMINISTRATION?**

DEVELOPING DRUG DELIVERY TECHNOLOGIES: BASED ON ROUTE OF ADMINISTRATION



Serial Numbers	Route of administration	Number of products
1	Injectable	2408
2	Oral	935
3	Dermal	550
4	Inhalation	468
5	Trans mucosal	359
6	Medical devices	303
7	Ophthalmic	229
8	Otic	29
9	Other miscellaneous	544

Figure taken from

<https://youbysia.com.au/treatment/cosmetic-injectables/>

LOOKING FURTHER AT INJECTABLE DRUG DELIVERY SYSTEMS

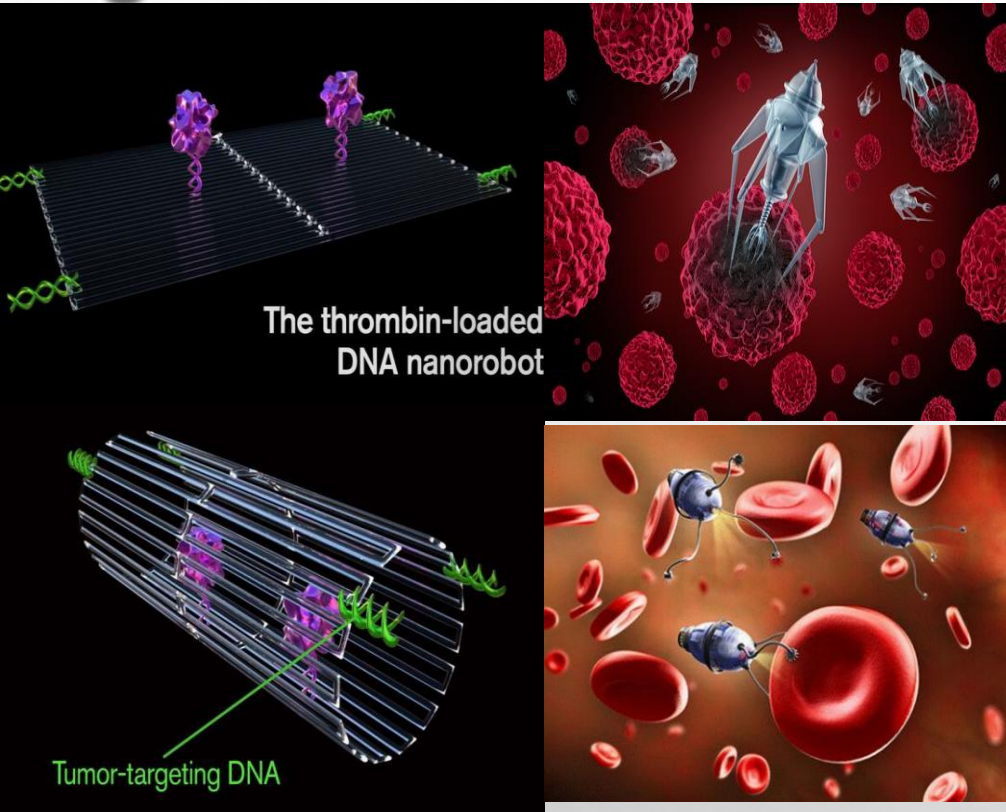


nanoXIM HAp pastes are nano-hydroxyapatite water based pastes specially recommended to manufacture bone graft substitutes such as injectables for bone regeneration and implants for hard tissues.

Figure taken from <https://www.fluidinova.com/nano-hydroxyapatite-pastes-for-injectable-bone-substitute-biomaterial>

Serial Number	Drug delivery technology : Injectable	Number of products
1	Targeted Injectable	960
2	Injection systems	768
3	Prodrugs	390
4	Injectable depot	244
5	Concentrated formulations for further dilution if needed	92
6	Water insoluble Injectable	46
7	Absorption enhancers	15

NEW TECHNOLOGIES TO TREAT SPECIFIC DISEASE OR DISORDER



Serial Number	Specific Disease or disorder	Number of products
1	Cancer	758
2	Endocrine	631
3	Infectious	562
4	Central nervous system (CNS)	549
5	Inflammation and Immune system	457
6	Pain management	435
7	Cardiovascular system	385
8	Skin disorders	311
9	Respiratory	282
10	Musculoskeletal	237
11	Eye disorders	227
12	Gastrointestinal system	224
13	All other	185

Cancer-fighting nanorobots programmed to seek and destroy tumors

Figures taken from <https://phys.org/news/2018-02-cancer-fighting-nanorobots-tumors.html>

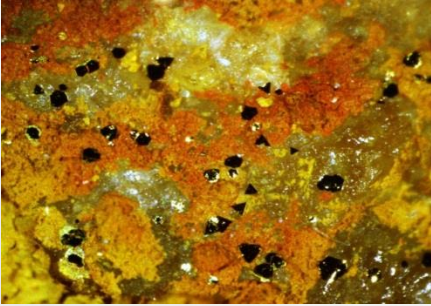
WHO IS THE ???????



• **GREATEST SCIENTIST IN
NANOTECHNOLOGY**

?????

GREATEST SCIENTIST IN NANOTECHNOLOGY ?????



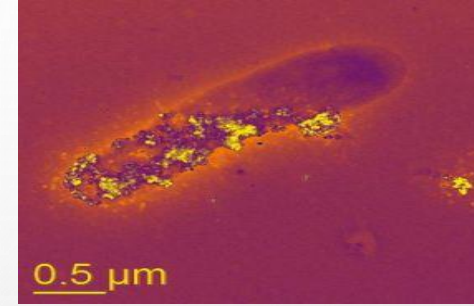
Natural Gold nanoparticles



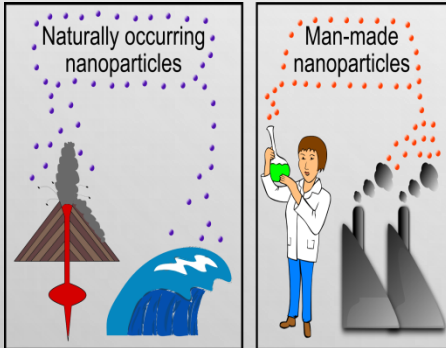
Volcanic Lava



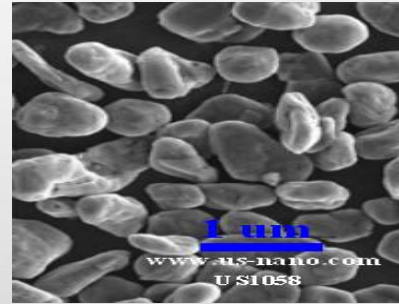
Grape fruit nanoparticles



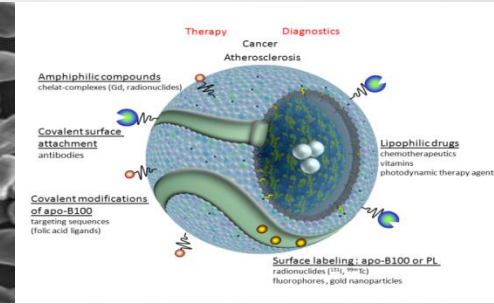
Bacterial Cells nano in size



Plant processes are nano in nature



Natural graphite powder



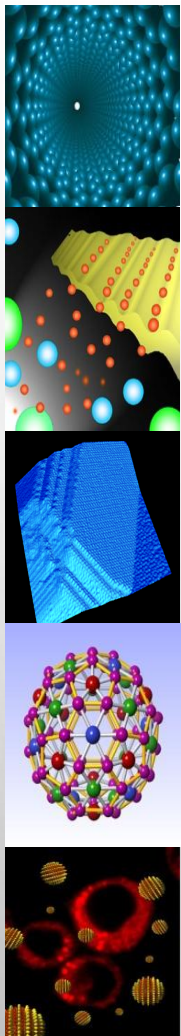
Natural lipoprotein structure nano in nature



Mother Nature



Nano is Too Big: Nanoparticulate drug delivery systems



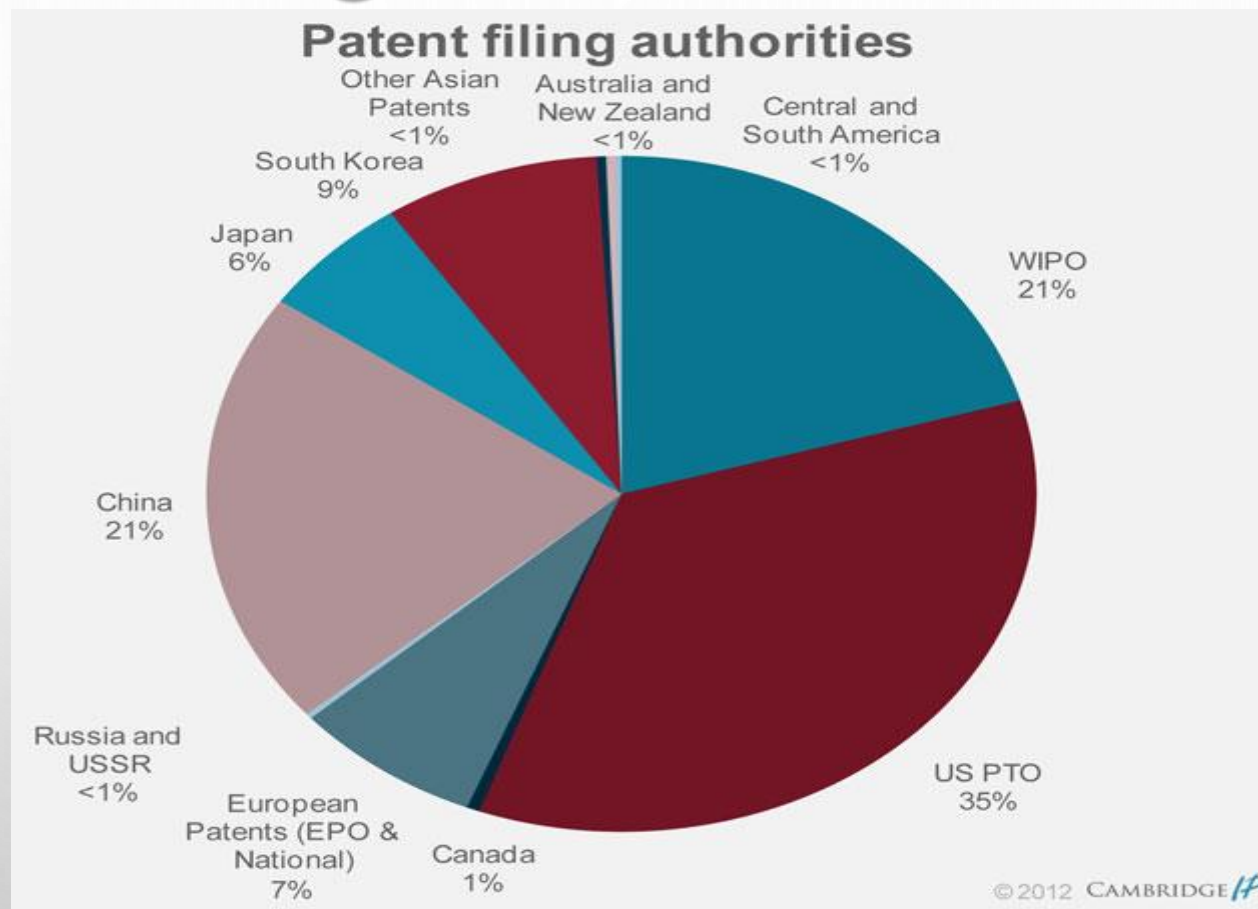
Countries receiving nanotechnology patents

USA	54%
South Korea	7.8%
Japan	7.1 %
Germany	6.2 %
China	4.9 %

Inventors based in the United States led the world in nanotechnology patent applications and grants in 2012, according to a new study by law firm McDermott Will & Emery.

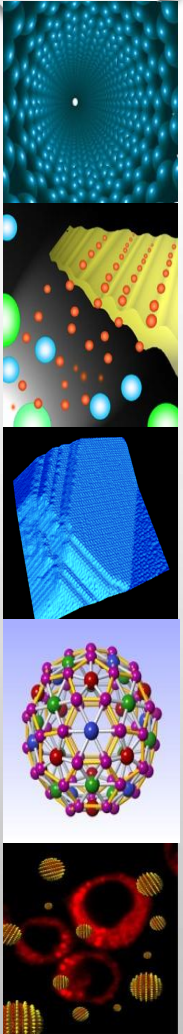
<http://www.reuters.com/article/us-patents-nanotechnology-idUSBRE>

Nano is Too Big: Nanoparticulate drug delivery systems



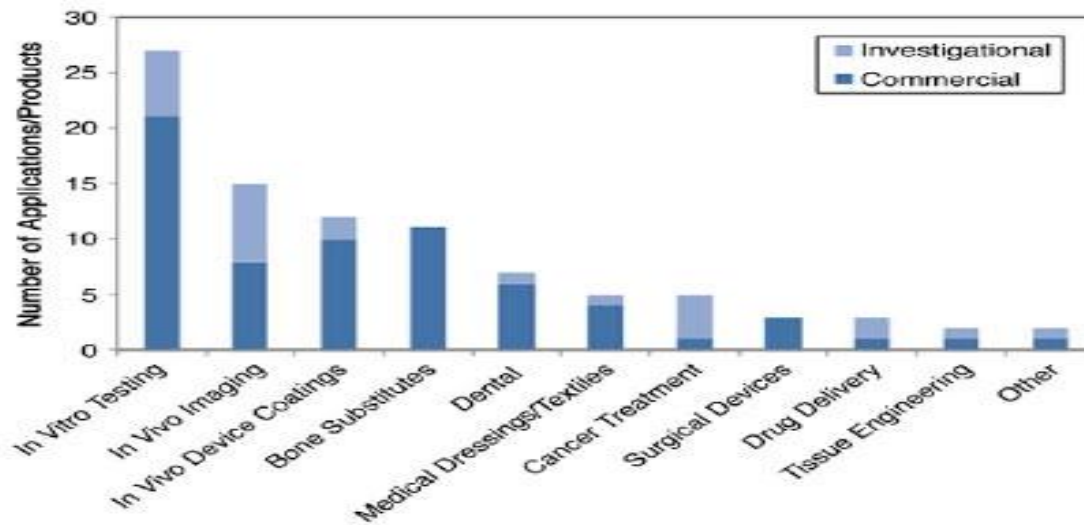
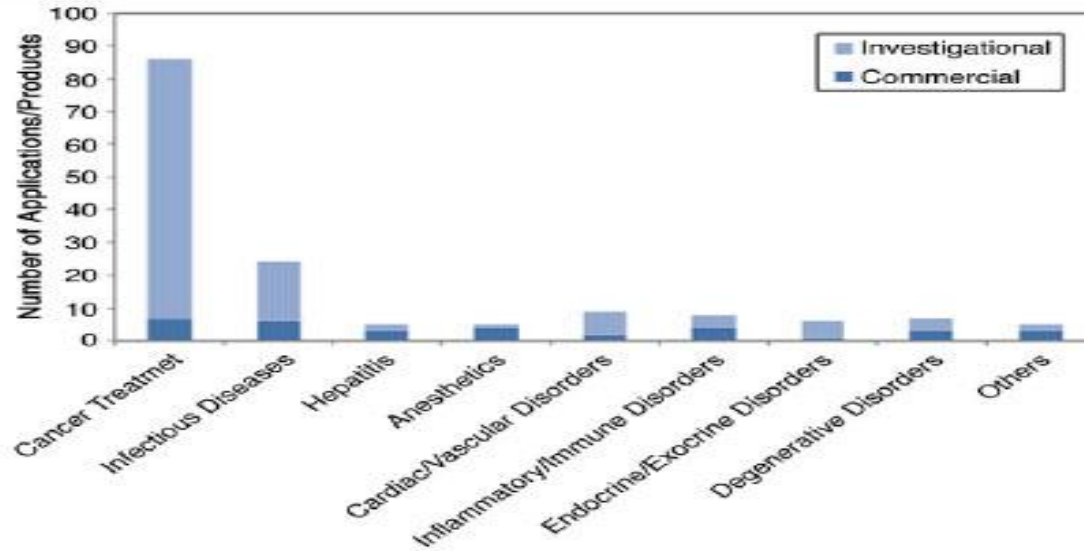
Taken from <http://www.rsc.org/chemistryworld/2013/01/nanotechnology-patent-thicket-jungle-graphene-nanotubes>

NANO PHARMACEUTICALS APPROVED OR IN CLINICAL STUDY



Nanocomponent	Investigational			Commercial		
	Therapeutic	Device	Total	Therapeutic	Device	Total
Hard NP	3	12	15	0	28	28
Nanodispersion	5	0	5	1	1	2
Polymeric NP	23	0	23	9	0	9
Protein NP	4	0	4	2	0	2
Liposome	53	0	53	7	1	8
Emulsion	18	1	19	9	0	9
Micelle	8	0	8	3	1	4
Dendrimer / Fleximer	2	2	4	0	3	3
Virosome	6	0	6	2	0	2
Nanocomposite	0	0	0	0	18	18
NP Coating	0	2	2	0	6	6
Nanoporous Material	0	3	3	0	2	2
Nanopatterned	0	2	2	0	2	2
Quantum Dot	0	1	1	0	4	4
Fullerene	0	1	1	0	0	0
Hydrogel	0	0	0	0	1	1
Carbon Nanotube	0	1	1	0	0	0
Totals	122	25	147	33	67	100

AREAS NANO IS GROWING



FDA APPROVAL APPLICATIONS

- INVESTIGATIONAL NEW DRUG APPLICATIONS (INDA)
- NEW DRUG APPLICATIONS (NDA)
- ABBREVIATED NEW DRUG APPLICATIONS (ANDA)



TYPES OF NANO PARTICLES APPROVED AND INVESTIGATIONAL DRUGS



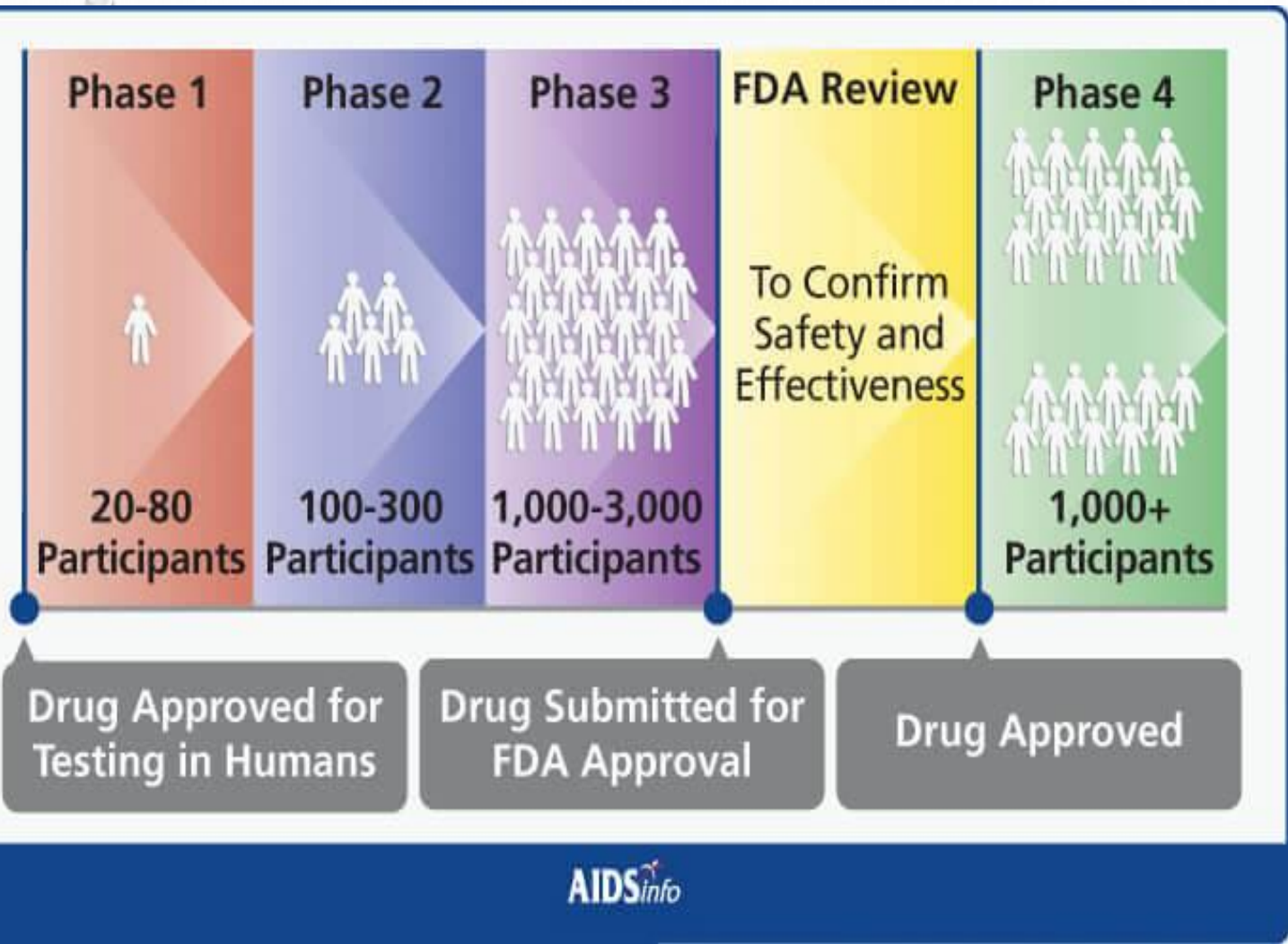
Approval

- LIPOSOMES 10
- POLYMER 15
- NANOCRYSTAL 15
- INORGANIC NANOPARTICLES 5
- MICELLES 1
- PROTEINS 2



FDAATTY.COM

INVESTIGATIONAL DRUGS



- LIPOSOMES 33
- POLYMER 11
- NANOCRYSTAL 2
- INORGANIC NANOPARTICLES 2
- MICELLES 9
- PROTEINS 1
- DENDRIMER 2

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESEARCH/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))



- **FDA IS MAINTAINING ITS PRODUCT-FOCUSED, SCIENCE-BASED REGULATORY POLICY.** TECHNICAL ASSESSMENTS WILL BE PRODUCT-SPECIFIC, TAKING INTO ACCOUNT THE EFFECTS OF NANOMATERIALS IN THE PARTICULAR BIOLOGICAL AND MECHANICAL CONTEXT OF EACH PRODUCT AND ITS INTENDED USE. AND THE PARTICULAR POLICIES FOR EACH PRODUCT AREA, BOTH SUBSTANTIVE AND PROCEDURAL, WILL VARY ACCORDING TO THE STATUTORY AUTHORITIES. WE ADVISE MANUFACTURERS TO CONSULT WITH THE FDA EARLY IN THEIR DEVELOPMENT PROCESS TO FACILITATE A MUTUAL UNDERSTANDING OF THE SCIENTIFIC AND REGULATORY ISSUES FOR THEIR NANOTECHNOLOGY PRODUCTS.

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

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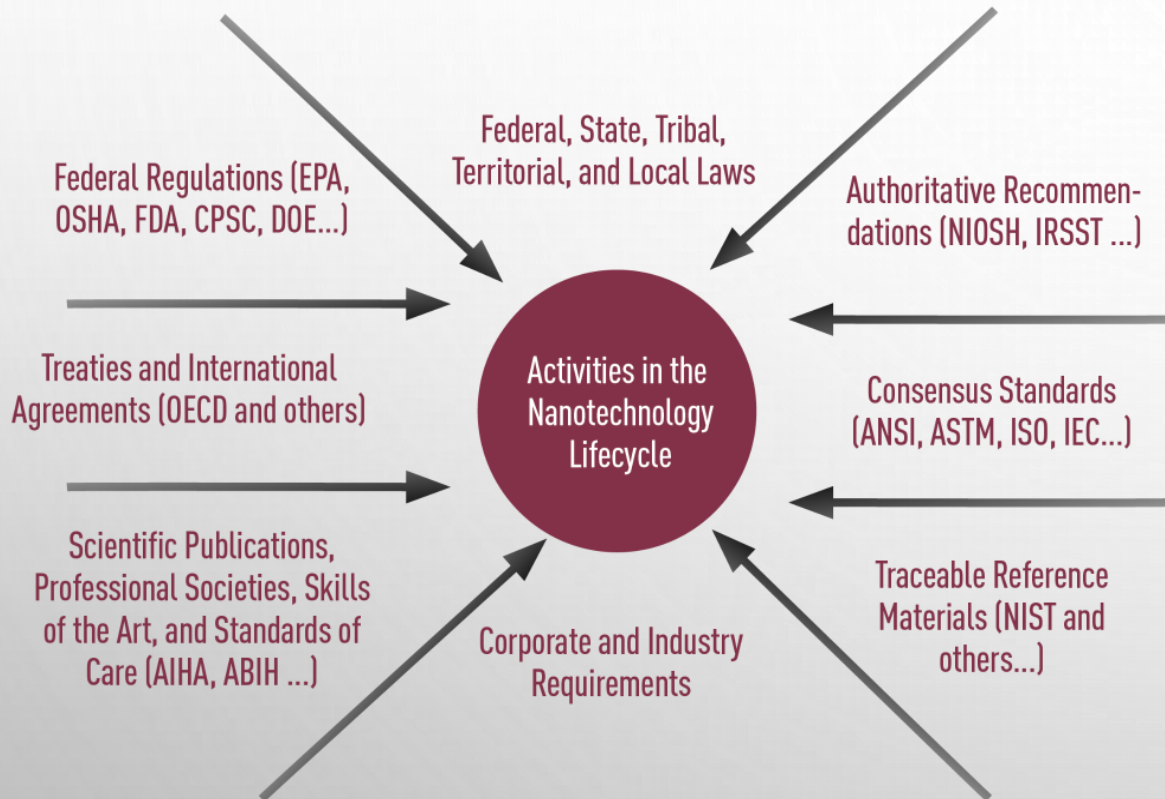
The three classes

		PREMARKET	CONTROLS	
CLASS I	Does not support or sustain human life and has a significant history of safety and effectiveness	Most exempt from 510(k) clearance	General	low
CLASS II	Has a similar intended use and a safety and effectiveness profile of a device already on the market; risk requires special controls	Most require 510(k) clearance	General + Special	RISK TO PATIENT ↓ high
CLASS III	Supports or sustains life or high risk of injury; typically requires clinical studies demonstrating safety and effectiveness	Nearly all require premarket approval (PMA)	General + Special + Ad hoc	

- **FDA'S APPROACH RESPECTS VARIATIONS IN LEGAL STANDARDS FOR DIFFERENT PRODUCT-CLASSES.** FOOD ADDITIVES ARE CONSIDERED SAFE WHEN THERE IS A REASONABLE CERTAINTY OF NO HARM FROM THEIR INTENDED USE. DRUGS, BY CONTRAST, ARE EVALUATED NOT ONLY ON THE BASIS OF THEIR RISK PROFILE BUT ALSO THEIR PREDICTED BENEFIT.
- THESE DIFFERING LEGAL STANDARDS DEMONSTRATE HOW DIFFERENT CONTEXTS COULD LEAD TO DIFFERENT REGULATORY OUTCOMES, EVEN IF TWO PRODUCTS PRESENT THE SAME LEVEL OF RISK. OTHER PRODUCTS REGULATED BY FDA ARE SUBJECT TO YET DIFFERENT STANDARDS FOR SAFETY OR EFFECTIVENESS.
- THE RESULT MAY BE DIVERGENT REGULATORY OUTCOMES FOR DIFFERENT PRODUCT CLASSES AND DIFFERENT APPLICATIONS OF NANOMATERIALS, EVEN WHERE OBJECTIVE MEASURES OF RISK ARE SIMILAR.

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESARCH/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))



Adapted from "Standards, Guidelines, Regulations, and Recommendations for Measuring Airborne Radioactivity" in *Radioactive Air Sampling Methods*, CRC Press (2010).

- **WHERE PREMARKET REVIEW AUTHORITY EXISTS, ATTENTION TO NANOMATERIALS IS BEING INCORPORATED INTO STANDING PROCEDURES.** FOR EXAMPLE, NEW DRUGS, NEW ANIMAL DRUGS, BIOLOGICS, FOOD ADDITIVES,^[3] COLOR ADDITIVES, CERTAIN HUMAN DEVICES, AND CERTAIN NEW DIETARY INGREDIENTS IN DIETARY SUPPLEMENTS ARE SUBJECT TO PREMARKET REVIEW REQUIREMENTS. PREMARKET REVIEW PROCESSES FOR THESE PRODUCTS REQUIRE APPLICANTS TO SUBMIT DATA TO ANSWER QUESTIONS RELATED TO THE SAFETY, EFFECTIVENESS (WHERE APPLICABLE), OR REGULATORY STATUS OF THE PRODUCT. INDIVIDUAL PREMARKET REVIEW PROCEDURES INCLUDE ATTENTION TO WHETHER THE USE OF NANOMATERIALS SUGGESTS THE NEED FOR ADDITIONAL DATA ON SAFETY OR EFFECTIVENESS, AS APPLICABLE^[4].

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESearch/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))

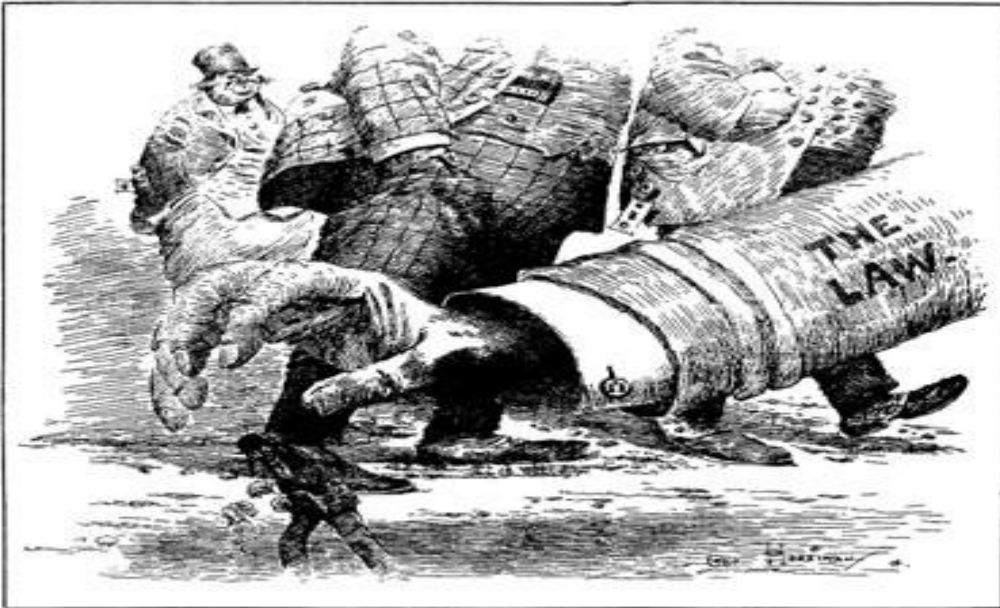


- **WHERE STATUTORY AUTHORITY DOES NOT PROVIDE FOR PREMARKET REVIEW, CONSULTATION IS ENCOURAGED TO REDUCE THE RISK OF UNINTENDED HARM TO HUMAN OR ANIMAL HEALTH.** SOME FDA REGULATED PRODUCTS, SUCH AS DIETARY SUPPLEMENTS (EXCEPT CERTAIN NEW DIETARY INGREDIENTS), COSMETICS (EXCEPT COLOR ADDITIVES), AND FOOD (EXCEPT FOOD OR COLOR ADDITIVES) ARE NOT SUBJECT TO MANDATORY PREMARKET REVIEW. IN THESE CASES, FDA RELIES ON PUBLICLY AVAILABLE OR VOLUNTARILY SUBMITTED INFORMATION, ADVERSE EVENT REPORTING (WHERE APPLICABLE), AND ON POST-MARKET SURVEILLANCE ACTIVITIES, TO PROVIDE OVERSIGHT. WHERE NANOTECHNOLOGY APPLICATIONS ARE INVOLVED, FDA ENCOURAGES MANUFACTURERS TO CONSULT WITH THE AGENCY BEFORE TAKING THEIR PRODUCTS TO MARKET. SUCH CONSULTATION CAN HELP FDA TO ADVISE COMPANIES, REVIEW SAFETY INFORMATION, AND DESIGN ANY NECESSARY POST-MARKETING SAFETY OVERSIGHT.
- **FDA WILL CONTINUE POST-MARKET MONITORING.** FDA WILL CONTINUE TO MONITOR THE MARKETPLACE FOR PRODUCTS CONTAINING NANOMATERIALS AND WILL TAKE ACTIONS, AS NEEDED, TO PROTECT CONSUMERS.

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESEARCH/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))

THE LAW'S LONG ARM.



It Reaches Far--Sometimes It Might Better Seize the Thing Close By.

- **INDUSTRY REMAINS RESPONSIBLE FOR ENSURING THAT ITS PRODUCTS MEET ALL APPLICABLE LEGAL REQUIREMENTS, INCLUDING SAFETY STANDARDS.** REGARDLESS OF WHETHER PRODUCTS ARE SUBJECT TO PREMARKET REVIEW OR AUTHORIZATION, MANUFACTURERS ARE REQUIRED TO ENSURE THAT THEIR PRODUCT SATISFIES APPLICABLE SAFETY STANDARDS AND COMPLIES WITH OTHER APPLICABLE REQUIREMENTS. THEREFORE, INDUSTRY MUST WORK WITH CURRENT INFORMATION IN PRODUCT DEVELOPMENT, AND CONTINUE TO MONITOR PRODUCTS ONCE MARKETED. FDA ENCOURAGES INDUSTRY TO CONSULT EARLY WITH THE AGENCY TO ADDRESS QUESTIONS RELATED TO THE REGULATORY STATUS, OR TO THE SAFETY, EFFECTIVENESS, OR OTHER ATTRIBUTES OF PRODUCTS THAT CONTAIN NANOMATERIALS OR OTHERWISE INVOLVE APPLICATION OF NANOTECHNOLOGY. THESE EARLY CONSULTATIONS AFFORD AN OPPORTUNITY TO CLARIFY THE METHODOLOGIES AND DATA THAT WILL BE NEEDED TO MEET THE SPONSOR'S OBLIGATIONS. ADDITIONAL PUBLIC MEETINGS OR WORKSHOPS MAY BE HELD TO ADVANCE REGULATORY SCIENCE, IDENTIFY PRODUCT-SPECIFIC DATA NEEDS, OR SEEK INPUT ON SPECIFIC ISSUES.

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESARCH/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))



- **FDA WILL COLLABORATE, AS APPROPRIATE, WITH DOMESTIC AND INTERNATIONAL COUNTERPARTS ON REGULATORY POLICY ISSUES.** FDA ENGAGES IN POLICY DIALOGUE WITH OTHER U.S. GOVERNMENT AGENCIES THROUGH THE EMERGING TECHNOLOGIES INTERAGENCY POLICY COORDINATION COMMITTEE AND OTHER FORUMS, AMONG OTHER THINGS, TO CONTRIBUTE TO OVERARCHING U.S. GOVERNMENT POLICIES RELEVANT TO NANOTECHNOLOGY AND, AS APPROPRIATE, COORDINATE ITS POLICY ACTIVITIES. FDA ALSO WORKS WITH FOREIGN REGULATORY COUNTERPARTS TO SHARE PERSPECTIVES AND INFORMATION ON THE REGULATION OF NANOTECHNOLOGY PRODUCTS AND THEIR INTENDED USES.

FDA'S APPROACH TO REGULATION OF NANOTECHNOLOGY PRODUCTS

(TAKEN FROM [HTTPS://WWW.FDA.GOV/SCIENCERESARCH/SPECIALTOPICS/NANOTECHNOLOGY/UCM301114.HTM](https://www.fda.gov/scienceresearch/specialtopics/nanotechnology/ucm301114.htm))



- **BOTH FOR PRODUCTS THAT ARE NOT SUBJECT TO PREMARKET REVIEW AND THOSE THAT ARE, FDA WILL OFFER TECHNICAL ADVICE AND GUIDANCE, AS NEEDED, TO HELP INDUSTRY MEET ITS REGULATORY AND STATUTORY OBLIGATIONS.** FDA PREPARES GUIDANCE DOCUMENTS FOR ITS STAFF, APPLICANTS/SPONSORS, AND THE PUBLIC TO DESCRIBE THE AGENCY'S INTERPRETATION OF OR POLICY ON A REGULATORY ISSUE. GUIDANCE DOCUMENTS WILL EMERGE OVER TIME, AND (DEPENDING UPON THE PRODUCT-CLASS) WILL ADDRESS INTERPRETATION OF RELEVANT STATUTORY AND REGULATORY STANDARDS, AND PROVIDE GUIDANCE ON THE TECHNICAL DATA NEEDED TO MEET THOSE STANDARDS (SEE LIST BELOW FOR GUIDANCES ALREADY PUBLISHED). FDA WILL TAILOR GUIDANCES TO THE UNIQUE CONFLUENCE OF THE STATUTE GOVERNING THE PRODUCT-CLASS, THE LEVEL OF SCIENTIFIC KNOWLEDGE RELEVANT TO THOSE APPLICATIONS, AND THE LIKELY EXTENT OF EFFECTS ON HUMAN AND ANIMAL HEALTH.
- **FOR ADDITIONAL INFORMATION OR SPECIFIC QUESTIONS RELATED TO FDA'S NANOTECHNOLOGY REGULATORY POLICIES, CONTACT:**
- **OFFICE OF POLICY, OFFICE OF THE COMMISSIONER, U.S. FOOD AND DRUG ADMINISTRATION, 10903 NEW HAMPSHIRE AVENUE, SILVER SPRING, MD 20993, PHONE: 301-796-4830, FAX: 301-847-3541**

APPLICATION OF NANOPARTICLES TO DRUG DISCOVERY AND BIOLOGY

- FDA HAS APPROVED MANY PRODUCTS WITH PARTICULATE MATERIALS IN THE NANO SIZE RANGE.
- MOST DRUGS ARE EXPECTED TO GO THROUGH A NANO SIZE PHASE DURING THE PROCESS OF ABSORPTION IN THE BODY.
- THERE HAVE BEEN NO SAFETY CONCERNS REPORTED IN THE PAST BECAUSE OF PARTICLE SIZE.
- FLUORESCENT BIOLOGICAL MARKERS
- DETECTION OF PROTEINS
- PROBING OF DNA STRUCTURES
- SEPARATION AND PURIFICATION OF BIOLOGICAL MOLECULES AND CELLS
- MRI CONTRAST ENHANCEMENT
- TUMOR DESTRUCTION VIA HEATING
- TISSUE ENGINEERING
- DRUG AND GENE DELIVERY

FDA-REGULATED PRODUCTS EXPECTED TO BE IMPACTED BY NANOTECHNOLOGY

- DRUGS (NOVEL NMES OR DELIVERY SYSTEMS)
- MEDICAL DEVICES
- BIOTECHNOLOGY PRODUCTS
- TISSUE ENGINEERING PRODUCTS
- VACCINES
- COSMETICS
- COMBINATION PRODUCTS
- COMBINATION PRODUCTS ARE MADE OF MULTIPLE CONSTITUENTS: DRUG-DEVICE, DRUG-BIOLOGIC, DEVICE, BIOLOGIC OR DRUG-DEVICE-BIOLOGIC THAT ARE PHYSICALLY OR CHEMICALLY COMBINED, CO-PACKAGED IN A KIT OR SEPARATE CROSS-LABELED PRODUCTS.
- ALL COMPONENTS WORK AS A SYSTEM AND ARE CRITICAL TO ACHIEVE DESIRED THERAPEUTIC EFFECT.

Current FDA Definition for Nanotechnology

- **FDA calls it "nanotechnology" only if it involves all of the following:**
 - **1. Research and technology development, or products regulated by FDA, that are at the atomic, molecular or macromolecular levels, and where at least one dimension, that affects the functional behavior of the product, is in the length scale range of approximately 1-100 nanometers.**
 - **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 at the atomic scale.**

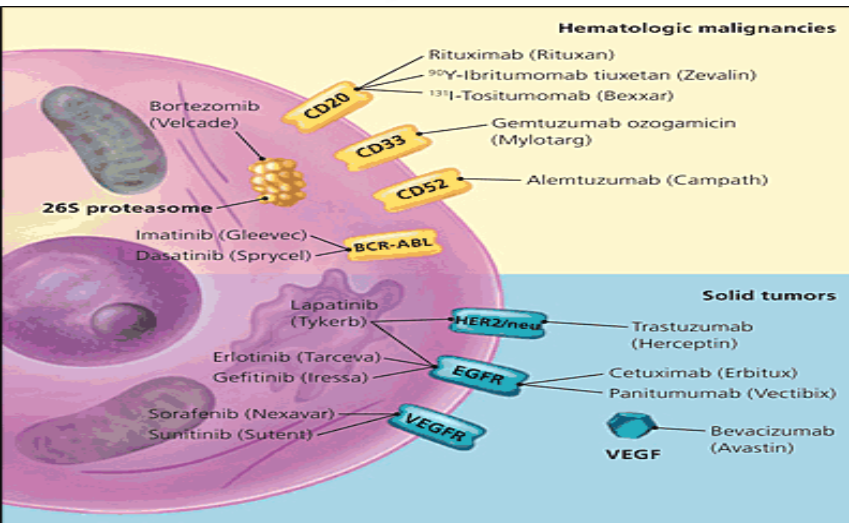
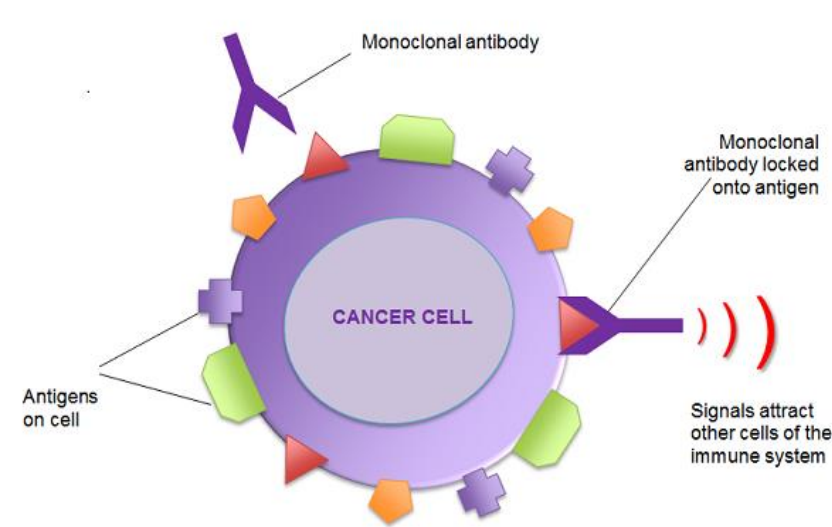
6

WHAT ARE NANO PHARMACEUTICALS/ NANO MEDICINES

- THE UNDERSTANDING AND CONTROL OF MATTER AT DIMENSIONS BETWEEN APPROXIMATELY 1 AND 100 NANOMETERS (NM), WHERE UNIQUE PHENOMENA ENABLE NOVEL APPLICATIONS NOT FEASIBLE WHEN WORKING WITH BULK MATERIALS OR EVEN WITH SINGLE ATOMS OR MOLECULES.

INTERESTING APPROACHES BASED ON SYSTEMS BIOLOGY OF CANCER

- **MONOCLONAL ANTIBODY CANCER THERAPIES THAT BLOCK HER PROTEINS:** THESE ARE MONOCLONAL ANTIBODIES THAT BIND SELECTIVELY TO HER PROTEINS AND COMPROMISE THE FUNCTIONALITY OF THOSE PROTEINS.
- **WHILE HER-BLOCKING MONOCLONAL ANTIBODY THERAPIES ARE USEFUL, SOMETIMES THEY ARE ONLY WEAKLY EFFECTIVE OR WON'T WORK AT ALL AS SINGLE THERAPIES.**
- **A MAJOR PROBLEM WITH CANCER THERAPIES BASED IN INHIBITING THE HER PATHWAY IS GRB7 UPREGULATION WHICH PROMOTES CANCER CELL SURVIVAL AND MIGRATION. DRUG INHIBITION OF AKT SIGNALING IS THE CULPRIT.**
- **ANOTHER LIMITATION OF EGFR-HER2 INHIBITION USING LAPATINIB IS THAT INSUFFICIENT INHIBITION OF PI3K-SURVIVIN SIGNALING LEADS TO ONLY A LIMITED PRO-APOPTOTIC EFFECT OF LAPATINIB IN HER2 AMPLIFICATION-POSITIVE CELLS WITH A PIK3CA MUTATION.**
- **THE COMBINATION OF TRASTUZUMAB AND LAPATINIB MAY HELP OVERCOME DRUG RESISTANCE IN HER2-POSITIVE BREAST CANCERS.**
- **THE RESISTANCE TO TRASTUZUMAB AND LAPATINIB OF BREAST CANCERS MAY BE OVERCOME BY DOWN-REGULATING MTOR EXPRESSION.**
- **HOWEVER, BLOCKING THE MTOR PATHWAY VIA USING A P13K INHIBITOR MAY BE INEFFECTIVE AS A SINGLE THERAPY FOR BREAST CANCER BECAUSE OF FEEDBACK UPREGULATION OF HER3.**
- **HISTONE DEACETYLASE INHIBITION (HDACI) IS ANOTHER VERY IMPORTANT EMERGING APPROACH TO CANCER THERAPY, AGAIN MOST-FREQUENTLY IN COMBINATION WITH OTHER PHARMA APPROACHES**



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FDA APPROVED AND PRODUCTS IN CLINICAL TRIALS FOR CANCER TREATMENT

Nanomedicine type	Drug	Product name/company	Indication	Phase
Liposomes	Doxorubicin	Myocet™/Teva UK	Metastatic breast cancer	Approved
		Doxil™/Janssen	Kaposi's sarcoma, Ovarian cancer (post-first line failure) Multiple myeloma	Approved
		ThermoDox™/Celsion	Primary hepatocellular carcinoma, Refractory chest wall breast cancer Colorectal liver metastases	Phase III
		2B3-101/2-BBB Medicines BV	Brain metastases Glioma	Phase II
	Vincristine	Marqibo™/Spectrum Pharmaceuticals	Acute lymphoblastic leukaemia	Approved
	Daunorubicin	DaunoXome™/Galen	HIV-related Kaposi's sarcoma	Approved
	Cytarabine	Depocyt™/Pacira Pharmaceuticals	Lymphomatous meningitis	Approved
	Irinotecan	Onivyde™/Merrimack Pharmaceuticals	Metastatic pancreatic cancer (2nd line), Gastric cancer	Approved Phase II

FDA APPROVED AND PRODUCTS IN CLINICAL TRIALS FOR CANCER TREATMENT

Cytarabine: daunorubicin 5:1 fixed ratio	CPX-351/Celator	Acute myeloid leukaemia	Phase III
Cisplatin	Lipoplatin/Regulon	Non-small cell lung cancer	Phase III
	SPI-77/ALZA Pharmaceuticals	Ovarian cancer	Phase II
	Aroplatin/Aronex Pharmaceuticals	Malignant mesothelioma	Phase II
Oxaliplatin	MBP-426/Mebiopharm	Gastrointestinal adenocarcinoma	Phase II
Paclitaxel	LEP—ETU/Insys	Breast cancer	Phase II
	EndoTAG-1/MediGene	Breast cancer	Phase II
	PNU-91934/MSKCC	Esophageal cancer	Phase II
SN-38	LE-SN38/Neopharm	Metastatic colorectal cancer	Phase II
Irinotecan: Floxuridine 1:1 ratio	CPX-1/Celator	Colorectal cancer	Phase II

FDA APPROVED AND PRODUCTS IN CLINICAL TRIALS FOR CANCER TREATMENT

Polymeric conjugates	Camptothecin	CRLX101 (cyclodextrin adamantane)/Cerulean	Renal cancer Small cell lung cancer Ovarian cancer	Phase II
	Asparaginase	Oncaspar™ (PEG)/Baxalta	Acute lymphoblastic leukaemia	Approved
	Paclitaxel	Opaxio™ (Polyglycerol adipate)/CTI Biopharma	Ovarian cancer Non-small cell lung cancer (women)	Phase III maintenance Phase II
	Irinotecan	NKTR102 (PEG)/Nektar	Metastatic breast cancer	Phase III
	Camptothecin	CRLX101 (nanoparticle)/Cerulean	Renal cell carcinoma (3rd/4th line), Ovarian cancer (2nd/3rd line)	Phase II
		XMT1001 (Fleximer™)/Mersana	Gastric cancer (2nd line), Non-small cell lung cancer (2nd/3rd line)	Phase II
	Diaminocyclohexane (DACH) Platinum	AP 5346 (Hydroxypropylmethacrylate)/ProLindac™	Ovarian cancer	Phase II
	Docetaxel	DEP™ (G5 PEG-Polylysine)/StarPharma	Advanced cancers	Phase I
		CriPec™ docetaxel (nanoparticle)/Cristal Therapeutics	Solid tumours	Phase I

FDA APPROVED AND PRODUCTS IN CLINICAL TRIALS FOR CANCER TREATMENT

Polymeric nanoparticles	Docetaxel + Prostate-Specific Membrane Antigen (PSMA)	BIND-014 (Accurin™)/BIND Therapeutics	Cholangiocarcinoma, Cervical cancer, Bladder cancer Head and neck cancer, Non-small cell lung cancer subtypes	Phase II
	AZD2811 (AZD1152 hydroxyquinazoline pyrazol anilide; Aurora-B Kinase Inhibitor)	AZD2811 (Accurin™) nanoparticle/AstraZeneca	Advanced solid tumours	Phase I
Polymeric micelles	Paclitaxel	Genexol-PM™/Samyang Biopharmaceuticals	Breast cancer, Non-small cell lung cancer, Ovarian cancer	Approved
		NK105/NanoCarrier™	Stomach cancer, Breast cancer	Phase III
		NC-4016/NanoCarrier™	Solid tumours	Phase I
		Nanoxel™/Samyang Biopharmaceuticals	Advanced breast cancer	Phase I
	DACH-platin	NC-6004 Nanoplatin™/NanoCarrier™	Pancreatic cancer, Head and neck cancer, Non-small cell lung cancer, Bladder cancer	Phase III
Other	Irinotecan	HA-irinotecan HyACT™/Alchemia	Colorectal cancer Lung cancer	Phase II Phase III
	Tumour Necrosis Factor (TNF)	CYT-6091/CytImmune	Non-small cell lung cancer	Phase II
	Paclitaxel	Abraxane™/Celgene	Advanced breast cancer Advanced non-small cell lung cancer Advanced pancreatic cancer	Appr



**THE SCOPE OF NANO
MEDICINES AND THE EXPECTED
VALUE OF THE MARKET.**

GROWING NANOMEDICINE AND NANOTECHNOLOGY APPLICATIONS IN HEALTHCARE

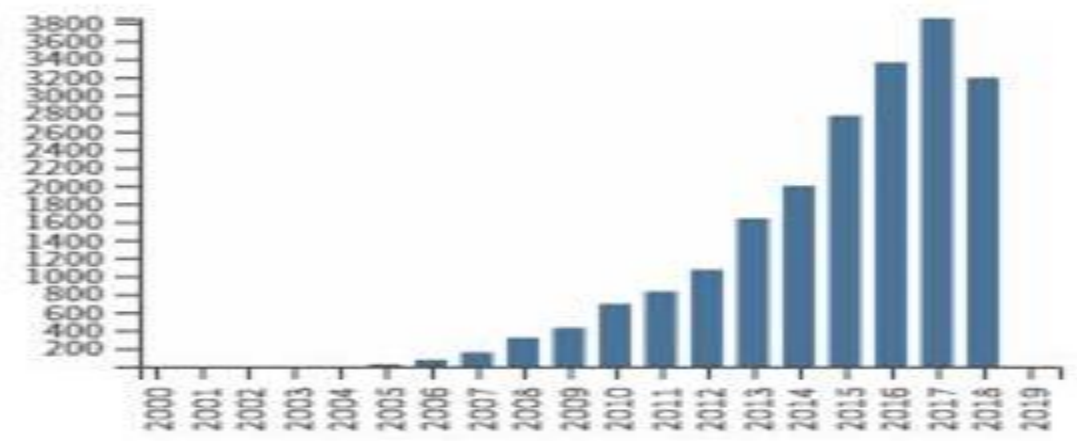
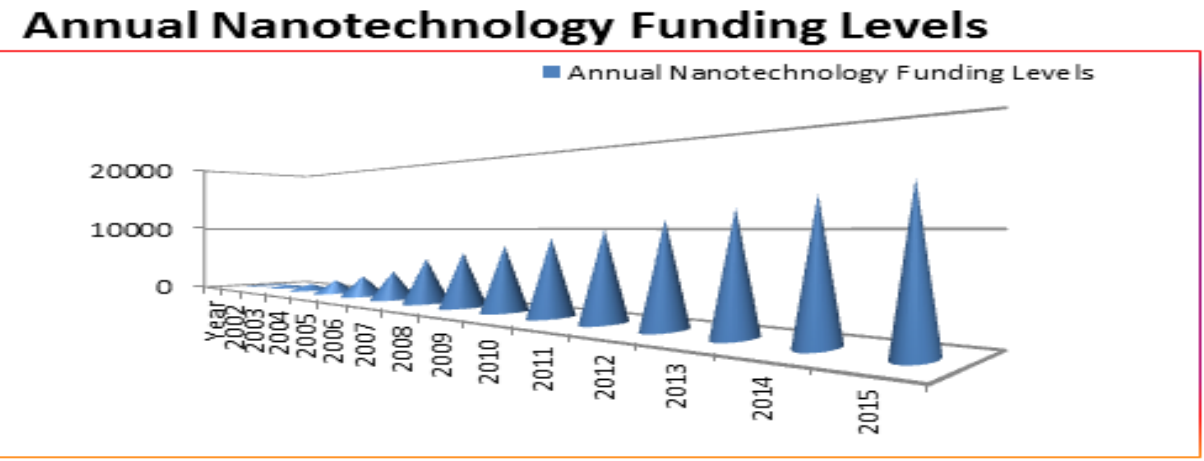
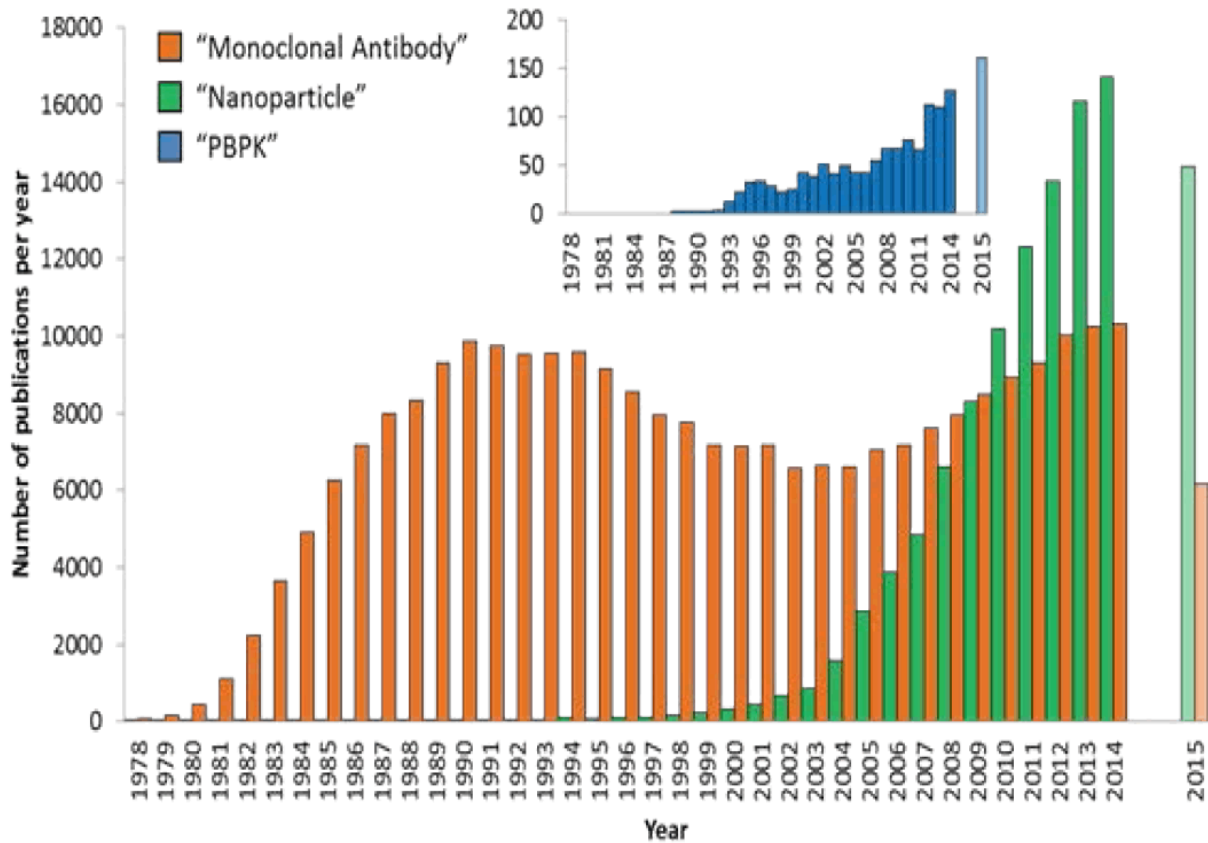


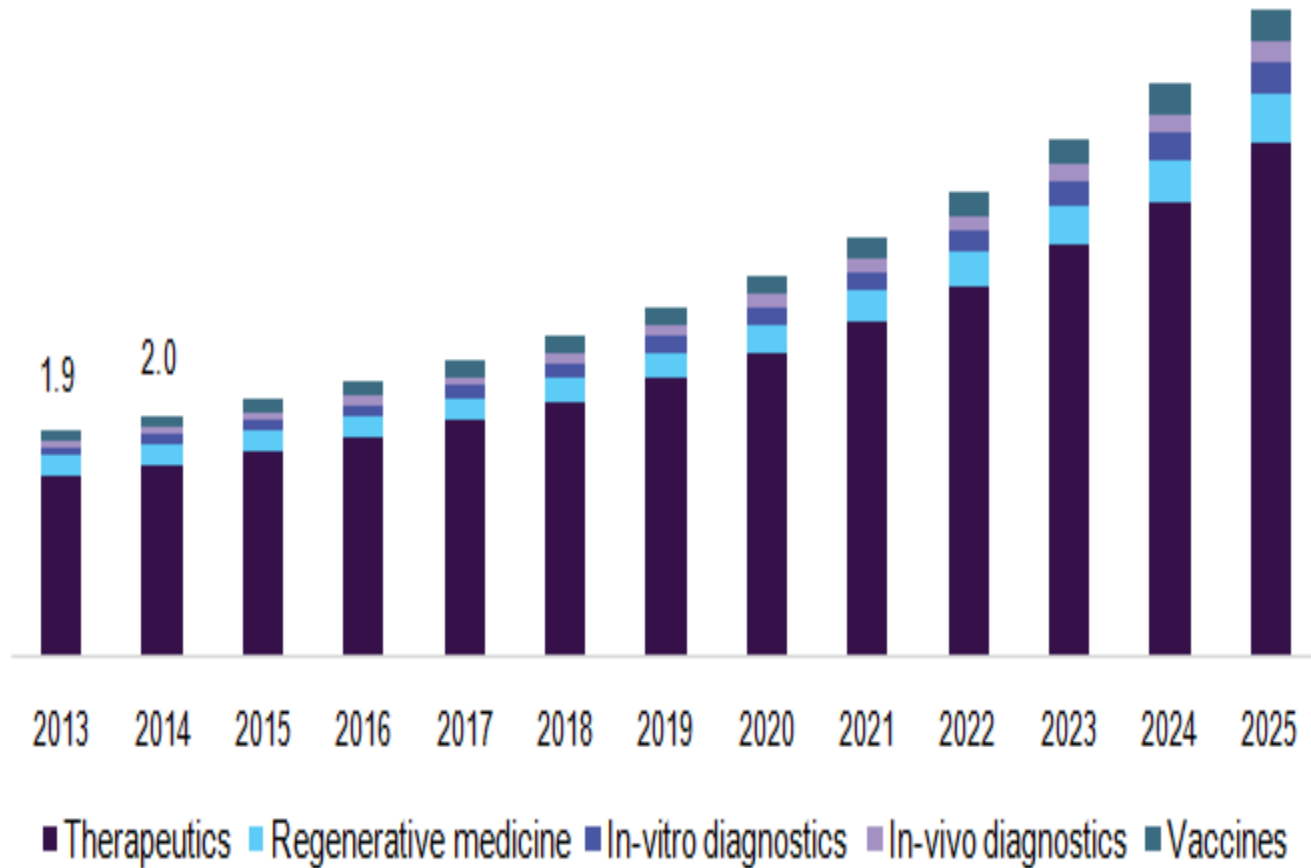
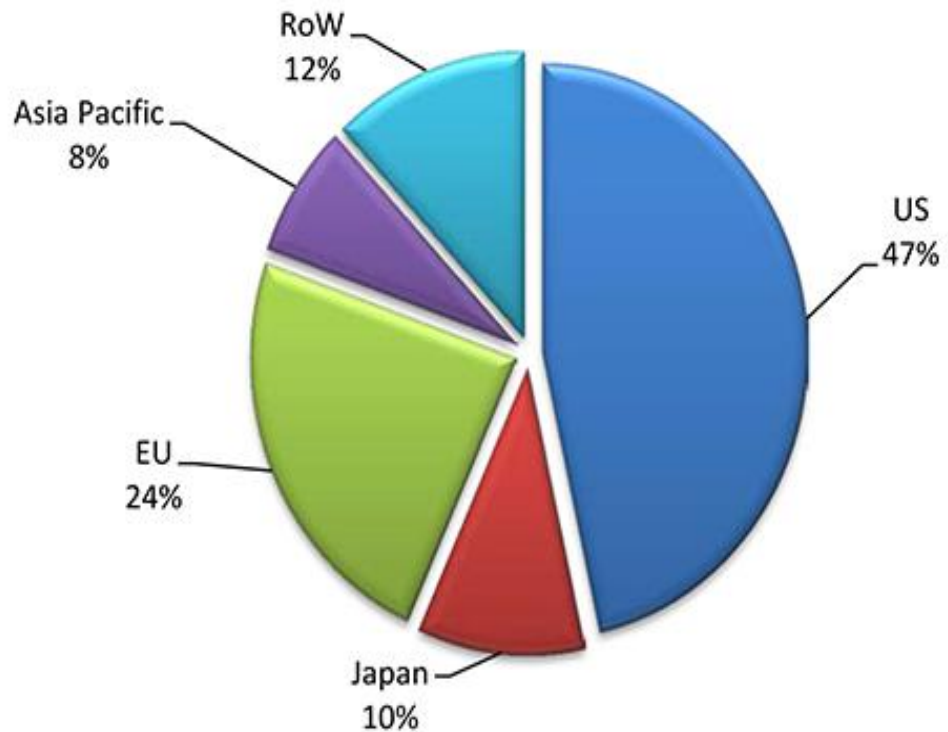
Figure 1 Publications per annum listed in PubMed between 1978 and 2015 for the search terms "monoclonal antibodies" versus "nanoparticles". The inset demonstrates the number of publications for "PBPK" over the same timeframe.

Taken from Siccardi M, Owen A. Towards A Computational Prediction of Nanoparticle Pharmacokinetics and Distribution. J In Silico In Vitro Pharmacol. 2016, 2:1.

Number of patents issued
<http://research.chem.psu.edu/axsgroup/research.html>

FUTURE PREDICTIONS OF NANO MEDICINE MARKET

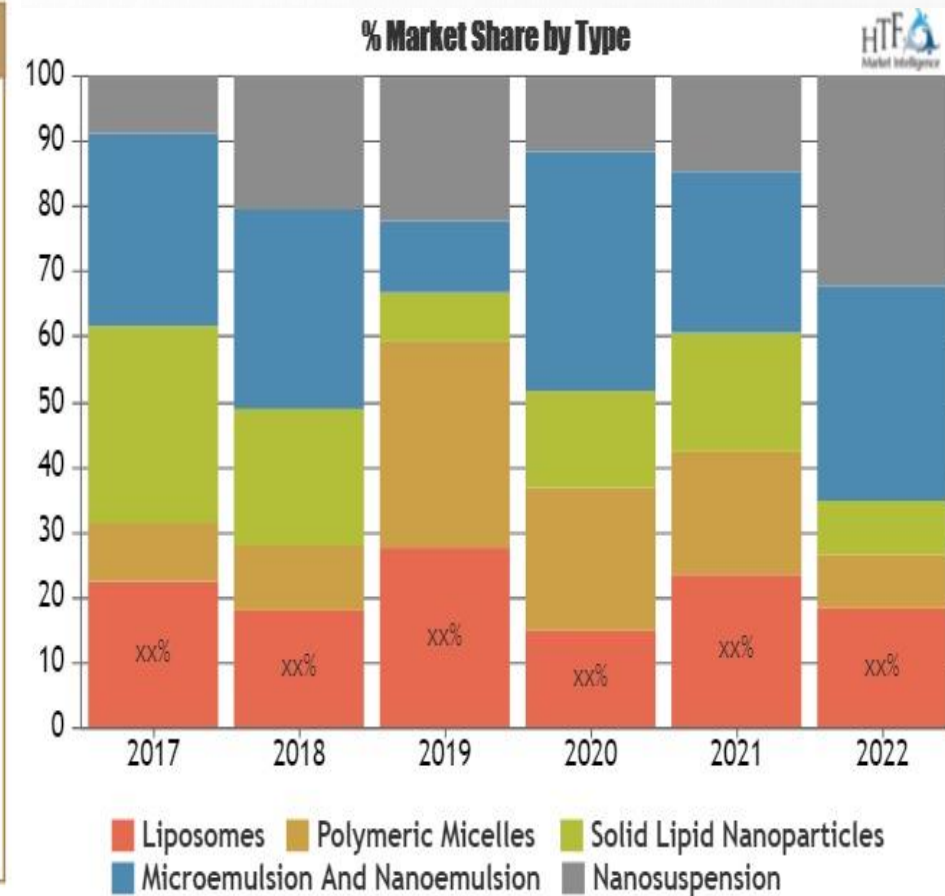
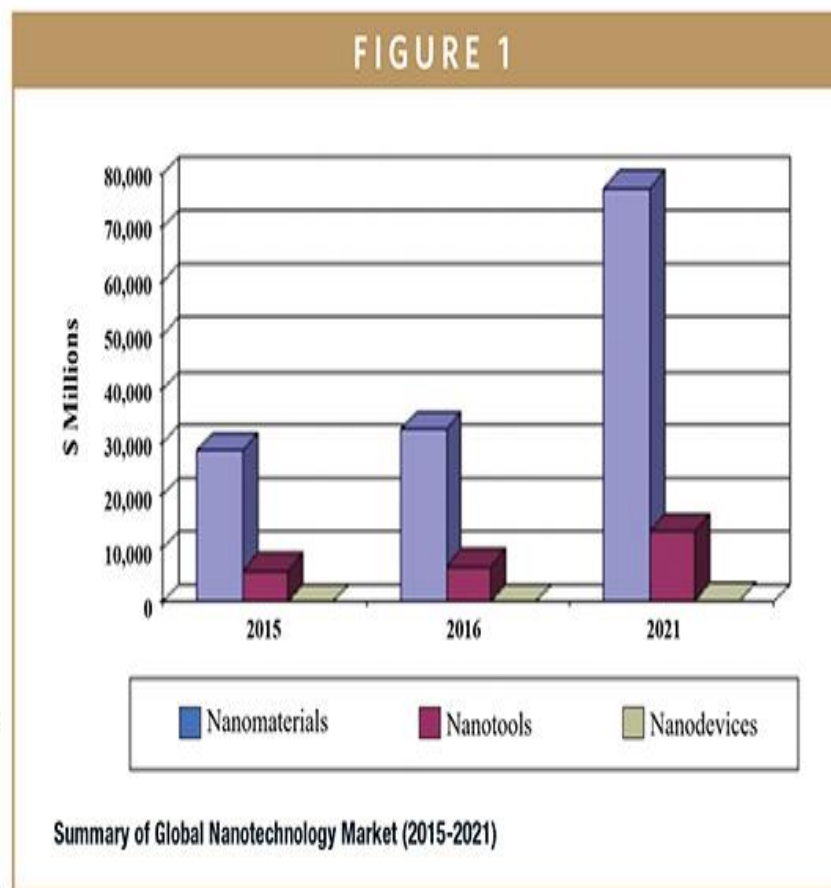
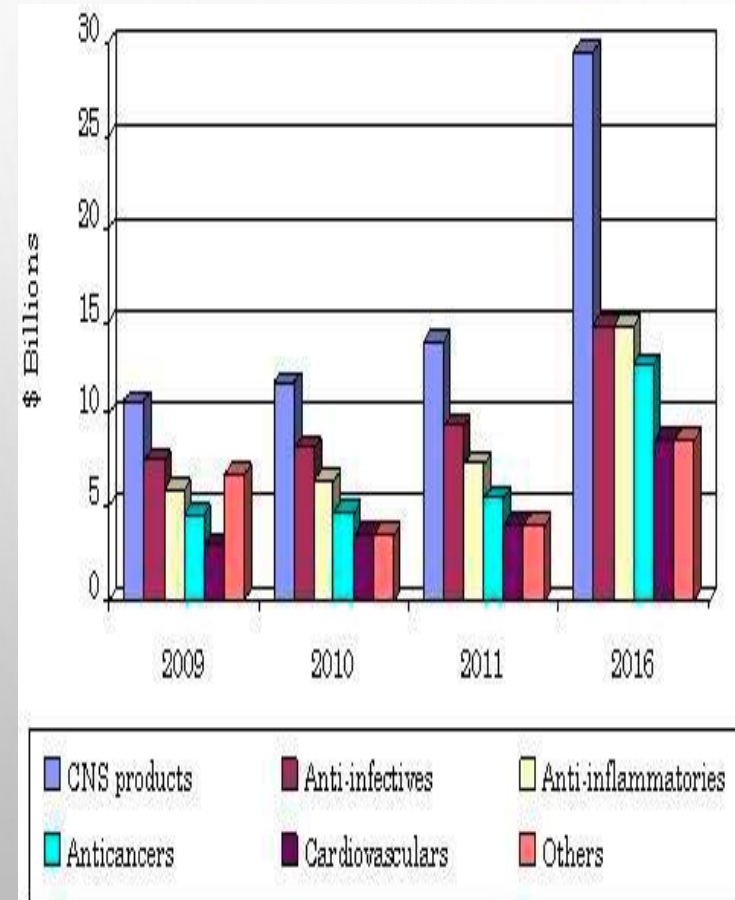
Figure 5.3 Leading National Nanomedicine Markets by Share of Global Market (%), 2025



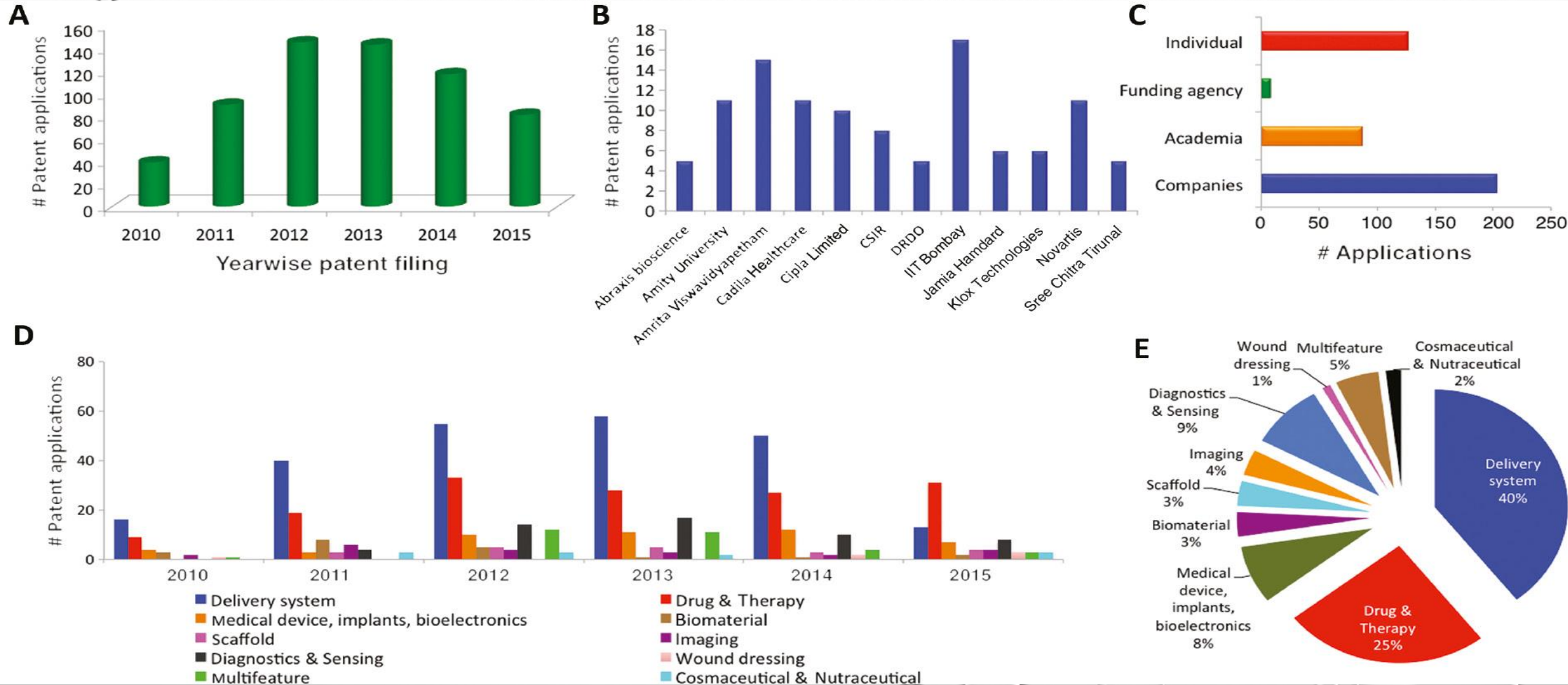
Source: visiongain 2015

Figure taken from <https://www.grandviewresearch.com/industry-analysis/nanomedicine-market>

FUTURE PREDICTIONS OF NANO MEDICINE MARKET

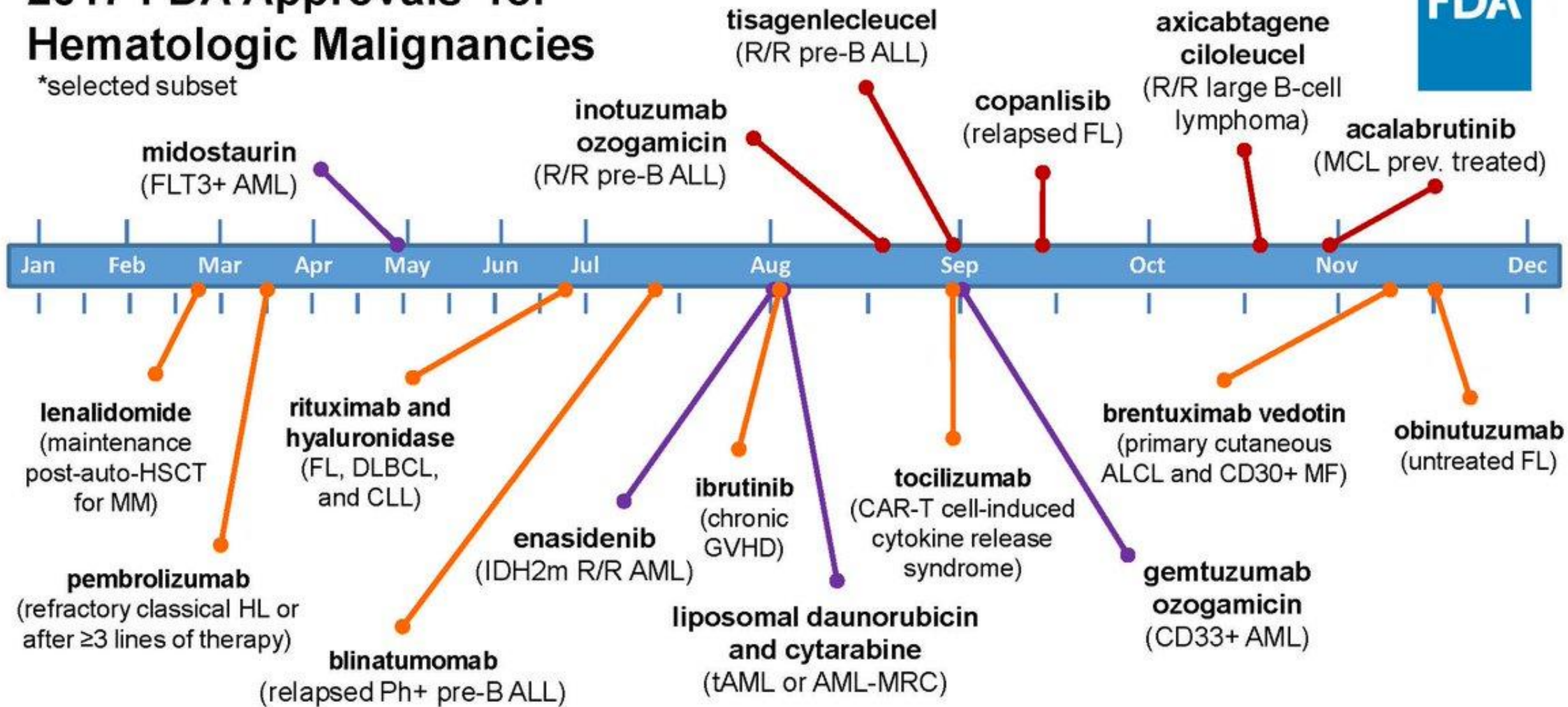


A LANDSCAPE OF NANO MEDICINE INNOVATIONS IN INDIA



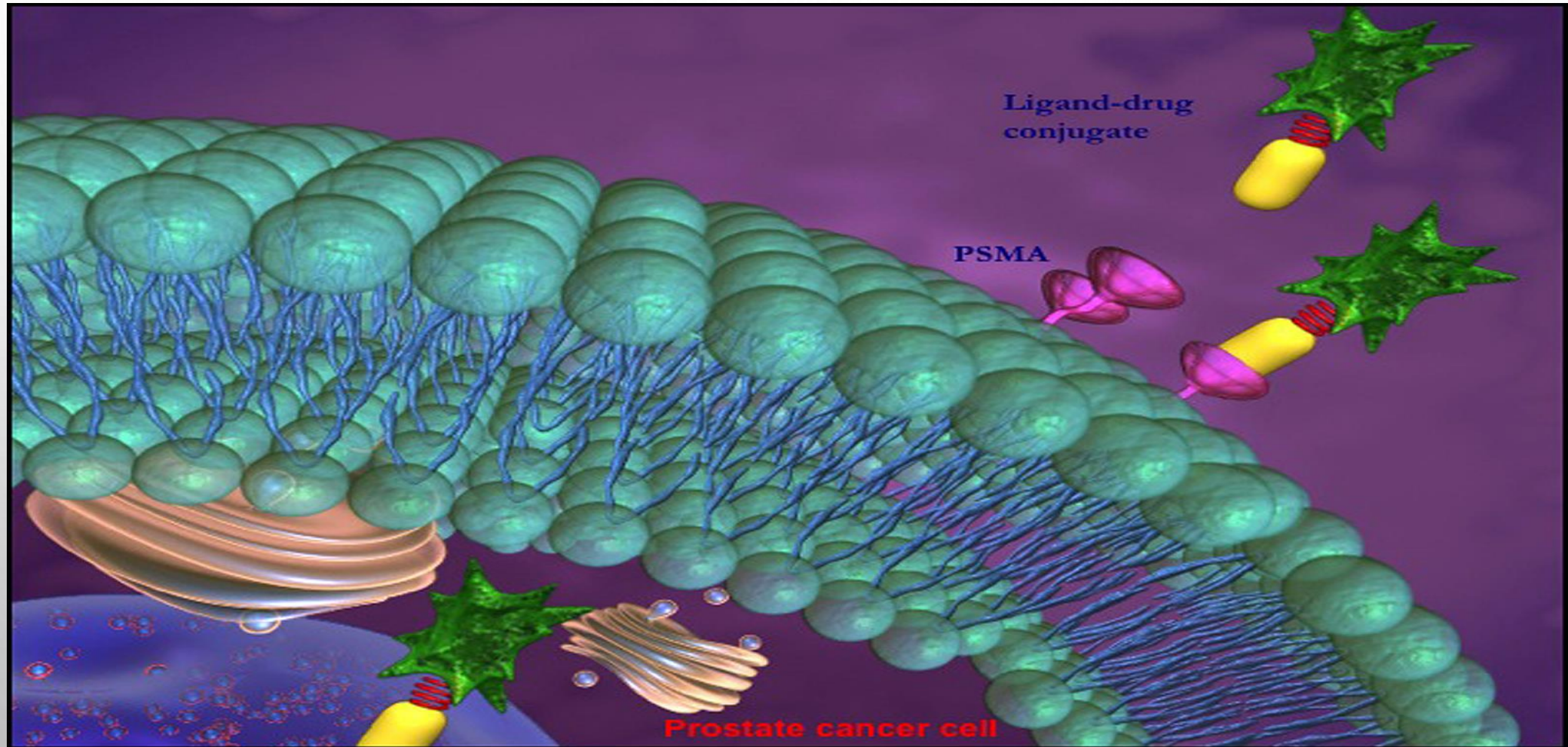
2017 FDA Approvals* for Hematologic Malignancies

*selected subset



Abbreviations: ALCL, anaplastic large cell lymphoma; AML, acute myeloid leukemia; CLL, chronic lymphocytic leukemia; DLBCL, diffuse large B-cell lymphoma; FL, follicular lymphoma; GVHD, graft-versus-host disease; HL, Hodgkin lymphoma; IDH2m, isocitrate dehydrogenase 2 mutated; HSCT, hematopoietic stem cell transplantation; MCL, mantle cell lymphoma; MF, mycosis fungoides; MM, multiple myeloma; MRC, myelodysplasia-related changes; pre-B ALL, B-cell precursor acute lymphoblastic leukemia; R/R, relapsed or refractory; tAML, therapy-related AML

A LOT TO LEARN : A LOT TO BE DONE



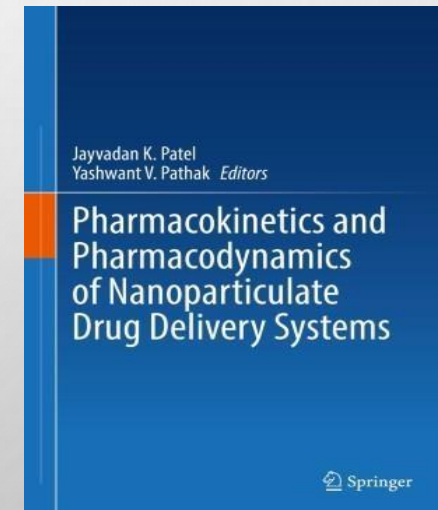
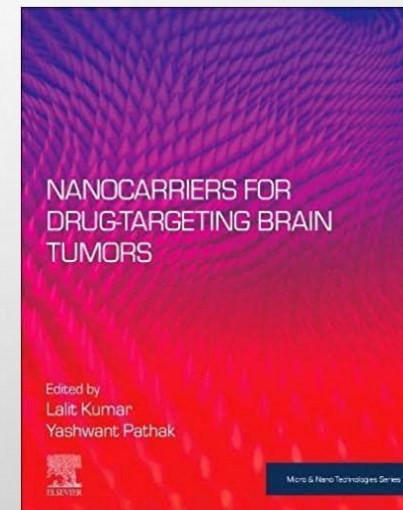
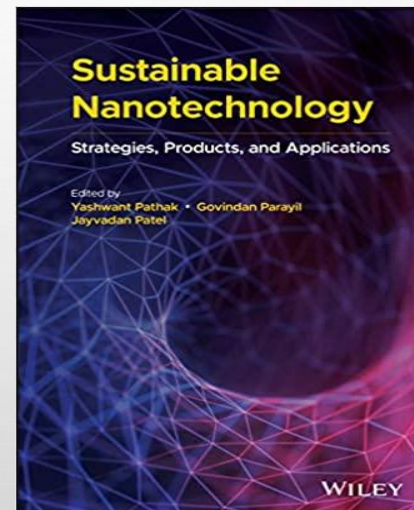
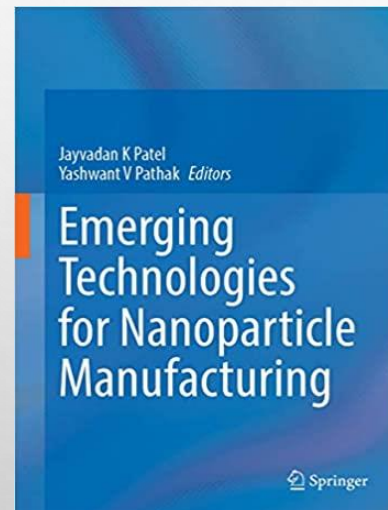
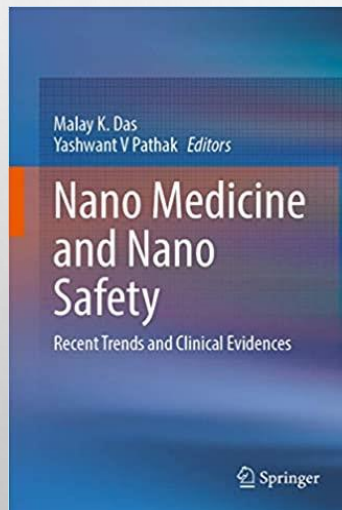
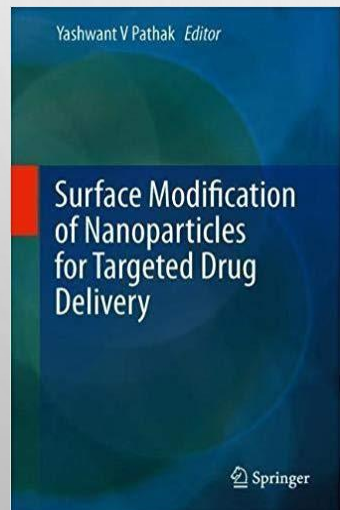
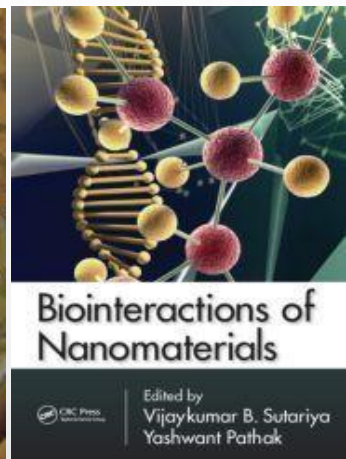
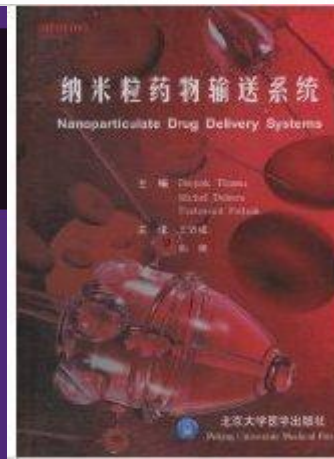
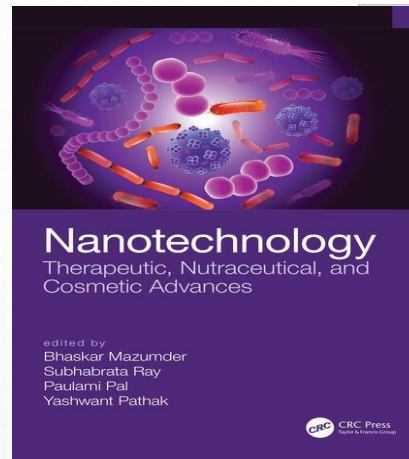
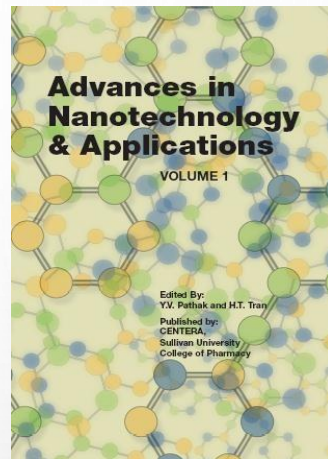
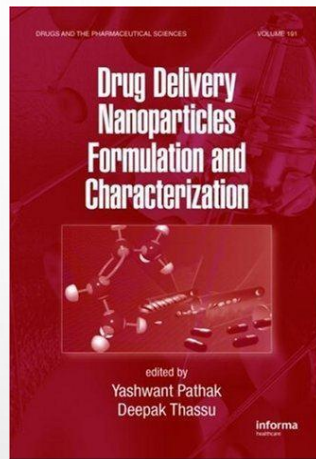
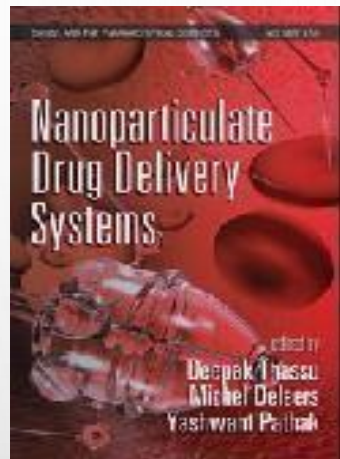
AREAS OF RESEARCH



- NANO PARTICULATE DRUG DELIVERY SYSTEMS
- IMPACT OF MICROGRAVITY ON DRUG DELIVERY SYSTEMS (WITH PUCRS)
- APPLICATIONS OF NANOTECHNOLOGY IN VARIOUS AREAS INCLUDING AGRICULTURE, HERBAL DRUGS AND WEST WATER MANAGEMENT
- COURSE COORDINATOR: RISK MANAGEMENT AND NANOTECHNOLOGY
- PUBLISHED OVER 350 RESEARCH PAPERS, REVIEWS, CHAPTERS IN BOOKS
- EDITED OVER 50 BOOKS IN THE FIELD OF NANOTECHNOLOGY, NUTRACEUTICALS AND DRUG DELIVERY SYSTEMS AND CONFLICT MANAGEMENT AND CULTURAL STUDIES
- PUBLISHED BY ELSEVIER, SPRINGER, TAYLOR AND FRANCIS, CRC PRESS, JOHN WILEY AND SONS, INFORM HEALTHCARE, DR GRUYTER (GERMANY)



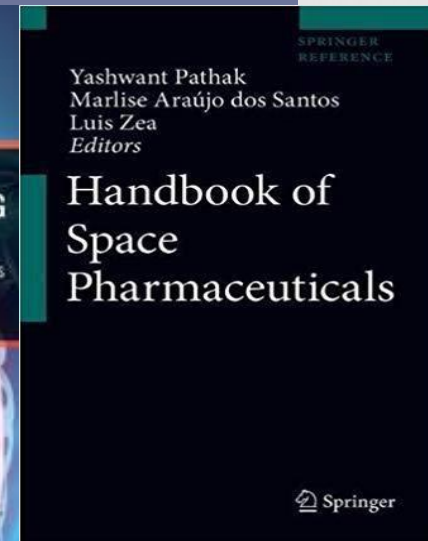
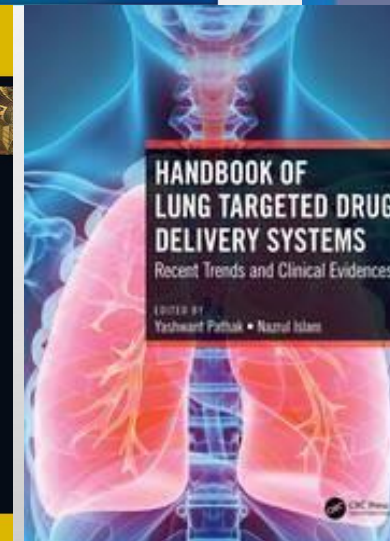
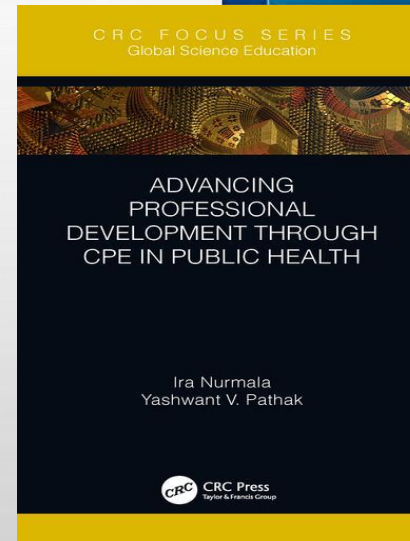
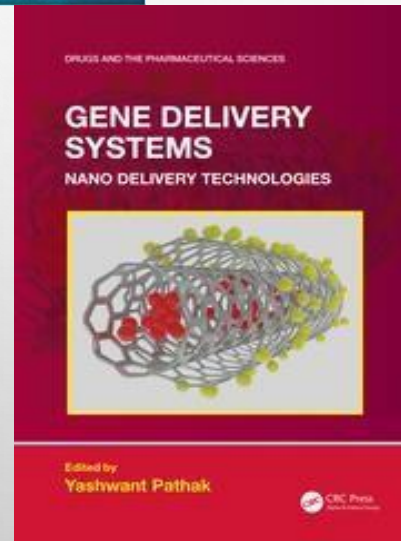
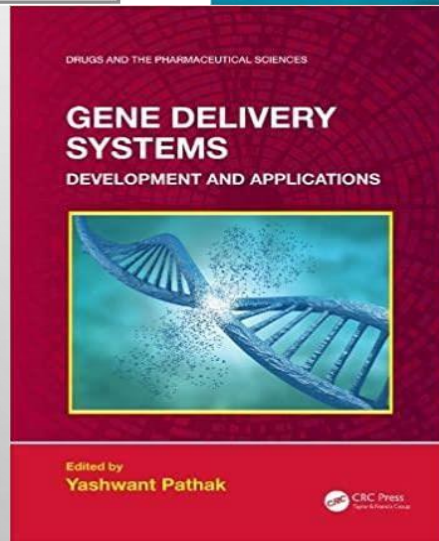
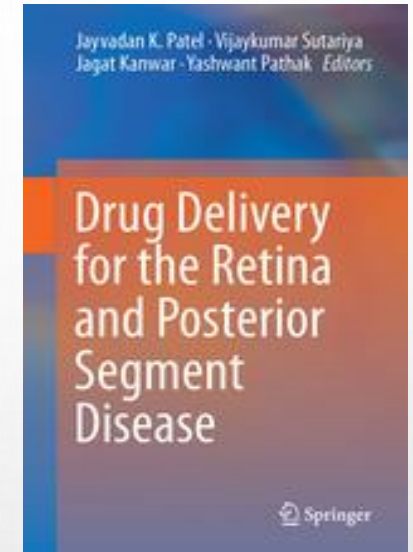
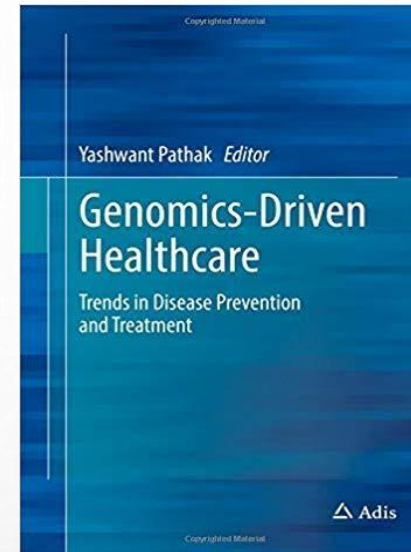
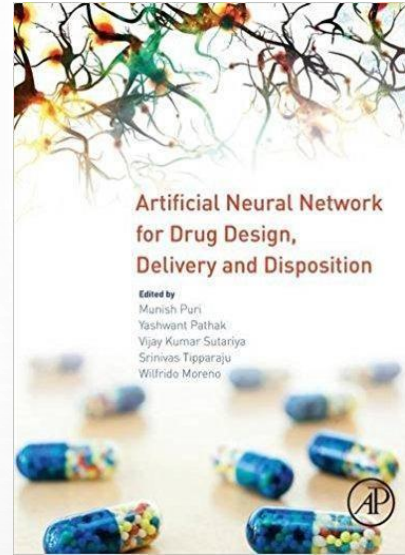
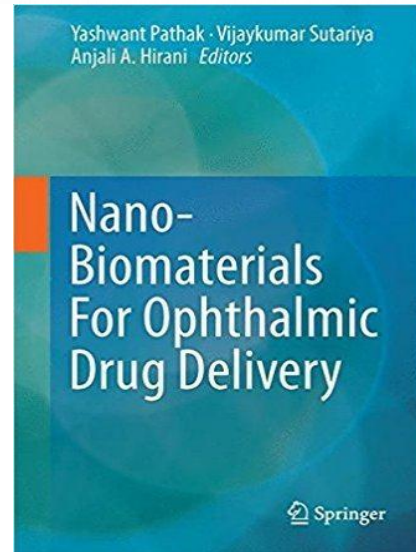
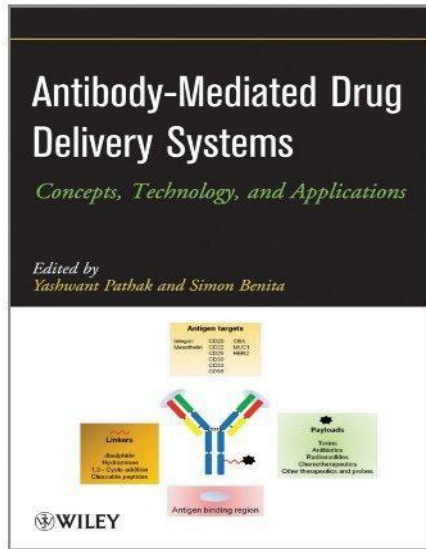
BOOKS IN NANO SCIENCES



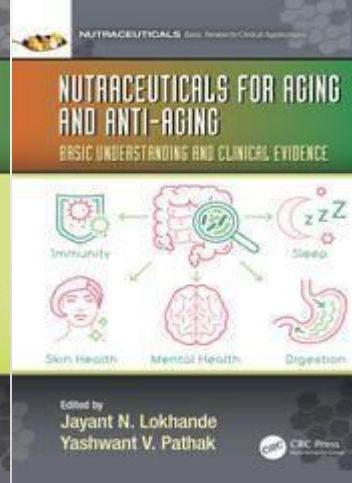
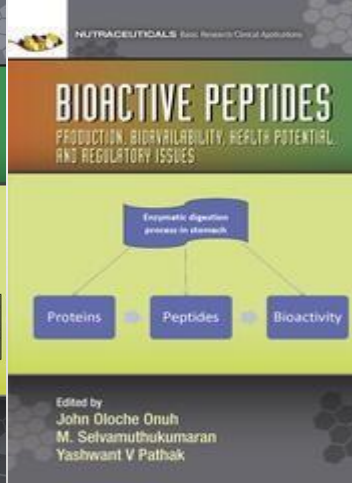
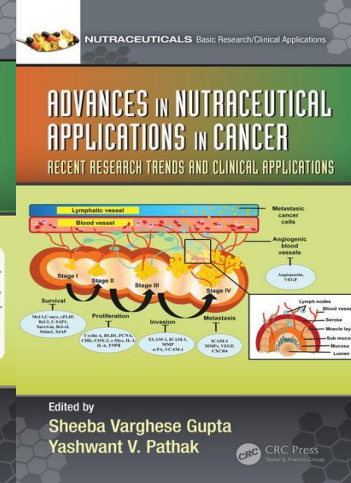
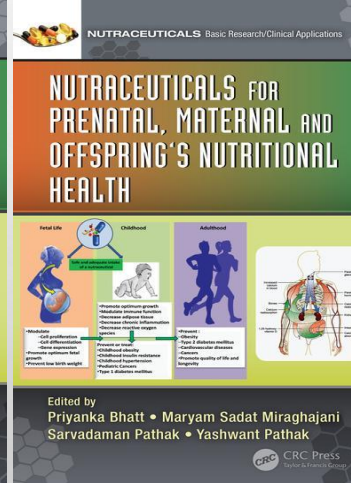
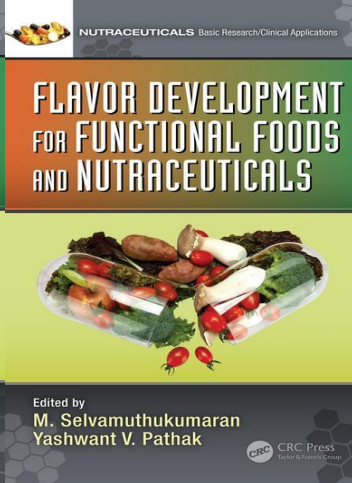
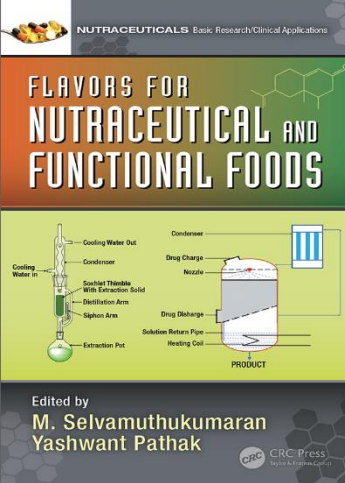
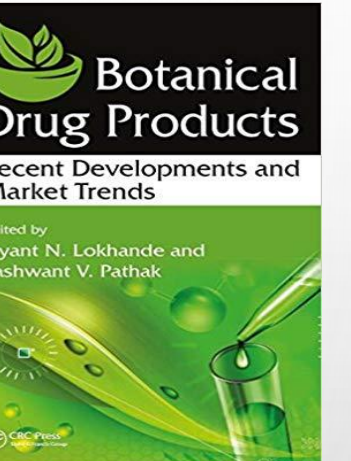
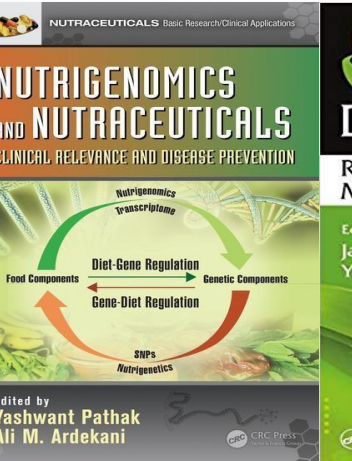
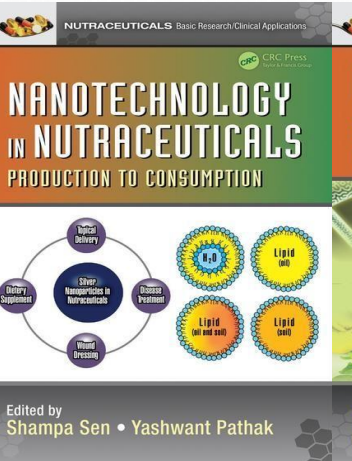
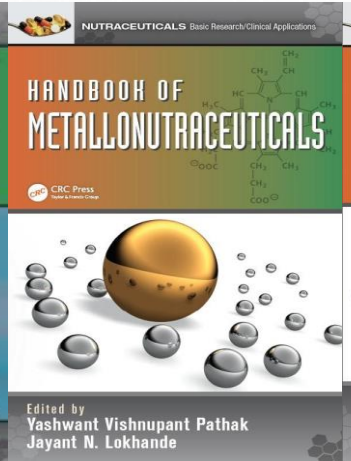
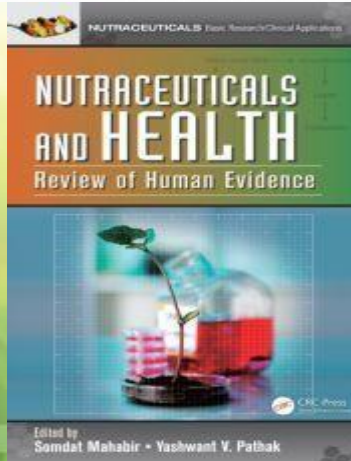
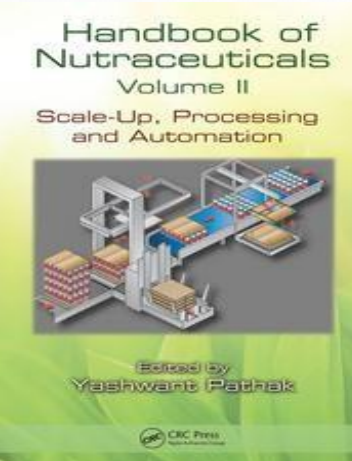
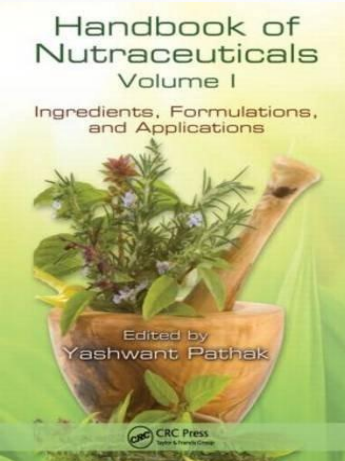
Forthcoming books:

Nano carriers for nasal drug delivery systems (2022)

BOOKS IN DRUG DELIVERY SYSTEMS



BOOKS IN NUTRACEUTICALS



MIGWE'C (MEGWITCH)
THANK YOU (NATIVE AMERICAN
LANGUAGE)

Ma-salama

Mochas Gracias

Minnetdaram

Obrigado

谢谢



תודה רבה
(todá rabá, "thank you
very much").

Thanks

Diversity is soul of humanity

