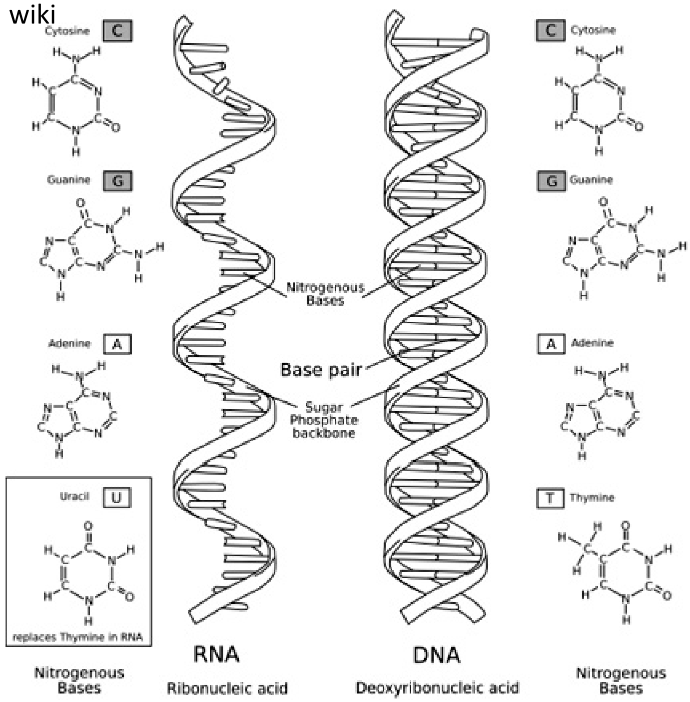
DNA/RNA based nanostructures and applications

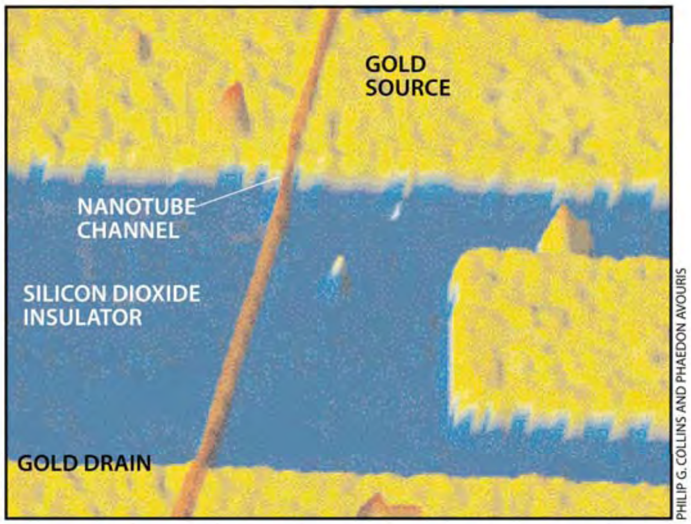
wiki



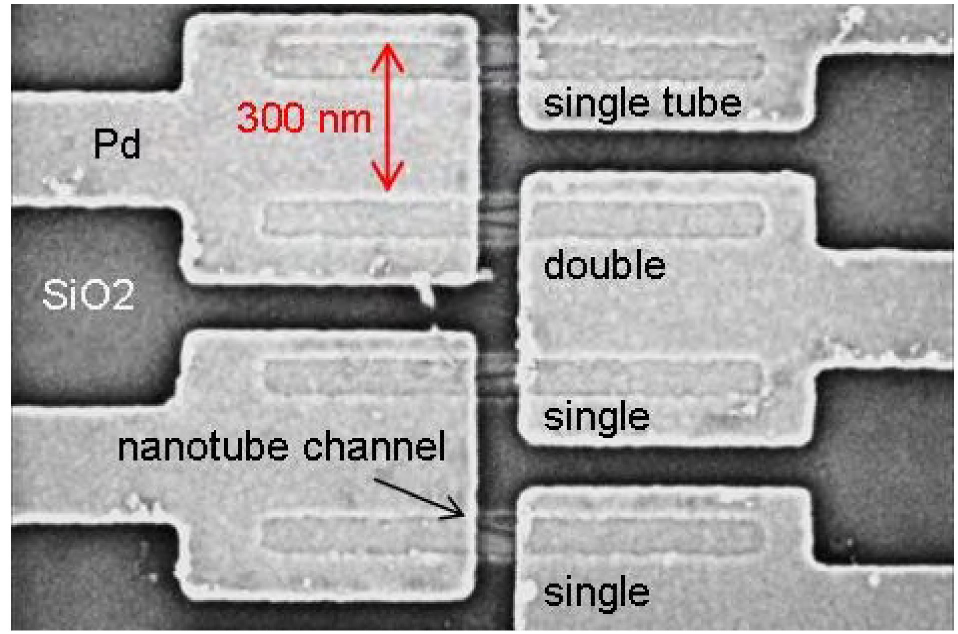
Sequence pairing
Polarizability
Conductivity
Self-assembly
functionalization

2012 Fall Nanotechnology Course, Student Seminar
Coordinator: Dr. Hossein hosseinkhani
Student: 100023457 Cheng-Wei Hsieh (謝正偉), CBMB, TIGP

IBM's carbon nanotube field-effect transistor array



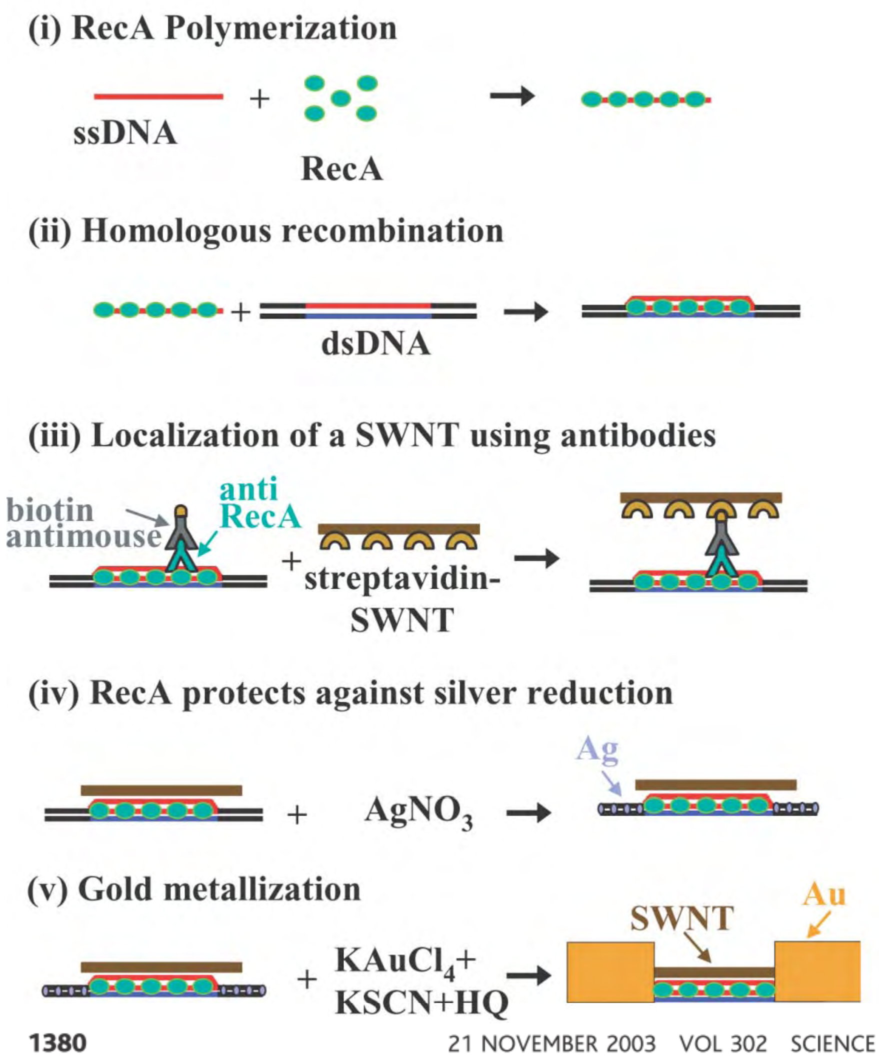
Single CNTFET (2000)



CNTFET arrays with a pitch of 300 nm (2012)

It is critical to be able to control the alignment and the location of carbon nanotube devices on a substrate.

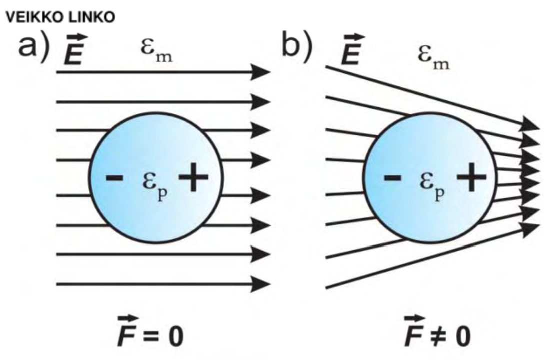
DNA-templated carbon nanotube field-effect transistor

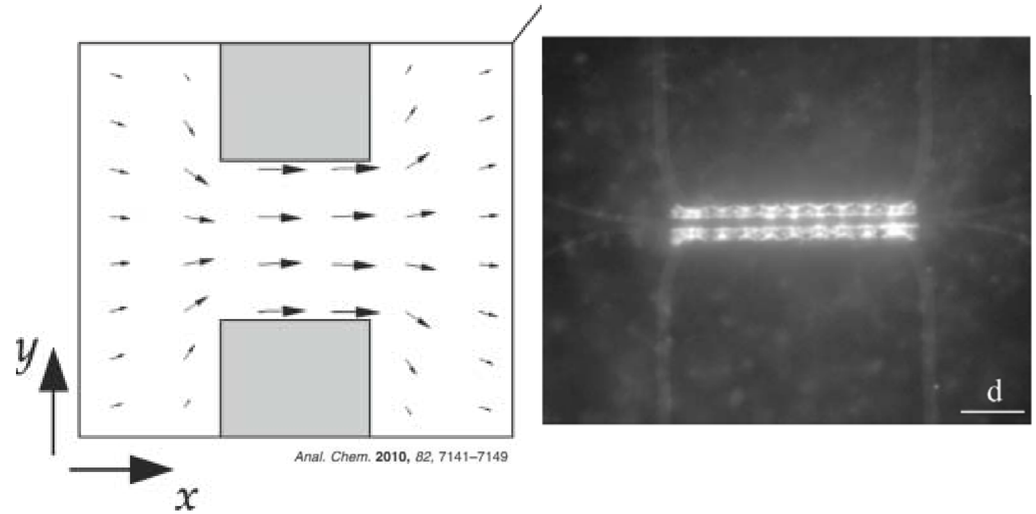


DNA scaffold molecule using homologous recombination provides the address for precise localization of a semiconducting single-wall carbon nanotube as well as the template for the extended metallic wires contacting it.

How to control the location of DNA molecule?

Dielectrophoric trapping and manipulating DNA molecule

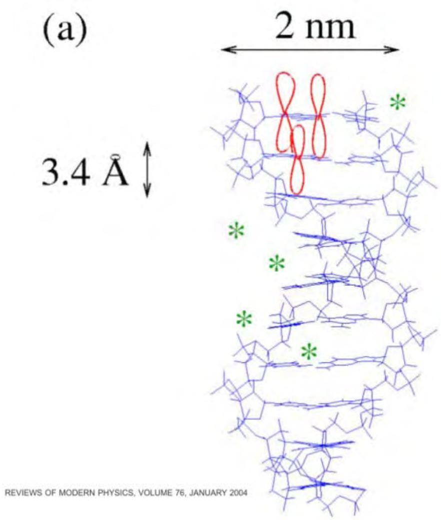


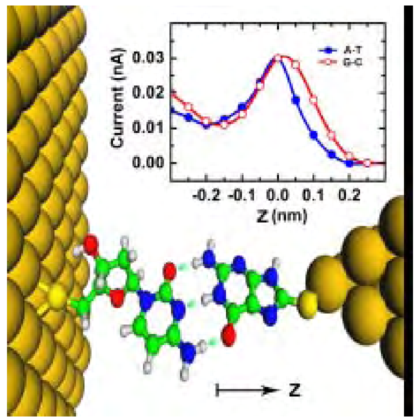


Dielectrophoresis as a tool for on-chip positioning of DNA

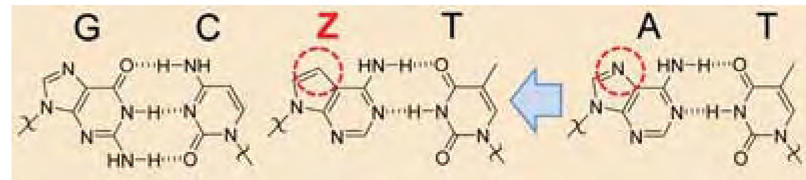
Does electron transfer/transport through double stranded DNA?

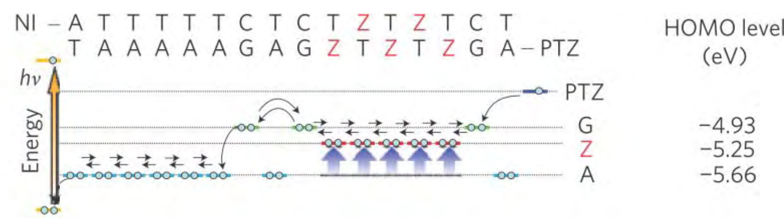
Electrical conductivity of DNA-transistor





theochem.kth.se





12 APRIL 2009 | DOI: 10.1038/NCHEM.171

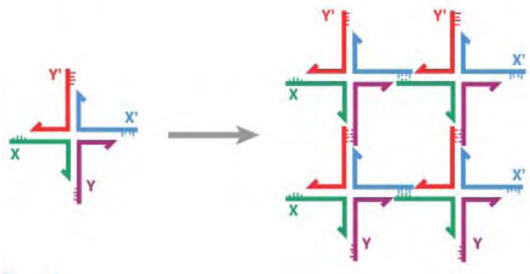
Conductivity due to overlapping π orbitals

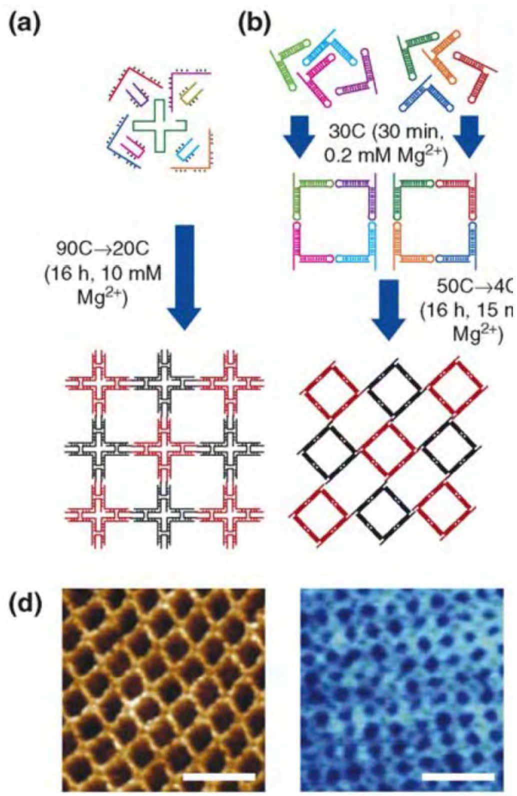
Improved conductivity by chemical modification

Is it possible to generate more complex DNA-based electronic circuit?

2D self-assembly DNA nanostructure

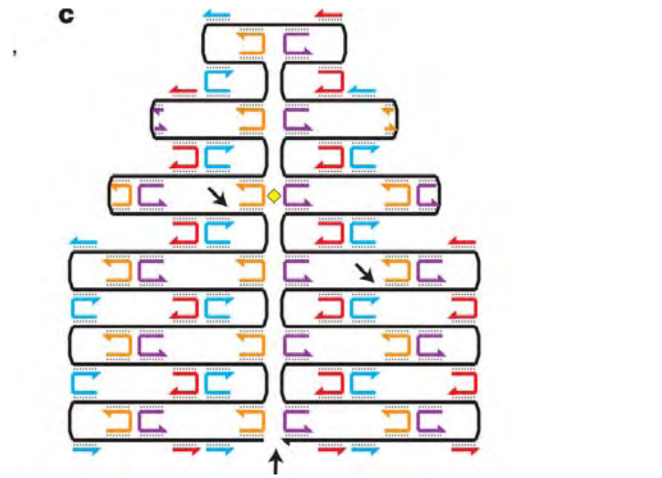
Building block model

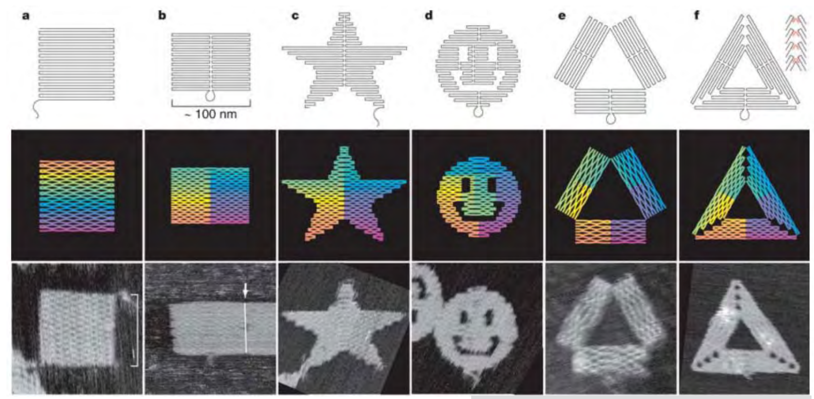




Current Opinion in Structural Biology 2006, 16:531–543

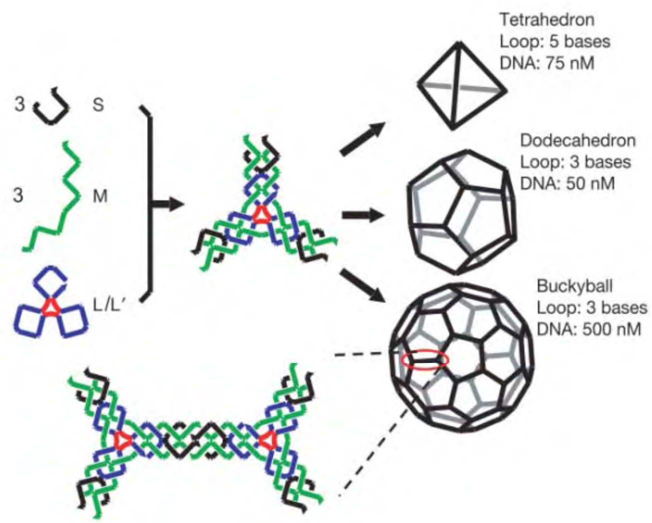
Folding (origami)

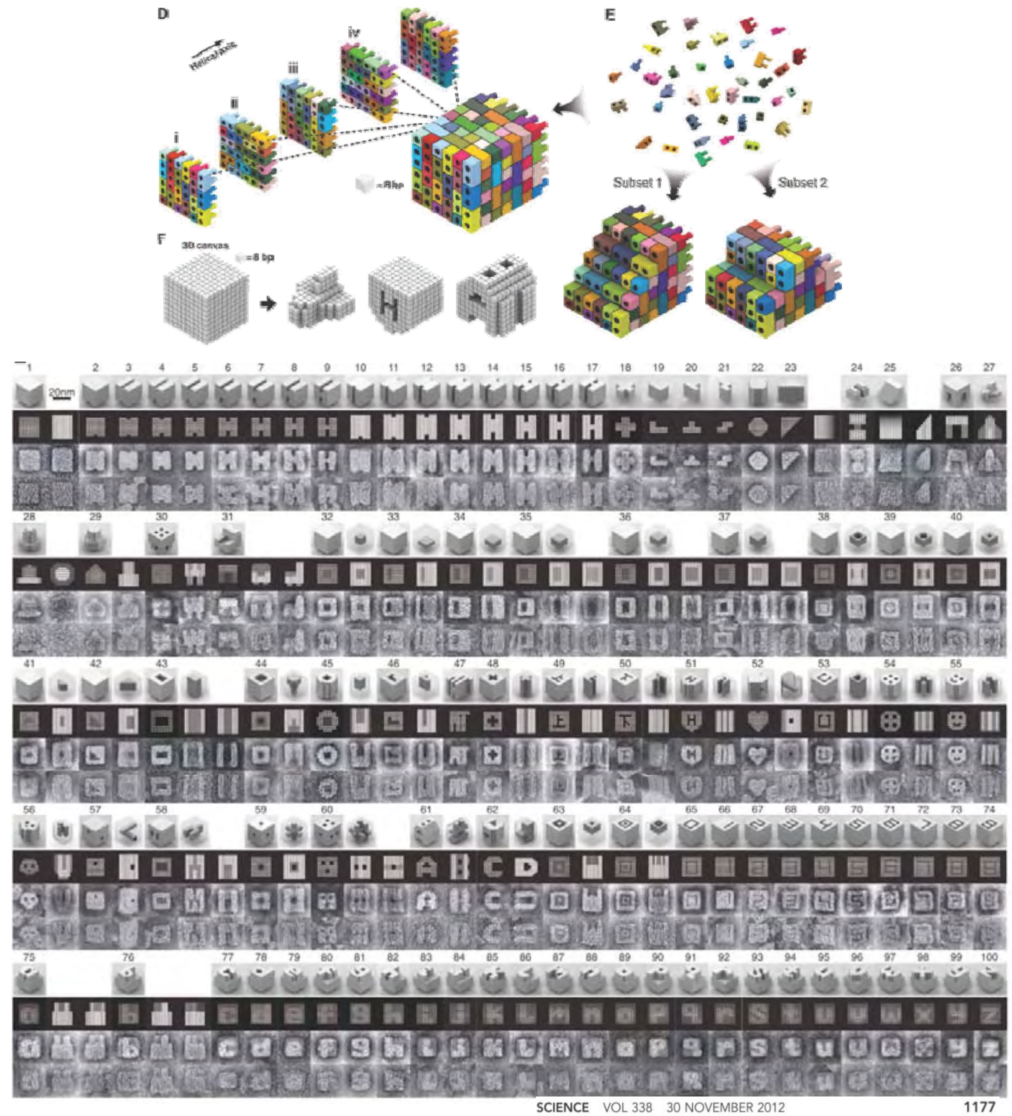




Vol 440|16 March 2006|**doi:10.1038/nature04586**

3D self-assembly DNA nanostructure



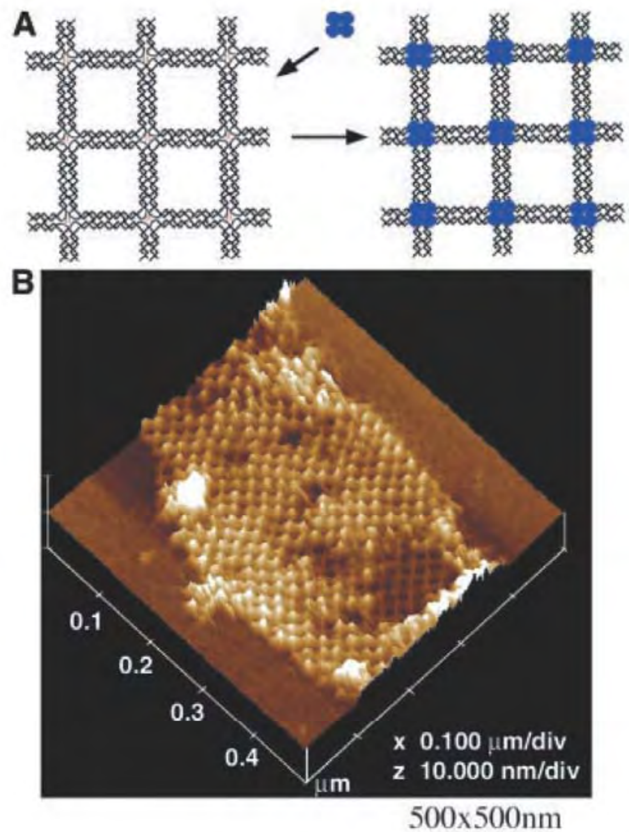


Sequence specific pairing
In silica programmable
One-pot reaction

Structure = Function?

Functionalization of DNA nanostructure

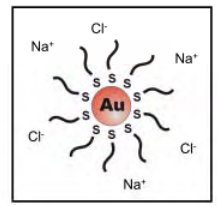
Biotin protein array

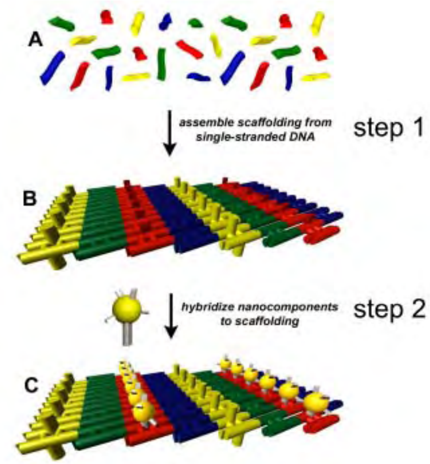


26 SEPT

How about RNA nanostucture?

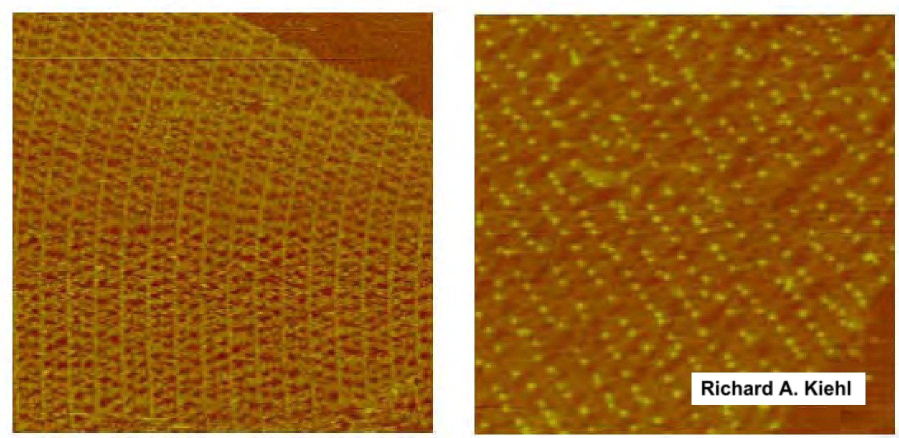
Gold conjugated array; metalization



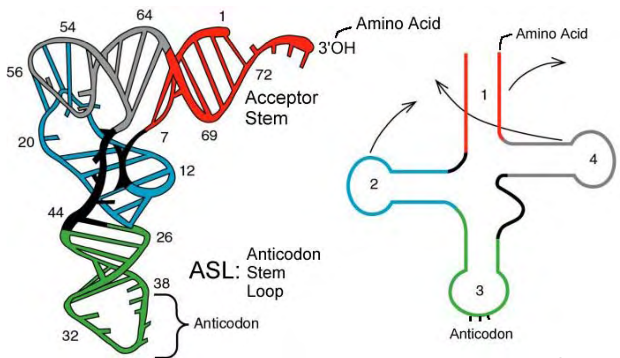


before hybridization

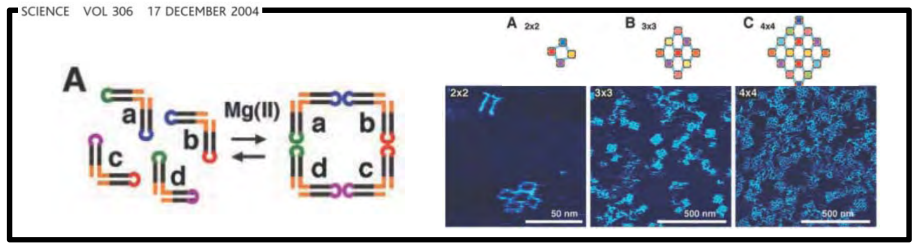
after hybridization

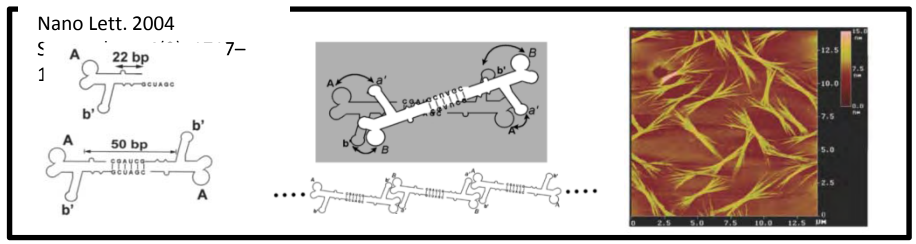


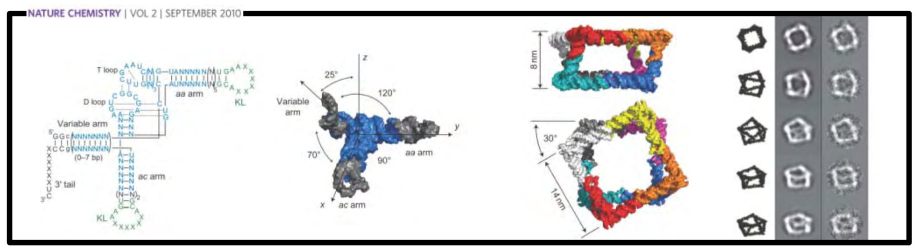
Programmable & Self-assembly RNA nanostructure



bio.miami.edu





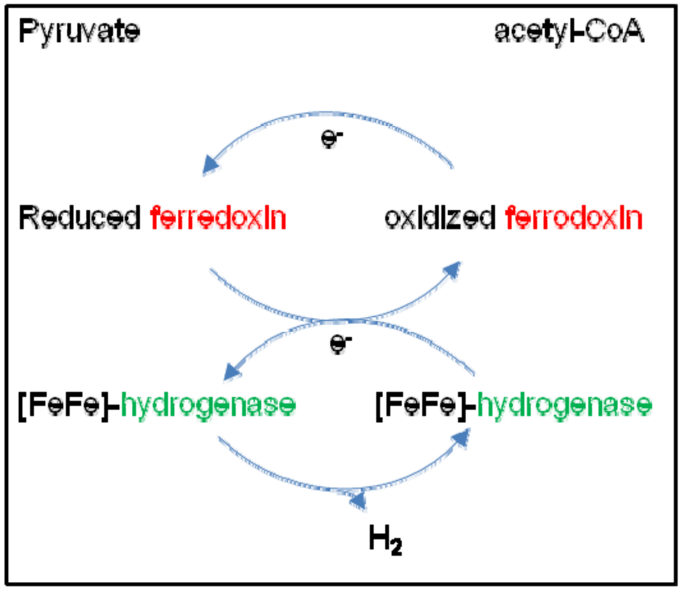


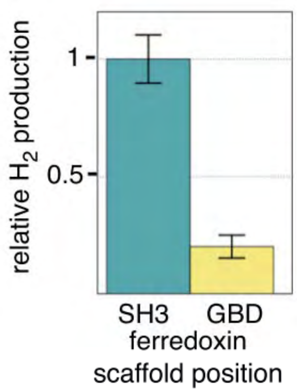
Stem
Loop
Bulge
Multi-loop
Non-WC base pair

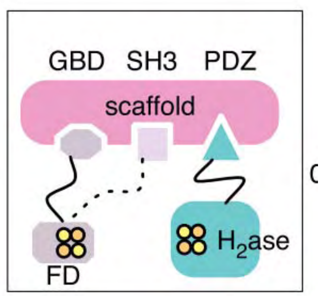
Kissing loop
Interlocking loop

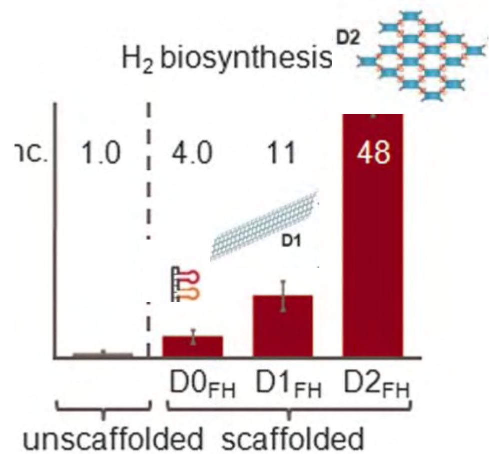
RNA functionalization?

RNA aptamer: metabolic engineering



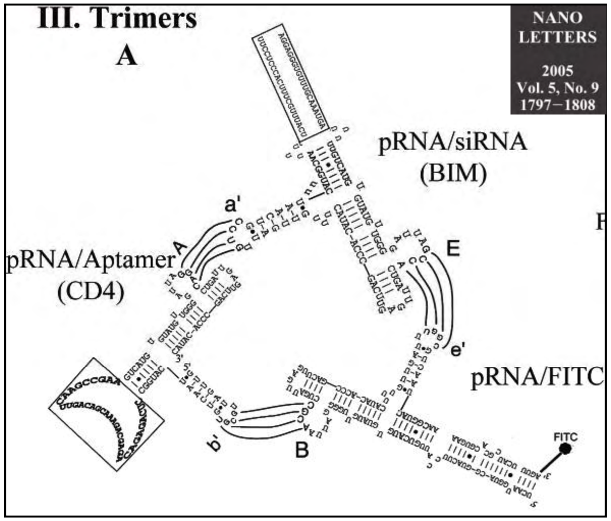






RNA aptamers are a family of oligonucleotides with functions similar to that of antibodies in their ability to recognize specific ligand.
Metabolic engineering :Optimizing metabolic processes within cells to increase the cells' production of a certain substance.

Funtional pRNA as nanomedicine



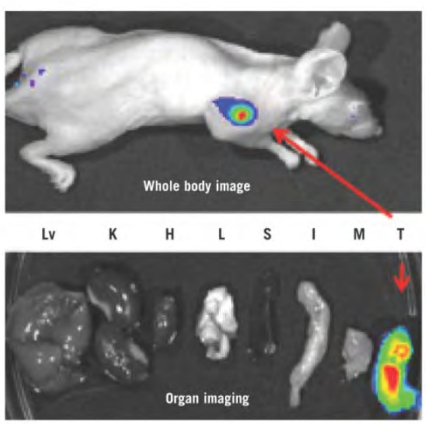
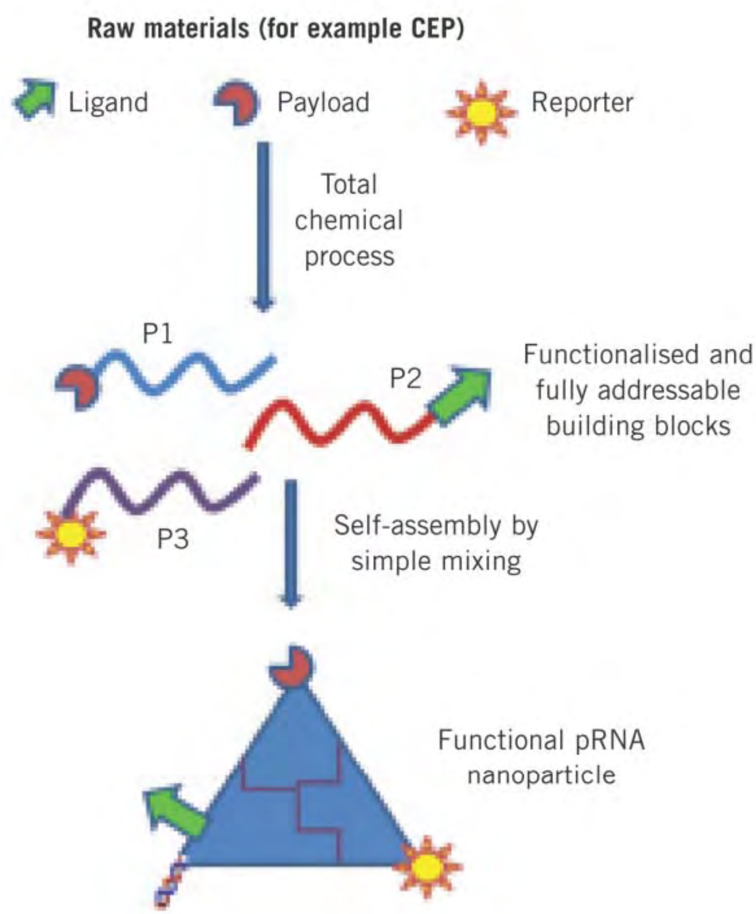


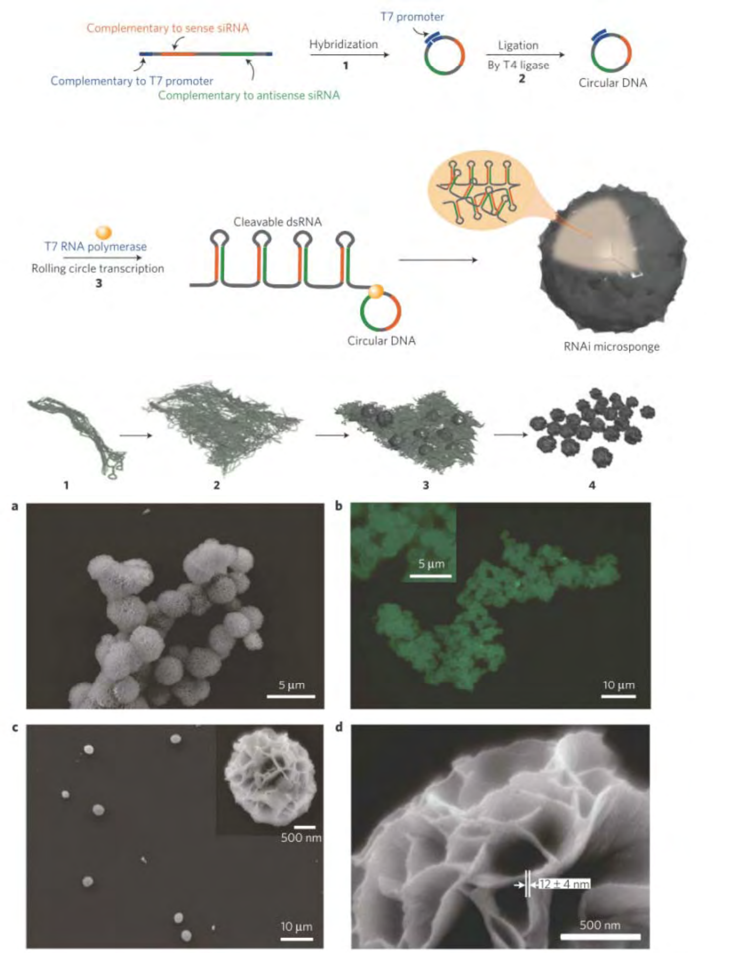
Figure 4: Far left four pa
internalisation of fluores
labelled folate-pRNA
nanoparticle to FR⁺ canc
cells through FR-mediat
endocytosis. Confocal
microscopy images of
fluorescence labelled (C
red) pRNA nanoparticles
hours post binding to KE
cancer cells (FR⁺) that e
endosome-resident eGFF
(green). Overlapping
fluorescences display
orange/yellow colours. Le
two panels: biodistributi
Alexafluor647-labeled F
pRNA nanoparticle in FF
tumour-bearing mice upon iv-
injection. Top, whole body
imaging; bottom panel,
organ imaging



By Henry QX Li at
Kylin Therapeutics, Inc

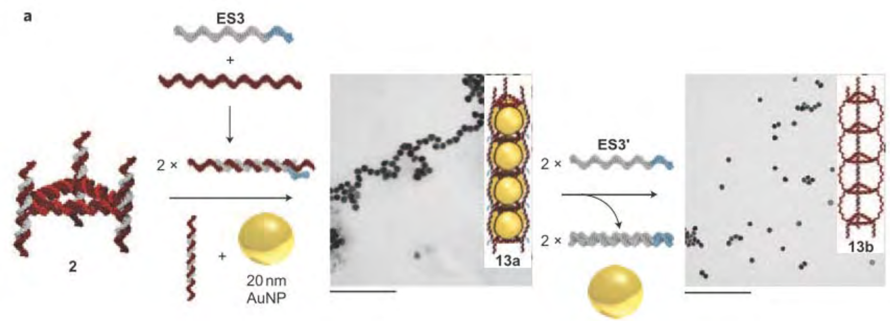
Nucleotide based drug carrier

Self-assembled RNA interference microsponges for efficient siRNA delivery



NATURE MATERIALS | VOL 11 | APRIL 2012 |

Loading and selective release of cargo in DNA nanotubes with longitudinal variation



Conclusion remarks

Sequence pairing
Polarizability
Conductivity
Self-assembly
functionalization

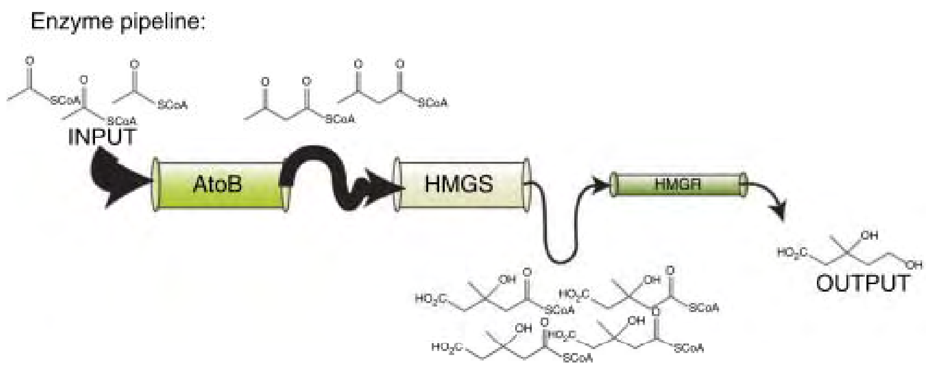
DNA is promising material to achieve high density memory and high sensitive detection technology due to intrinsic properties.

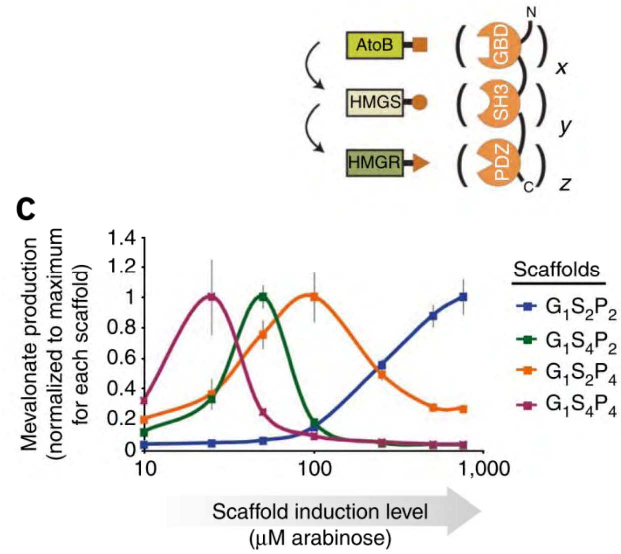
Using rational design and self-assembly, nucleotide based nanostucture offers a possible route to three dimensional microsystems.

Multiple functional modules, such as siRNA, riboswitch, ribozyme, aptamer, miRNA, allows RNA nanoparticles serve as useful nanomedicine in drug targeting and delivery.

Thanks for your attention !!

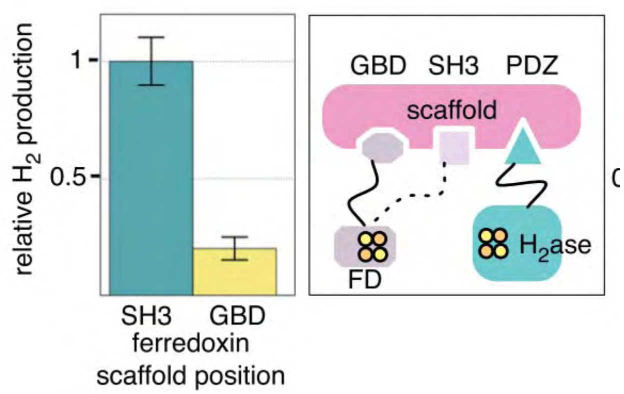
Stoichiometries





NATURE BIOTECHNOLOGY VOLUME 27 NUMBER 8 AUGUST 2009

Proximity effect



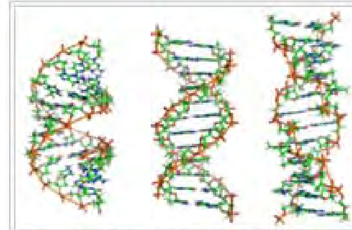
Agapakis *et al. Journal of Biological Engineering* 2010, **4**:3

synthetically and have not been observed in naturally occurring biological systems. There are also triple-stranded DNA forms and quadruplex forms such as the G-quadruplex.

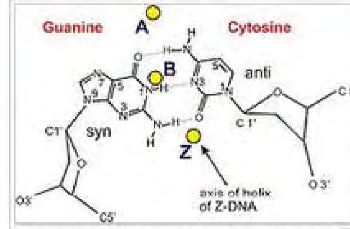
Structural features of the three major forms of DNA

Geometry attribute	A-DNA	B-DNA	Z-DNA
Helix sense	right-handed	right-handed	left-handed
Repeating unit	1 bp	1 bp	2 bp
Rotation/bp	32.7°	35.9°	60°/2
bp/turn	11	10.5	12
Inclination of bp to axis	+19°	−1.2°	−9°
Rise/bp along axis	2.3 Å (0.23 nm)	3.32 Å (0.332 nm)	3.8 Å (0.38 nm)
Pitch/turn of helix	28.2 Å (2.82 nm)	33.2 Å (3.32 nm)	45.6 Å (4.56 nm)
Mean propeller twist	+18°	+16°	0°
Glycosyl angle	anti	anti	C: anti, G: syn
Sugar pucker	C3'-endo	C2'-endo	C: C2'-endo, G: C2'-exo
Diameter	23 Å (2.3 nm)	20 Å (2.0 nm)	18 Å (1.8 nm)

Sources:[29][30][31]



The structures of A-, B-, and Z-DNA.

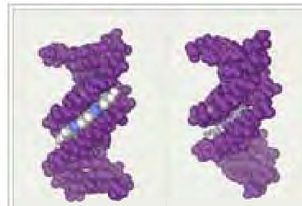


The helix axis of A-, B-, and Z-DNA.

Grooves

[edit]

Twin helical strands form the DNA backbone. Another double helix may be found by tracing the spaces, or grooves, between the strands. These voids are adjacent to the base pairs and may provide a binding site. As the strands are not directly opposite each other, the grooves are unequally sized. One groove, the major groove, is 22 Å wide and the other, the minor groove, is 12 Å wide.[32] The narrowness of the minor groove means that the edges of the bases are more accessible in the major groove. As a result, proteins like transcription factors that can bind to specific sequences in double-stranded DNA usually make contacts to the sides of the bases exposed in the major groove.[33] This situation varies in unusual conformations of DNA within the cell *(see below)*, but the major and minor grooves are always named to reflect the differences in size that would be seen if the DNA is twisted back into the ordinary B form.



Major and minor grooves of DNA. Minor groove is a binding site for the dye Hoechst 33258.

Non-double helical forms

[edit]

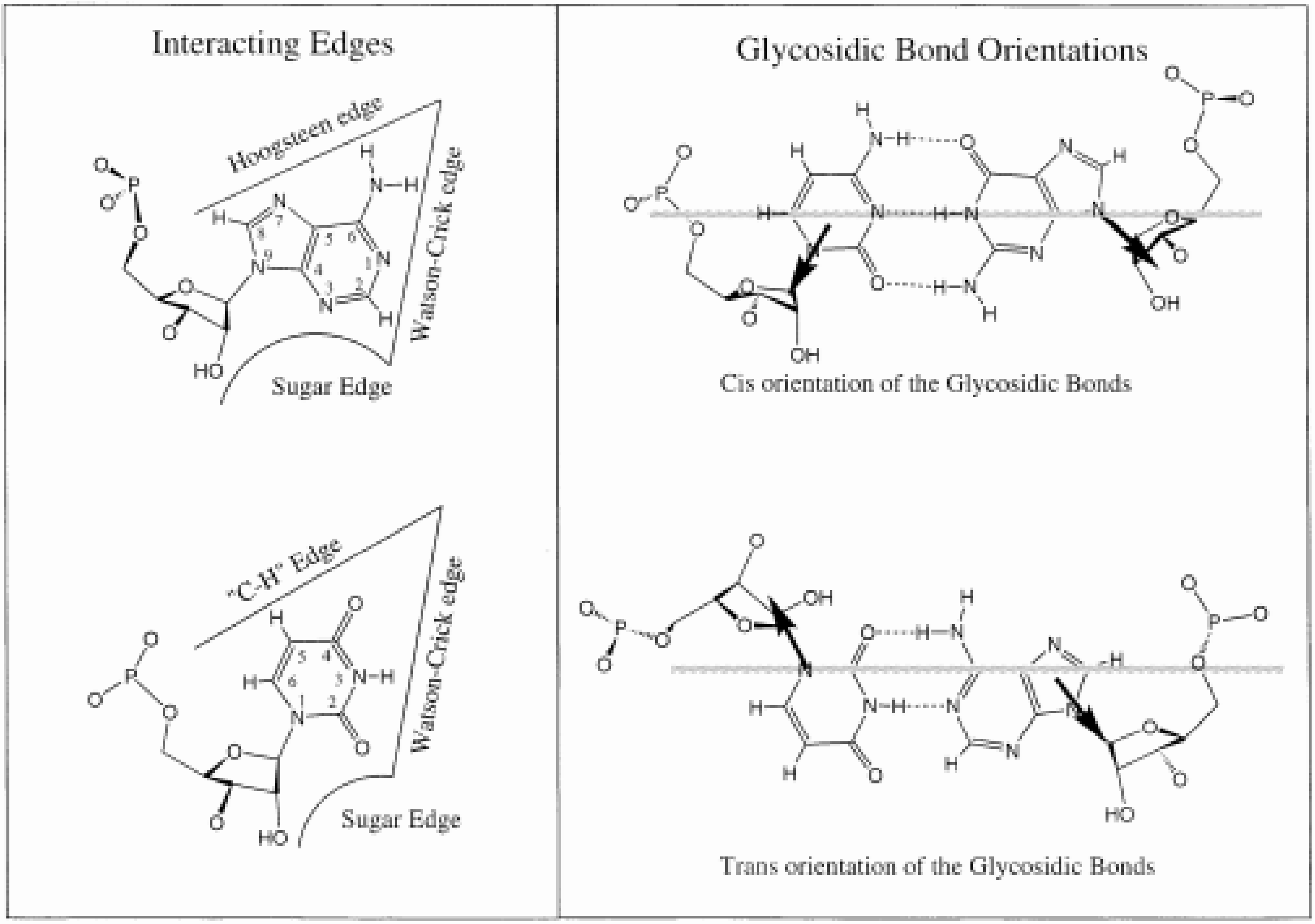
Other non-double helical forms of DNA have been theorized, for example the side-by-side (SBS) geometry where the two strands do not wind around each other. Side-by-side models of DNA were proposed early in the history of molecular biology, but these were set aside in favor of the double-helical model due to X-ray crystallography of DNA duplexes and later the nucleosome core particle, as well as the discovery of topoisomerases. The state of current understanding in the field was aptly outlined in an exchange of correspondence in Current Science in 2004.[34]

Single-stranded nucleic acids do not adopt a helical formation, and are described by models such as the random coil or worm-like chain.

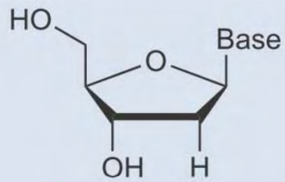
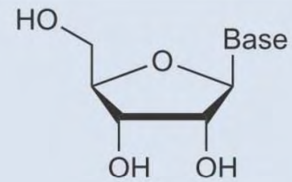
Bending

[edit]

DNA is a relatively rigid polymer, typically modelled as a worm-like chain. It has three significant degrees of freedom; bending, twisting and compression, each of which cause

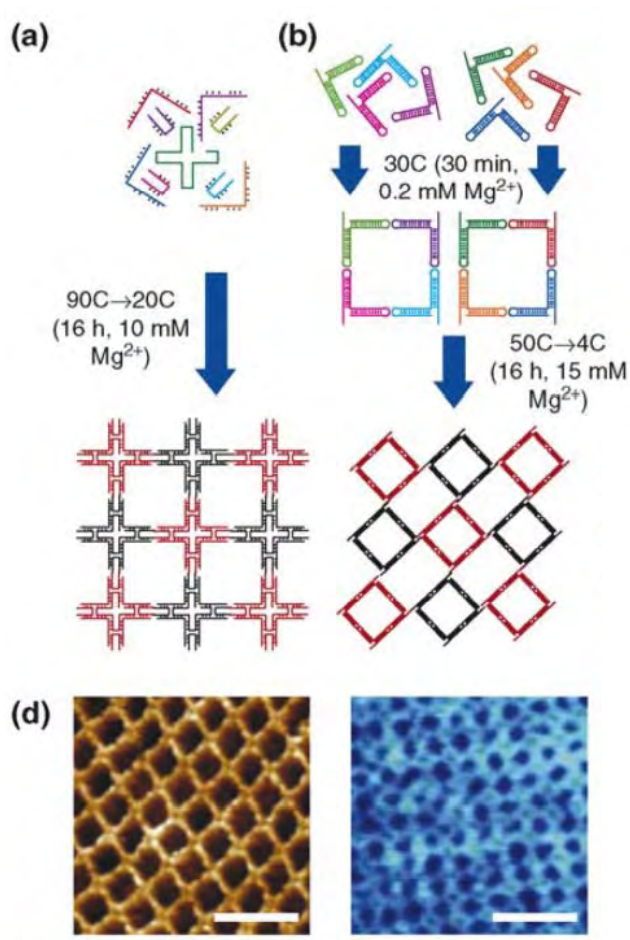

Interacting Edges
Hoogsteen edge
Watson-Crick edge
Sugar Edge
"C-H" Edge
Watson-Crick edge
Sugar Edge
Glycosidic Bond Orientations
Cis orientation of the Glycosidic Bonds
Trans orientation of the Glycosidic Bonds

Comparison between RNA and DNA as building block

	DNA	RNA
Elements	 A, C, G, T 2′-deoxyribose	 A, C, G, U ribose
Base pairing	Canonical Watson–Crick (W–C)	Canonical and non-canonical W–C
Acidic effect	Depurination: apurine DNA sensitive to cleavage	Stable
Alkaline effect	Stable up to pH 12	Sensitive to alkaline hydrolysis
Configuration	Predominantly B-form: -base pairs/turn of the helix: 10.5; -pitch: 3.5 nm; -helix rise/base pairs: 0.314 nm; -humidity: nucleotide: H_2O = 1:1	A-form: -base pairs/turn of the helix: 10.9; -pitch: 2.5 nm; -helix rise/base pairs: 0.275 nm; -humidity: nucleotide: H_2O = 1:0.7
Chemical stability	Relatively stable but sensitive to DNase	Unstable, sensitive to RNase, but stable after chemical modification, for example, 2′-F or 2′-OMe modification
Thermal stability	G:C more stable than A:T	Thermally more stable than DNA, especially for RNA motifs and modules with particular bends or stacks
Free energy, ΔG^0	-1.4 KJmol^{-1} per base pair stack[25]	-3.6 to -8.5 KJmol^{-1} per base pair stack[25]
Helix formation	Needs a minimum of four nucleotides	Needs a minimum of two nucleotides[26,27]
Intermolecular interactions	Cohesive ends, crossover motifs	Cohesive ends, crossover motifs, kissing loops, interlocking loops
In vivo replication		
Initiation	Origin of replication with primer	Promoter, exact nucleotide to start without primer
Termination	No nature sequence for replication termination	Specific transcription terminators
In vitro synthesis		
Enzymatic	DNA polymerase, polymerase chain reaction (PCR)	T7/SP6 transcription
Chemical	Up to 160 nucleotides; low cost	Up to 117 nucleotides; high cost and low yield

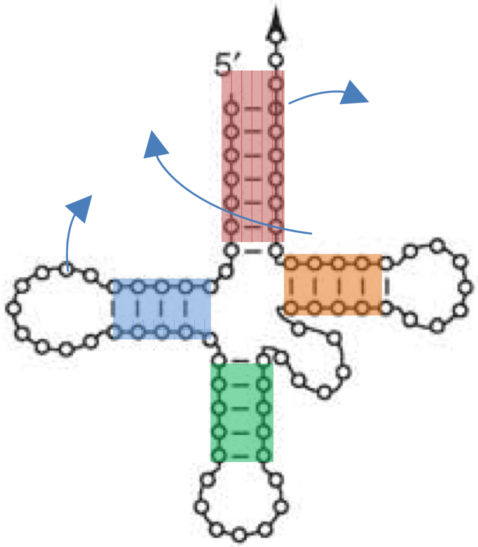
NATURE NANOTECHNOLOGY | VOL 5 | DECEMBER 2010

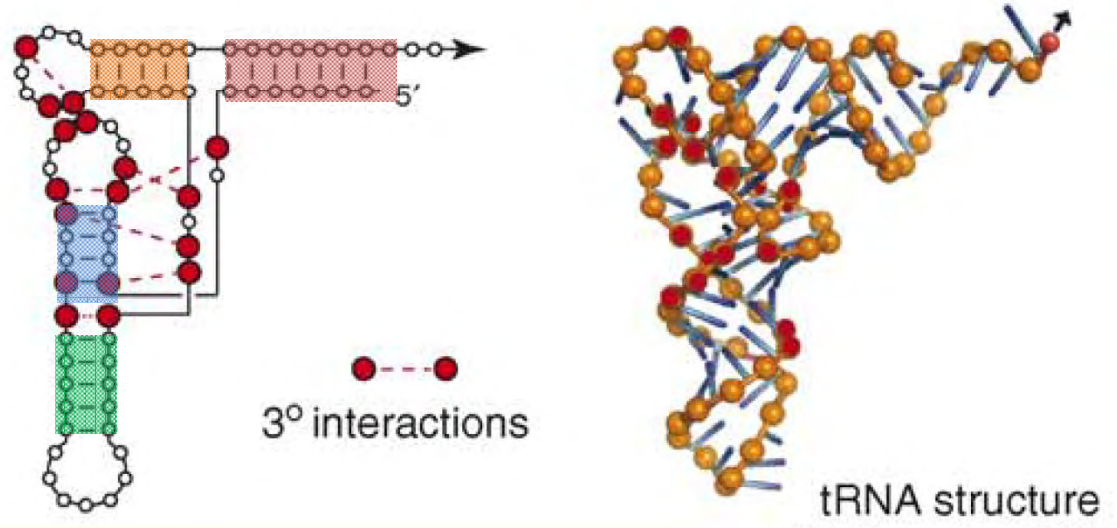
DNA based nanostructure



Complexity of RNA molecule

Cloverleaf





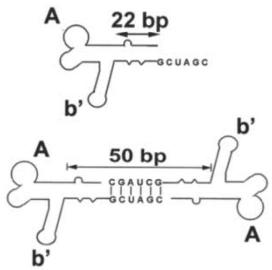
Stem
Loop
Bulge
Multi-loop
Non-WC base pair

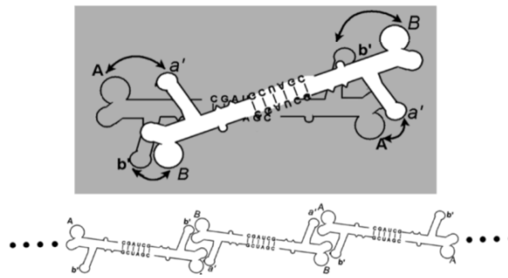
Kissing loop
Interlocking loop

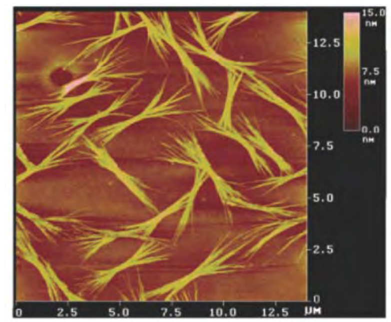
Current Opinion in Structural Biology 2006, 16:531–543

RNA based nanostrcuture

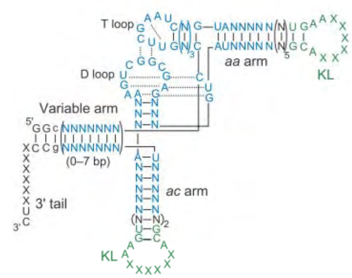
Nano Lett. 2004 September ; 4(9): 1717–1723

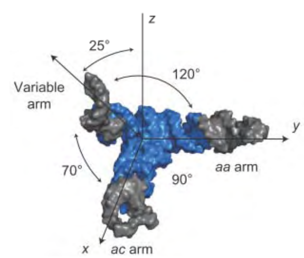


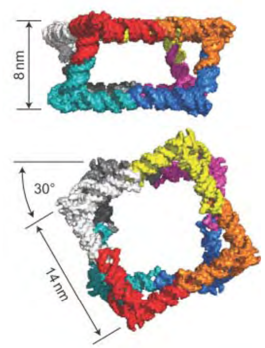




NATURE CHEMISTRY | VOL 2 | SEPTEMBER 2010





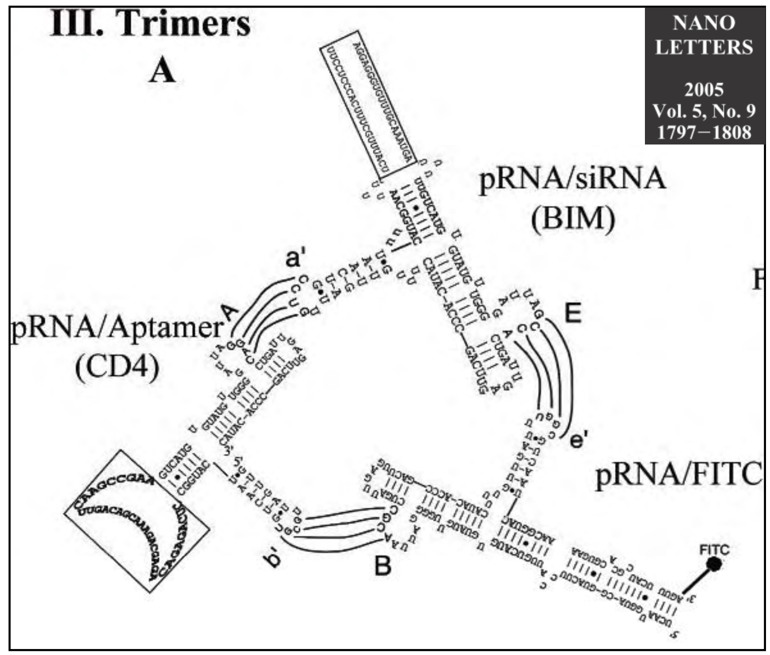


RNA nanoparticle in medicine application

<u>In vitro</u> transcription

<u>In vitro</u> assembly & labeling

Inject nanoparticle into mouse

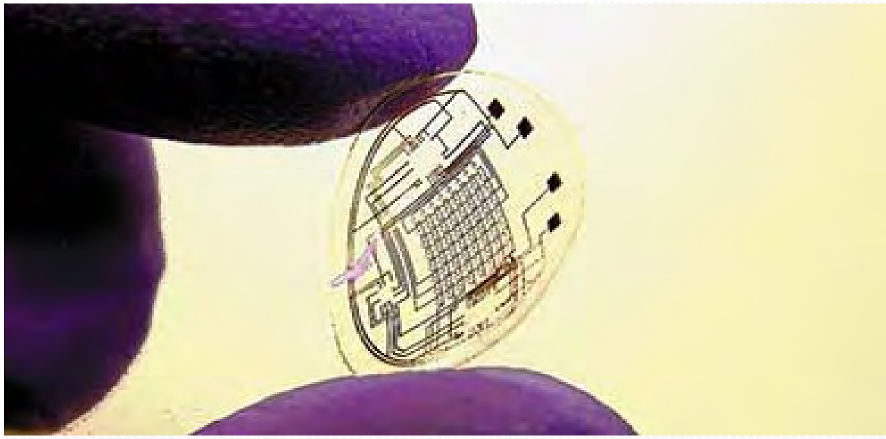


Nanotechnology &

Future Challenges

Syed Ali Abbas

- Nanotechnology is simply handling materials at nano scale



What NEXT?

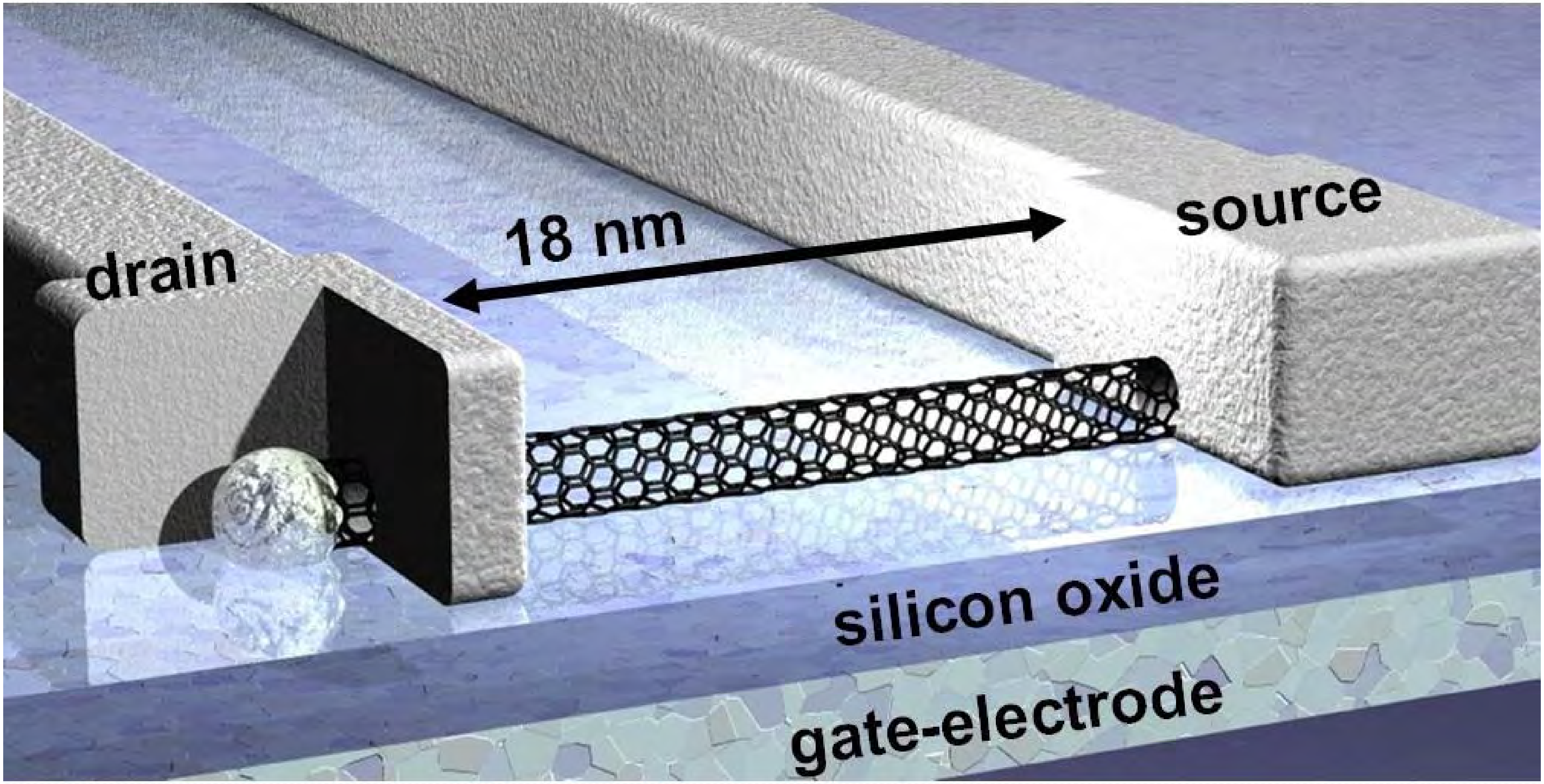
- Solar cells and Thermo Electric materials helping us to manage the energy needs
- Drug Delivery and diagnostics in Bio Medication
- Filtration & Biosensors
- MOsFets & BJT's (Frequency >30Ghz)
- Aerospace
- Food
- Textile

Future Of Nanotechnology

My Emphasis On some new Ideas

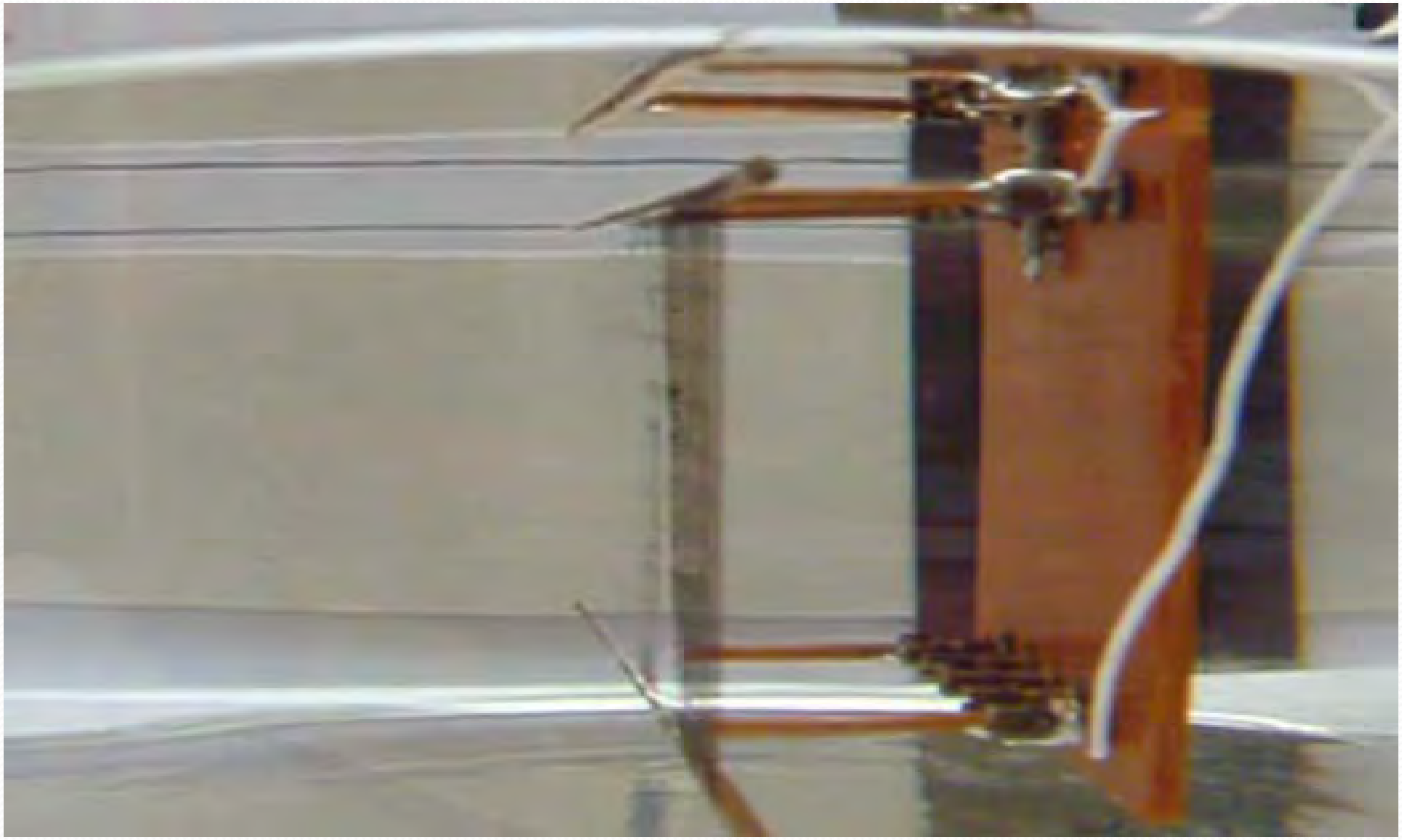
- Faster Devices
- Food Crises
- Defense (Military)

- Carbon nano tube as a Channel in MOSFETS?????



Mirage Effect (Invisible Soldier??)

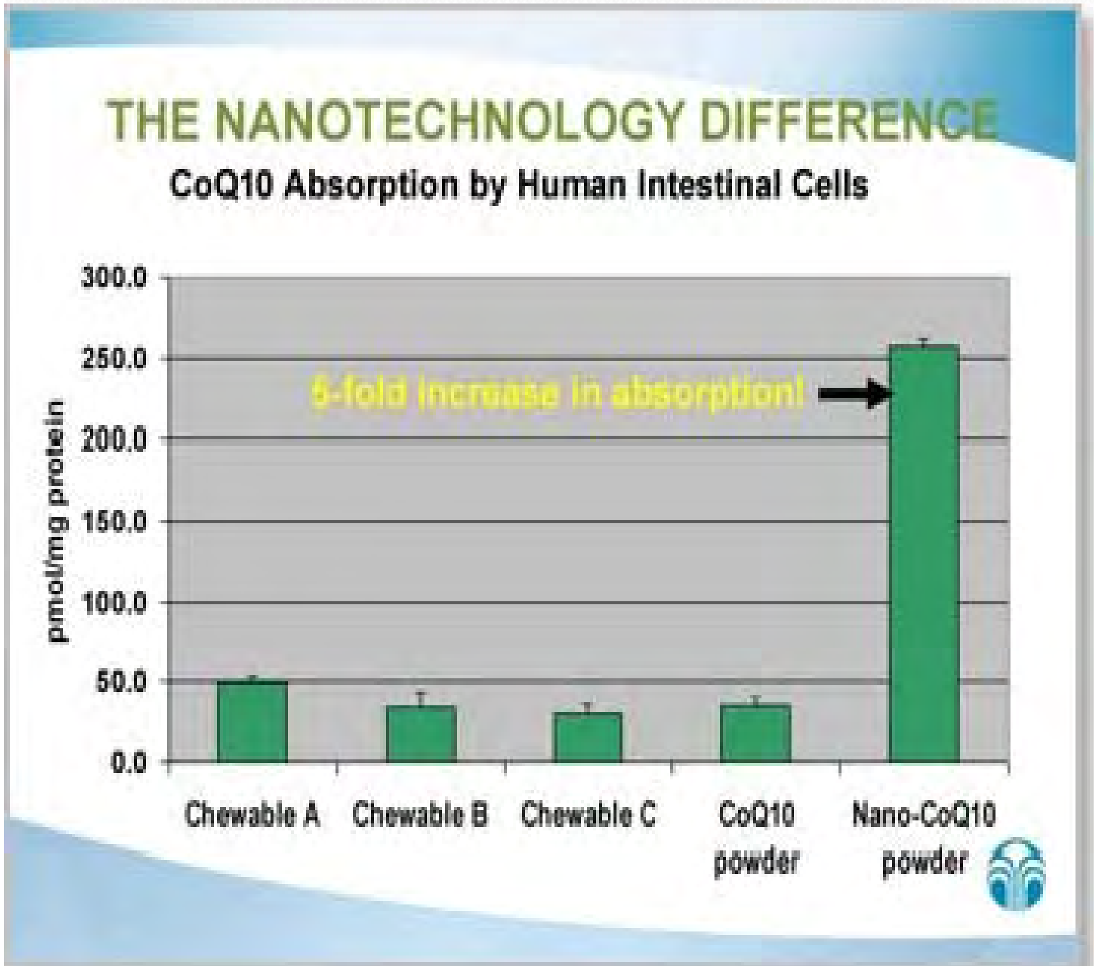
- Carbon nano tubes are used




RoboTroop
The US Army's vision for 2030. Many of these technologies are already under development.
The headgear has biometric facial recognition to identify insurgents, while targets are illuminated on the display.
Advanced nanomaterial armor protects against blasts, burns and rifle rounds. The entire ensemble is embedded with behavioral and physiological sensors that continuously monitor the soldier's health.
The "data glove" may be used to operate robots and unmanned drones.
Unlocked by voice command or electronic trigger, the weapon would shoot high explosive munitions up to 1,000 meters. Another feature: it could be scaled from nonlethal ("stun") to lethal force.
The external armor, or "exoskeleton," not only provides the protection of traditional body armor, it enhances the strength of soldiers' legs.
The custom-fit boot will be designed to minimize effort and increase endurance.
Source: US Army

Food Crises ??? Nanotechnology is there to help

- Nutritional and anti aging supplement is there (LifePak Nano)
- DNA protection, Cardiovascular health, Immune system support, Bone health and more
- Pharmanex hopeful of making medicine that can reduce the dependence on Food


THE NANOTECHNOLOGY DIFFERENCE
CoQ10 Absorption by Human Intestinal Cells
pmol/mg protein
300.0
250.0
200.0
150.0
100.0
50.0
0.0
5-fold increase in absorption!
Chewable A
Chewable B
Chewable C
CoQ10 powder
Nano-CoQ10 powder


PHARMANEX
lifepak nano
DIETARY SUPPLEMENT
60 PACKETS

- Thanks for your attention

Gold Nanoclusters: Synthesis and Application

“Cool” technology without “Hot” products

Krishnendu Chatterjee

101011862

Contents

- Introduction
- Synthesis Routes
- Present Application
- Problem definition??
- Future Application-Work Plan
- Discussions
- Reference

Introduction

- NCs alternative to organic dyes and QDs
- Good photostability, larger Stoke's shift, [advantage over organic dyes]
- Ultra-small size (1-2 nm), low toxicity, easy synthesis [advantages over QDs]
- Various methods of synthesis of NCs.
- Polymer directed Au NC synthesis not feasible for usage. Protein directed Au NC & Au-MUA NC more suitable.

Synthesis

- Polymer Directed Au NCs synthesis

Example-ELR Glu15 [Rodriguez et al., 2010], PAMAM [Zheng et al., 2003], PVP [Gonza´lez et al., 2010], etc

- ➢ Advantages- higher QY, higher stability
- ➢ Disadvantages- complexity involved, bioconjugation not easy, more time consuming

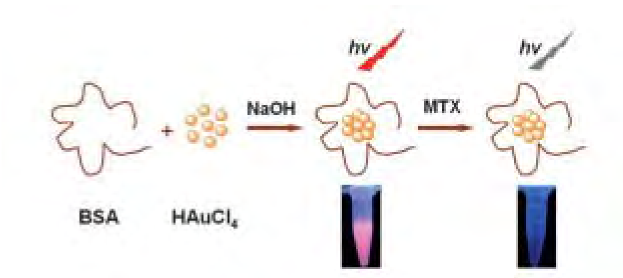
- Protein Directed Au NCs synthesis

Example- rec1-resilin [Mayavan et al., 2011], lysozyme [Wei et al., 2011], GSH [Shichibu et al., 2007], BSA [Xie et al., 2009], HRP [Wen et al., 2011], etc

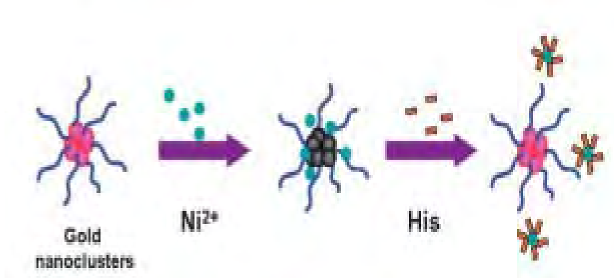
- ➢ Advantages- less complex, bioconjugation easier, less time consuming
- ➢ Disadvantages- lower QY

Present Applications

• Applications-Sensor for quercetin [Chen et al., 2012], methotrexate [Chen et al., 2012], histidine [Hu et al., 2012], cyanine in water [Liu et al., 2010], copper ions in live cells [Durgadas et al., 2010], GA detection [Wang et al., 2011], amino acid detection [Wang et al., 2012], etc.



Fluorescent Quenching
[Chen et al., 2012]



Turn-On Sensor
[Hu et al., 2012],

Problem defination??

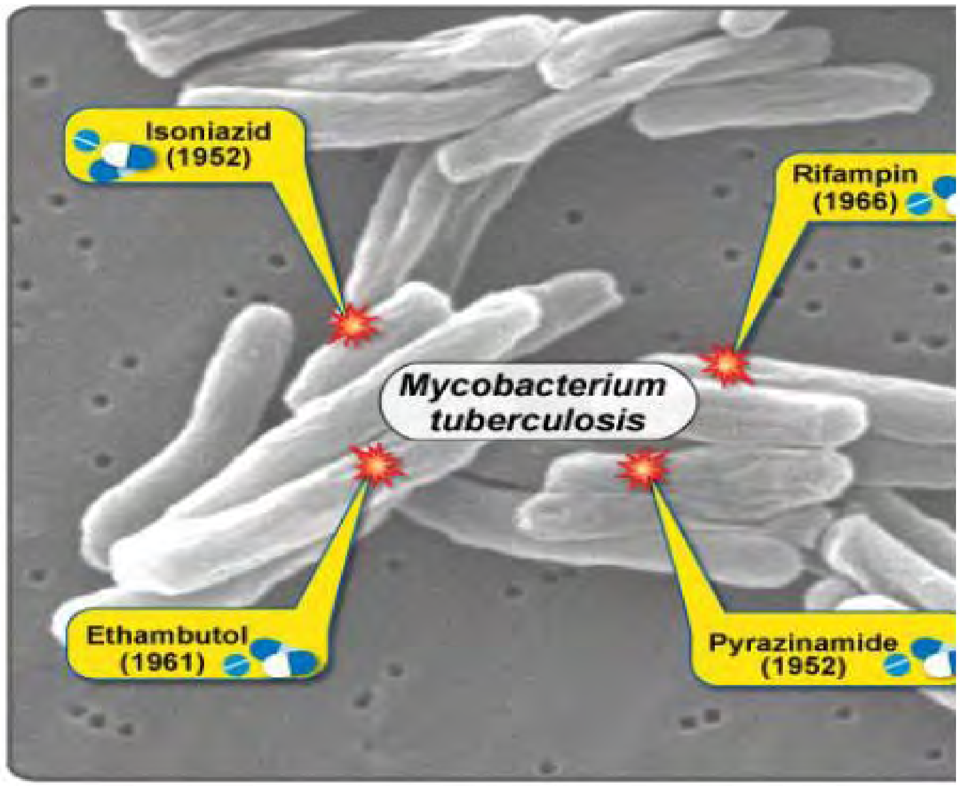
- Increase PL
- Improve biocompatibility to make it applicable for biological system
- Limited applications

Future Prospect-Work Plan

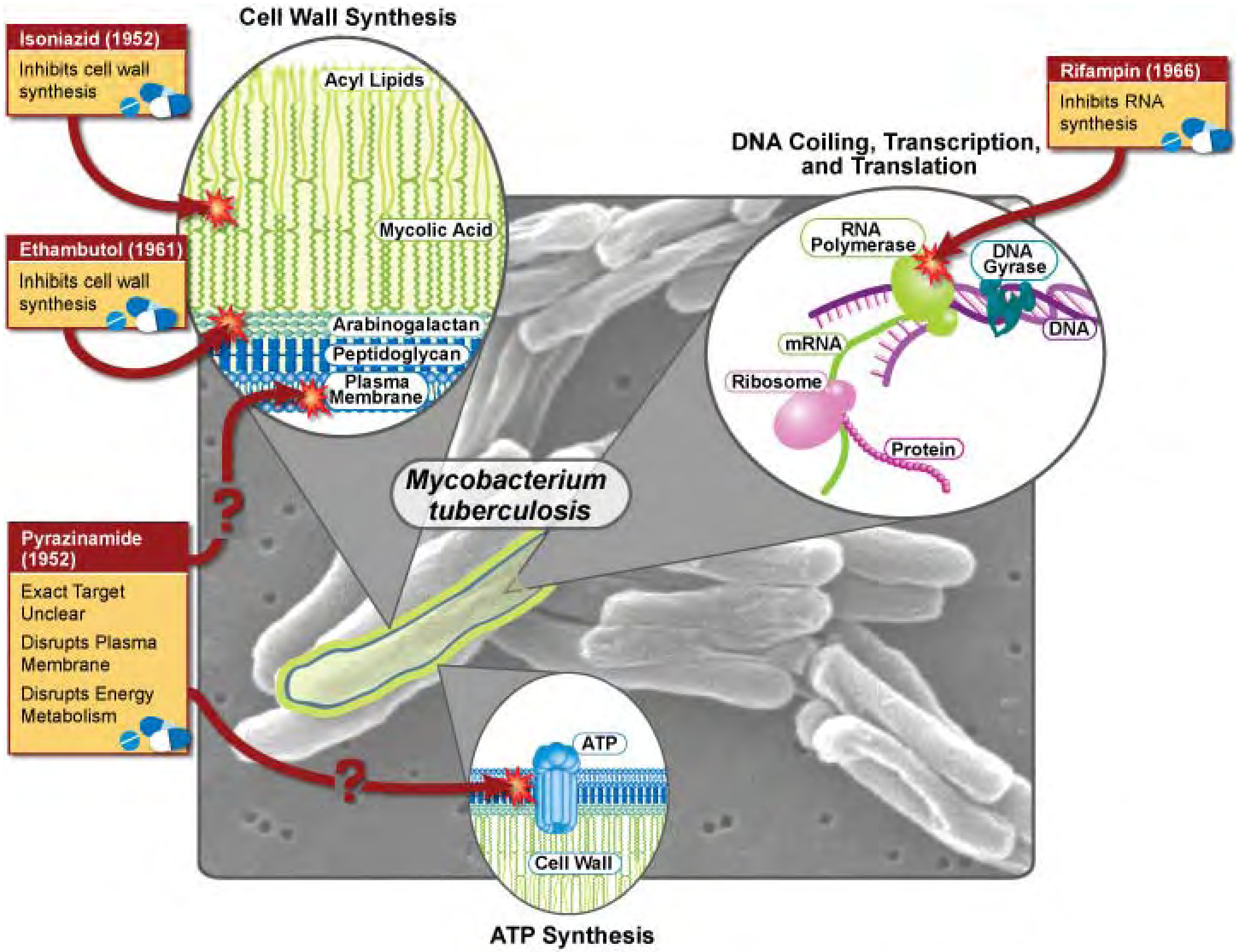
- Application in Sensor- Detection of Rifampicin antibiotic
- Application in drug delivery & fluorescence imaging
- Application in drug delivery & multi-modal imaging

Sensor

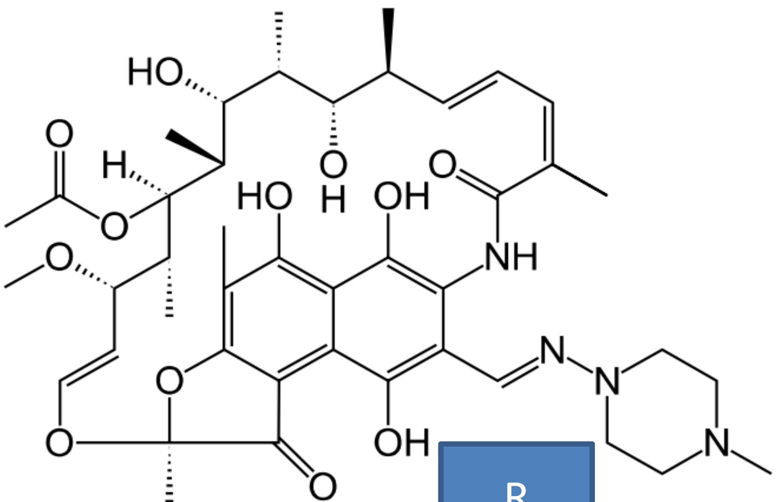
- Why Rifampicin??
  - First line drug for TB
  - Develops drug-resistant
  - Dosage adjusted (cause of renal failure)
  - Needs careful monitoring else can become resistant (Other drugs need not be adjusted in renal failure)



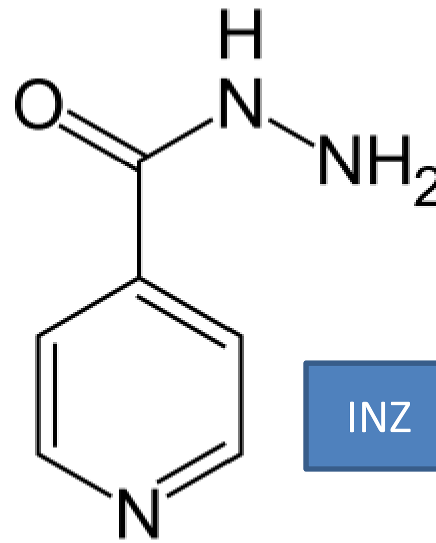
Mode of Action



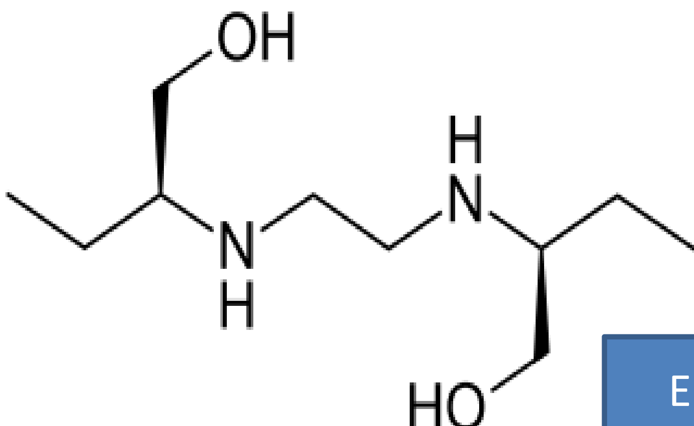
Structure



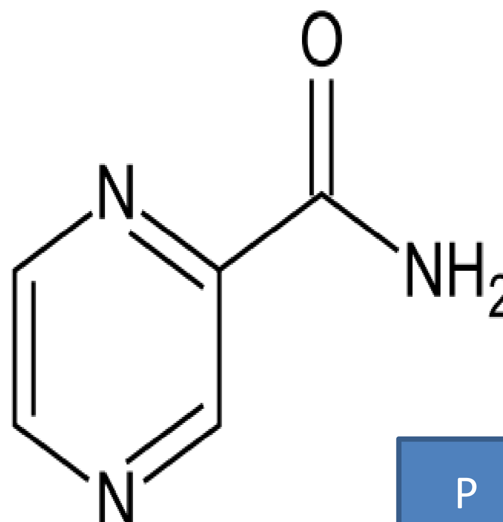
R



INZ



E



P

Rifampicin sensor based on BSA-Au NCs

- HPLC with UV-vis, single MS, tandem MS, LC used to monitor antibiotics in urine and plasma.
- R binds to BSA quite strongly [Yu O.Y et al., 2011]
- INH, E and Z are not usually binding strongly with proteins—fluorescence quenching based sensor.
- R analogue binds to Cu ions and not Mg ions as found from literature
- Turn-on based sensor
- Novelty-paper based testing!!

Sensor Methodology

- Preparation of BSA-Au NC

  Advantages-

✓ Au with red NIR emission:

  Improves tissue penetration

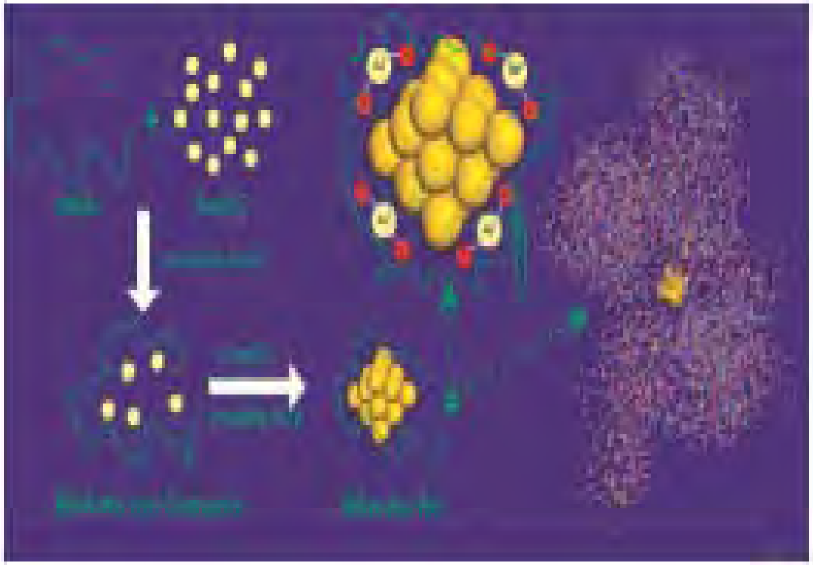
  Reduce background fluorescence

✓ BSA retains biological activity

  Modification of surface

  Analyte recognition

  Change in emission spectra



[Xie et al., 2007]

Characterization-using FTIR/CD spectra, fluorescence spectra, TEM

Fluorescent Quenching based sensor

Calibration curve

Detection of unknown quantity of R

Effects of INH, E, Z in emission spectra of BSA-Au+R

Optimization, sensitivity, specificity

Application

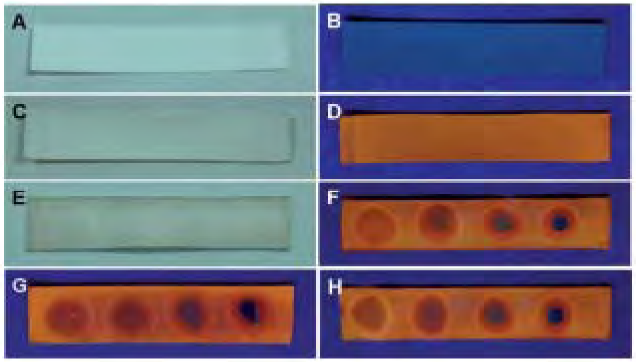
Sensor Methodology

- Alternative way- **Turn on Sensor**
  Paramagnetic materials completely quenches the fluorescence
  Affinity of R analogue to Cu ions

  BSA-Au NC→BSA-Au NC+Cu ions-→BSA-Au+ Cu-R
  F activity No F activity F activity

  More specific, high sensitivity, lower limits of detection

Novelty- Test papers for detection of R
A & B-Before modification with Ag NC
C & D-After modification with Ag NC
E & F- Addition of Cu ions in deionized water
G- Addition of Cu ions in river water
H- Addition of Cu ions in barelled drinking water
Paper based assay:
Robust, simple, inexpensive, quick determination



[Liu X et al., 2012]

Discussion

- Application of Au-BSA for sensor and possibility of paper based testing for initial estimation.

- Possibility of further extension on other quenching or turn on sensing based sensor mechanism.

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THANK
YOU

ATOMIC FORCE MICROSCOPY (AFM)

Joshoua Condicion Esmenda
TIGP Nanoscience and Technology Program 2012
NTHU-ESS

Outline

- Atomic Force Microscopy
- Imaging Modes
- Applications
- Advantages and Disadvantages
- Summary

Atomic force microscopy

- A type of Scanning Probe Microscopy that uses the force between the probe tip and the atoms of the substrate surface.
- Developed by Binnig et al. in 1985 after STM
- Basic Principle
  - The distance between the probe and the surface is maintained by measuring the relationship of the force and distance according to Hooke’s Law:

$$F = -kx$$

Atomic Force Microscopy

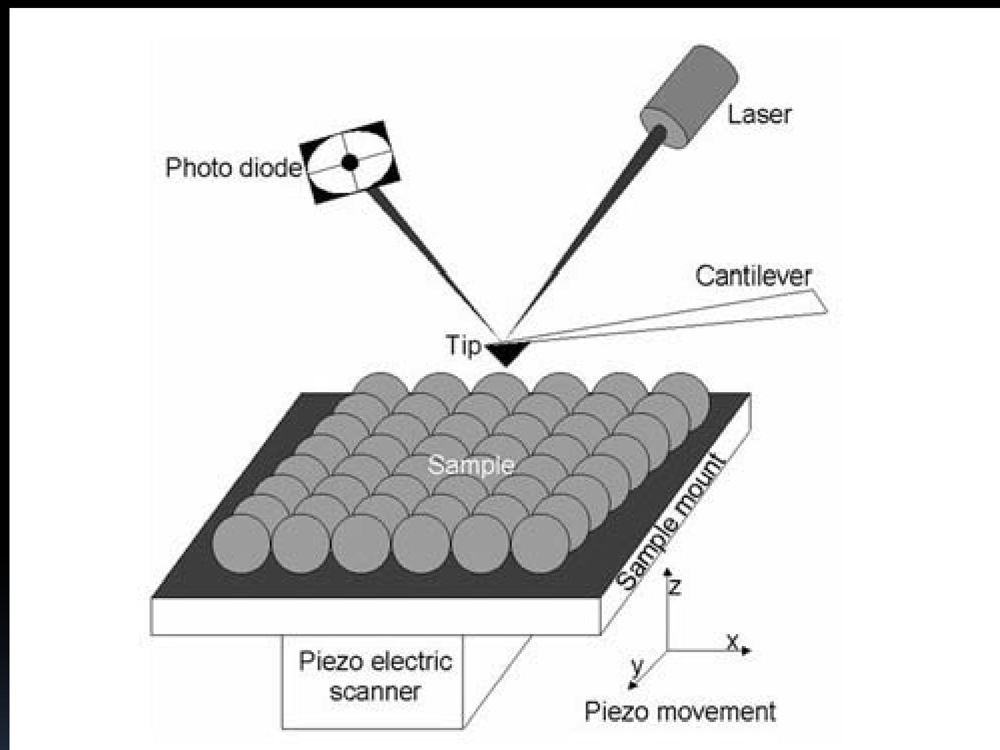


Image: http://scienceinyoureyes.memphys.sdu.dk/atomarkraftmikroskopi_en.php

Atomic Force Microscopy

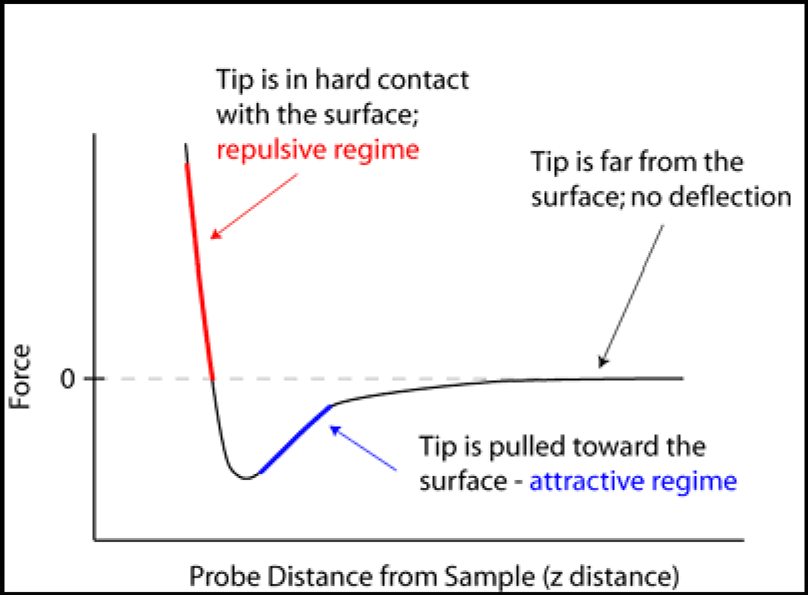


Image: http://www.nanoscience.com/education/afm.html

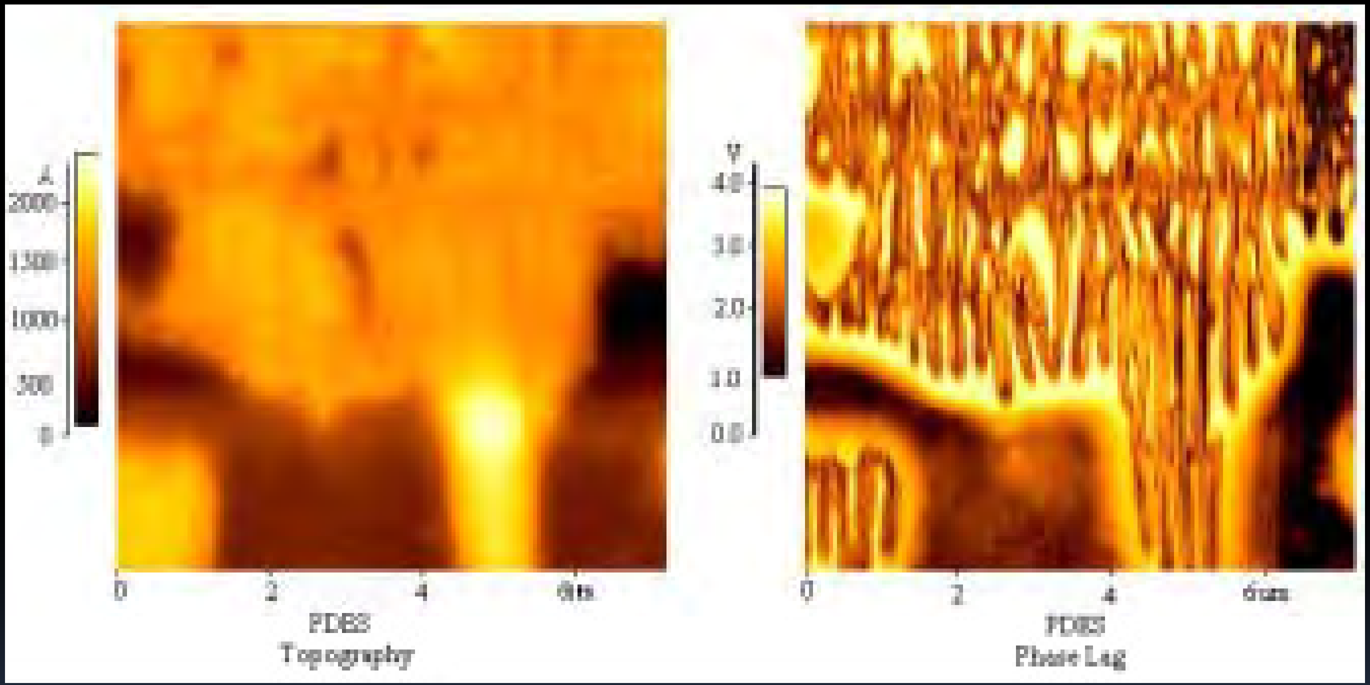
Imaging Modes

- Contact Mode
  - Force between the probe and surface is kept constant
- Tapping Mode
  - Cantilever is oscillating in the repulsive regime
- Noncontact mode
  - Cantilever is oscillating in the weak attractive regime

Applications

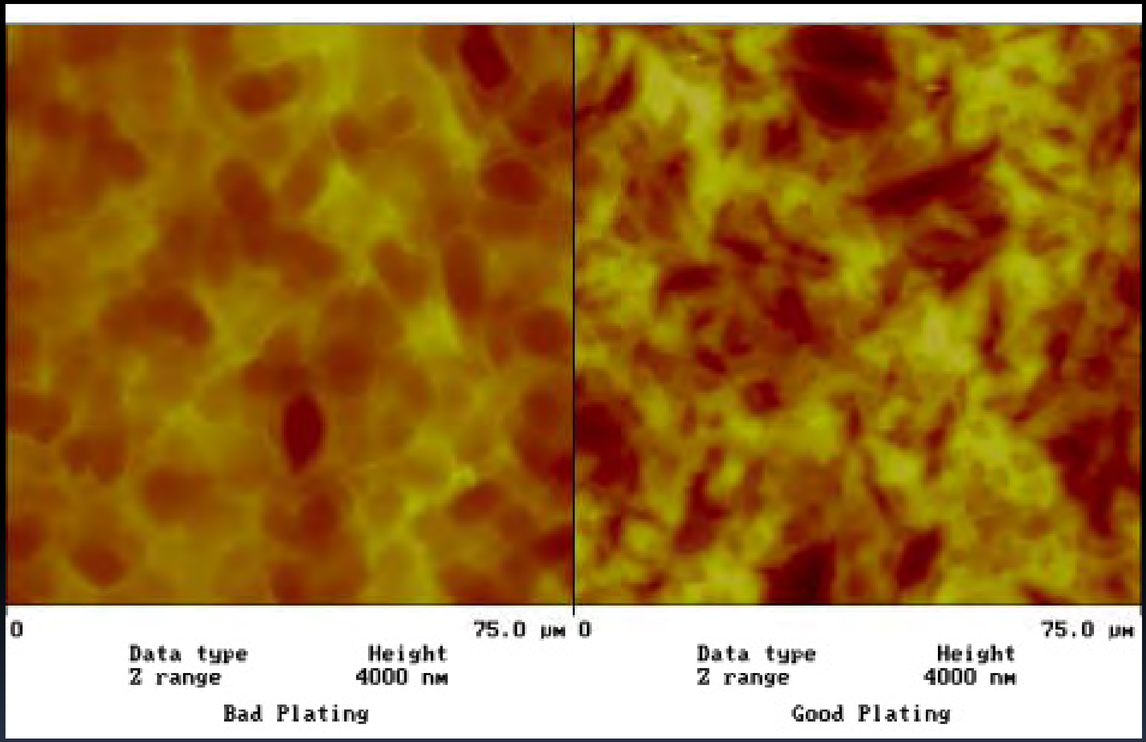
- Biological
  - Microscopic phase distribution in polymers
  - Fragile biological sample imaging
- Non-biological
  - Topography of IC devices
  - Mechanical and physical properties of thin films
  - Imaging magnetic domains in storage media
  - Electrochemical studies

Applications



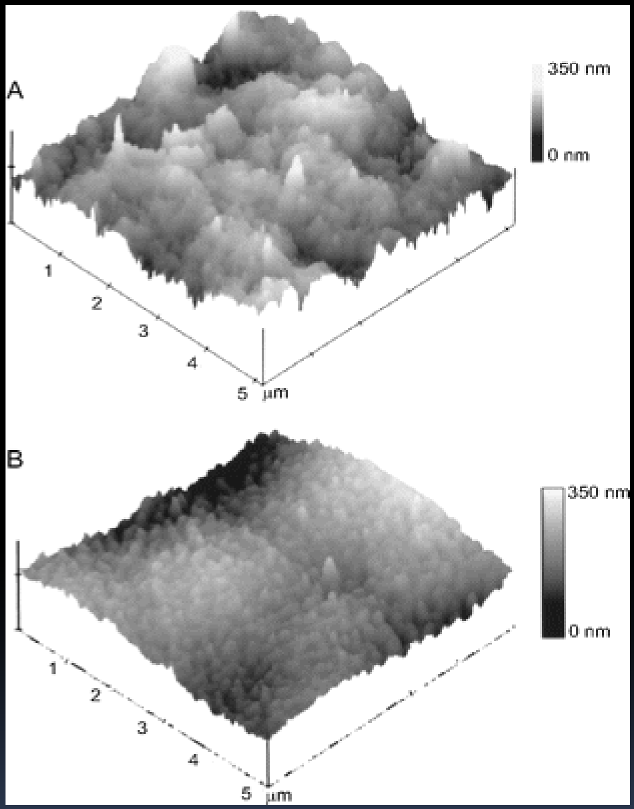
Height and Phase of Polymer Sample
Image: http://mee-inc.com/afm.html

Applications



Gold Plating for Wire Bond Failure Analysis
Image: http://mee-inc.com/afm.html

Applications



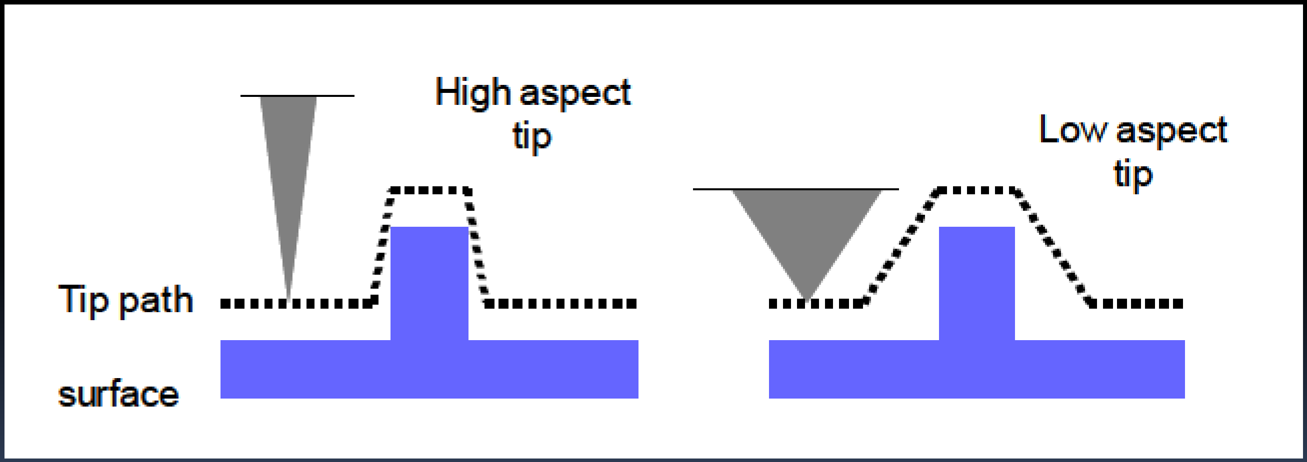
Tapping mode image of a human cornea
Image: http://www.iovs.org/content/51/12/6083.full

Advantages and Disadvantages

- Advantages
  - Resolution is not limited by diffraction
  - Do not require partial vacuum
  - New uses such as nanolithography
- Disadvantages
  - Scanning rates are usually slow
  - Tip convolution

Advantages and Disadvantages

- Tip Convolution



Summary

- Atomic Force Microscopy (AFM) can scan many materials such as plastics, metals, glasses, semiconductors, and biological samples such as the walls of the cells.
- There are also limitations of the AFM that needs to be addressed to achieve higher resolution and accurate imaging.

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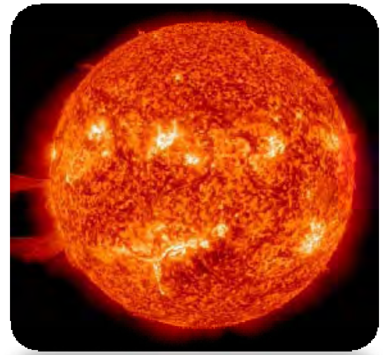
Xiexie ni men!






Nanomorphology Control for High Performance Organic Photovoltaics

Nano-Class Project,

Jan. 10th 2013,

By: Mahmoud E. Farahat.

Outlines

✓**Introduction and Basics.**

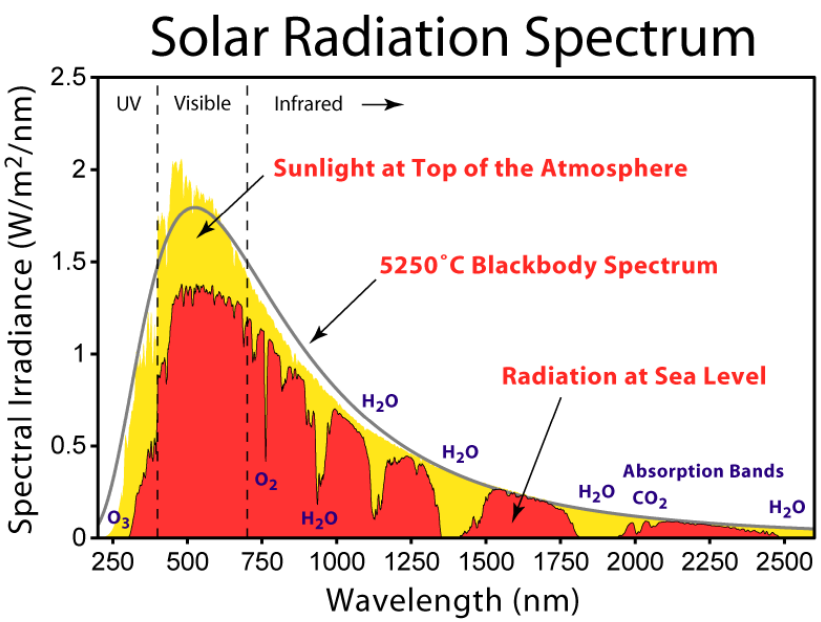
✓**Why we need to control nanomorphology?**

✓**Ways to control nanomorphology and illustrative examples.**

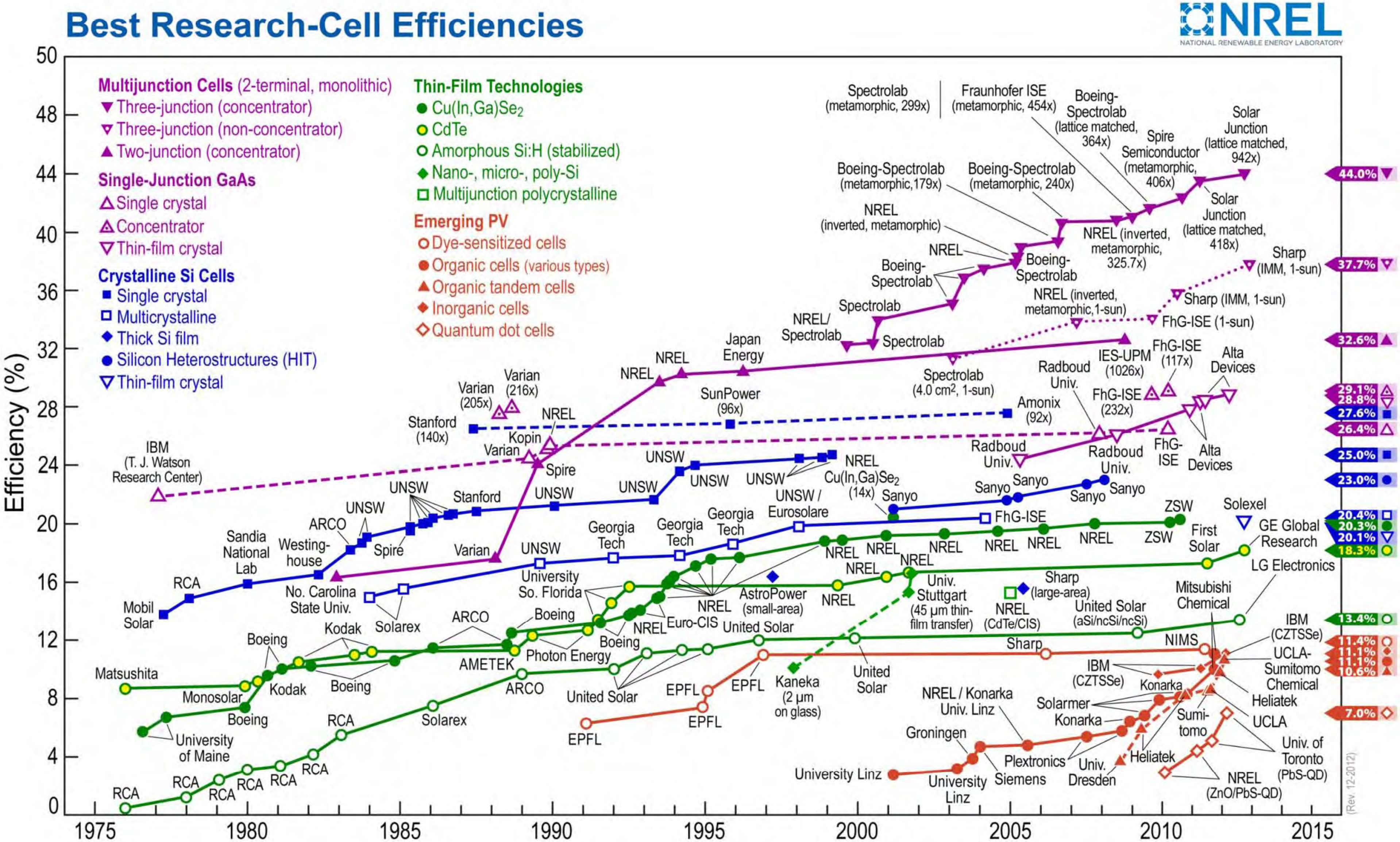
✓ **About Additives and illustrative examples.**

✓**Conclusion.**

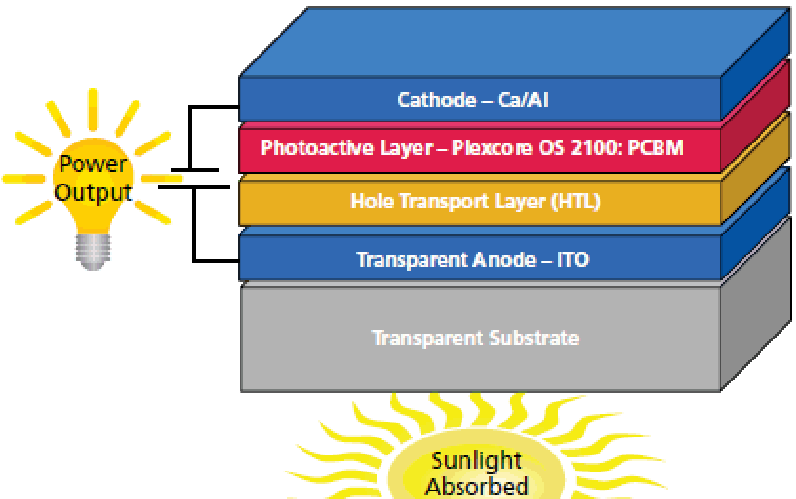
UV (<400 nm)
Visible (400-800 nm)
Infrared (>800 nm)

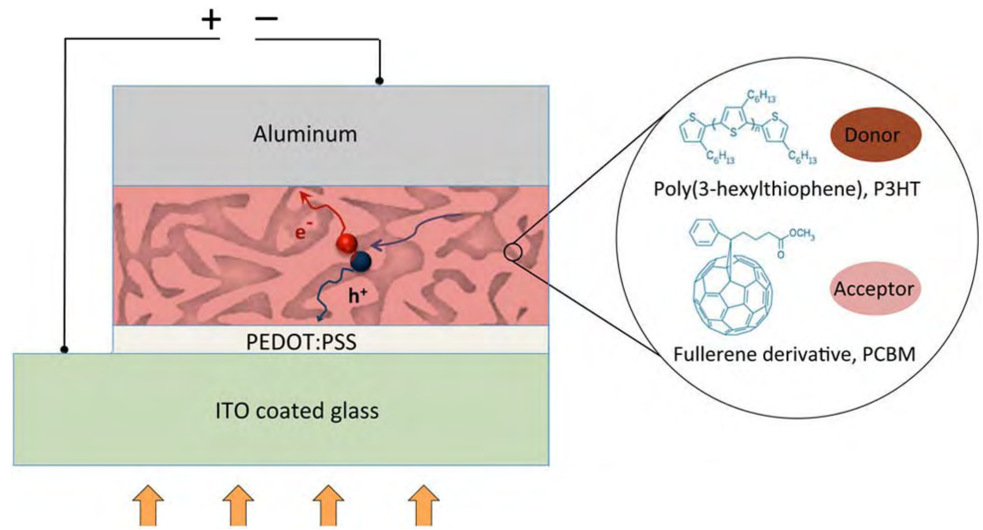


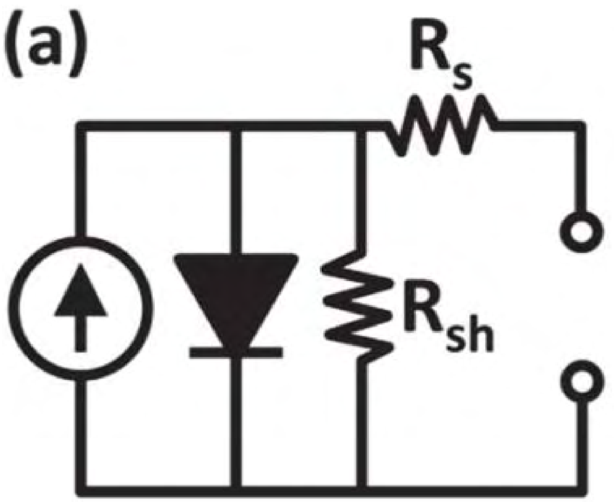
Best Efficiencies Records in 2012

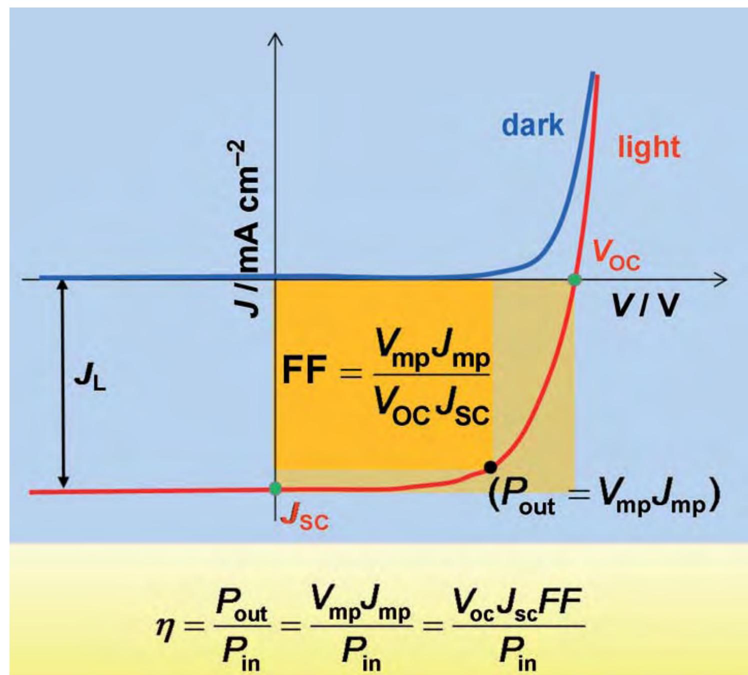


Introduction

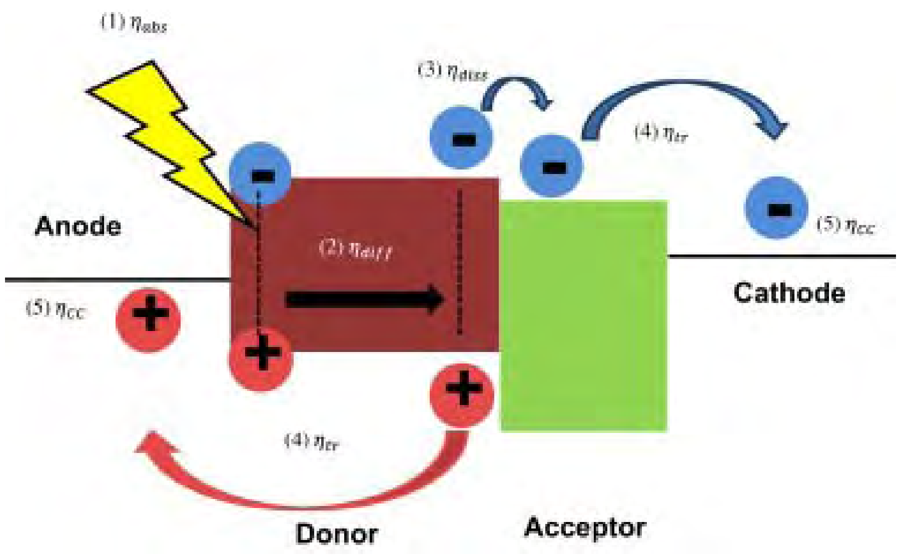




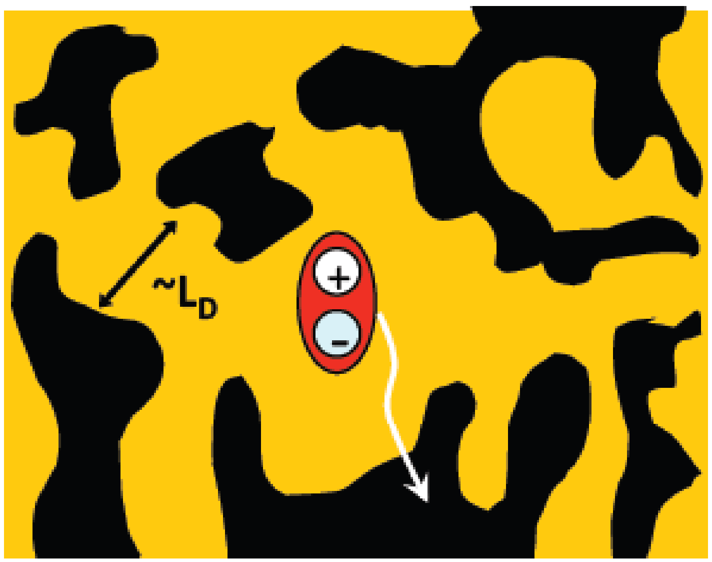




Why we need to control nanomorphology?



1. Absorption of light and generation of excitons
2. Diffusion of excitons to an active interface
3. Charge dissociation
4. Charge transport
5. Charge collection



Charge separation within active layer

Ways to control nanomorphology

1- Annealing via solvent evaporation, Example (1)

2-Thermal annealing, Example (2)

3-Ratio and concentration of the components in the blend, Example (4)

4- Photoactive materials chemical structure, Chemical Synthesis

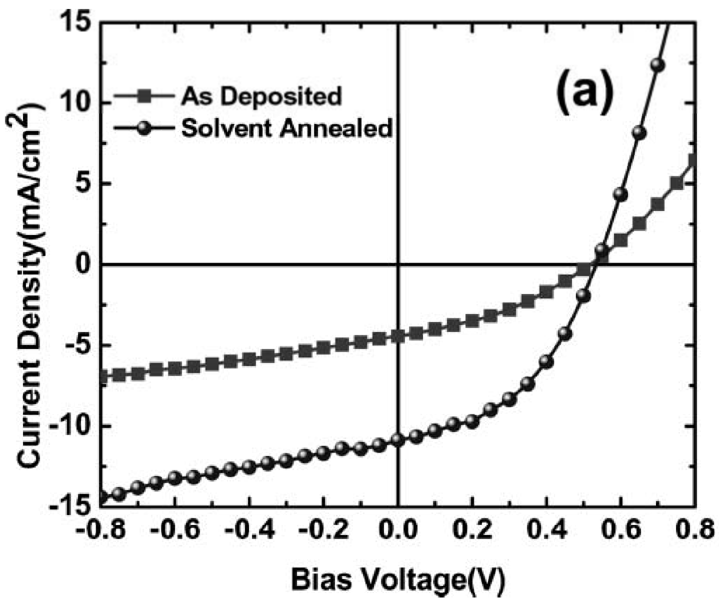
5- Additives (solvents, polymers, SM, etc) , Example (2,3,4)

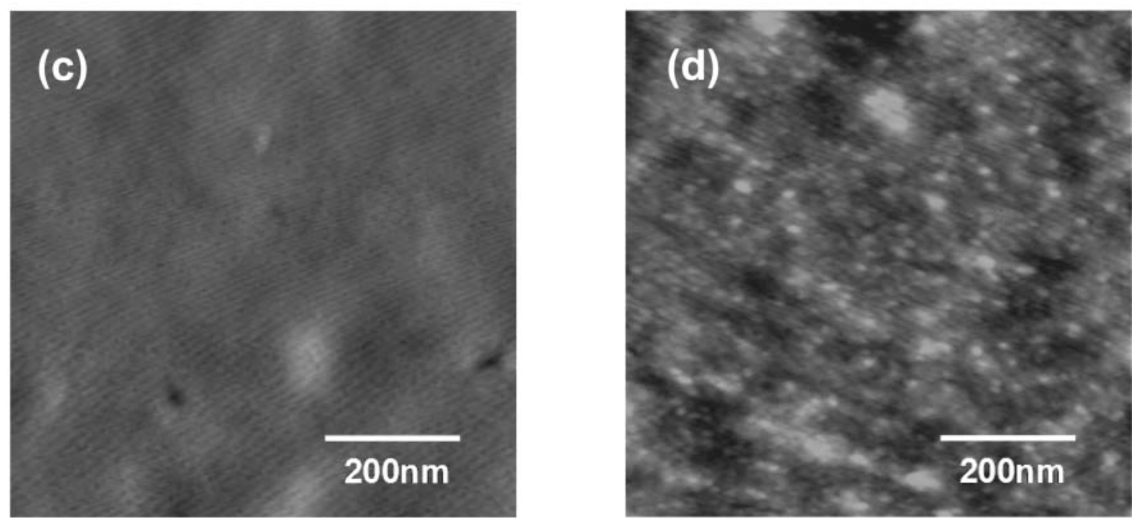
Investigation of nanoscale morphological changes in organic photovoltaics during solvent vapor annealing

Steve Miller,*[a] Giovanni Fanchini,*[a] Yun-Yue Lin,[b] Cheng Li,[c] Chun-Wei Chen,[b] Wei-Fang Su[b] and Manish Chhowalla[a]

Example (1)

Received 11th September 2007, Accepted 1st November 2007





P3HT : PCBM in chlorobenzene, 2 minutes of solvent annealing

(c) as deposited and (d) solvent vapor annealed P3HT : PCBM films

About Additives

✓**<u>Additives</u>: Small amounts of solvents that added to the solution blend in order to control the film forming kinetics leading to nanomorphology control.**

✓**Additives should have higher melting points than the host solvents.**

✓**They should not chemically react with any of the blend's components.**

✓**They should have higher solubility tendency towards some components than others [Usually towards polymers than Fullerenes].**

✓**This differentiation in solubility gives the chance for crystallization and self-organizing of [polymers] due to the relatively long time of additive evaporation compared to the host solvent evaporation time.**

✓**Polymers and SM might be also used as an additives.**

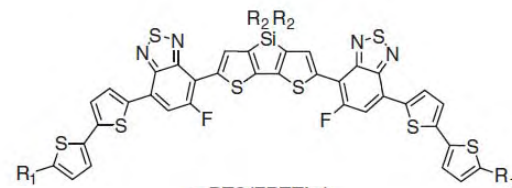
ADVANCED MATERIALS
www.advmat.de

Published online: June 6, 2012

Materials Views
www.MaterialsViews.com

Non-Basic High-Performance Molecules for Solution-Processed Organic Solar Cells

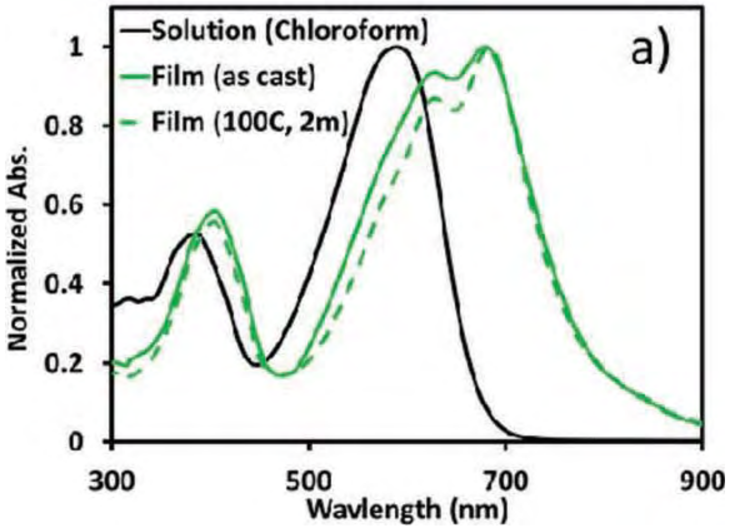
Thomas S. van der Poll, John A. Love, Thuc-Quyen Nguyen, and Guillermo C. Bazan**

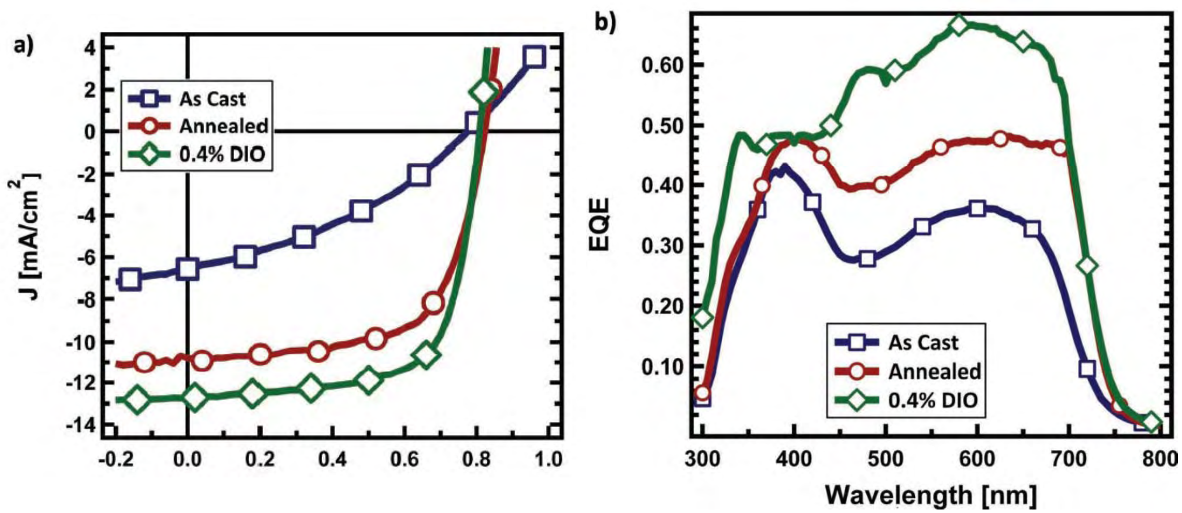


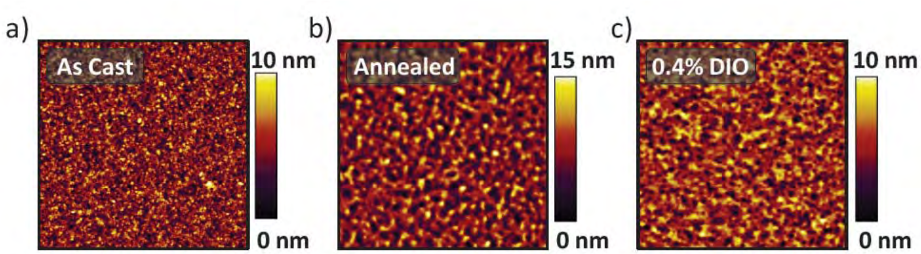
p-DTS(FBTTh$_2$)$_2$

Figure 1. Chemical structures of p-DTS(PTTh$_2$)$_2$ and p-DTS(FBTTh$_2$)$_2$. R_1 = n-hexyl R_2 = 2-ethylhexyl.

Example (2)







Sample	Jsc (mA/Cm^2)	Voc (V)	PCE%	FF%
As Cast	6.6	0.78	1.8	0.36
Annealed	10.8	0.82	5.8	0.65
0.4% DIO	12.8	0.81	7	0.68

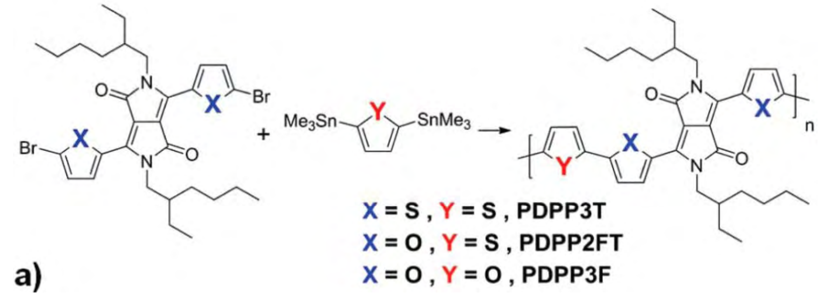
J|A|C|S COMMUNICATIONS

Published on Web 10/14/2010

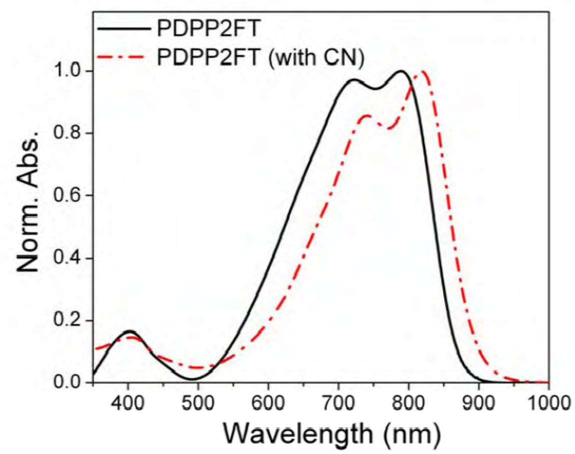
Incorporation of Furan into Low Band-Gap Polymers for Efficient Solar Cells

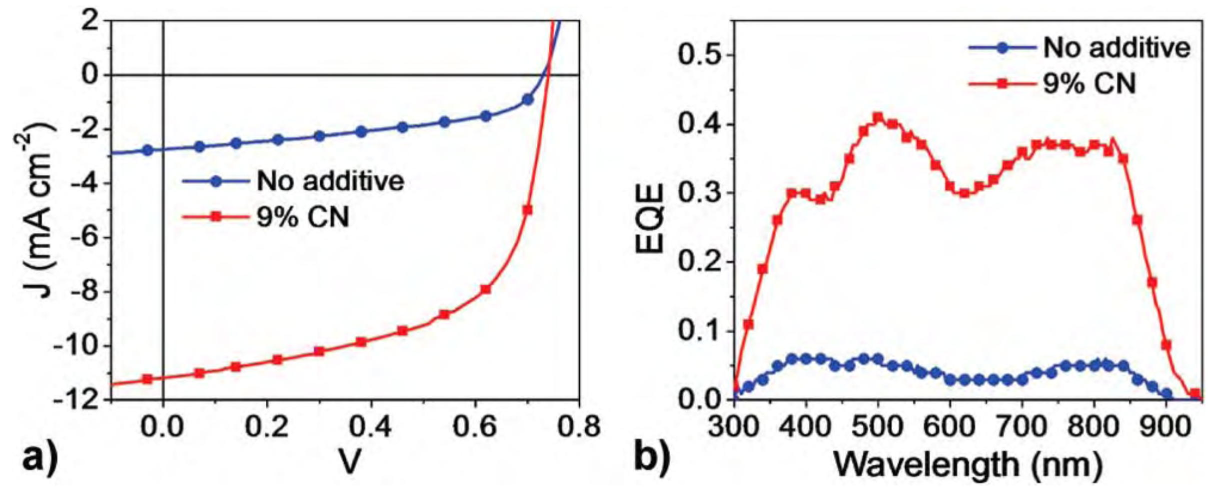
Claire H. Woo,[†,§] Pierre M. Beaujuge,[†,‡] Thomas W. Holcombe,[‡] Olivia P. Lee,[‡] and Jean M. J. Fréchet*[,†,‡,§]

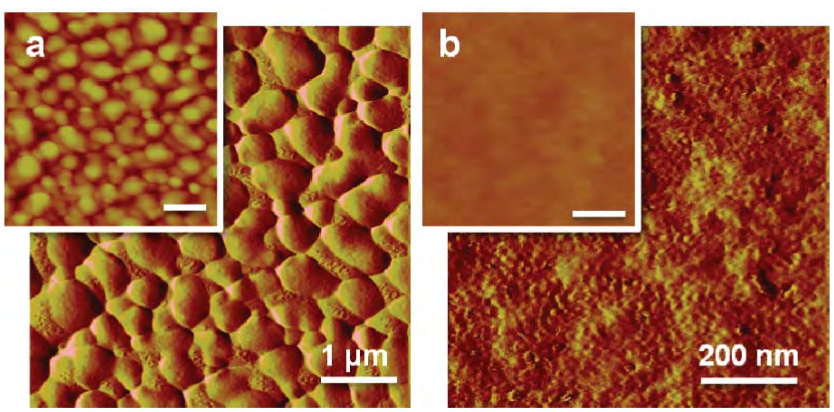
Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States, and Departments of Chemistry and Chemical Engineering, University of California, Berkeley, California 94720-1460, United States



Example (3)







blends of PDPP2FT:PC71BM at a 1:3 weight ratio in chlorobenzene. without any additive, PCE of only 0.86%.

***The best device was* obtained with the addition of 9% CN by volume relative to chlorobenzene, and it achieved a *Voc of 0.74 V, a Jsc of 11.2 mA* cm-2, a FF of 60%, and a PCE of 5.0%**

Example (4)

APPLIED PHYSICS LETTERS 99, 223305 (2011)

Improving the efficiency of an organic solar cell by a polymer additive to optimize the charge carriers mobility

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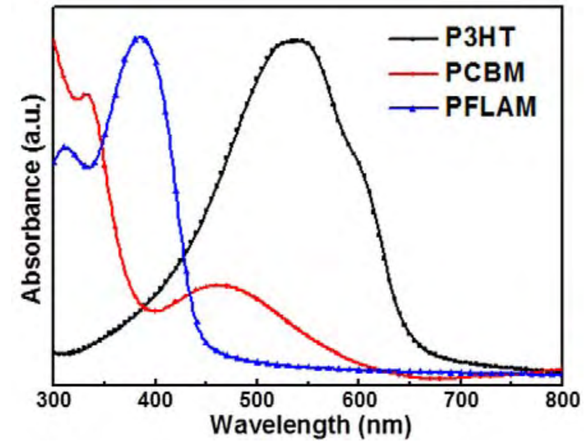
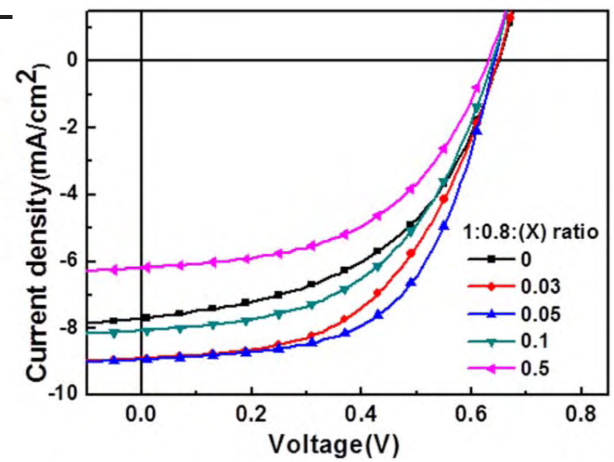
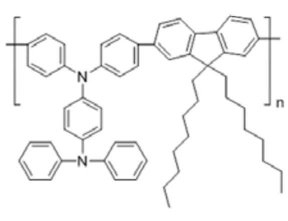
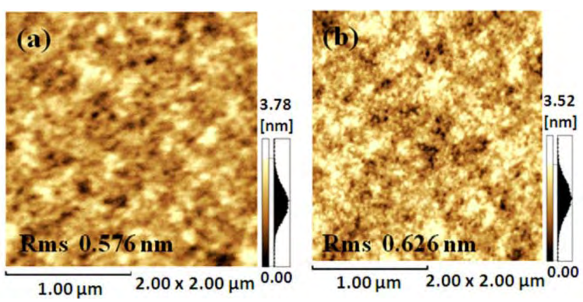


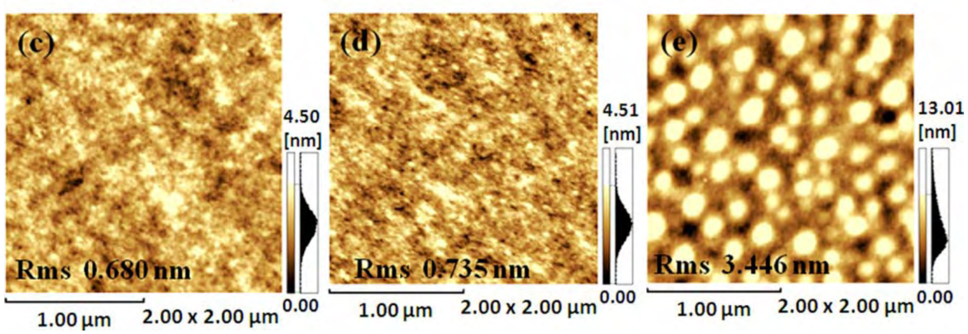
P3HT:PCBM:PFLAM (wt. %)	μ_h/μ_e	Jsc (mA/cm)	Voc (V)	FF (%)	PCE (%)
1:0.8:0	0.09	7.75 ± 0.07	0.66 ± 0.01	48 ± 1.0	2.47 ± 0.06
1:0.8:0.03	0.63	8.79 ± 0.04	0.65 ± 0.01	52 ± 1.0	2.99 ± 0.03
1:0.8:0.05	1.14	8.94 ± 0.06	0.65 ± 0.01	57 ± 0.5	3.31 ± 0.06
1:0.8:0.1	1.78	8.04 ± 0.05	0.65 ± 0.01	51 ± 0.9	2.62 ± 0.02
1:0.8:0.5	4.22	6.17 ± 0.07	0.64 ± 0.01	50 ± 0.7	1.98 ± 0.03

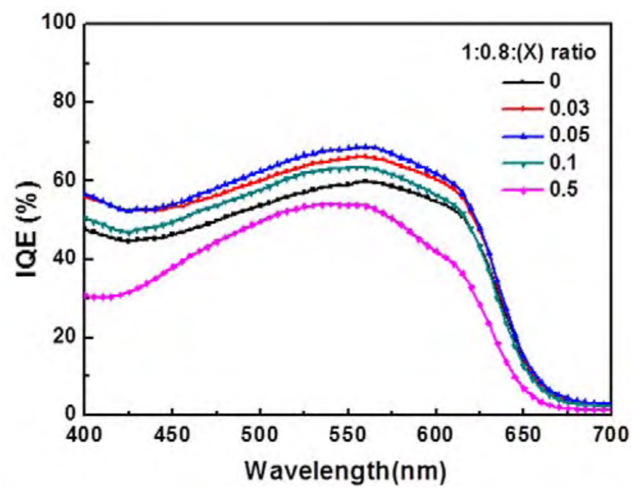




PFLAM







Conclusion

✓Nanomorphology of the BHJ organic solar cells is a critical issue and it needs more detailed studies to be fully understood and controlled.

✓ Forming well-defined, small domain features of donor and acceptor interfaces in the range of diffusion length (10-20 nm) to enhance the carrier transport and dissociation are the main target in morphology control.

✓Additives are promising candidates to control the nanomorphology of the BHJ organic solar cells.

✓Additives can eliminate the thermal annealing step which is not practical for the commercialization of organic solar cells.

✓Up-to-date no specific additive can be used for all or even most of active layers used in organic solar cells.

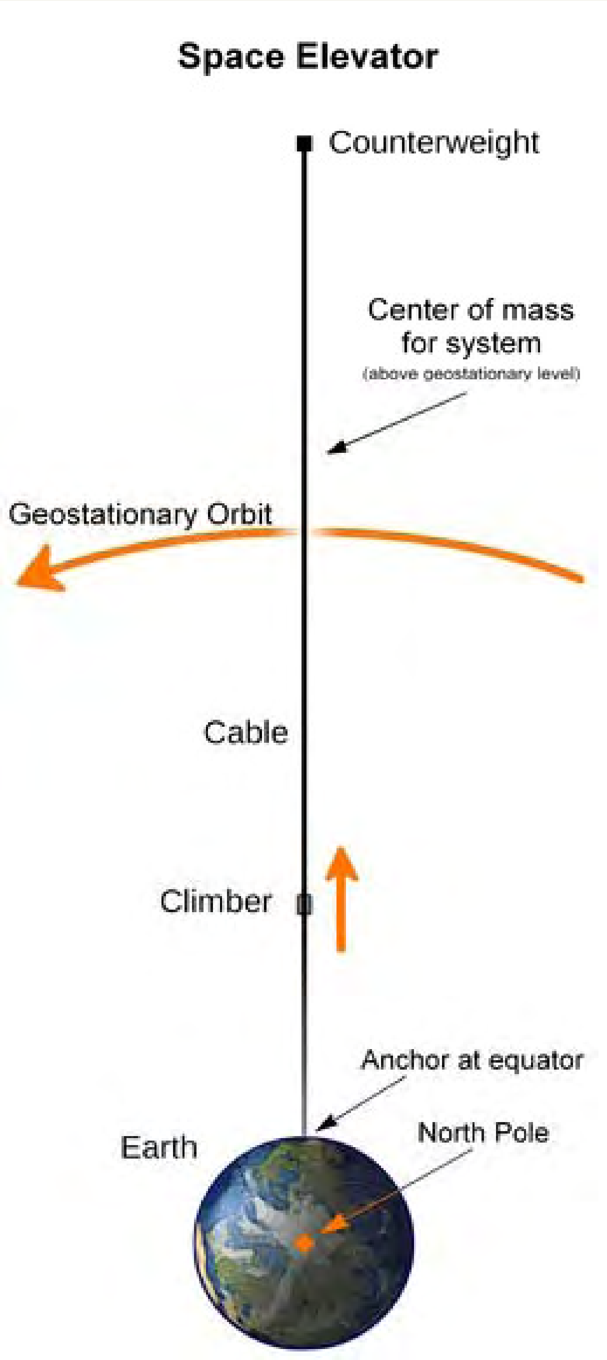
✓Now, people are trying to state controlling rules for the selection of the suitable additive candidates for each photoactive material based on solubility parameters.


Thank you
Cover of Chem. Soc. Rev., 2012, 41, 4245–4272

Applications in Nano Technology: Space Elevator

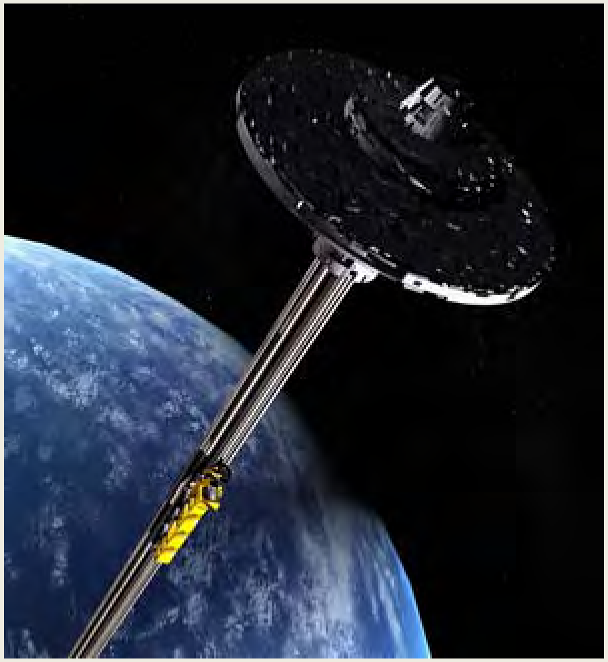
Berco Dan 100011807

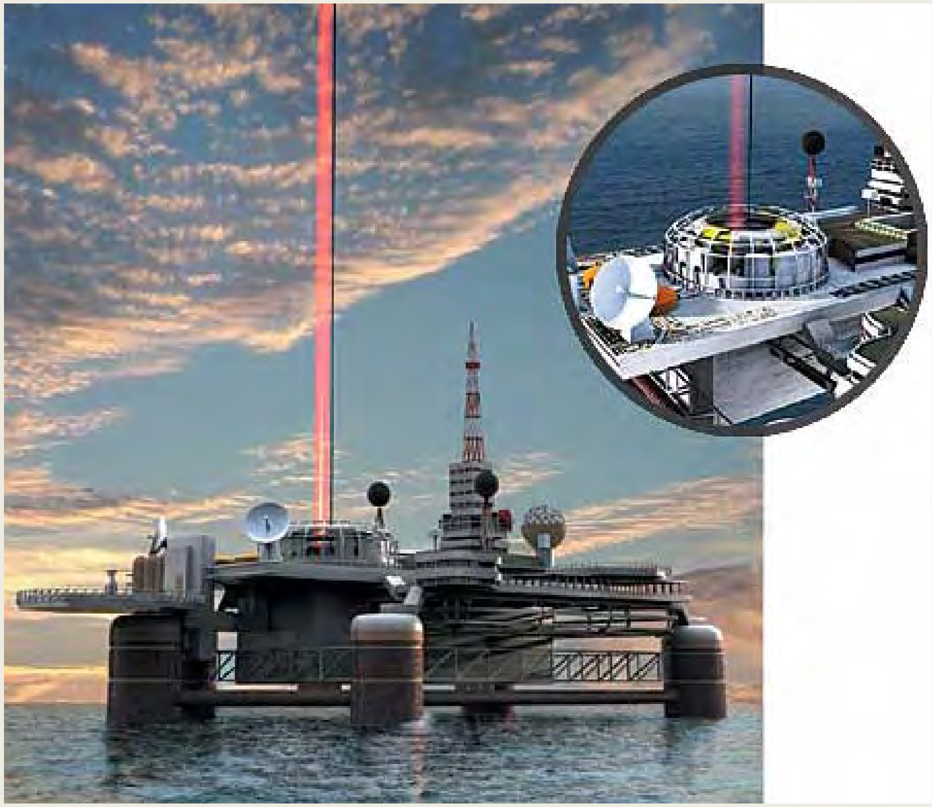
Slingshot effect:



Space Elevator

- conventional rocket designs cost about $25,000 per kg for transfer to geostationary orbit.
- Envisioned payload prices starting as low as $220 per kilogram





Cable

- must carry its own weight and weight of climbers - large tensile strength/density ratio

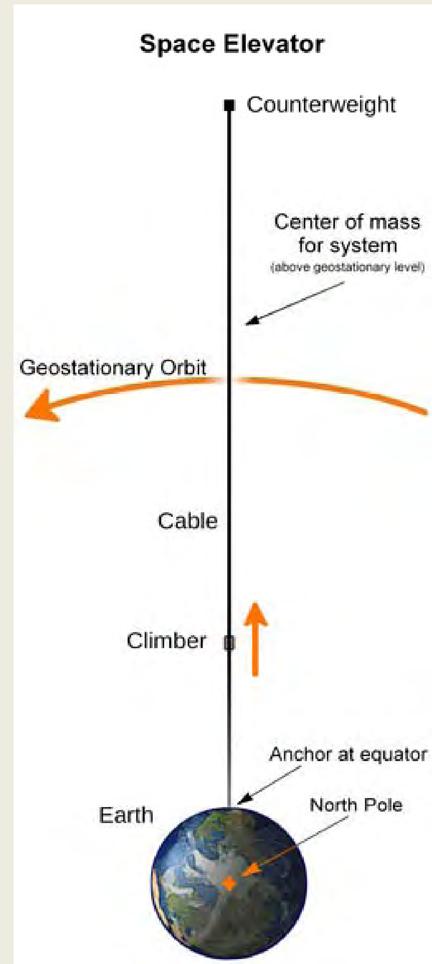
- retain the cable and counterweight above

- maximum is at geosynchronous altitude so the cable must be thickest there and taper exponentially as it approaches Earth

Cable Physics

- The vertical point with the greatest tension on a cable is at the level of geostationary orbit, (35,786 km) above the Earth's equator.

- cable material combined with its design must be strong enough to hold up the weight of its own mass from the surface up to 35,786 km



Cable Physics

- Gravitational force

$$g = -G \cdot M/r^2$$

- Centrifugal force

$$a = \omega^2 \cdot r$$

- The overall

$$g = -G \cdot M/r^2 + \omega^2 \cdot r$$

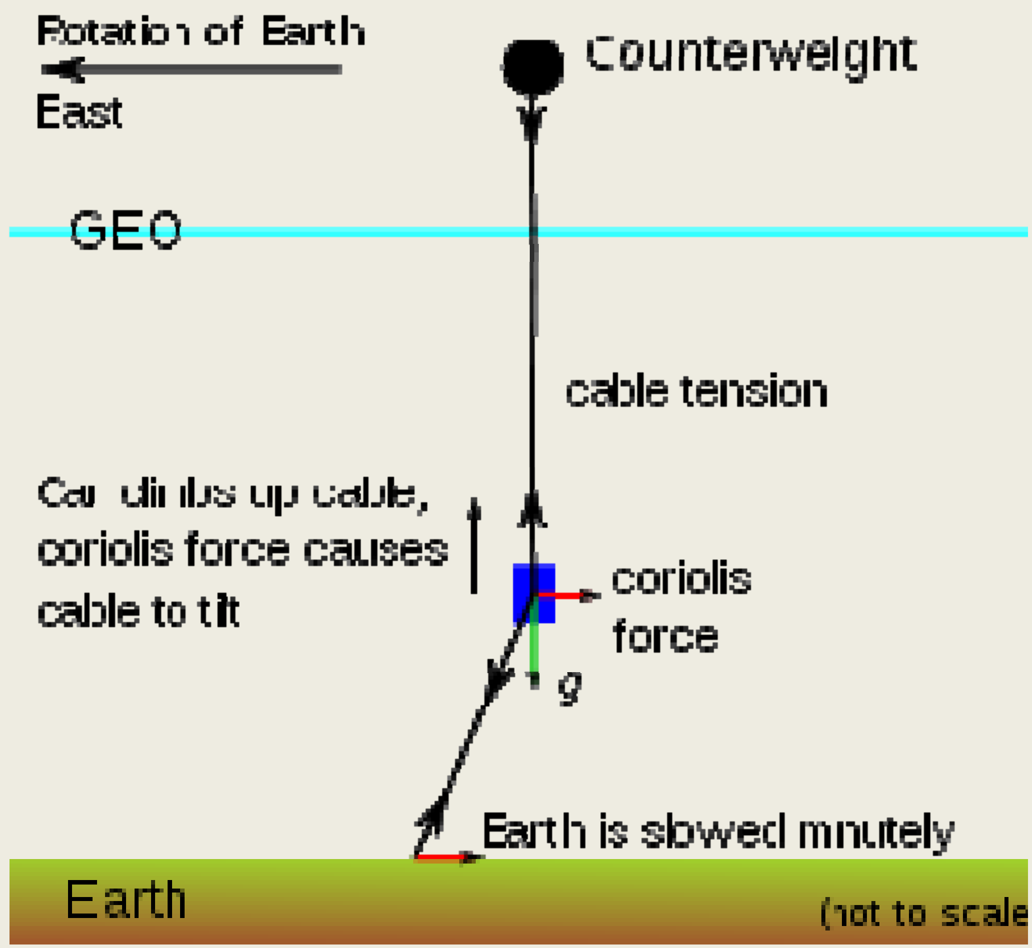
- Solving for g=0 (stationary orbit)

$$r_1 = (G \cdot M/\omega^2)^{1/3}$$

- 35,786 km above the surface

Cable Physics

As the car climbs, the elevator takes on a 1 degree lean, due to the top of the elevator traveling faster than the bottom around the Earth (Coriolis force).



Cable Cross Section

the cross-section will follow this differential equation:

$$\sigma \cdot dS = g \cdot \rho \cdot S \cdot dr,$$

g is the acceleration along the radius (m·s^{-2}),

S is the cross-area of the cable at any given point r, (m^2) and dS its variation (m^2 as well),

ρ is the density of the material used for the cable (kg·m^{-3}).

σ is the stress the cross-section area can bear without yielding (N·m^{-2}=kg·m^{-1}·s^{-2}), its elastic limit.

$$\Delta\left[\ln(S)\right]_{r1}^{r0} = \rho/\sigma \cdot \Delta\left[G \cdot M/r + w^2 \cdot r^2/2\right]_{r1}^{r0},$$

Which gives an exponential dependence

$$\Delta\left[\ln(S)\right] = \rho/\sigma \cdot g_0 \cdot r_0 \cdot (1 + x/2 - 3/2 \cdot x^{1/3}),$$

$$S_0 = S_1 . e^{\rho/\sigma \cdot g_0 \cdot r_0 \cdot (1+x/2-3/2 \cdot x^{1/3})}$$

$$x = \omega^2 \cdot r_0/g_0$$

Cable Cross Section

- g_0 r_0 factor is quite large
  - influence on the maximal cross-section is exponential

- needs material where σ will be large enough to cancel gravity

$g_0 \cdot r_0 = 62.5 \cdot 10^6 \ m^2 s^{-2}$ (or Joules per kg)
$\rho \approx 3 \cdot 10^3 \ kg \ m^{-3}$ for most solid materials, so that σ needs to be:
$\sigma \approx 300 \cdot 10^9 \ kg \ m^{-1} s^{-2}$.

- This corresponds to a cable capable of sustaining 30 tons with a cross-section of one square millimeter

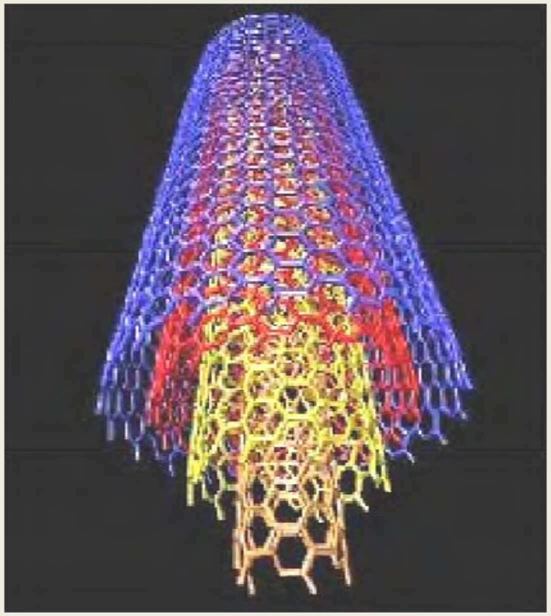
Cable Material

- capable of sustaining a length of 4,960 kilometers of its own weight *at sea level* to reach a geostationary altitude of 35,786 km without tapering and without breaking

Material	Breaking length (sea level)
titanium, steel or aluminum	20–30 km
kevlar, fibreglass	100–400 km
graphene ribbons	5000–6000 km

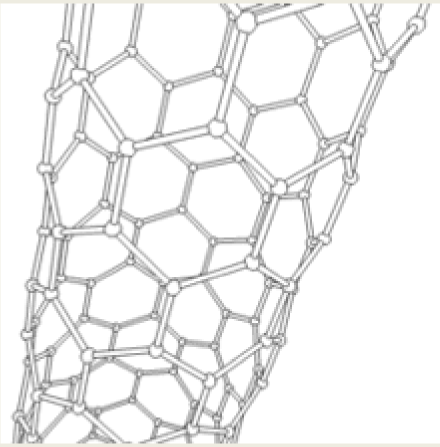
Carbon

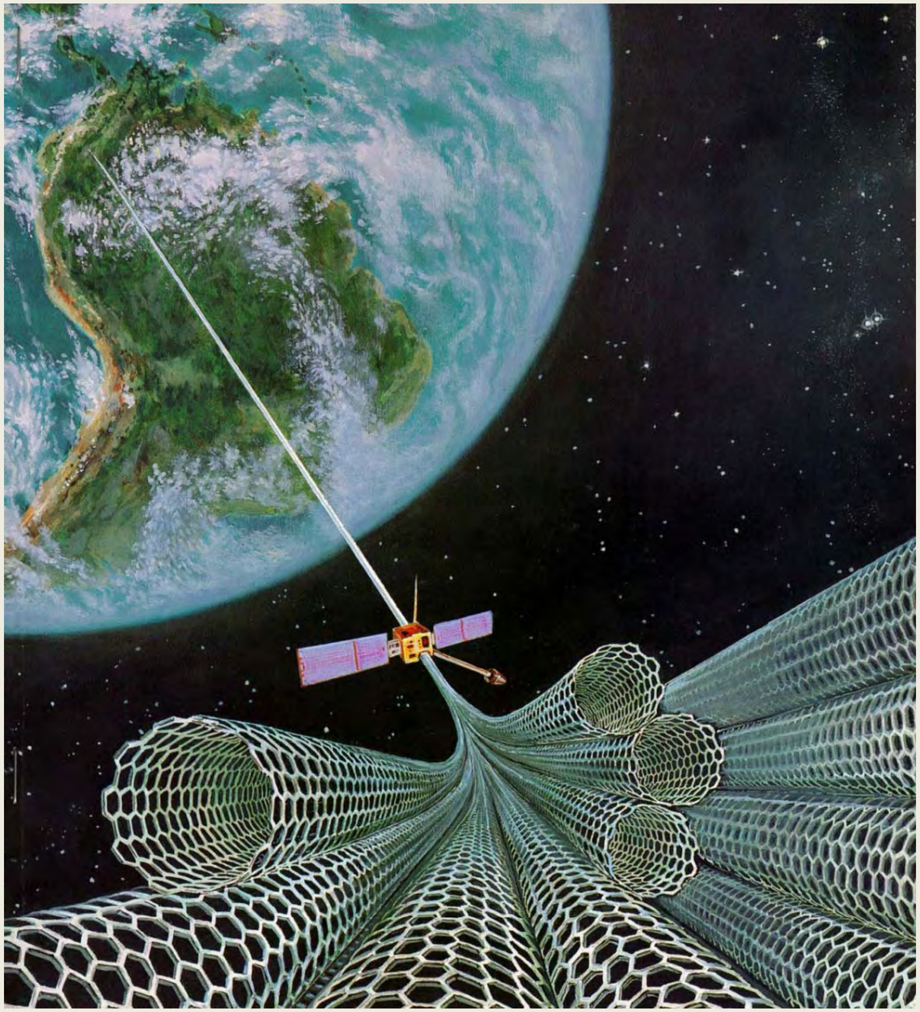
- Is a very light material – 6th in the periodic table
- Does not carry a lot dead weight
- Strong bonding forces



CNT Space Elevator

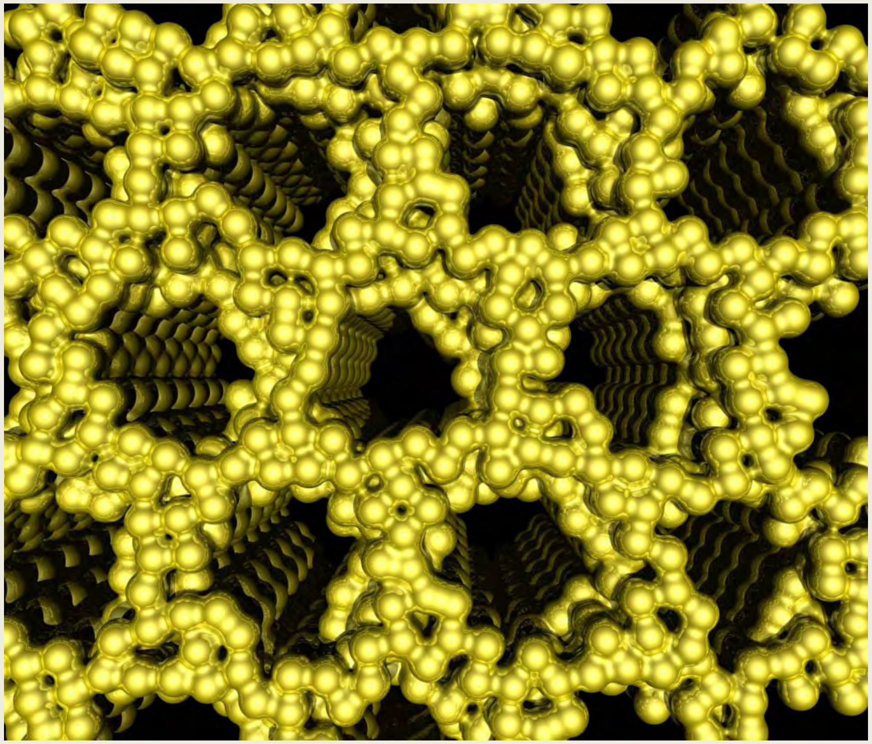
- can span 23,000 miles without failing due to its own weight.
- 100 times stronger than steel.
- Stiffer than any known material
- Conducts heat better than diamond
- Can be a conductor or an insulator without doping.
- Lighter than a feather.

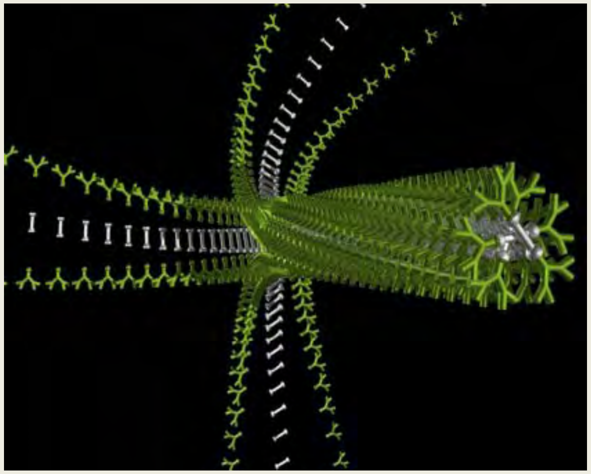




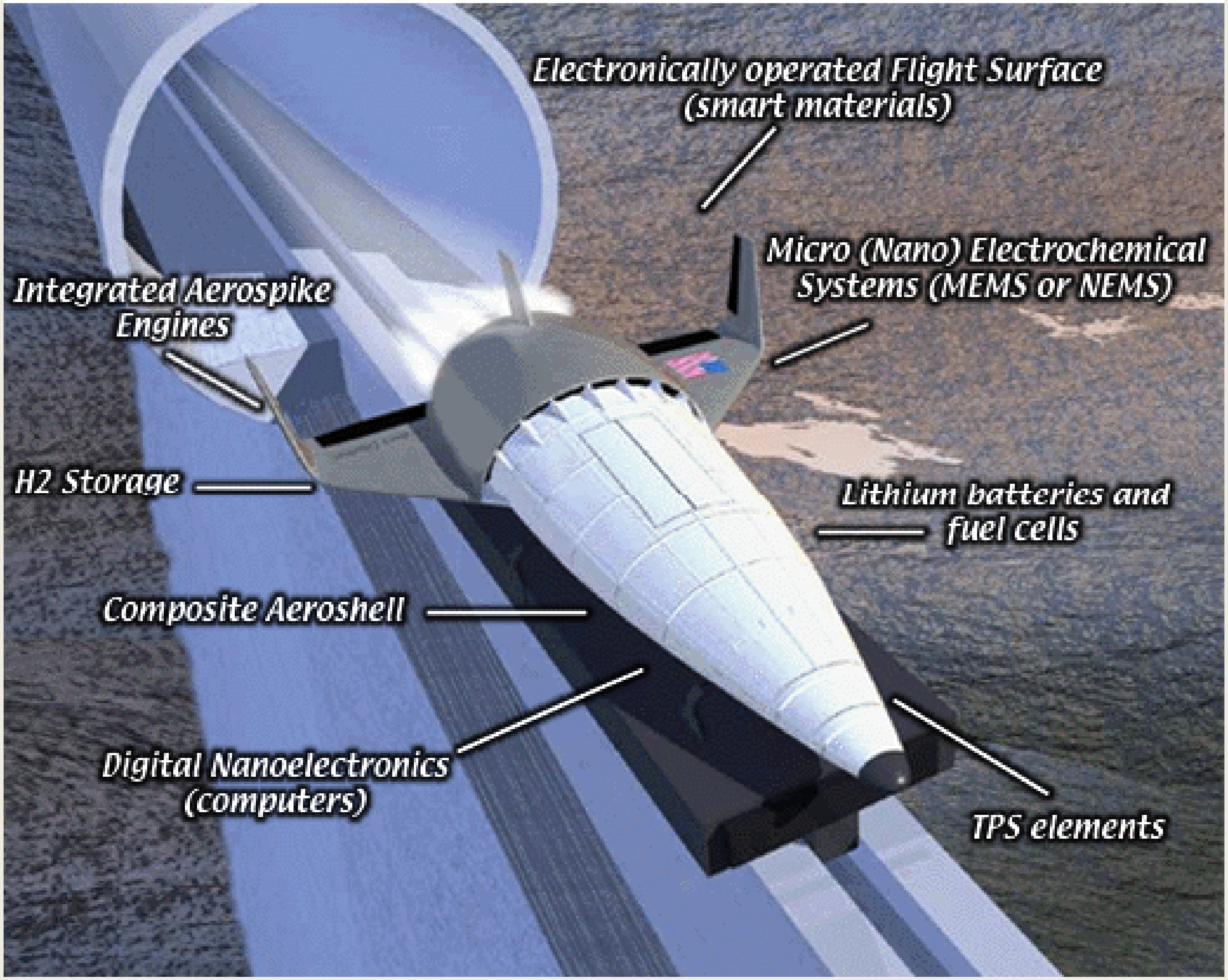
Construction

- Self Assembly
- Top – Down
- Bottom – Up
- Defect Free





Faster, Better, Cheaper Space Transportation with Nanotubes



Blink and you'll miss it. Don't blink, and you'll still miss it.

Hamza Qayyum
TIGP-MST (Physics)

SCIENTIFIC AMERICAN™

Berkeley Laser Fires Pulses Hundreds of Times More Powerful Than All the World's Electric Plants Combined

By John Matson | August 1, 2012 | 9

Share Email Print

BELLA laser. Credit: Roy Kaltschmidt, Lawrence Berkeley National Laboratory

Peak Power = 1 Petawatt (10^{15})

Peak Intensity = 10^{22} J/cm^2

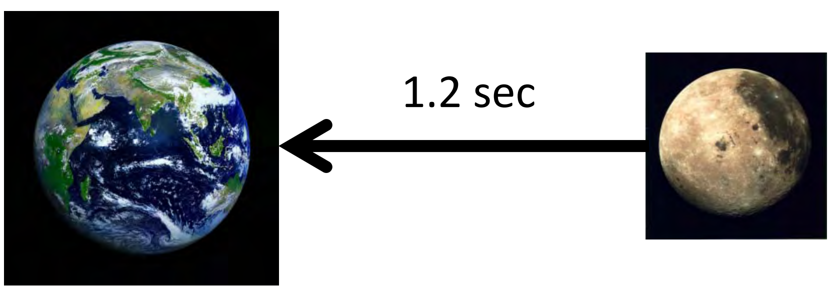
laser at Lawrence Berkeley National Laboratory was put through its paces July 20, delivering pulses with a petawatt of power once per second. A

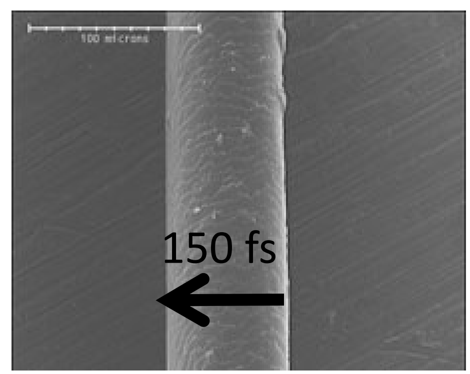
- $P = \frac{Energy}{Time}$

Energy → Only 40 J

Time → Pulse duration 40 femtosecond (10^{-15})

- **A 40 femtoseconds laser pulse is same fraction of one minute that one minute is of age of universe.**

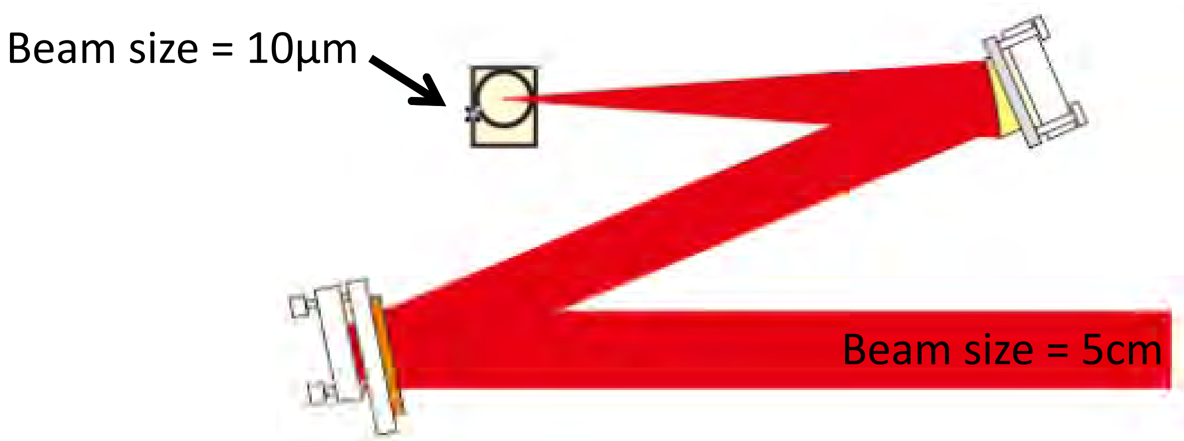




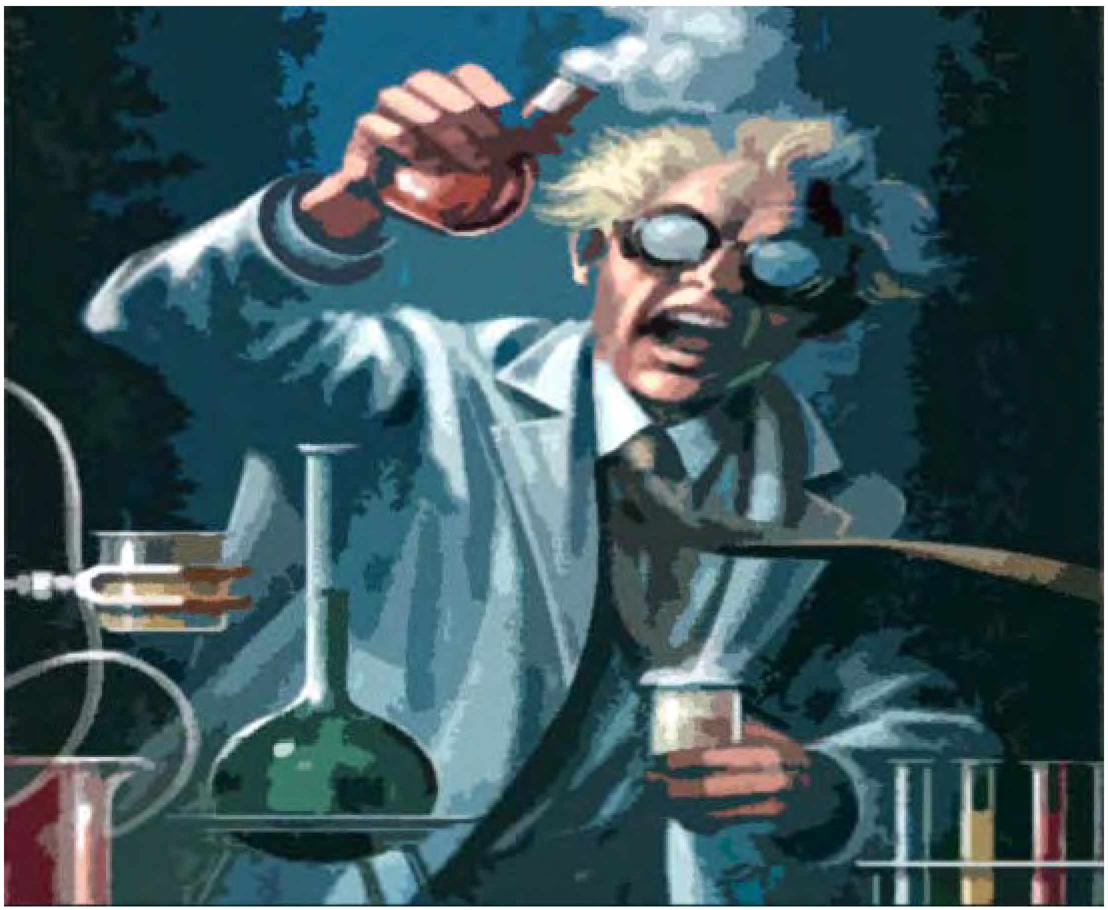
- $$I_{peak} = \frac{E}{\Delta t A}$$

Beam Area

- Increase the energy (E)
- Decrease the duration (Δt)
- Decrease the area of the focus (A)

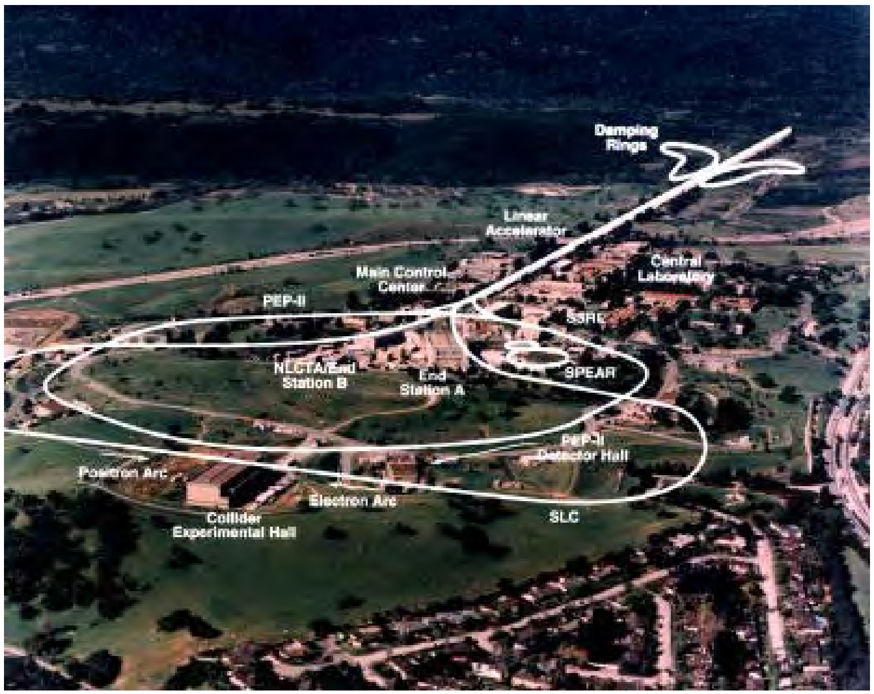


Is it worth or just an idea of some crazy scientist



Particle accelerators

<u>Stanford Linear accelerator</u>



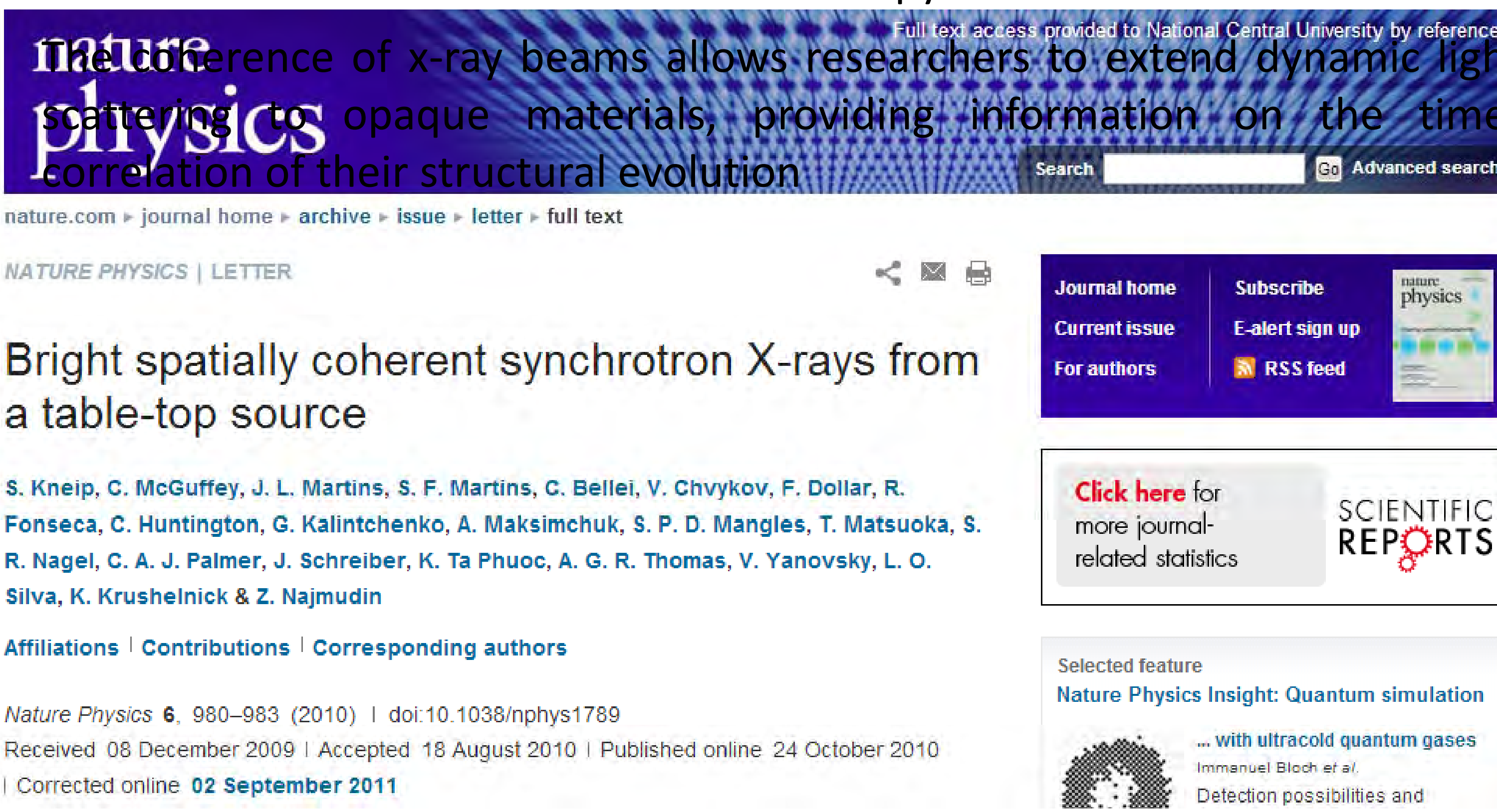
SIZE: 3.2 Km
Energy: 50GeV (limit)

Wim leemans from Berkeley
Holding particle accelerator

SIZE: 1 cm
Energy: 1GeV

Synchrotron Radiation

- Synchrotron radiation techniques allow a refinement in the non-destructive characterization of these materials
- The coherence of synchrotron X-ray beam allows an easy use of phase sensitive techniques. Phase imaging, combined with three dimensional reconstruction achieves ‘lenseless’ microscopy
- The coherence of x-ray beams allows researchers to extend dynamic light scattering to opaque materials, providing information on the time-correlation of their structural evolution


nature physics

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NATURE PHYSICS | LETTER

Bright spatially coherent synchrotron X-rays from a table-top source

S. Kneip, C. McGuffey, J. L. Martins, S. F. Martins, C. Bellei, V. Chvykov, F. Dollar, R. Fonseca, C. Huntington, G. Kalintchenko, A. Maksimchuk, S. P. D. Mangles, T. Matsuoka, S. R. Nagel, C. A. J. Palmer, J. Schreiber, K. Ta Phuoc, A. G. R. Thomas, V. Yanovsky, L. O. Silva, K. Krushelnick & Z. Najmudin

Affiliations | Contributions | Corresponding authors

Nature Physics 6, 980–983 (2010) | doi:10.1038/nphys1789
Received 08 December 2009 | Accepted 18 August 2010 | Published online 24 October 2010 | Corrected online 02 September 2011

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Selected feature
Nature Physics Insight: Quantum simulation
... with ultracold quantum gases
Immanuel Bloch et al.
Detection possibilities and

日本語要約

Controlling dielectrics with the electric field of light

Martin Schultze, Elisabeth M. Bothschafter, Annkatrin Sommer, Simon Holzner, Wolfgang Schweinberger, Markus Fiess, Michael Hofstetter, Reinhard Kienberger, Vadym Apalkov, Vladislav S. Yakovlev, Mark I. Stockman & Ferenc Krausz

Affiliations | Contributions | Corresponding authors

Nature **493**, 75–78 (03 January 2013) | doi:10.1038/nature11720
Received 20 December 2011 | Accepted 24 October 2012 | Published online 05 December 2012

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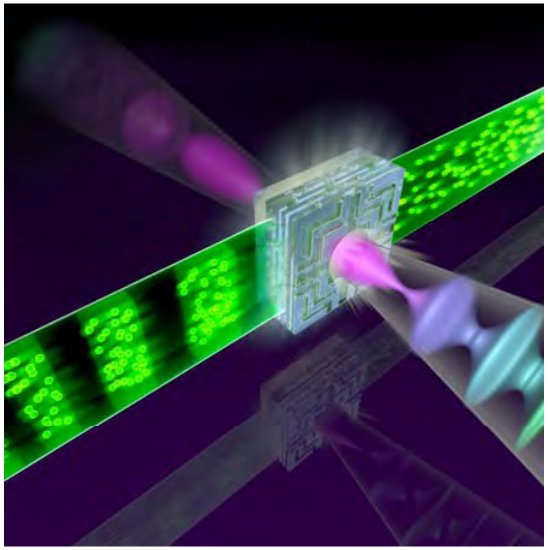

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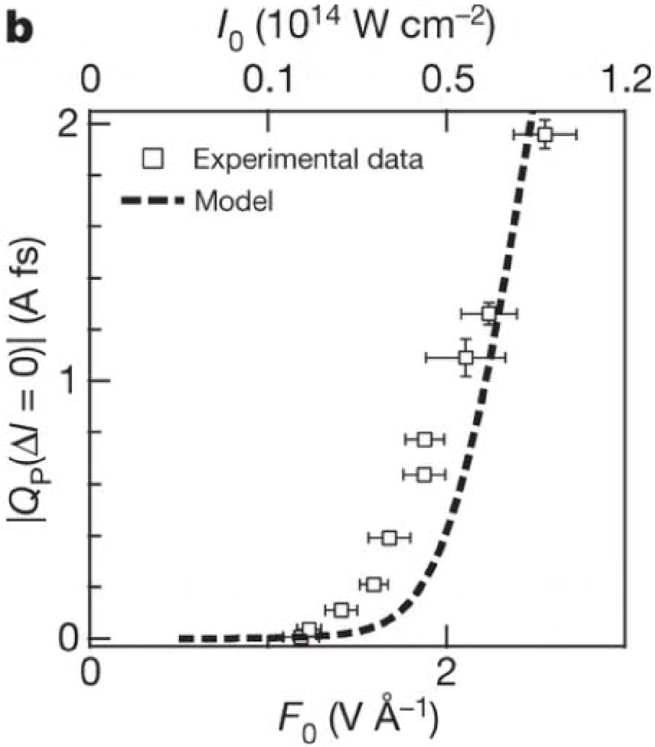
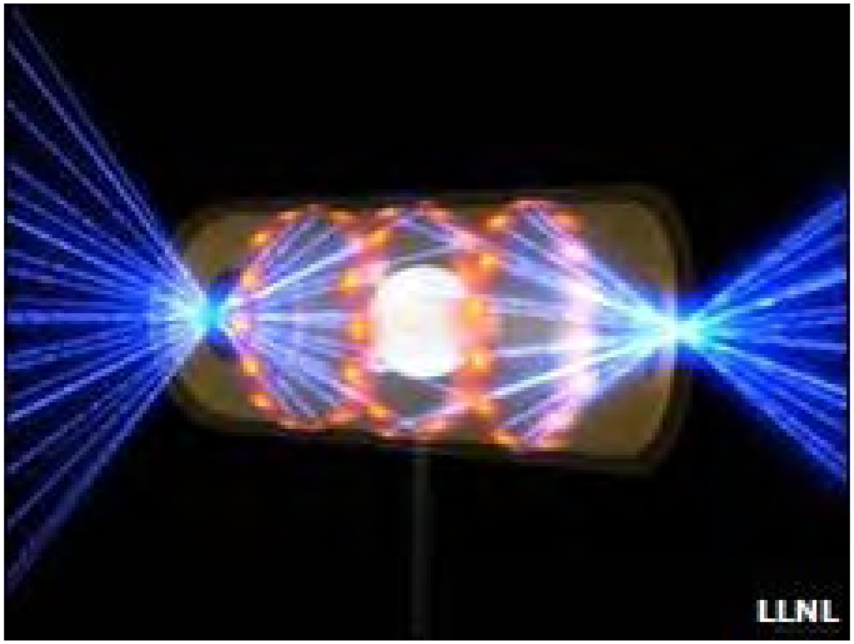
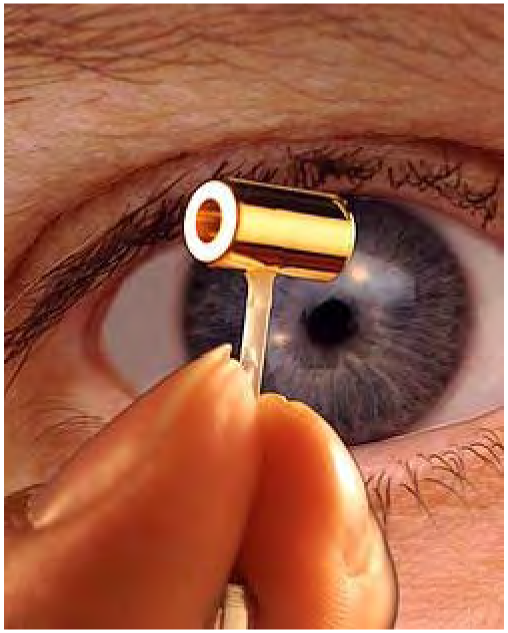


Nuclear Fusion





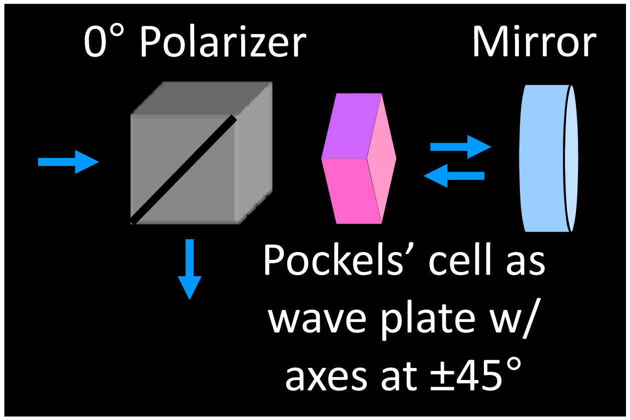
- 1 Gallon can generate energy equivalent to 800 gallon of gasoline

Thank You for your patience

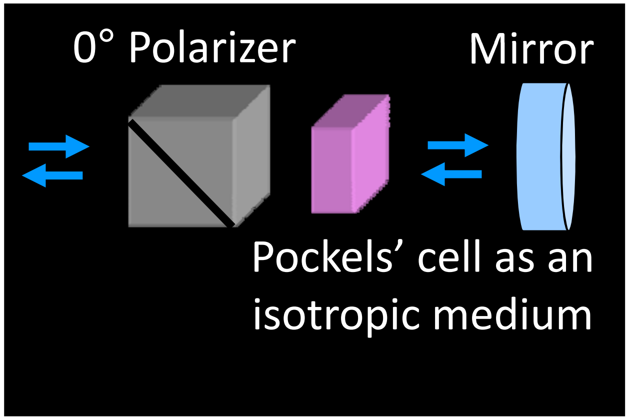
How to generate such short pulses??????

- Q-Switching

Before switching



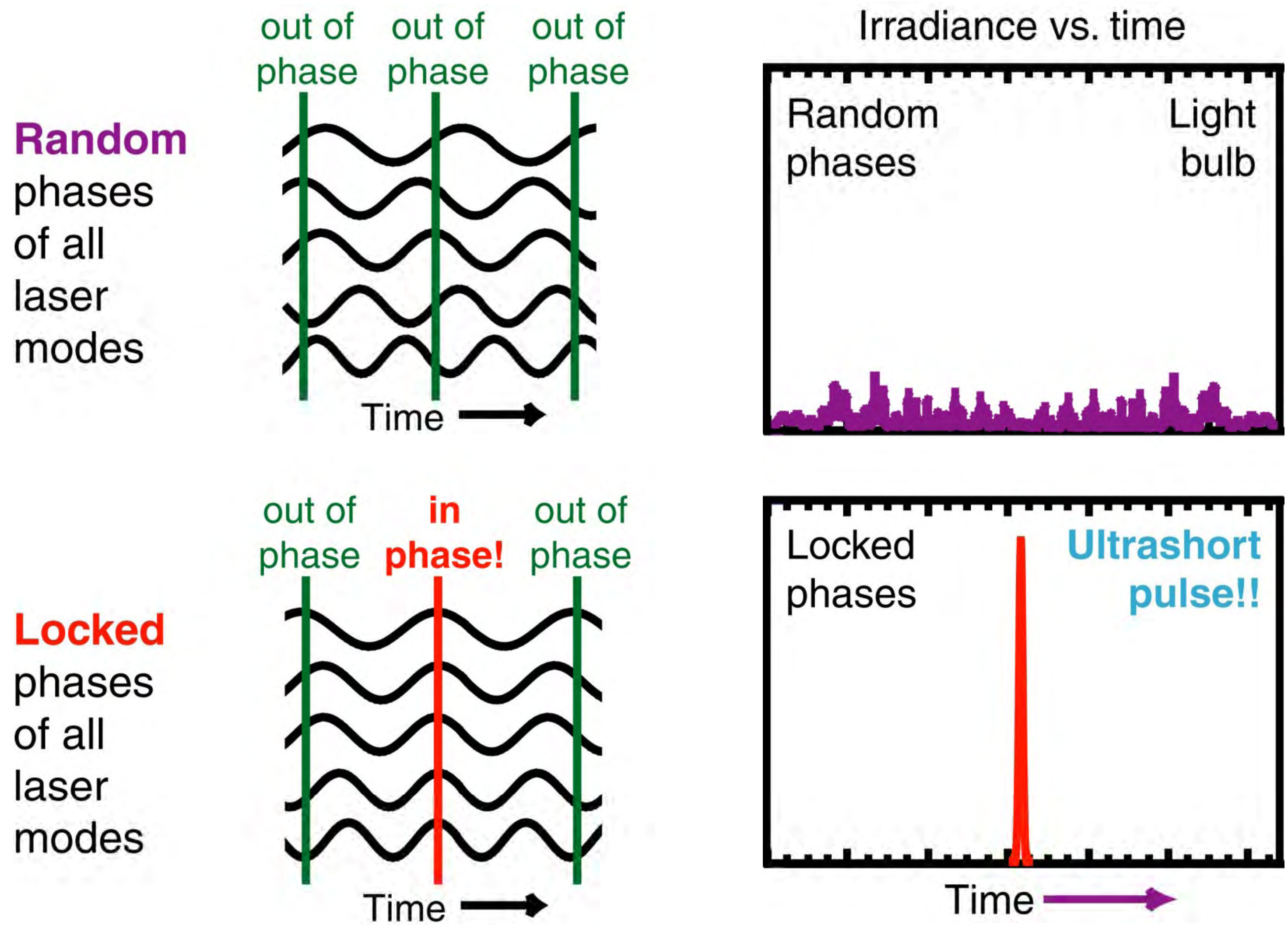
After switching



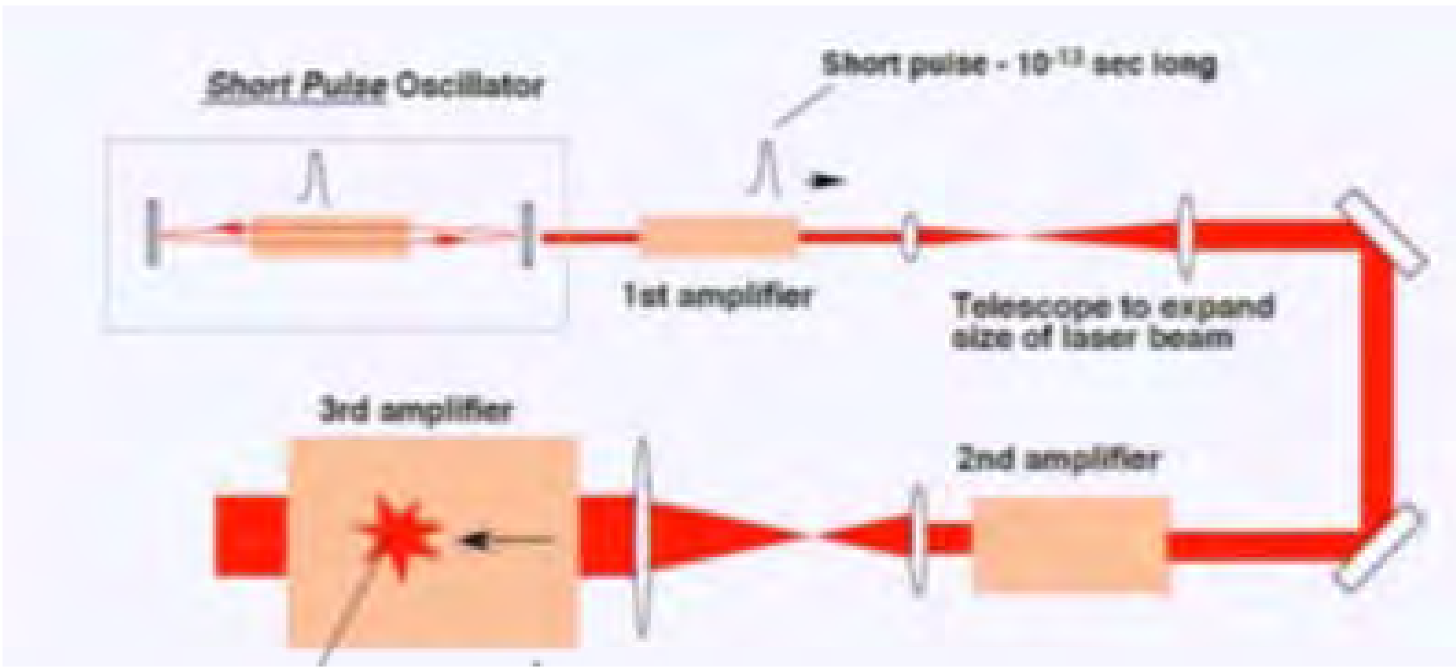
Light becomes circular on the first pass and then horizontal on the next and is then rejected by the polarizer.

Light is unaffected by the Pockels' cell and hence is passed by the polarizer.

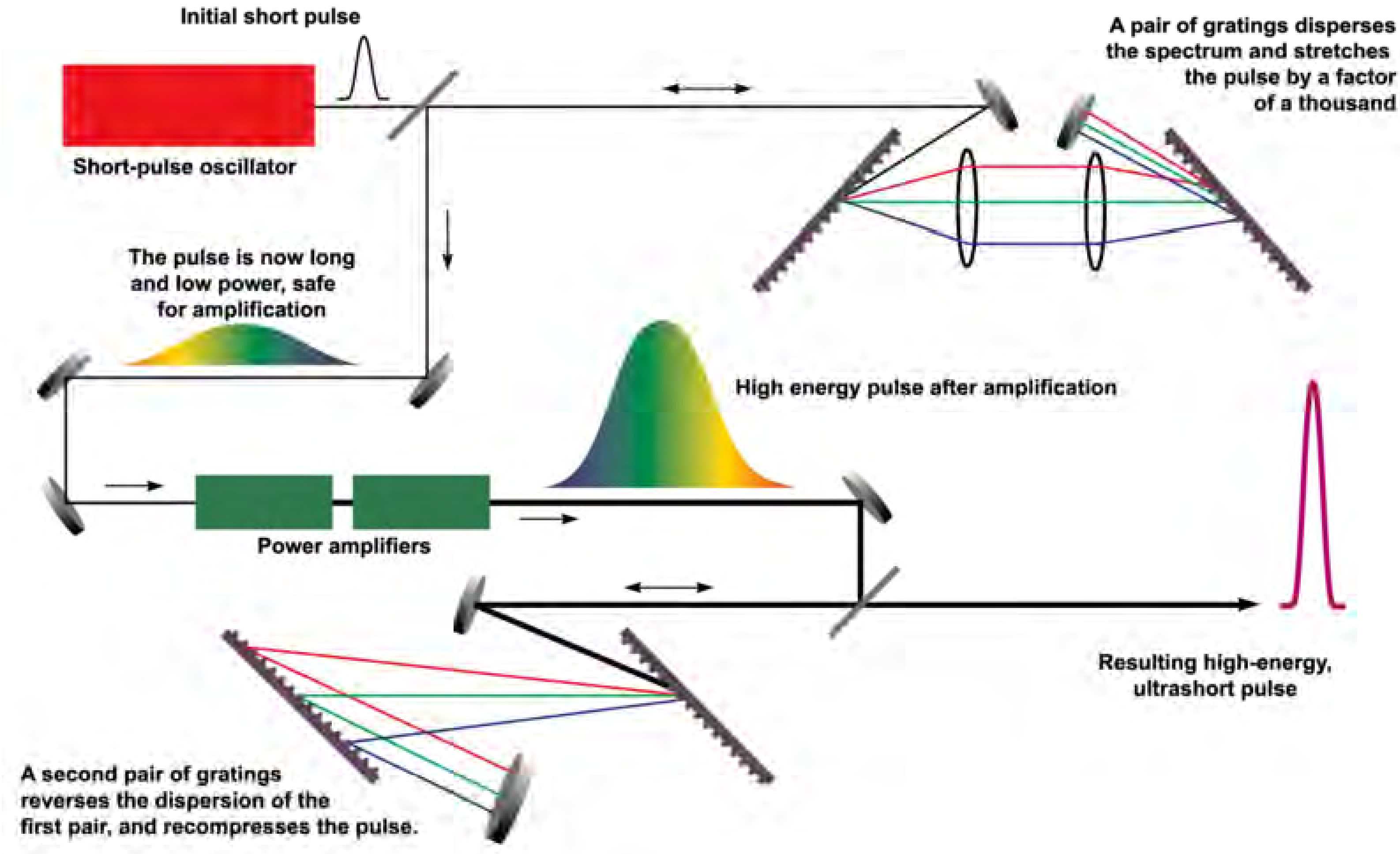
- Mode Locking



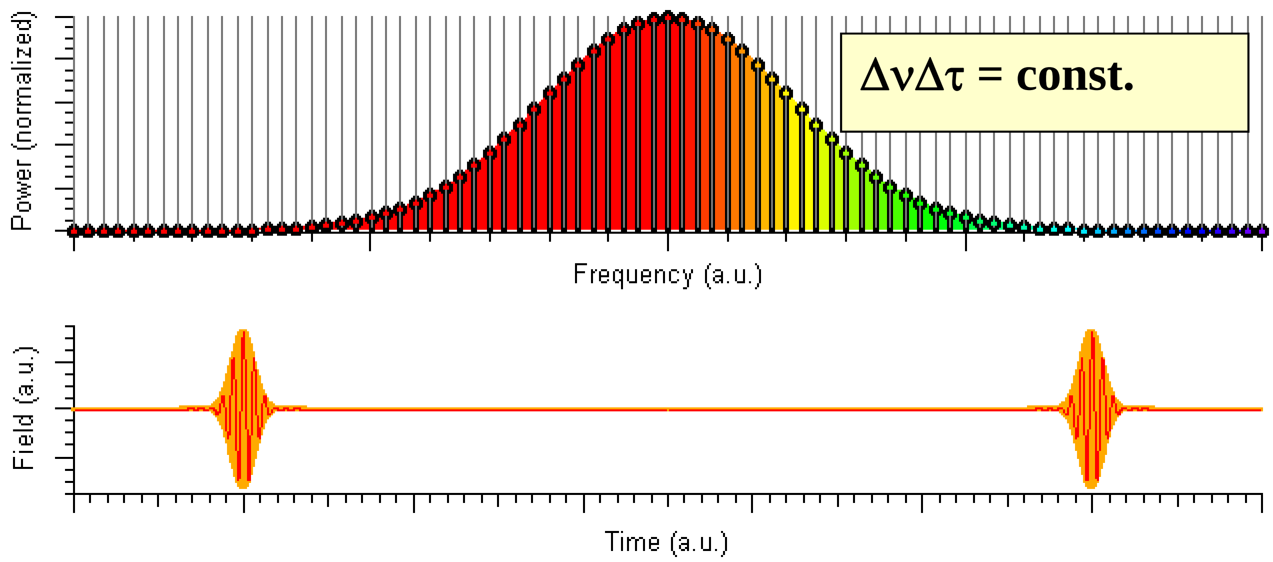
Master Oscillator Power Amplifier

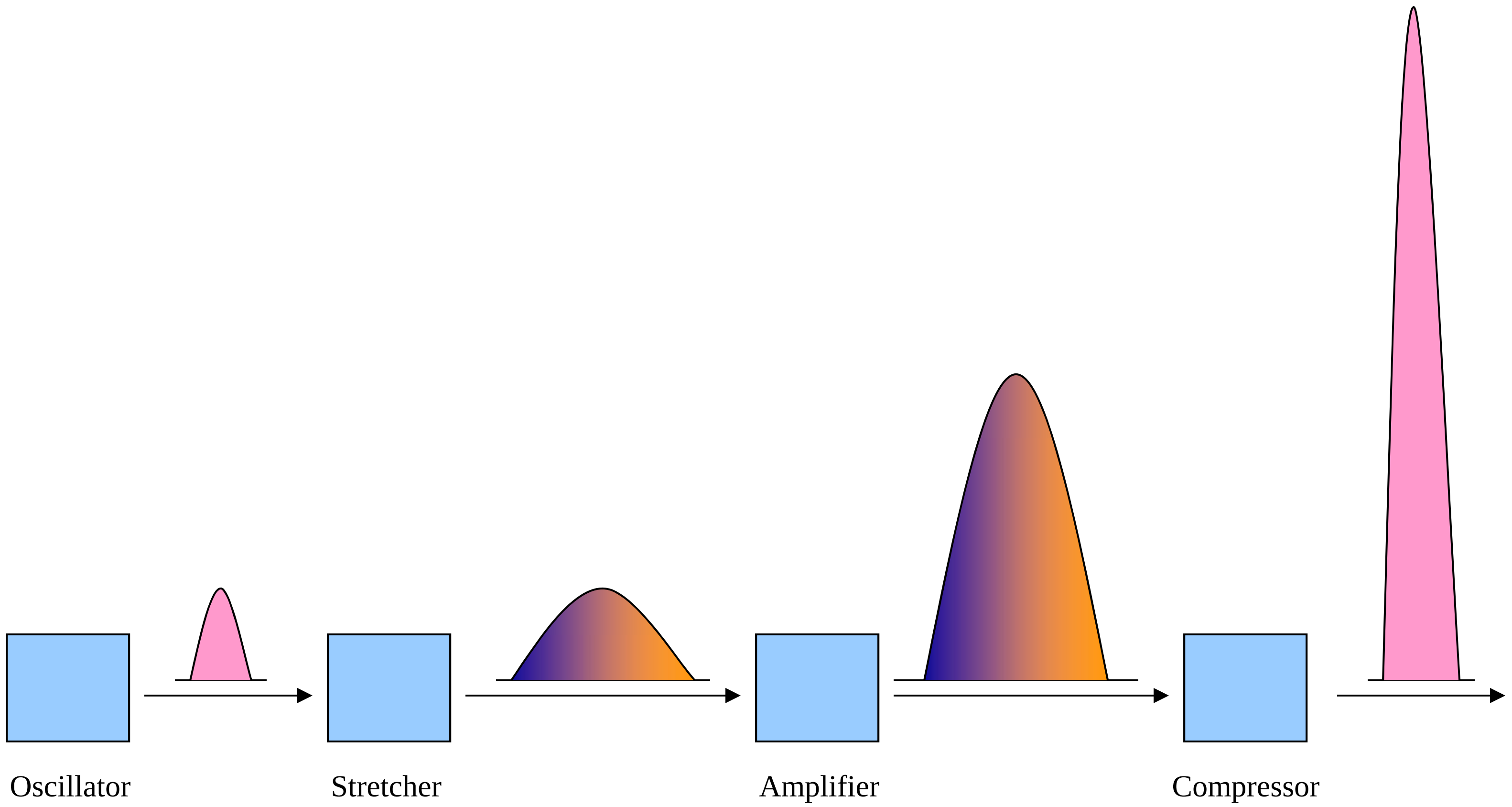


Chirped Pulse Amplification

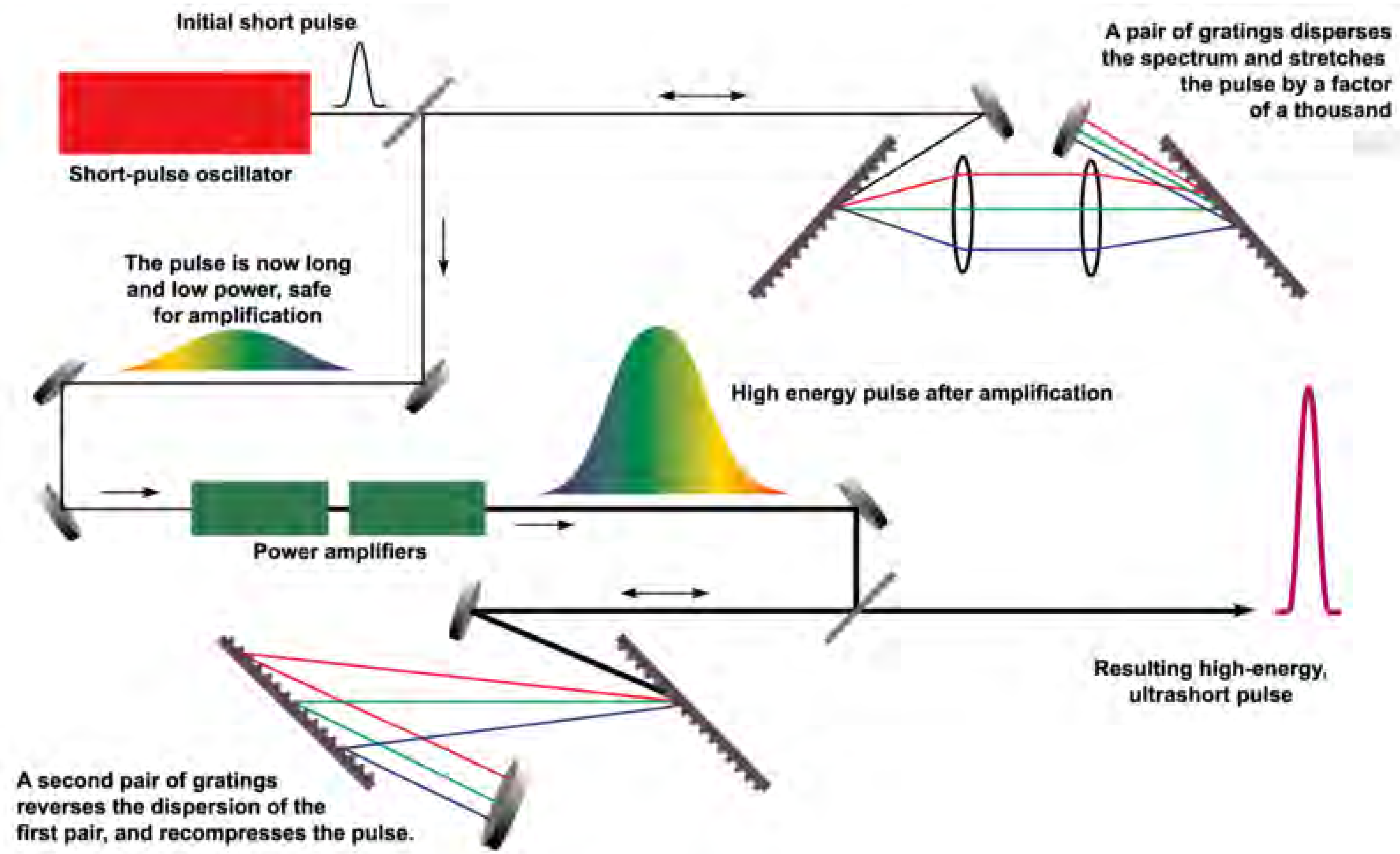


Bandwidth vs Pulsewidth




Oscillator
Stretcher
Amplifier
Compressor

CPA


Initial short pulse
A pair of gratings disperses the spectrum and stretches the pulse by a factor of a thousand
Short-pulse oscillator
The pulse is now long and low power, safe for amplification
High energy pulse after amplification
Power amplifiers
Resulting high-energy, ultrashort pulse
A second pair of gratings reverses the dispersion of the first pair, and recompresses the pulse.

Applications

- Fusion reaction
- High intensity radiation sources
- Particle accelerators
- High energy physics

eli | beamlines

About

The project Extreme Light Infrastructure (ELI) is part of a European plan to build a new generation of large research facilities selected by the European Strategy Forum for Research Infrastructures (ESFRI).

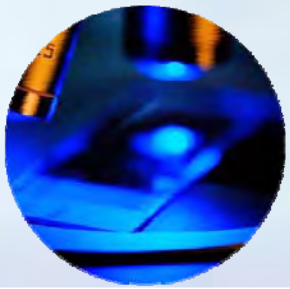
10 times more intense than others

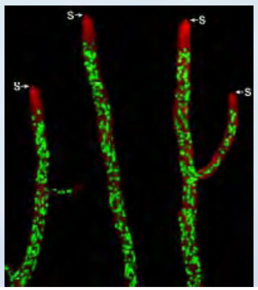
The main goal of ELI consists in creating the latest laser equipment in the world. There will be accomplished and implemented research projects covering the interaction of light with matter at intensity being 10 times higher than currently achievable values. ELI will provide ultra-short laser pulses of a few femtoseconds (10-15 fs) duration and give performance up to 10 PW.

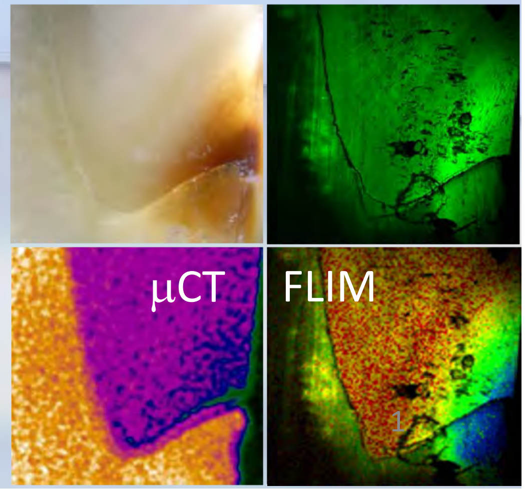
Introduction to Nanotechnology
A novel tool for molecular biology

Speaker: Yen-Chun Lin

H. Hosseinkhani







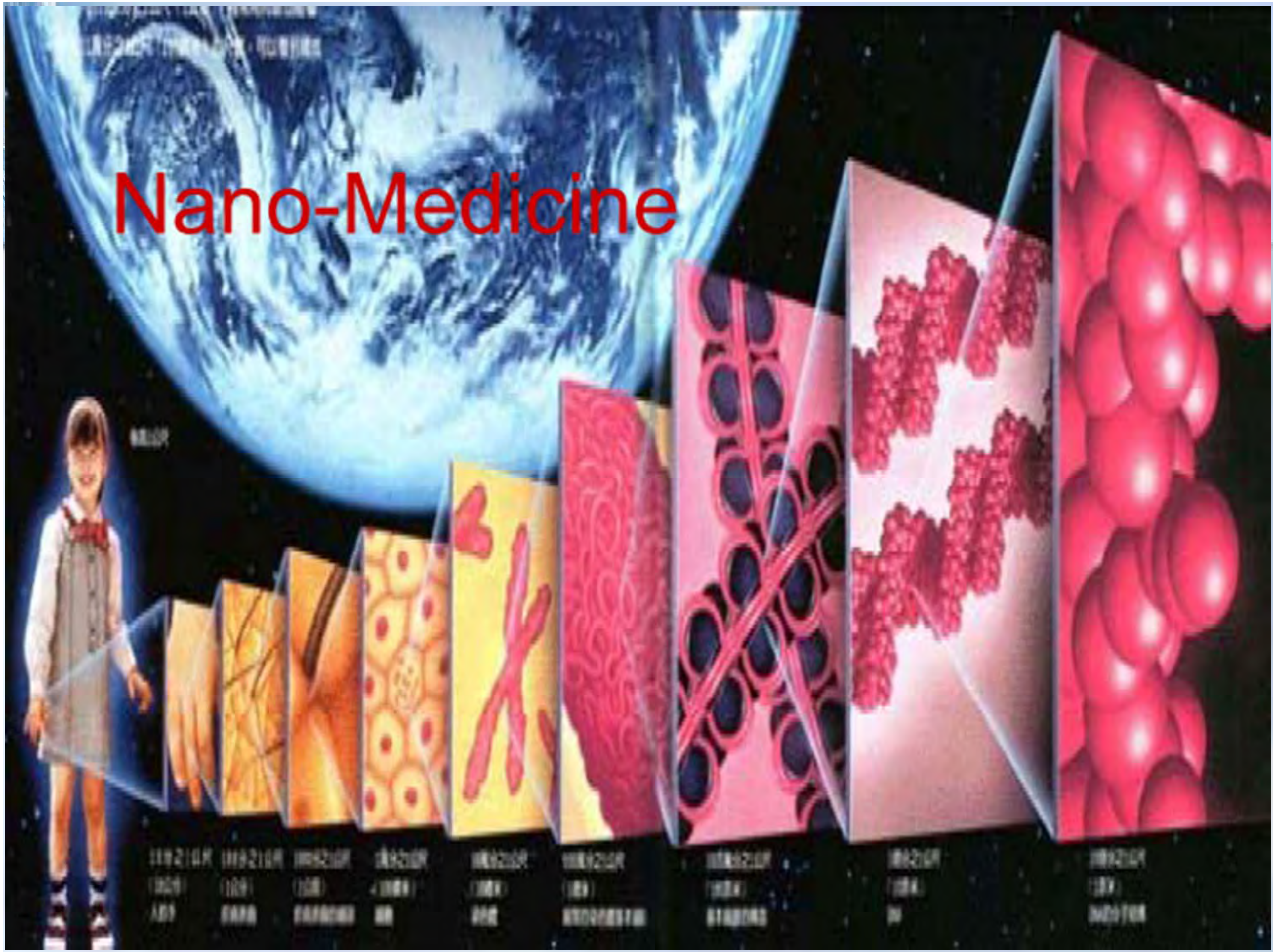
Outline

Introduction

- Motivation
- FLIM
- SHG

Part II

Application


Nano-Medicine

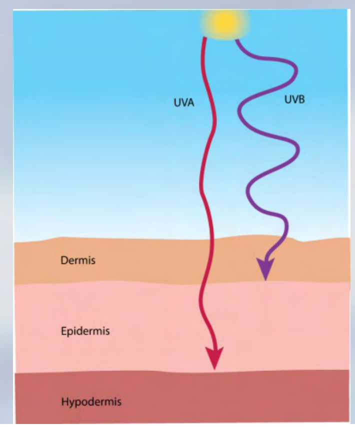
Motivation

Wound Healing

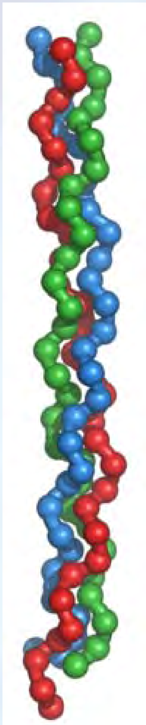
Applications	Wavelength (nm)	No. of Treatments	Irradiance (mW/cm^2)	Fluence (J/cm^2)	Treatment Time (min;sec)	Interval Treatment Time (hours)	Mode (Pulsed/CW)
Wound healing	660 & 850 combination	3-12	50 (minimal)	4	2:40	24-72	Sequential pulsing**

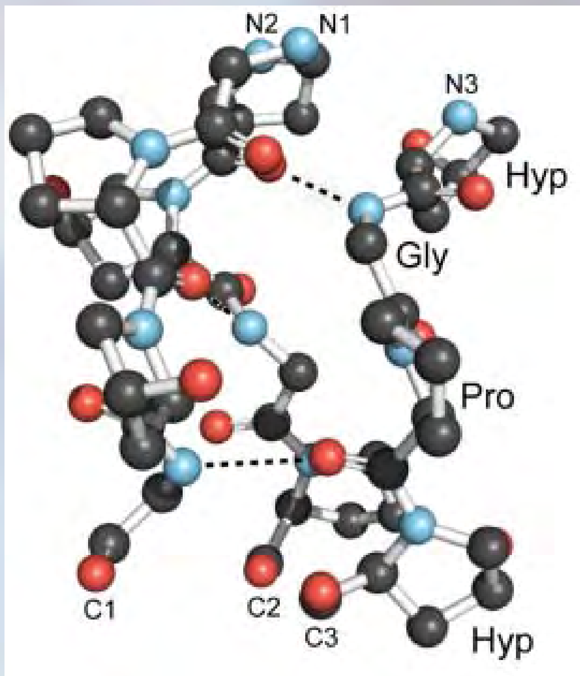
Introduction

- Collagen is the most abundant protein in human body.
- The most prevalent and widely used as a biomaterial collagen is type I collagen.
- UV radiation is widely application in biomedical and investigated in biomaterial.



Collagen



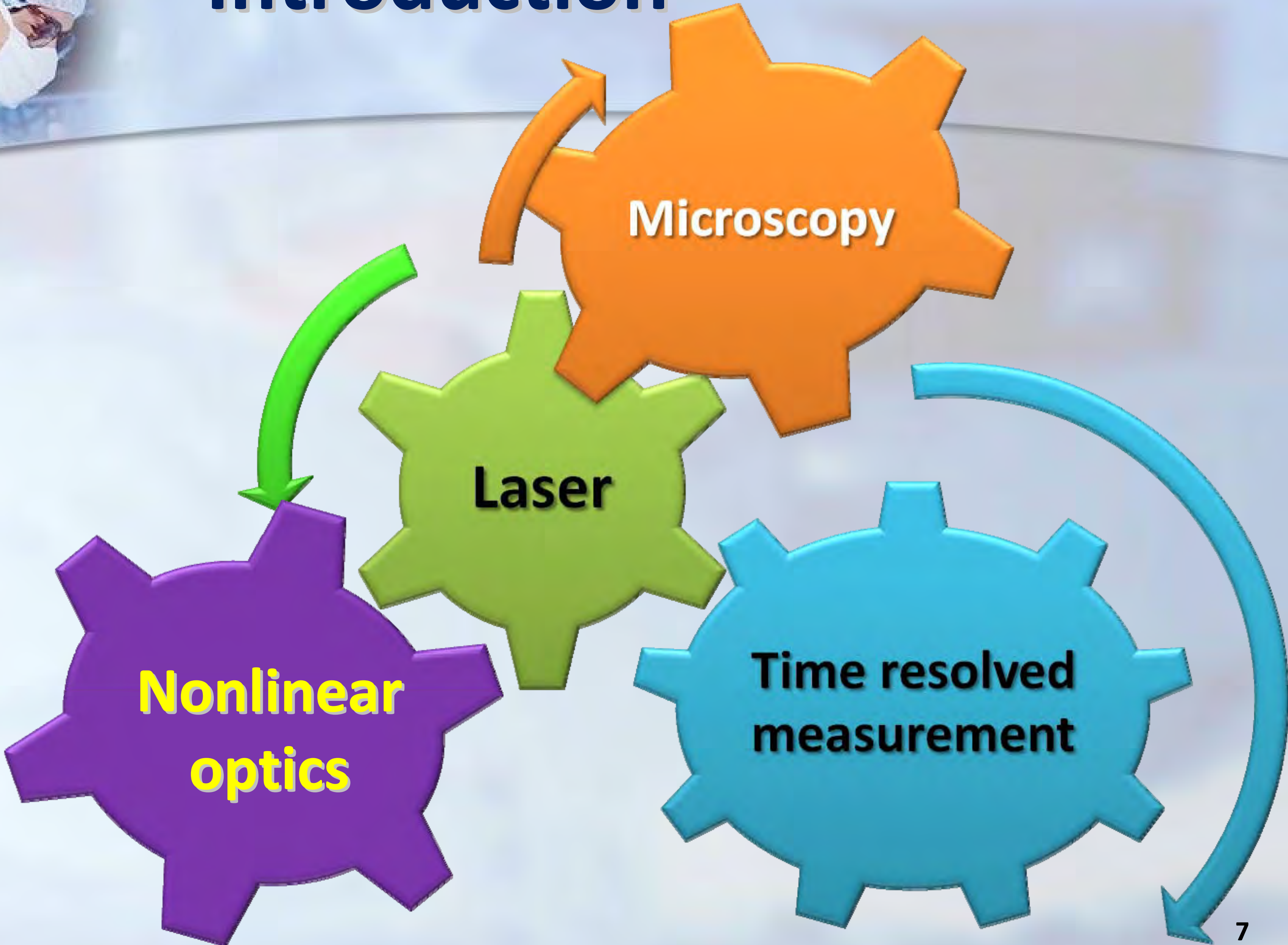


- Triple-helical structure

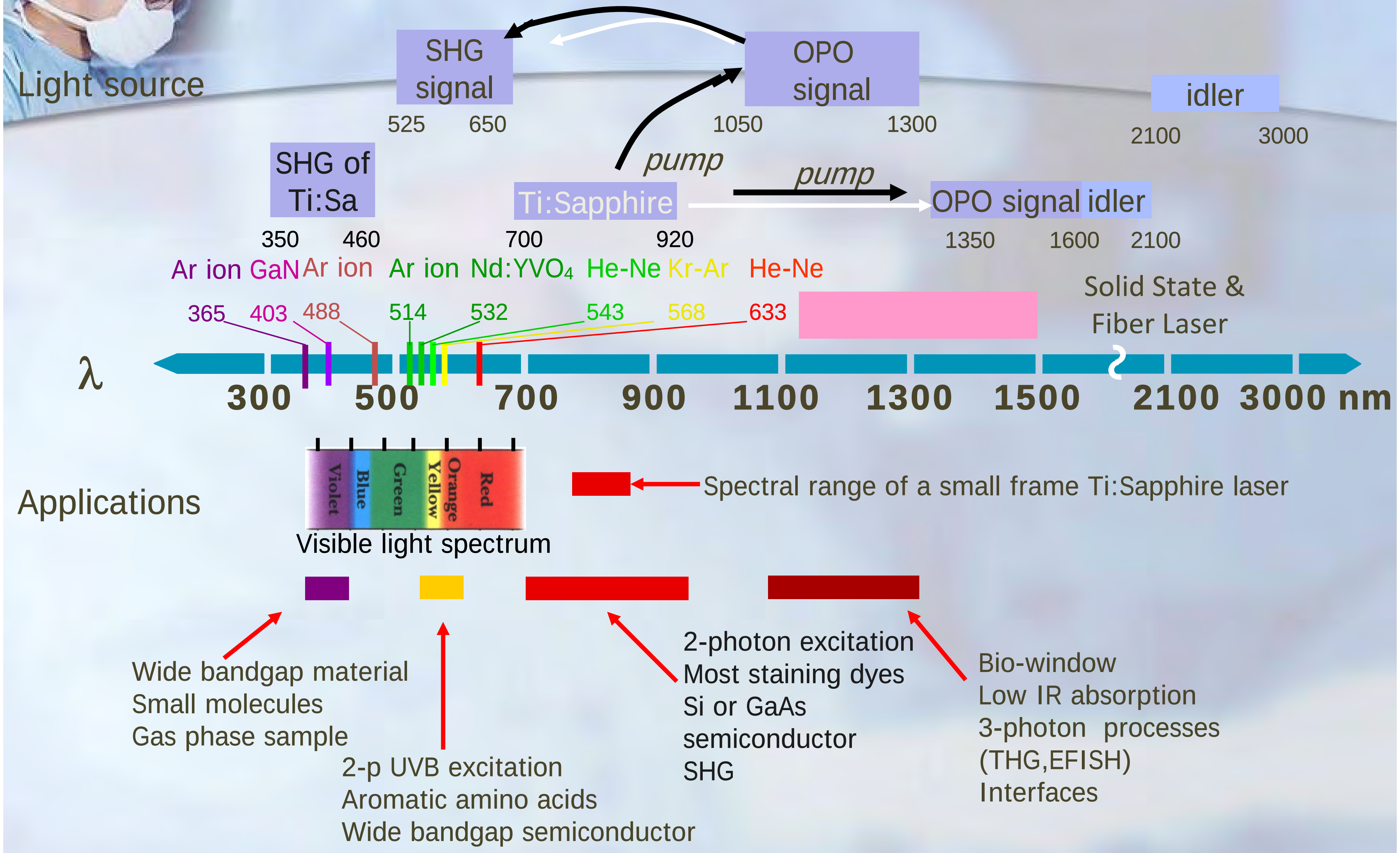
$$(G - X - Y)_n$$

$$(Gly - Pro - Hyp)_n$$

Introduction

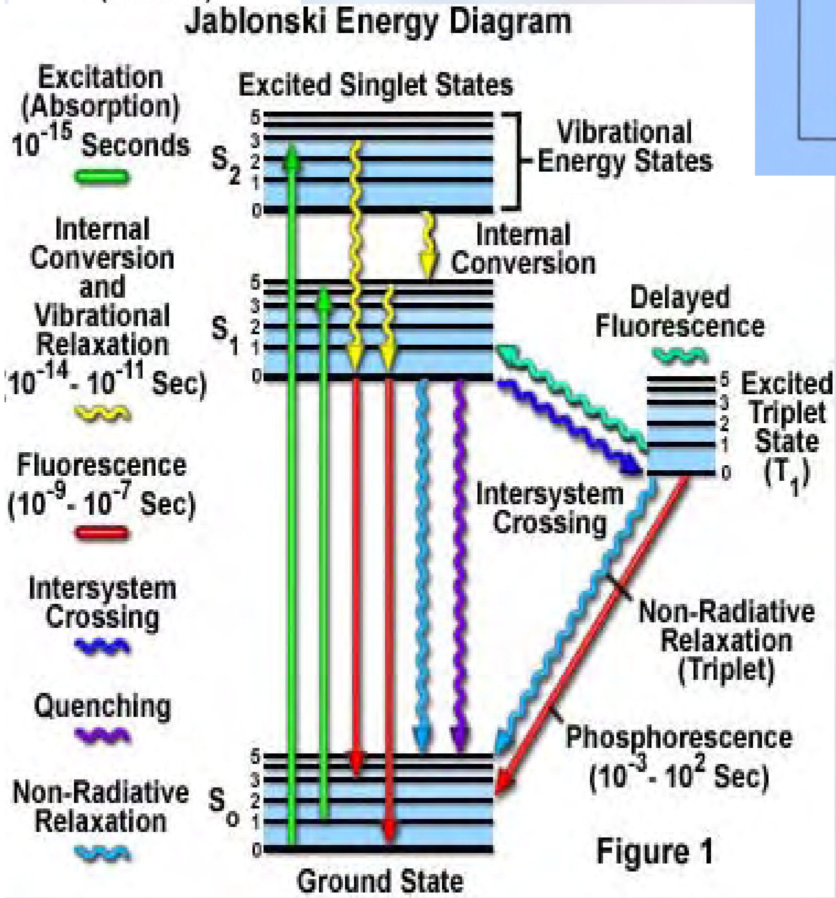


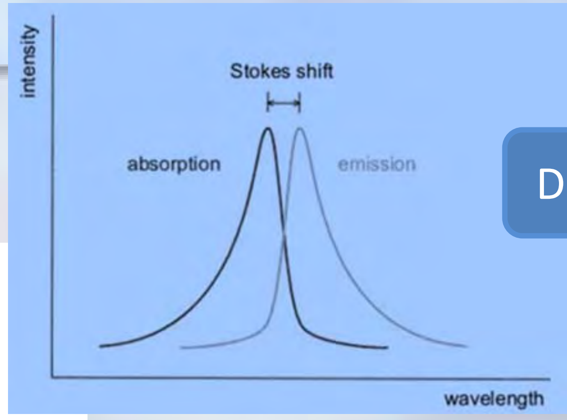
Light Sources for Laser Scanning Microscopy

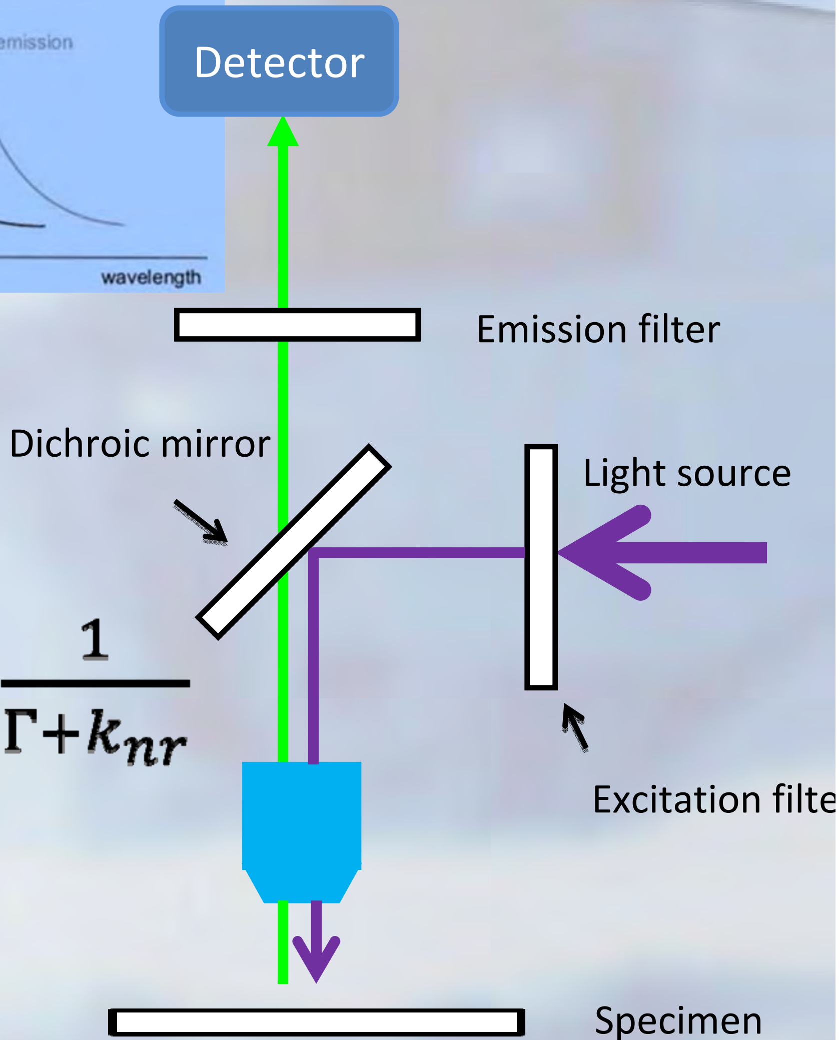


Characteristic of Fluorescence

Alexander Jablonski (1898-1980)



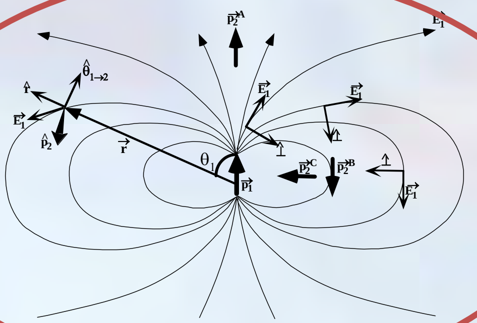




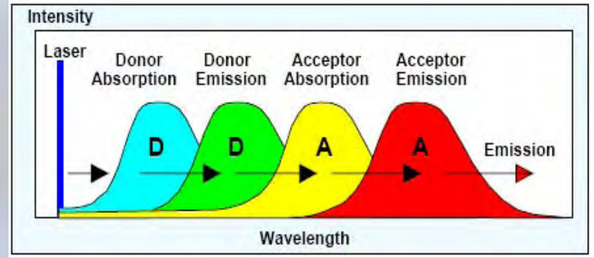
- $$\tau = \frac{1}{\Gamma + k_{nr}}$$

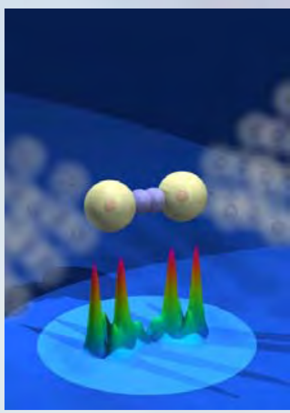
- J.R. Lakowicz, et al. JBO 13 (2008) .

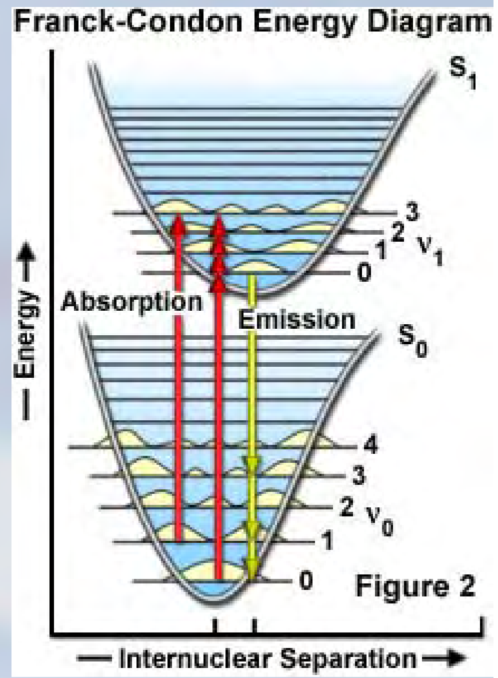
Starting with Molecular States



$$k_T = \frac{1}{\tau_{r_D}}\left(\frac{R_0}{R}\right)^6$$

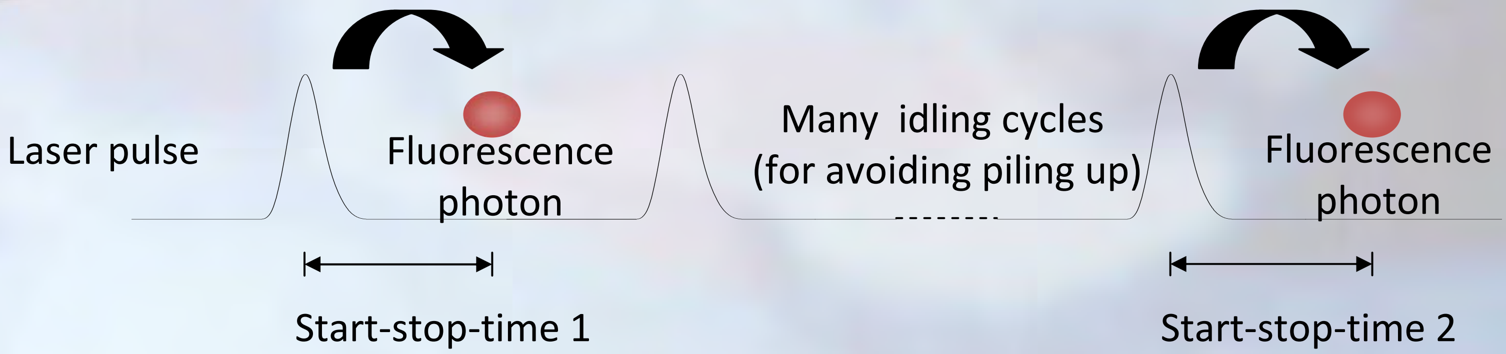




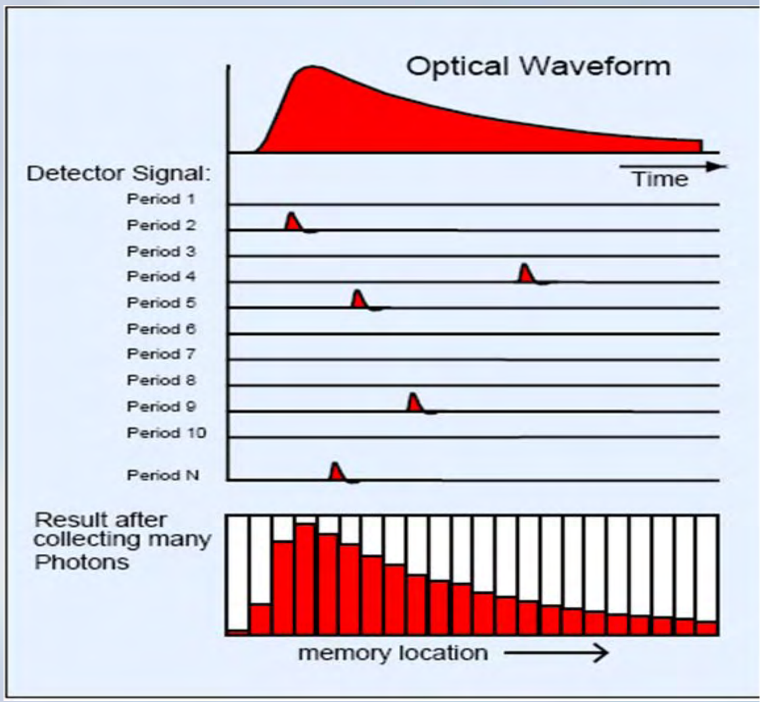


$\kappa^2 \approx 2/3$ κ : orientation factor

Time Correlated Single Photon Counting (TCSPC)

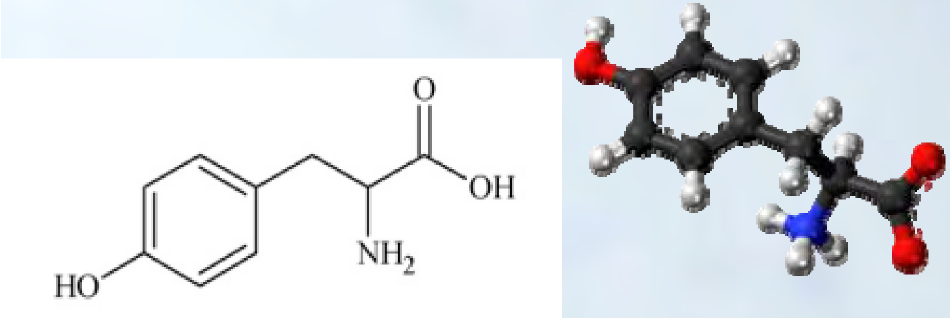


- $I(t) = I_0 e^{-t/\tau}$
- $F(t) = \sum_{i=1}^{n} a_i e^{-t/\tau_i}$
- $\tau_{int} = \frac{\sum_j Ampl_j \times \tau_j^2}{\sum_j Ampl_j \times \tau_j}$



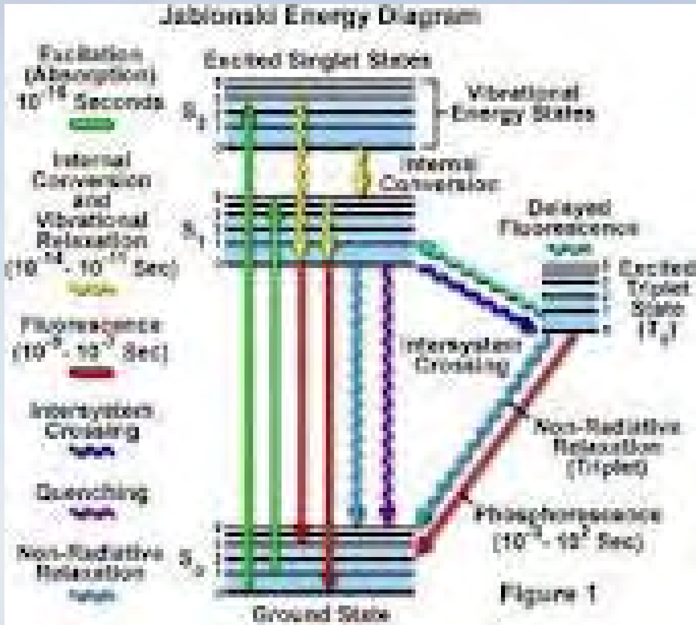
Optical Method for Collagen

- **Autofluorescence**
  - Tyrosin is a aromatic amino acid and is major chromophore of collagen
  - It is capable to absorb UV light.



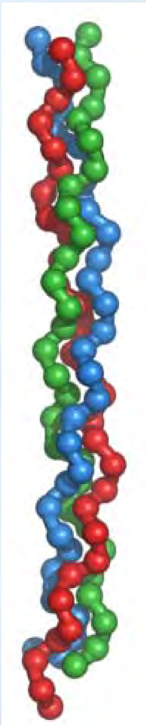
phenoxyl of tyrosine

- **Fluorescence lifetime**
  - Lifetime τ :sensitive to nano-physical and chemical environments



Optical Method for Collagen

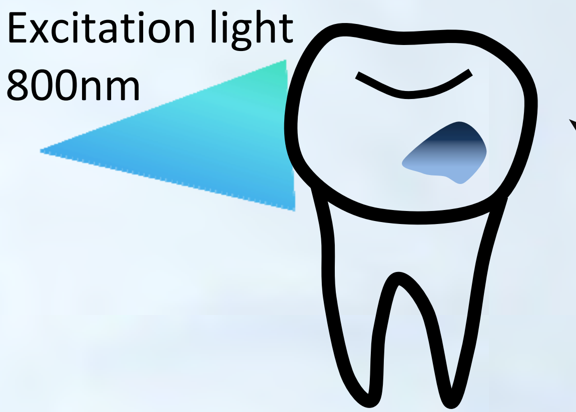
- **SHG (second harmonic generation)**
  - Nonlinear optical process

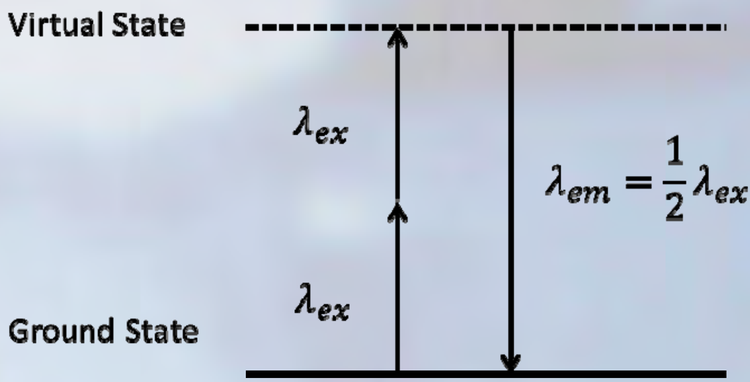


- SHG is sensitive to the structure and arrangement of the molecules that produces the signal.
- SHG suffer no inherent photobleaching or toxicity .

SHG and collagen

- **Non-linear optical signals →** SHG, THG…
- **The most organic matrix of dentin is collagen.**





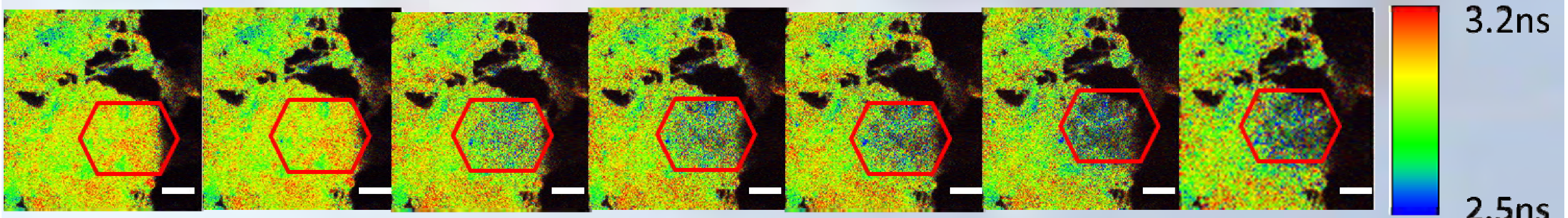
$$P = \varepsilon_0 \chi^{(1)} E^1 + \varepsilon_0 \chi^{(2)} E^2 + \varepsilon_0 \chi^{(3)} E^3 + \cdots$$

$$P_i^{(2)} = \sum_{j,k} \varepsilon_0 \chi_{ijk}^{(2)} \; E_j E_k$$

- ◆ SHG is sensitive to the structure and arrangement.
- ◆ SHG suffer no inherent photobleaching or toxicity .

- R., Elbaum,et al J Dent. 35 (2007) 150-155.
- M.H. Chen, et al. JBO. 12 (2007) 064018.
- J.H. Chen, et al. (2009)

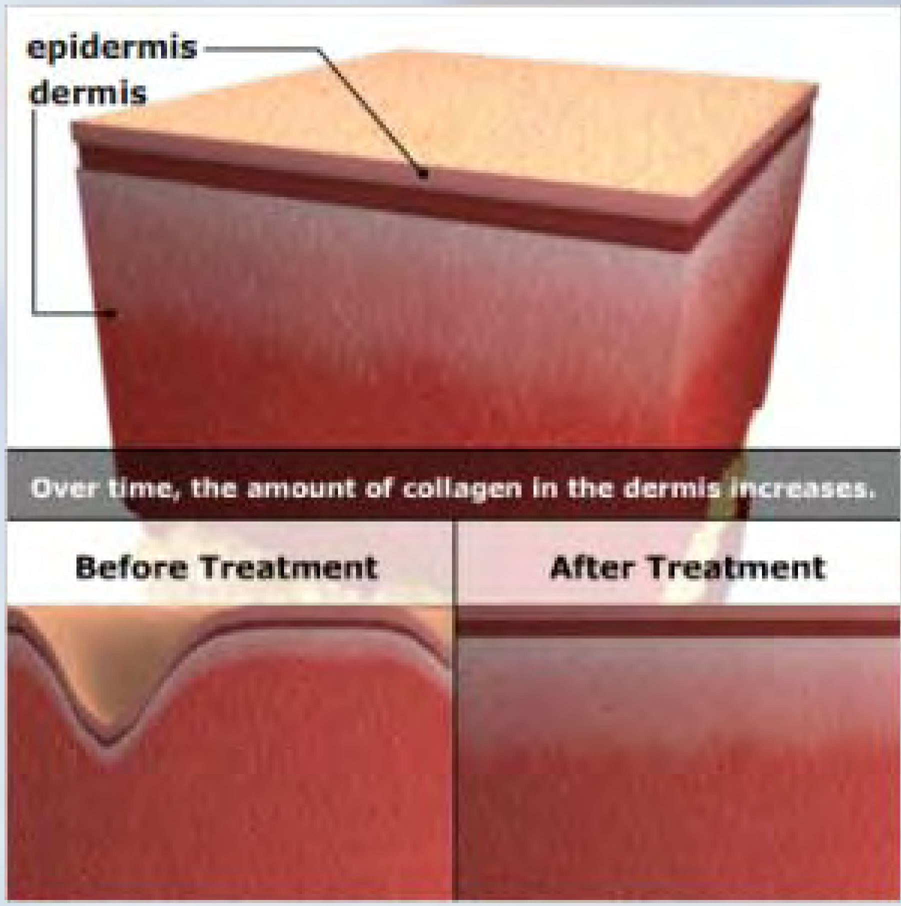
Collagen By UV Expose



0min 10min 20min 30min 40min 50min 60min

Laser resurfacing can improve minor facial flaws

- Fine lines or wrinkles around or under your eyes, forehead or mouth
- Scars from acne or chickenpox
- Non-responsive skin after a facelift
- Aged or sun-damaged skin
- Liver spots
- Improve your complexion if you have yellowish or grayish skin tones
- Warts
- Birthmarks such as linear epidermal nevi
- Enlarged oil glands on the nose



Discussion

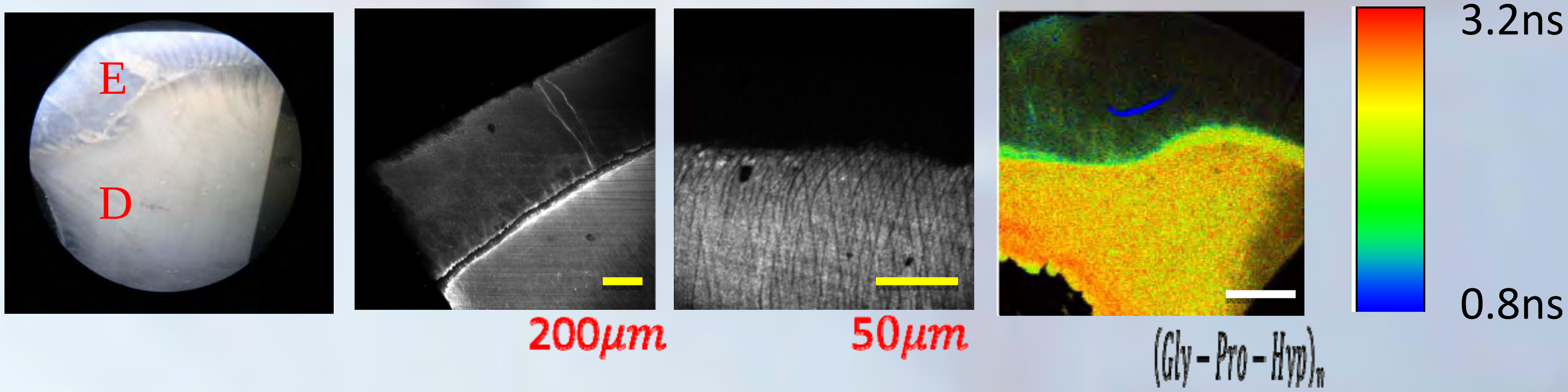
- The collagen matrices in dentin were more highly cross-linked than the soft tissue collagen.
- Collagen heat treatment would cause dehydration and conformational changes of collagen into higher order.
- The conformational changes in collagen will resto … gina …
  dena …

Water

self-associate

Micrographs from Dental Tissues

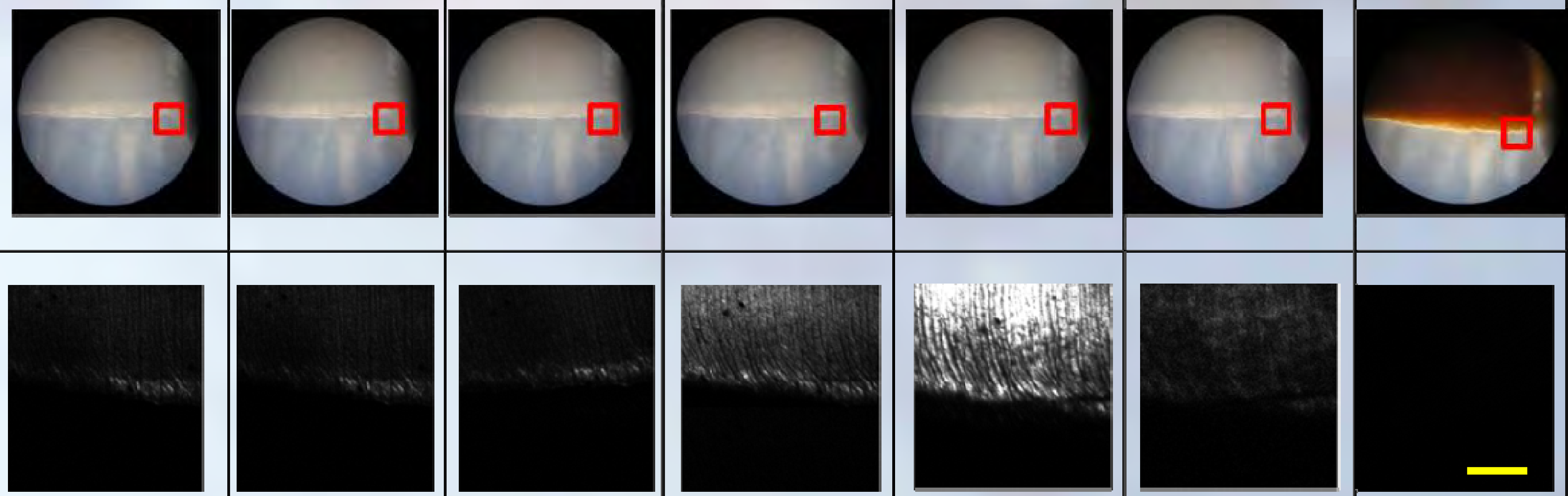
- **Autofluorescence**
- **Nonlinear optical signal→ SHG**



Dental slice AF image SHG FLIM image

★ The **changes** in optical properties may reflect the **pathological** and **physiological** conditions of dental tissues.

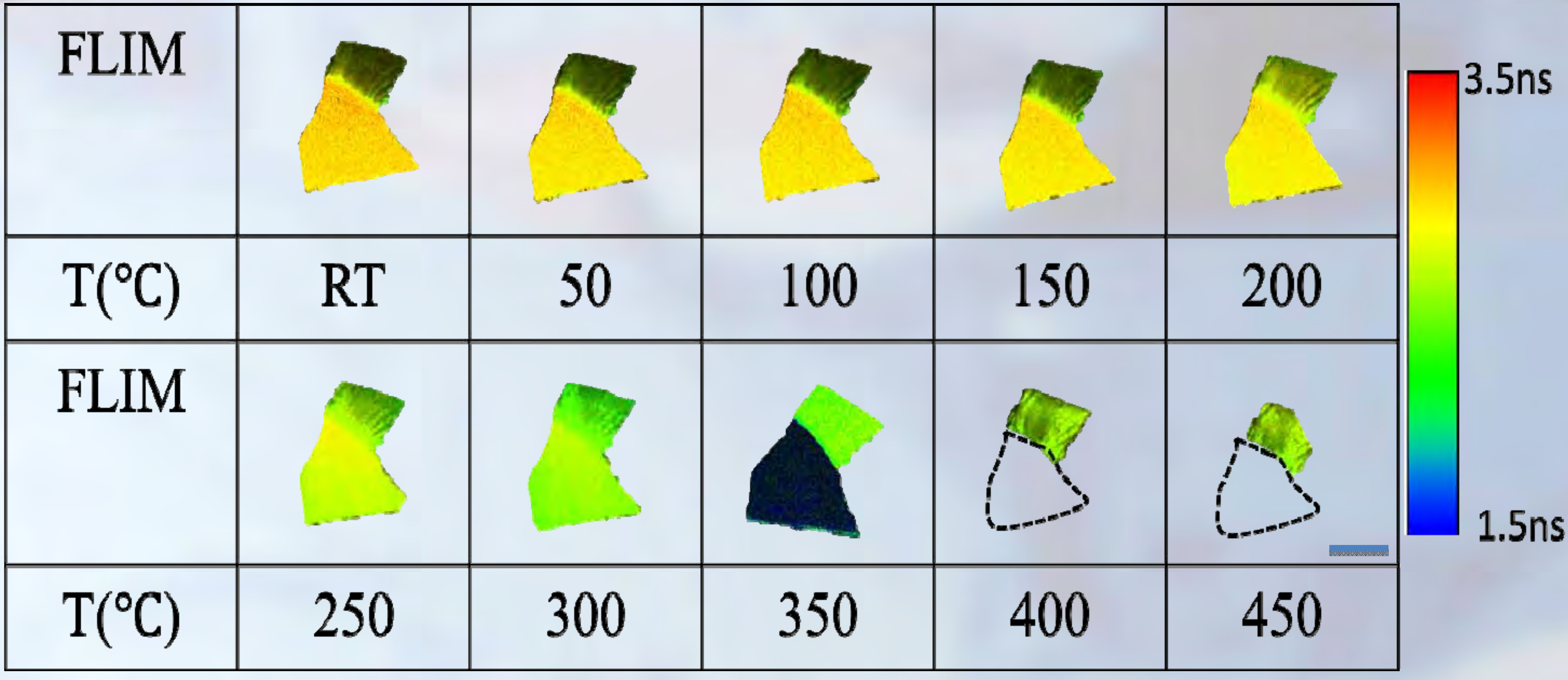
SHG Micrographs of Thermally Treated Dental Sections



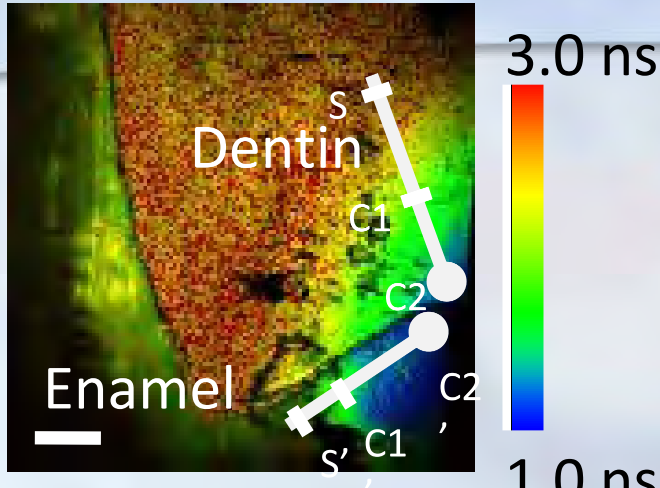
T(°C)	RT	50	100	150	200	250	300

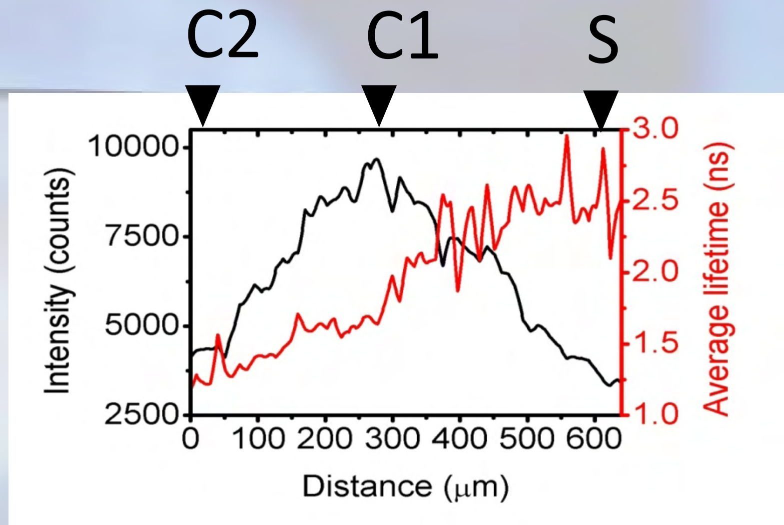
Second-harmonic generation images of a dental section after thermal treatment at various temperatures. The period of thermal treatment is 10min for each temperature step (50℃).

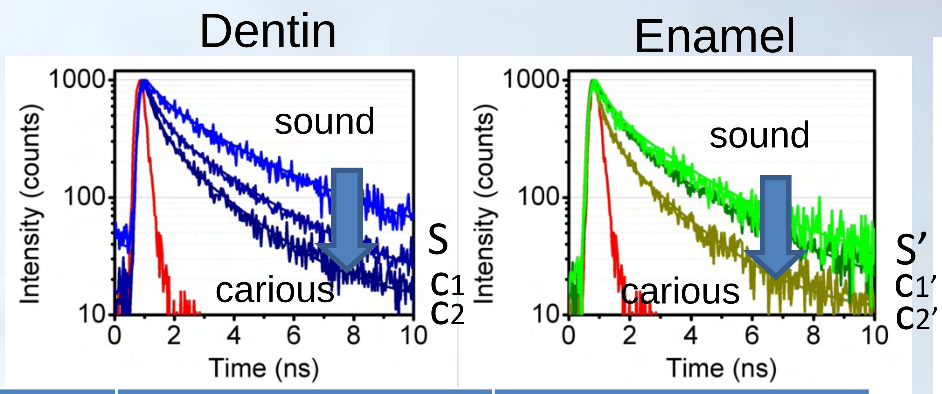
FLIM Micrographs of Thermally Treated Dental Section

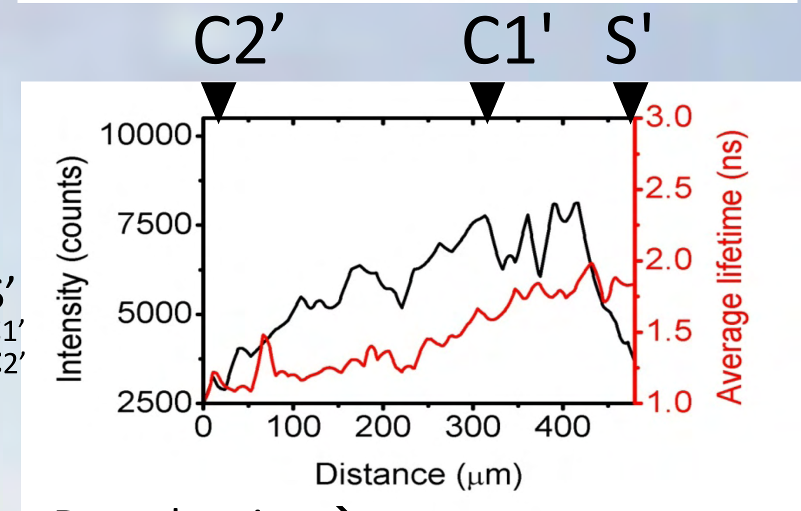


- 4X objective
- pulsed laser diode emitting at 375nm



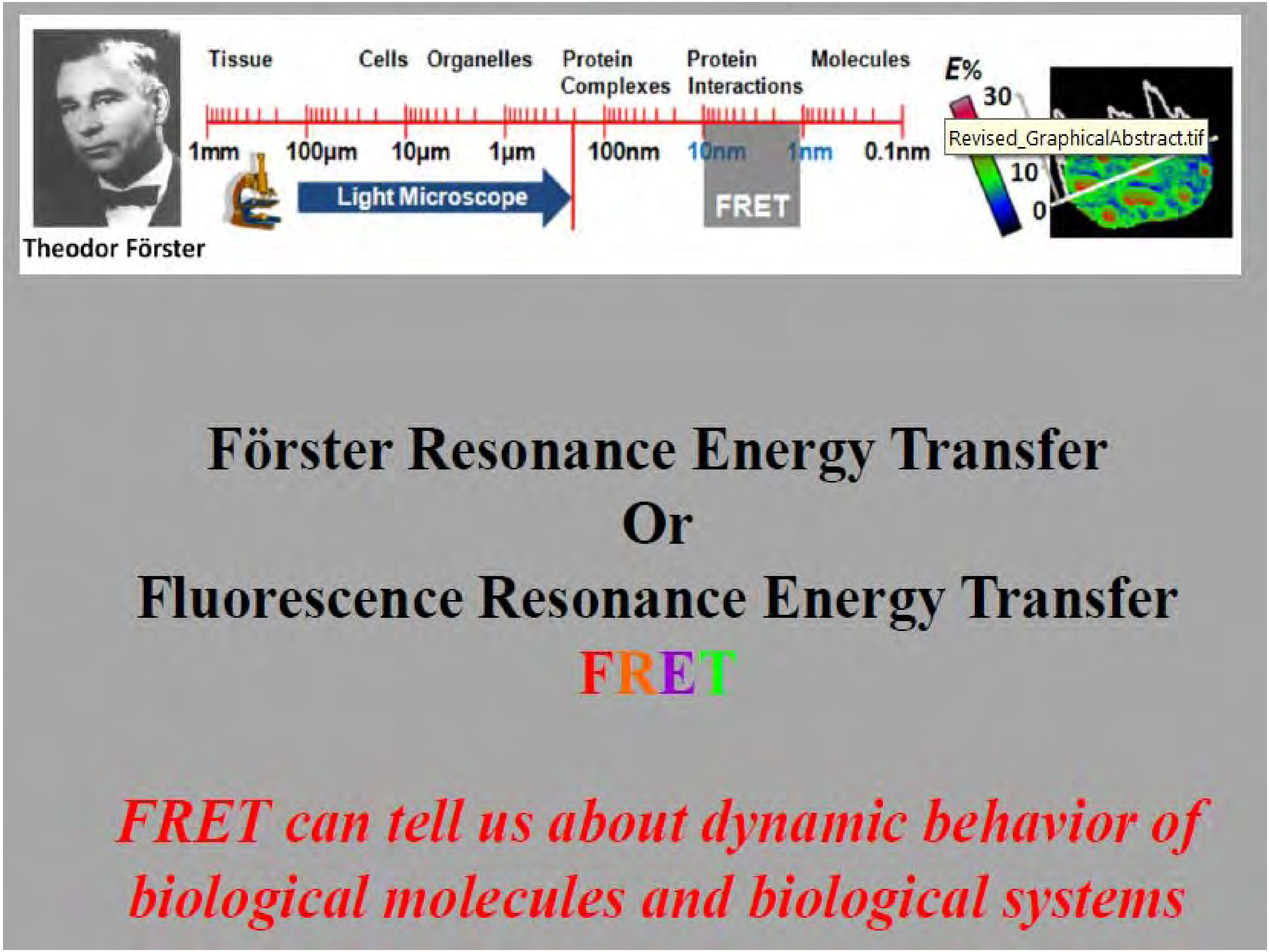






Sound S, S'	**τ_1=0.5 ns, A_1= 40% τ_2= 2.9 ns, A_2=60%**	**τ_1=0.3ns, A_1= 47% τ_2= 2.4 ns, A_2=53%**
Carious C2,C2'	τ_1=0.4 ns, A_1= 82% τ_2= 2.2 ns, A_2=18%	τ_1=0.4 ns, A_1= 75% τ_2= 1.9 ns, A_2=25%

Dental caries →
destruction of tissue,
accumulation of fluorophores.


Tissue
Cells
Organelles
Protein Complexes
Protein Interactions
Molecules
1mm
100μm
10μm
1μm
100nm
10nm
1nm
0.1nm
Light Microscope
FRET
Theodor Förster
E%
30
10
0
Revised_GraphicalAbstract.tif
Förster Resonance Energy Transfer
Or
Fluorescence Resonance Energy Transfer
FRET
FRET can tell us about dynamic behavior of biological molecules and biological systems

Basics of FRET technique

Donor ---

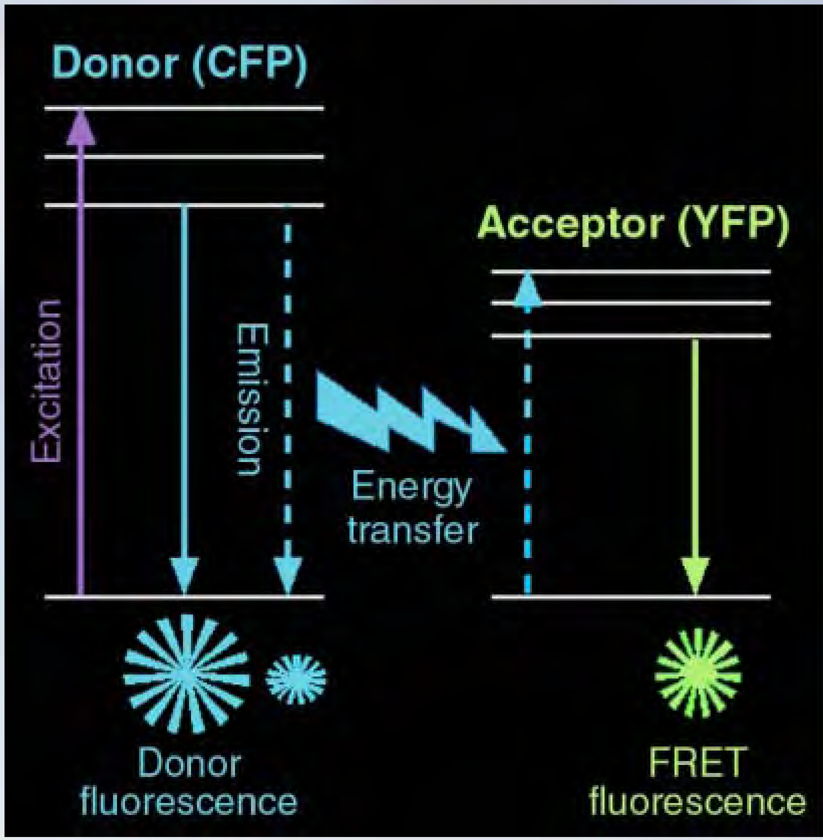
molecules excited from ground state to excited state upon excitation of light or absorption

Acceptor---

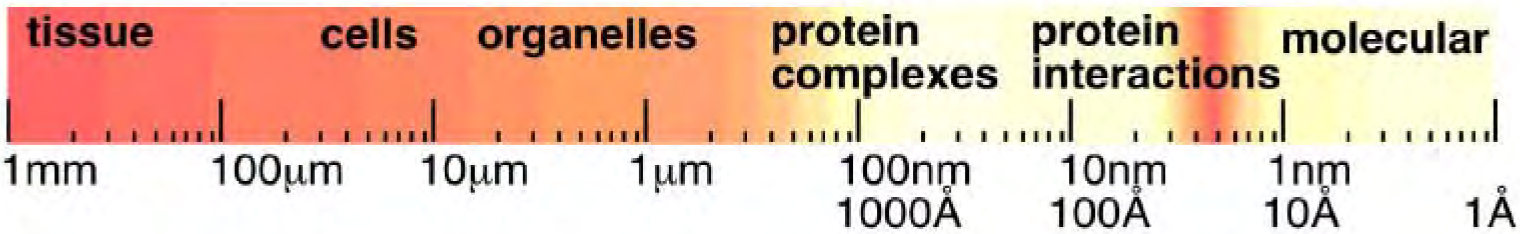
if acceptor molecules are close enough with donor in excited state,

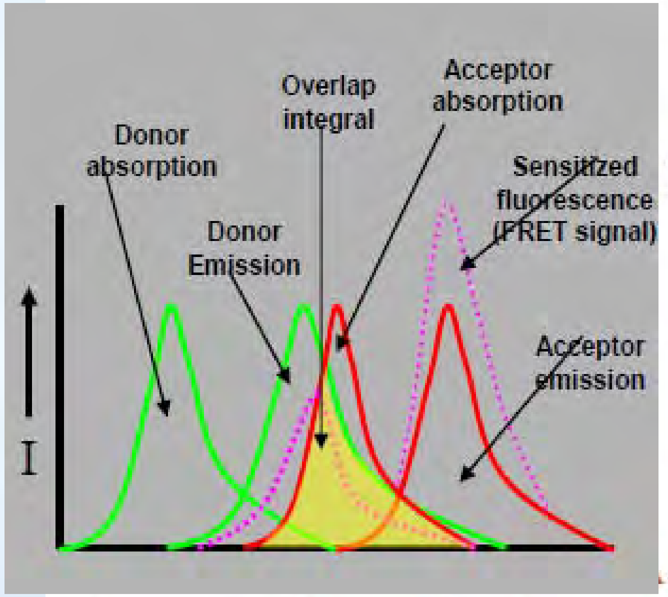
Energy is transferred from D to A.
This radiationless transfer of energy is called RET or **FRET**.

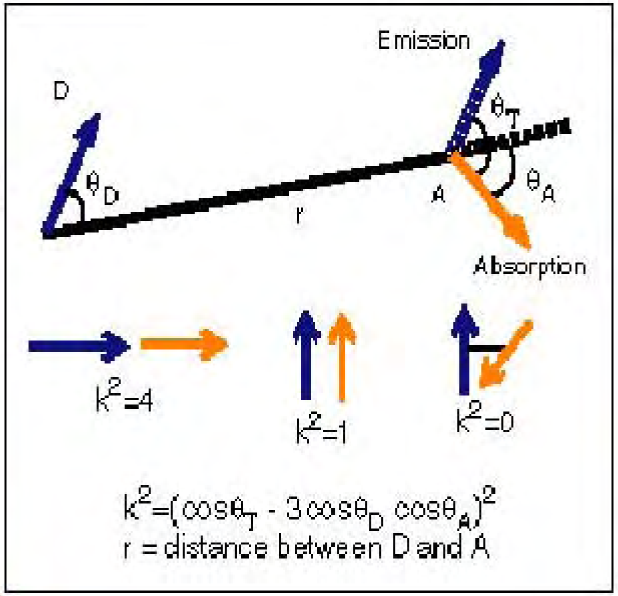
Non-invasive
Spatio-temporal dynamics-
Interactions between partners in living cell

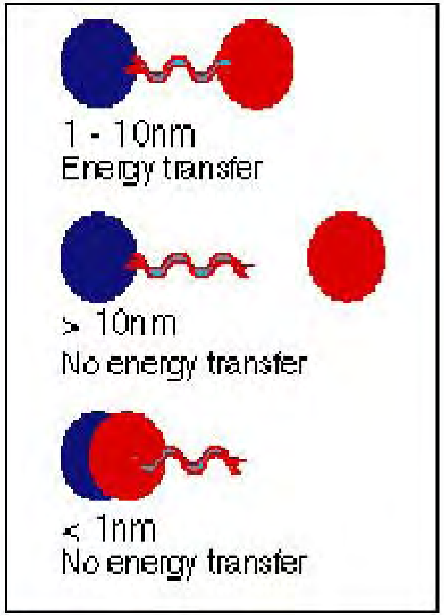


Conditions for FRET to Occur





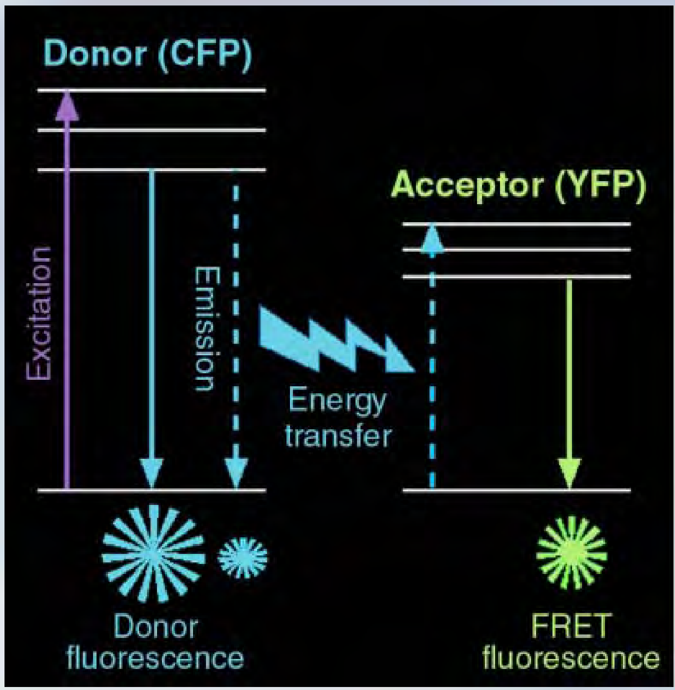




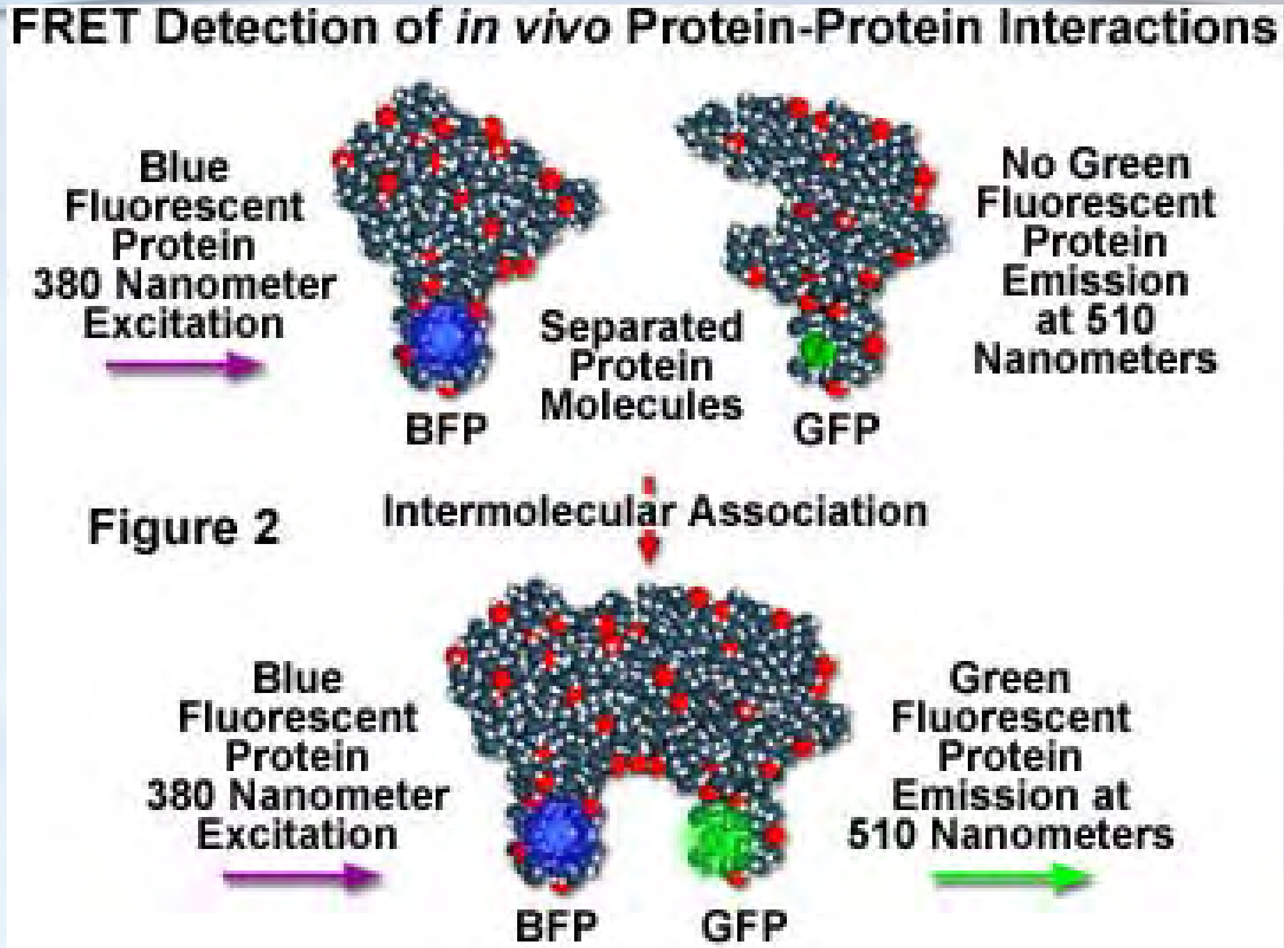
Conditions for FRET to Occur

- FRET – process, radiationless transfer of energy from a donor fluorophore to an appropriately positioned acceptor fluorophore.

- FRET occur when emission spectrum of donor fluorophore overlaps (>30%) the absorption spectrum of an acceptor.
- **No overlap, no FRET.**

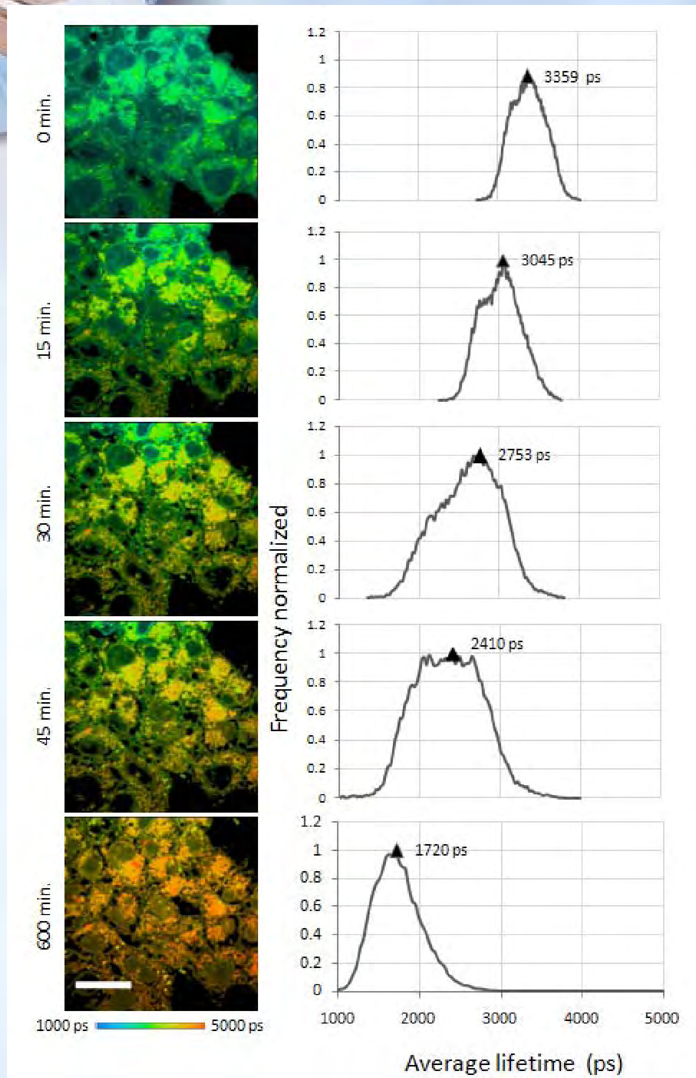


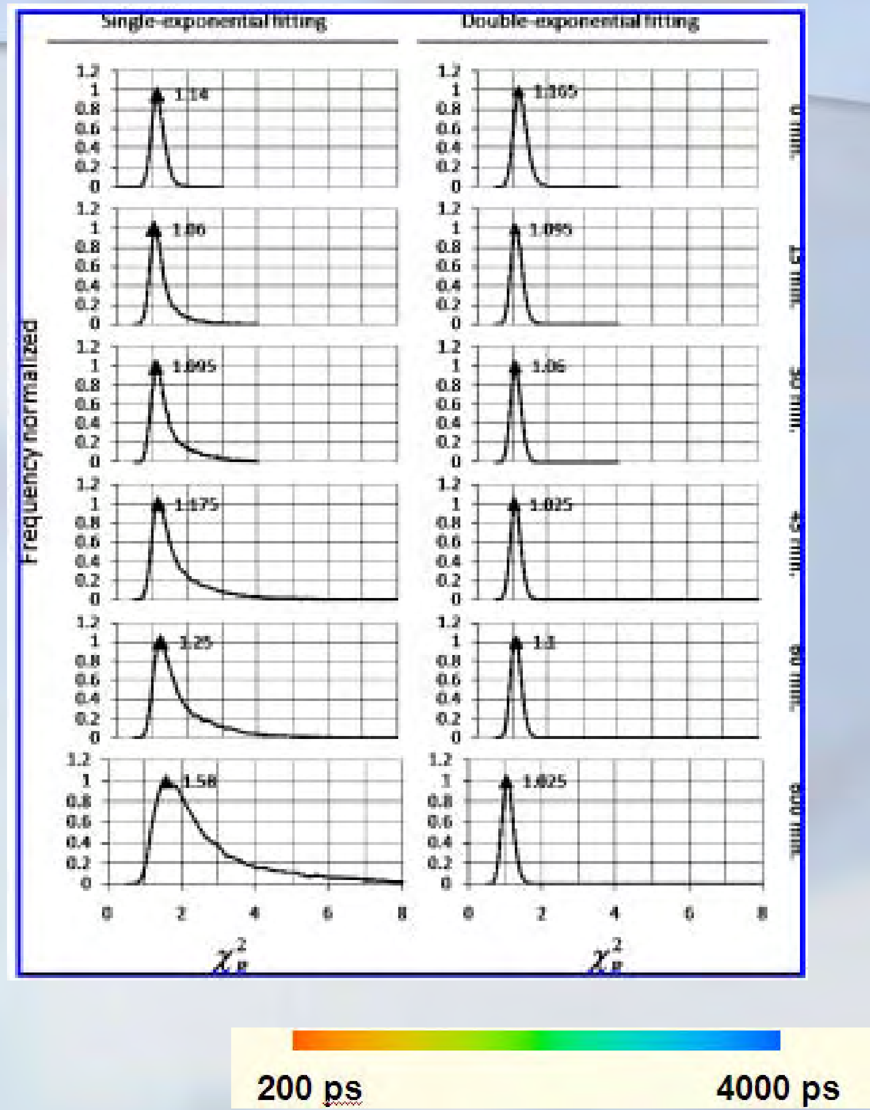
FRET microscopy



http://www.olympusmicro.com/primer/techniques/confocal/applications/flimintro.html

Apoptosis vs. necrosis discrimination

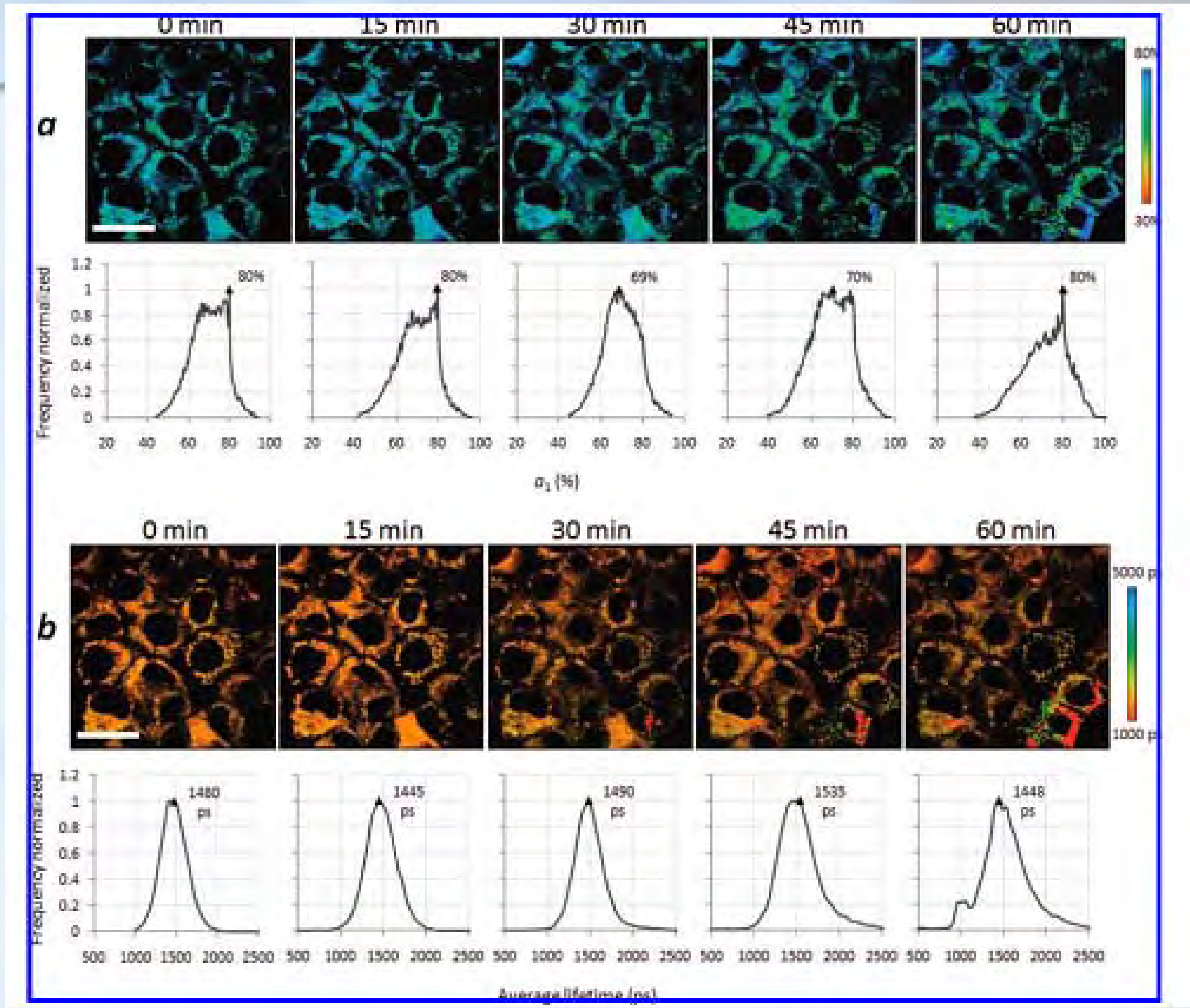




Ghukasyan et al., J. Phys. Chem., 2009,

Wang et al. J.Biomed. Opt. (2008);

Apoptosis vs. necrosis discrimination



Ghukasyan et al., J. Phys. Chem., 2009, Wang et al. J.Biomed. Opt. (2008);

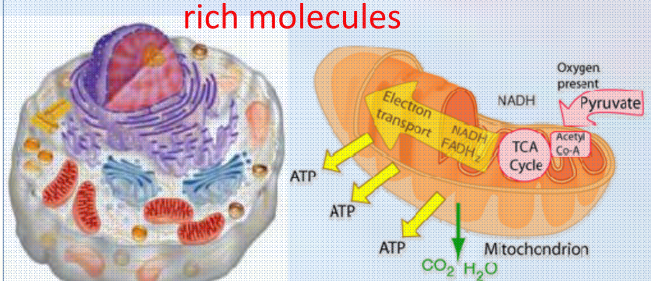
Metabolic mapping of live cells

Introduction

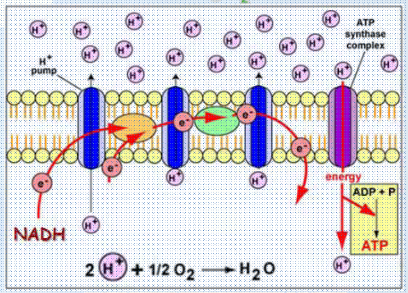
Need for energy:

synthesis ♦ motion ♦ transport

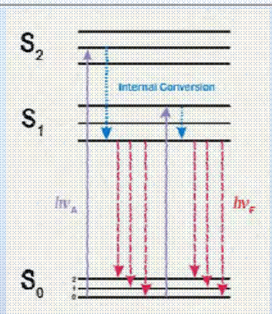
ATP: The basic fuel molecule, formed in the process of the oxidation of energy-rich molecules

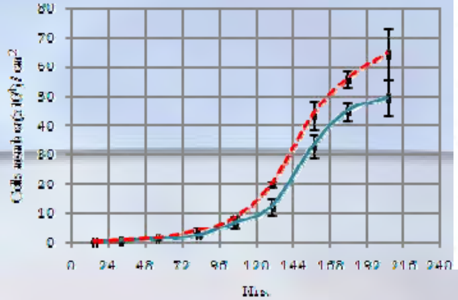


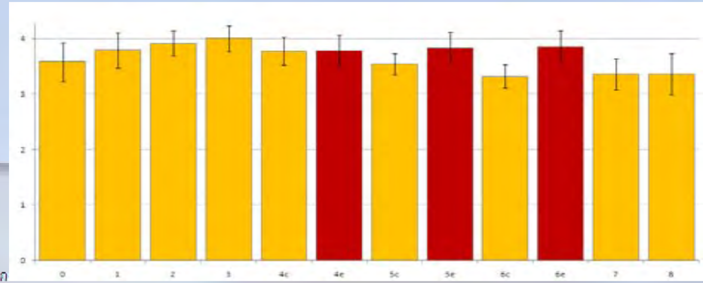
NADH:

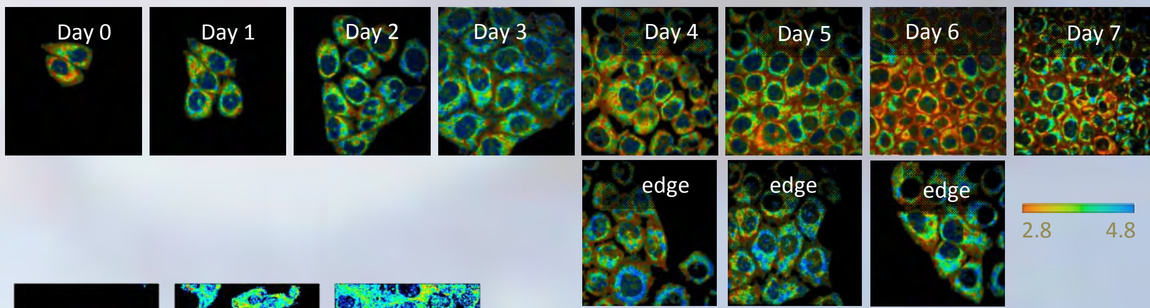


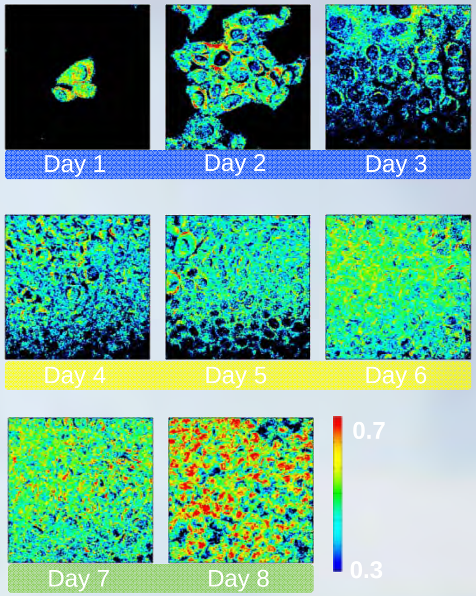
Fluorescence lifetime, τ

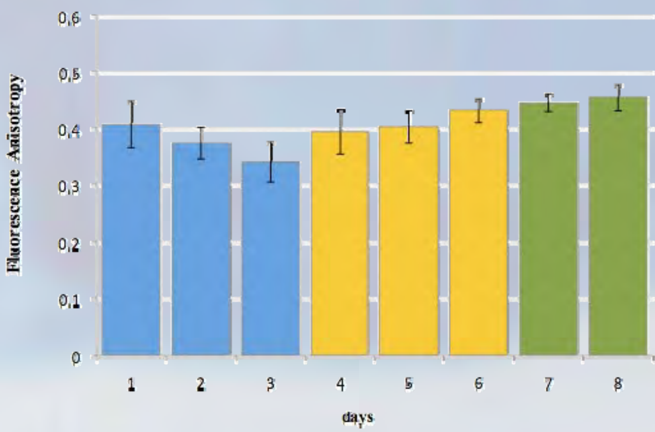






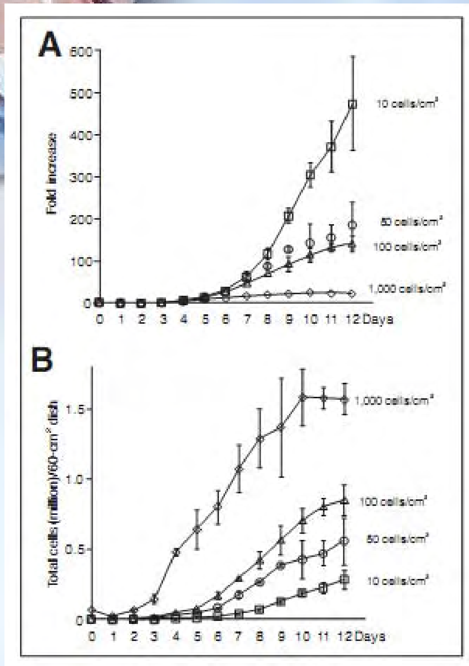


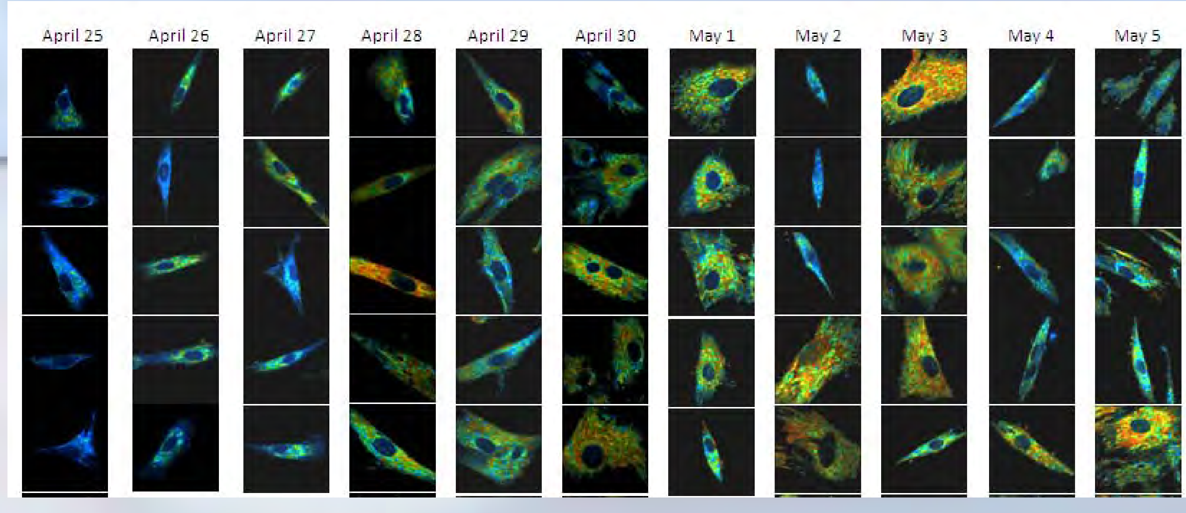




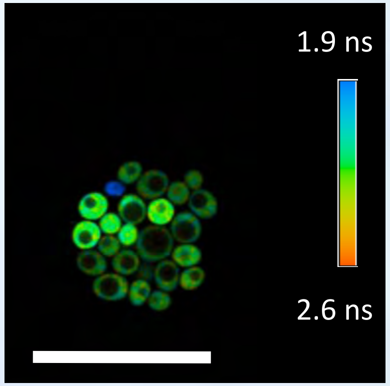
V. Ghukasyan, F. J. Kao, J. Phys. Chem. C (2009)

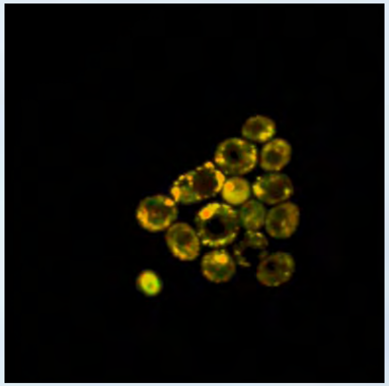
Detection of aggregation by means of FLIM

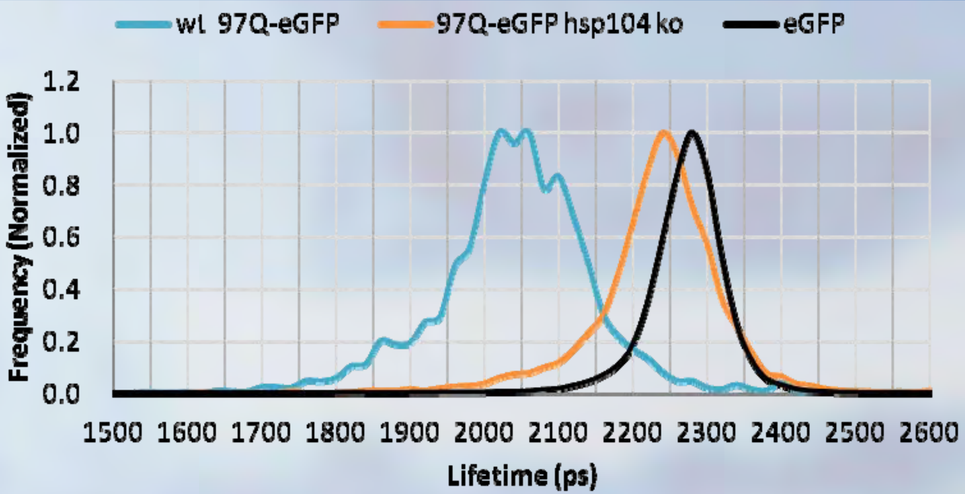




Sekiya et al. Stem Cells, 2002, 20, 530-541







V. Ghukasyan et al., Journal. Biomed. Opt. (submitted).

Scope of FLIM/FRET:

Detection of Bio-interactions and Micro-environment changes that may be revealed by dipole-dipole interaction

1. **Cell-to-Cell Signaling: ligand/receptor.**
2. **Immune System: antigen-antibody interactions.**
3. **Expression of Genes : DNA/regulator protein interactions.**
4. **Metabolism: Formation of enzyme complex.**
5. **Cell Division: DNA hybridization.**
6. **Protein Folding.**
7. **Changes of micro-environment surrounding the reporting fluorophores.**

Thank you for your attention

Any suggestion？

SI-BARCODE DETECTION USING MICROFLUIDIC SYSTEM

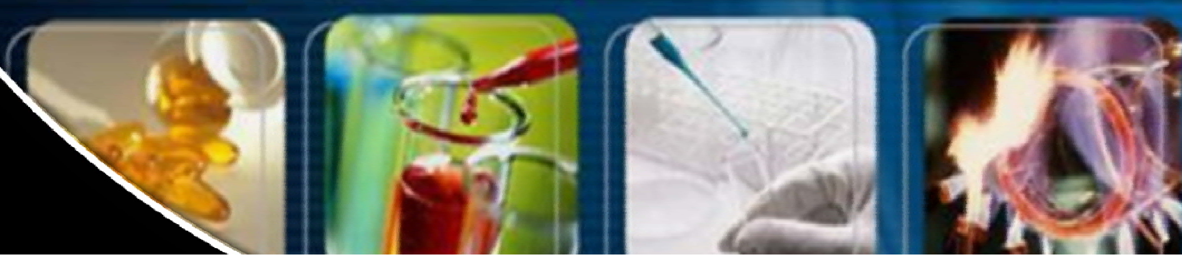
Presented by

FEBY WIJAYA

Nanotechnology and Nanoscience 2013

THE OUTLINE

- WHAT IS MICROFLUIDIC
- COMPONENT OF MICROFLUIDIC
- FABRICATION OF MICROFLUIDIC
- SI-BARCODE DETECTION
- CONCLUSION



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Solar Vapour Generation Enabled by Nanoparticles

Solar Vapor Generation Enabled by Nanoparticles

Oara Neumann †, Alexander S. Urban †, Jared Day †, Surbhi Lal †, Peter Nordlander †‡*, and Naomi J. Halas †‡*
†Department of Electrical and Computer Engineering, ‡Department of Physics and Astronomy, Laboratory for Nanophotonics, and the Rice Quantum Institute, Rice University, 6100 Main Street, Houston, Texas 77005, United States

ABHISHEK PATHAK
TIGP NANO SCIENCE
NTHU

Introduction

- Rice University scientists developed new technology that uses nanoparticles to convert solar energy directly into steam.
- The new “solar steam” method is so effective it can even produce steam from icy cold water.
- The technology has an overall energy efficiency of 24 percent than Photovoltaic solar panels(15 percent).
- Important benefits are water purification, desalination, sterilize medical waste and surgical instruments, to prepare food and solar thermal power.
- Another potential use could be in powering hybrid air-conditioning and ethanol water mixture, solar distillation.

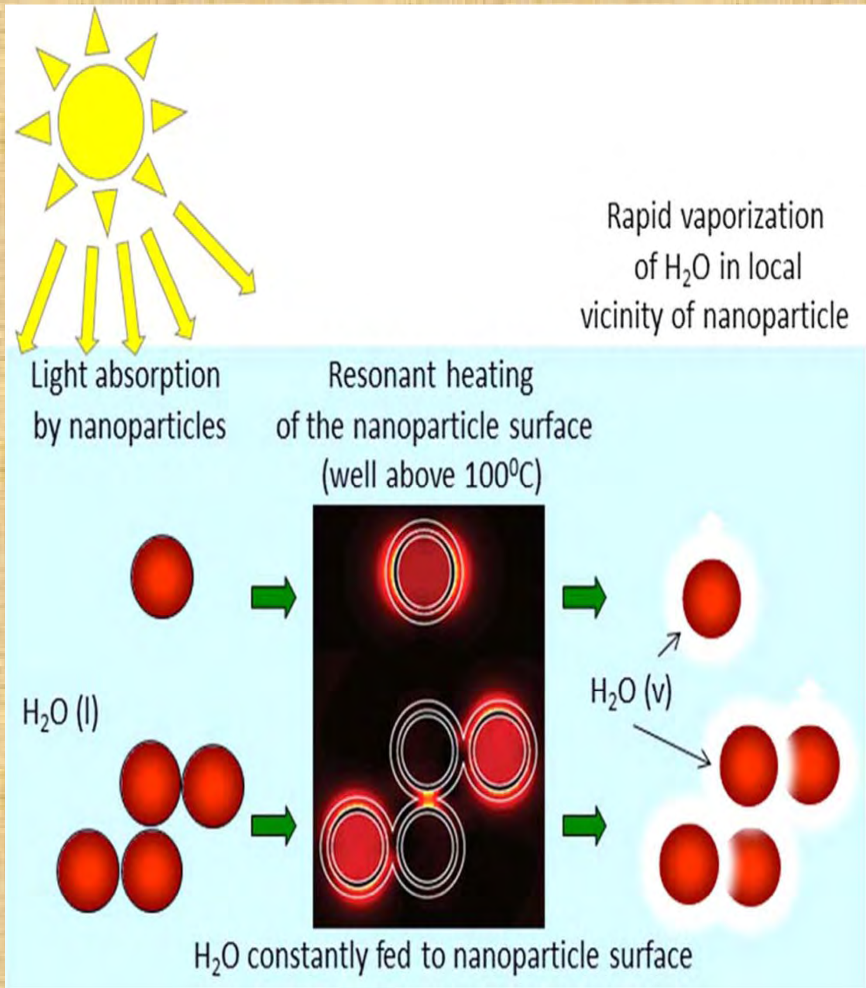
Basic Concept

- Sub wavelength metallic particles are intense absorbers of optical radiation, due to the collective oscillations of their delocalized conduction electrons, known as surface plasmons.
- When excited on resonance, energy not reradiated through light scattering is dissipated through Landau (nonradiative) damping, resulting in a rise in temperature in the nanometer-scale vicinity of the particle surface.
- Particle-based approaches have also been of interest for solar energy applications.

Solar Vapour generation by nanoparticles

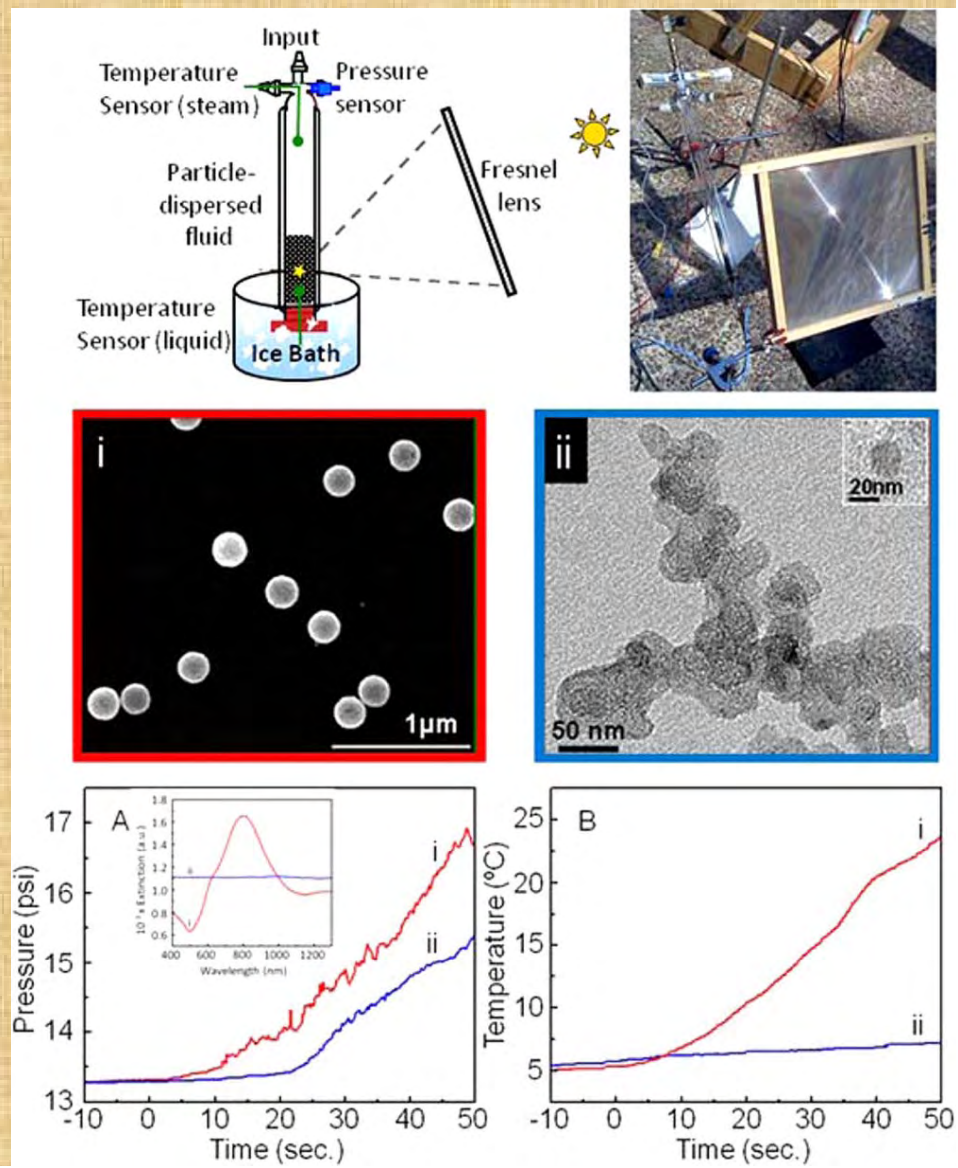
- On illumination ,light-absorbing nanoparticles, can reach temperatures above the boiling point of liquid water, creating a nonequilibrium condition between the hot nanoparticle surface and the cooler fluid.

- Once vapor is formed at the particle liquid interface, the metallic nanoparticle is enveloped in a thin layer of steam with a reduced thermal conductance compared to the liquid.
- The vapor volume increases, coalesce with other nanobubble, moves to the liquid air interface where the vapor is released and the nanoparticles revert back to the solution to repeat the vaporization process.



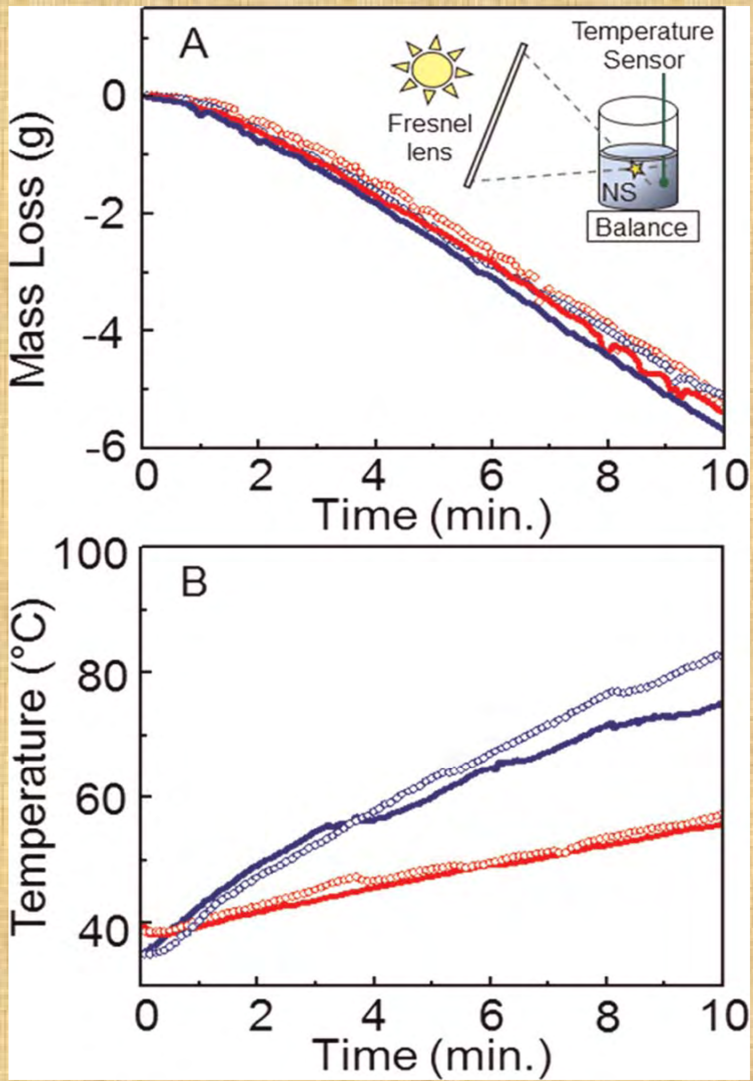
Result and Discussion

- SiO2/Au nanoshells and water-soluble N115 carbon nanoparticles were prepared.
- Upon solar illumination, the pressure over the solution of nanoshells began to increase, indicate steam generation, less than 5 s after illumination while for carbon nanoparticles the pressure increase was delayed by 20 s.
- We observe a slow and measurable increase in the fluid temperature for the illuminated nanoshell solution, while the carbon nanoparticle solution shows only a negligible increase in temperature for the same illumination conditions.



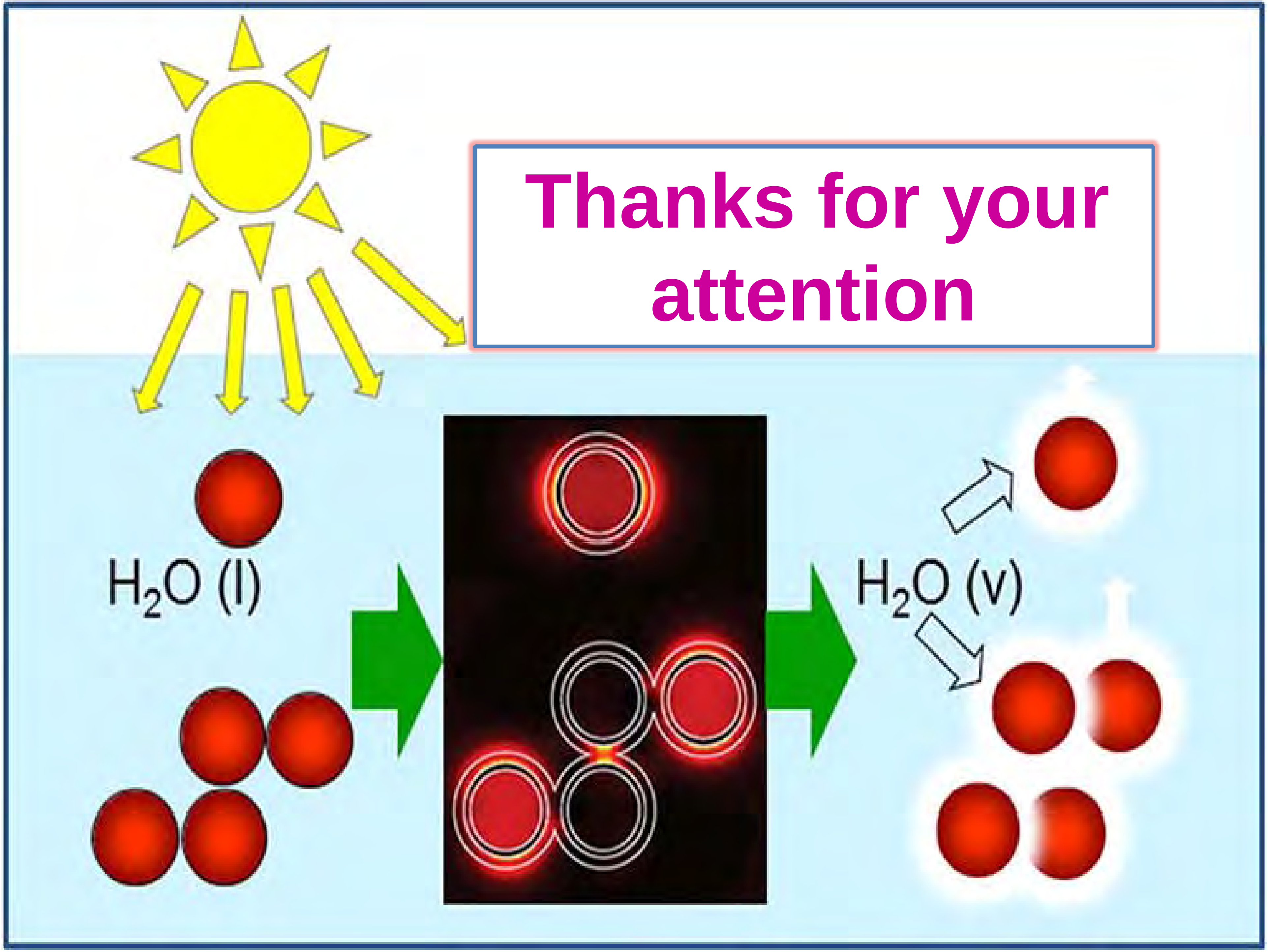
Mass Loss and Fluid Heating

- To quantify the energy efficiency of solar steam generation, the mass loss due to steam generation is similar for SiO2/Au and N115 carbon nanoparticles.
- The temperature increase due to heating of the liquid is less in 35 ml(red) and more in 25ml(blue) for both SiO2/Au and N115 carbon nanoparticles.
- **These measurements indicate that 80%of the solar energy absorbed by the nanoparticles contributes directly to steam generation. The overall energy efficiency is 24%.**



Summary

- Efficient direct steam generation using solar illumination.
- 80% of the absorbed sunlight is converted into water vapour and only 20% of the absorbed light energy is converted into heating of the surrounding liquid.
- In ethanol distillation a higher percentage of ethanol observed from the water ethanol azeotrope.
- Solar energy can be used for distillation, desalination, sterilization and sanitation in resource-poor locations.
- In future this technology can be used in solar thermal power generation.


Thanks for your attention
H2O (l)
H2O (v)

Binary Self-Assembled Monolayers Modified Au Nanoparticles as Carriers in Biological Applications

101011861 Hsun Yun Chang

SAM-AuNPs

- AuNPs: gold nanoparticles

  =>ease of synthesis and conjugation in biochemistry
- SAM: self-assembly monolayer

  =>provide a tunable system to change the interfacial properties of AuNPs

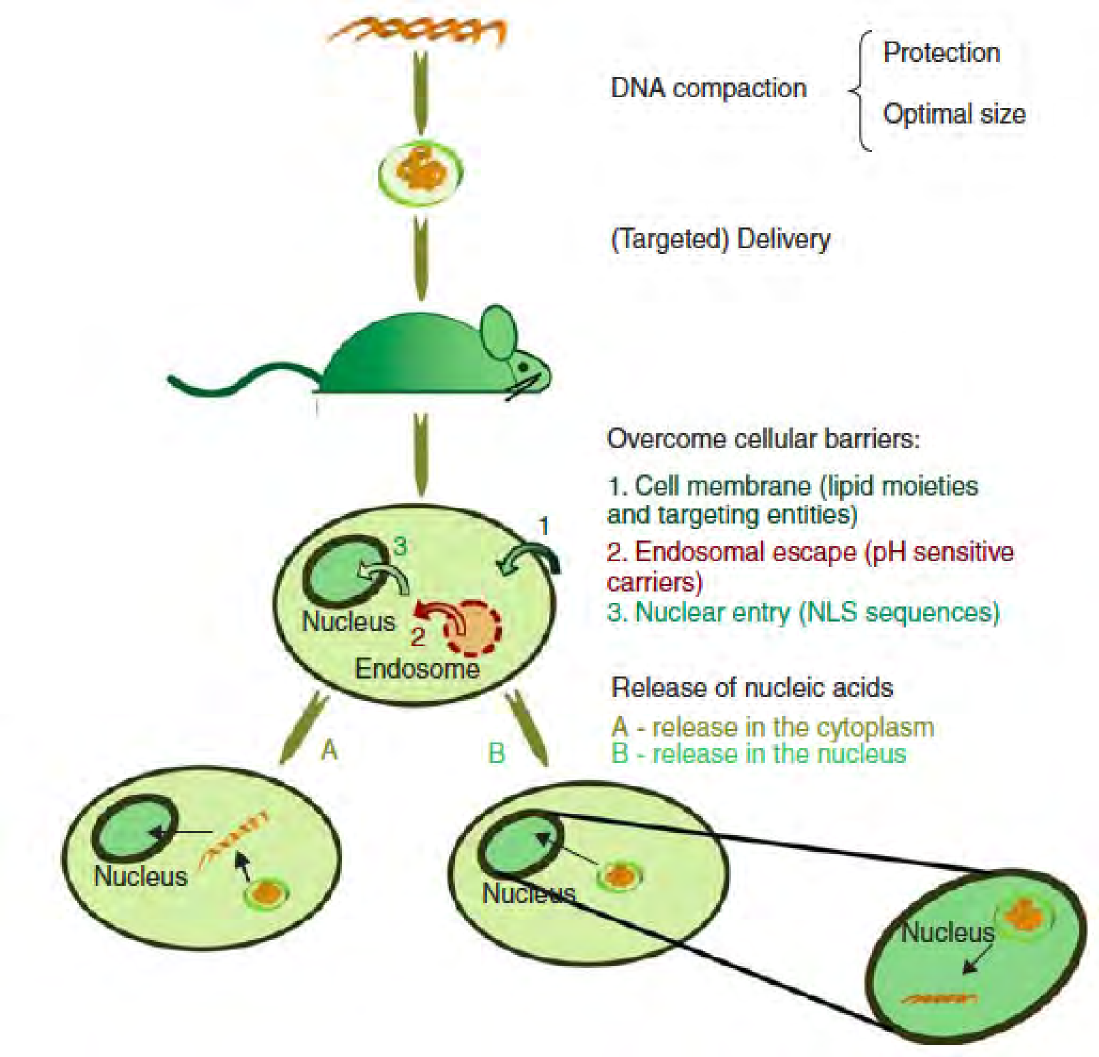
  =>transport biological molecules including DNA and proteins

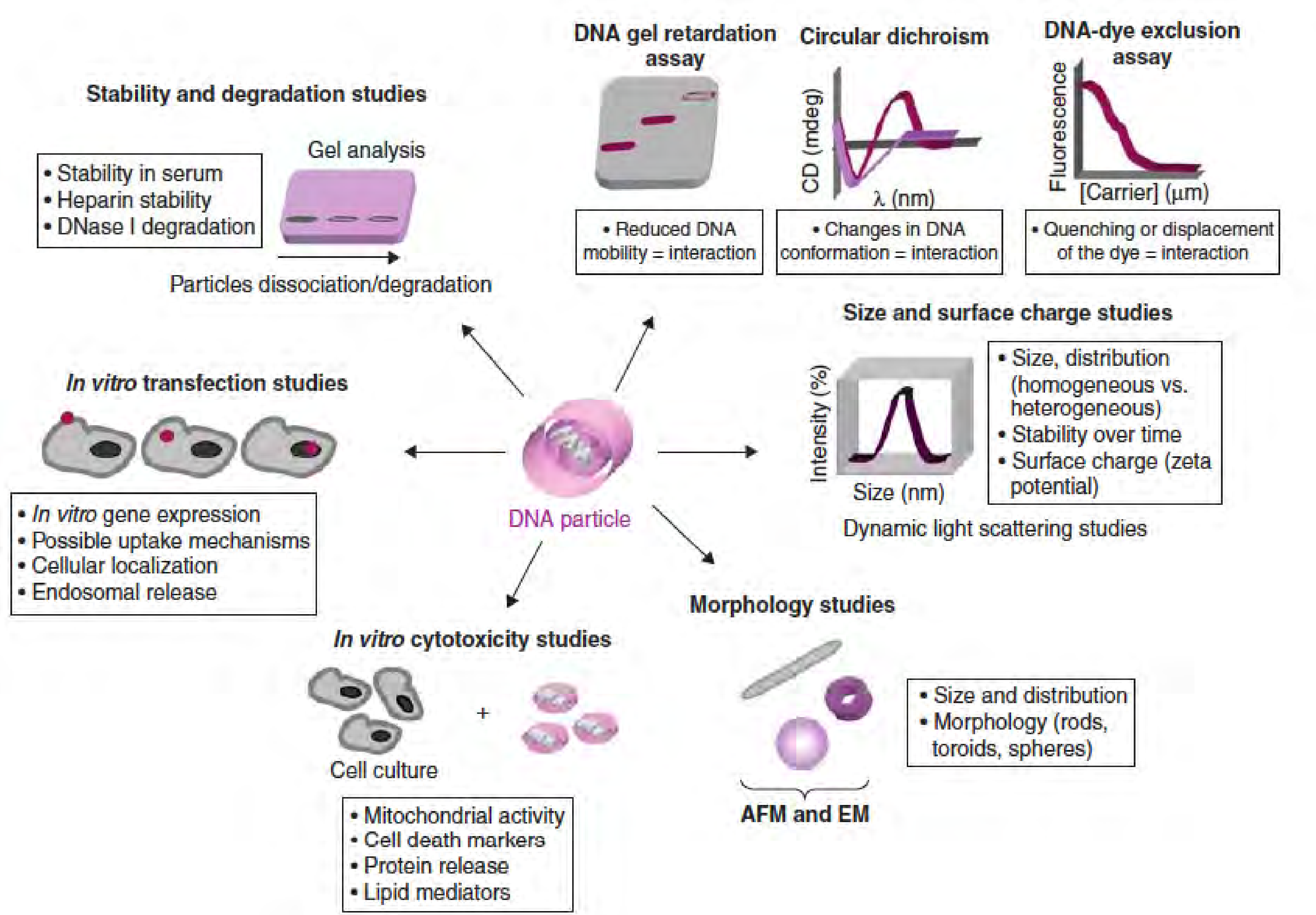
  =>might be beneficial to use electrostatic interaction

Gene delivery=>gene therapy

- Non-viral nanovectors

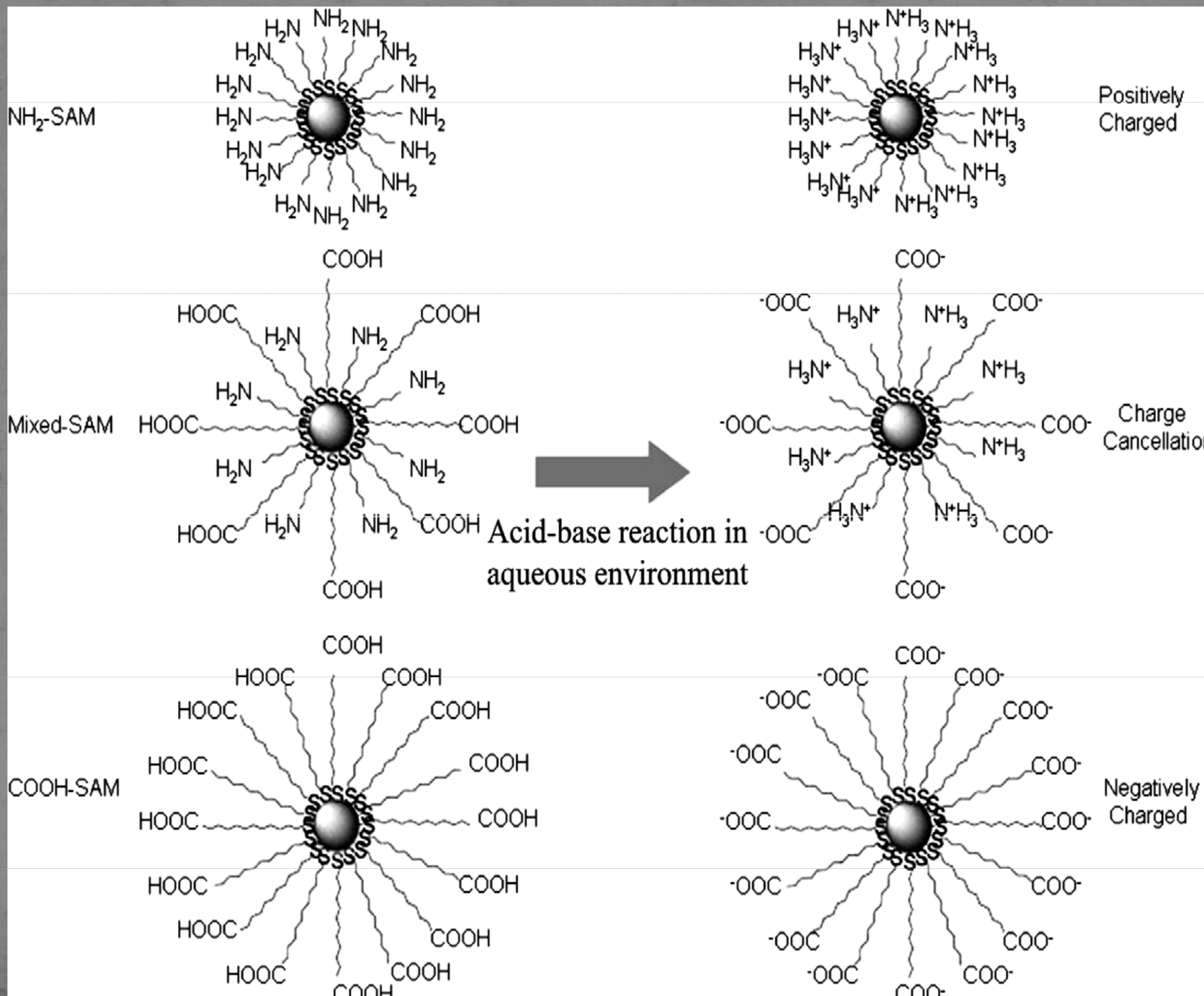
Expert Opin. Drug Deliv. (2010) **7**(6)



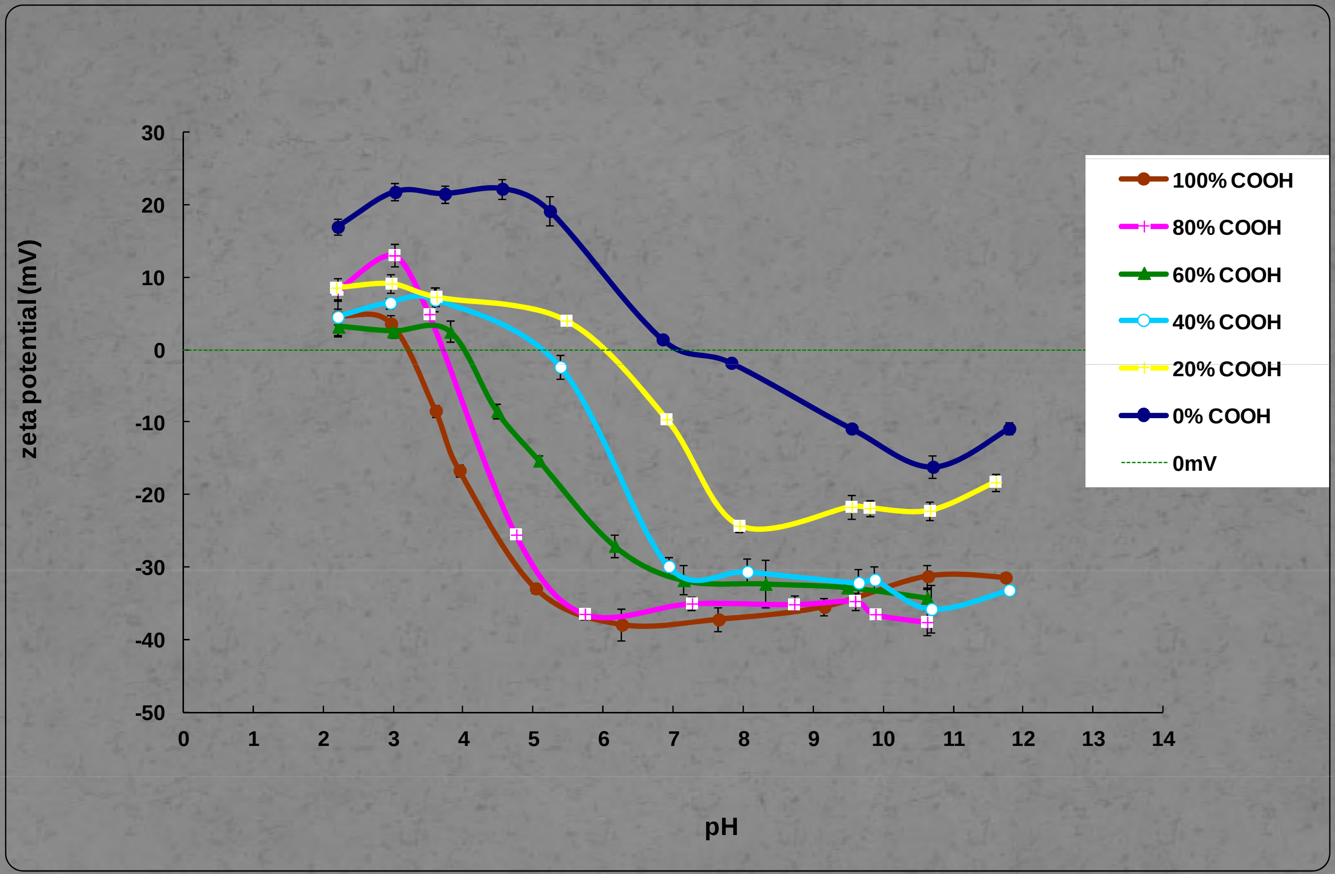


Stability and degradation studies
• Stability in serum
• Heparin stability
• DNase I degradation
Gel analysis
Particles dissociation/degradation
DNA gel retardation assay
• Reduced DNA mobility = interaction
Circular dichroism
CD (mdeg)
λ (nm)
• Changes in DNA conformation = interaction
DNA-dye exclusion assay
Fluorescence
[Carrier] (μm)
• Quenching or displacement of the dye = interaction
Size and surface charge studies
Intensity (%)
Size (nm)
• Size, distribution (homogeneous vs. heterogeneous)
• Stability over time
• Surface charge (zeta potential)
Dynamic light scattering studies
In vitro transfection studies
• *In vitro* gene expression
• Possible uptake mechanisms
• Cellular localization
• Endosomal release
DNA particle
In vitro cytotoxicity studies
Cell culture
+
• Mitochondrial activity
• Cell death markers
• Protein release
• Lipid mediators
Morphology studies
• Size and distribution
• Morphology (rods, toroids, spheres)
AFM and EM

- AuNPs were modified with SAMs of homogeneously mixed carboxylic acid and amine functional groups



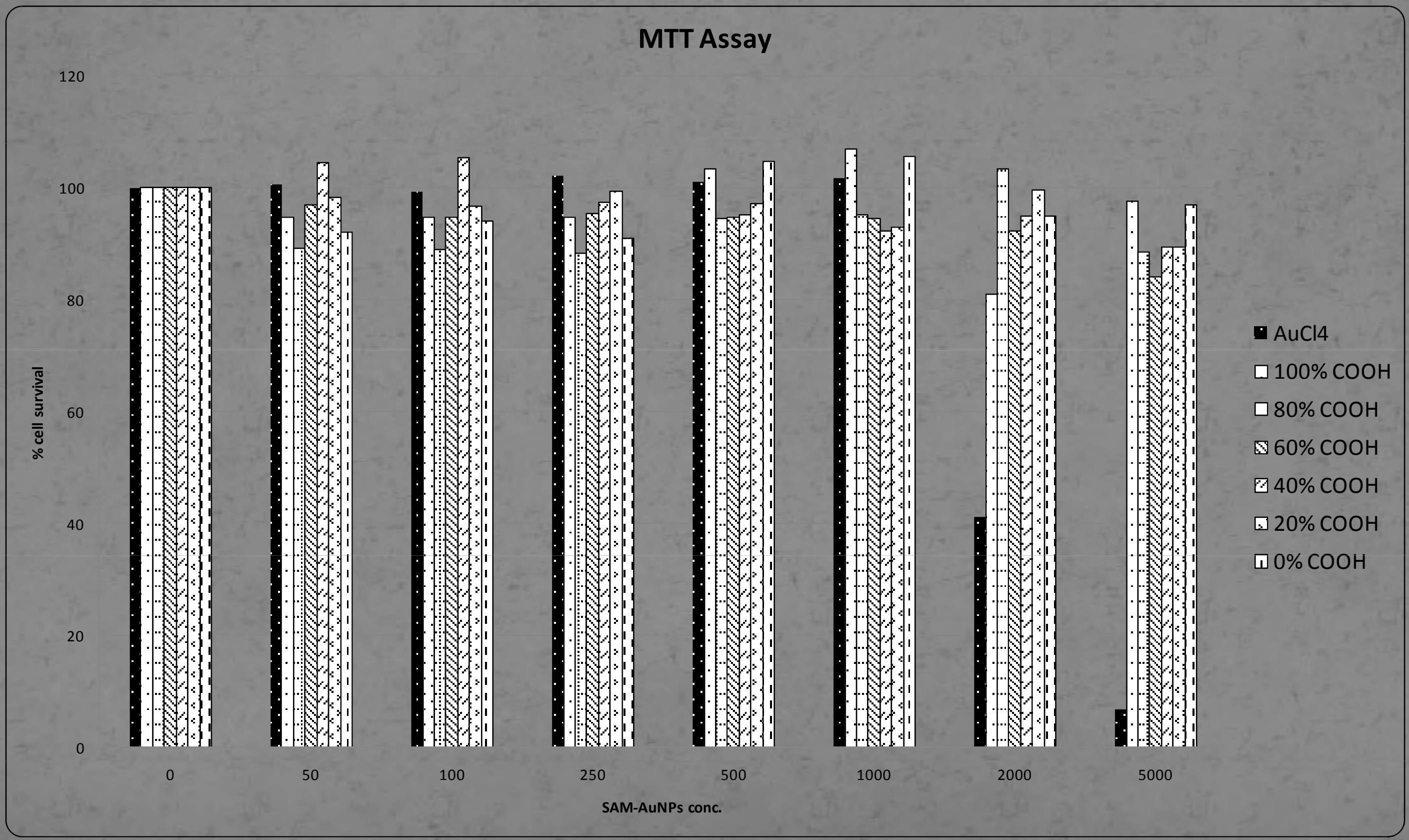
- Zeta potential=>IEP



Percentage of functional groups on AuNPs	100% COOH	80% COOH	60% COOH	40% COOH	20% COOH	0% COOH
IEP value	3.2	3.7	3.9	4.9	5.9	7.3

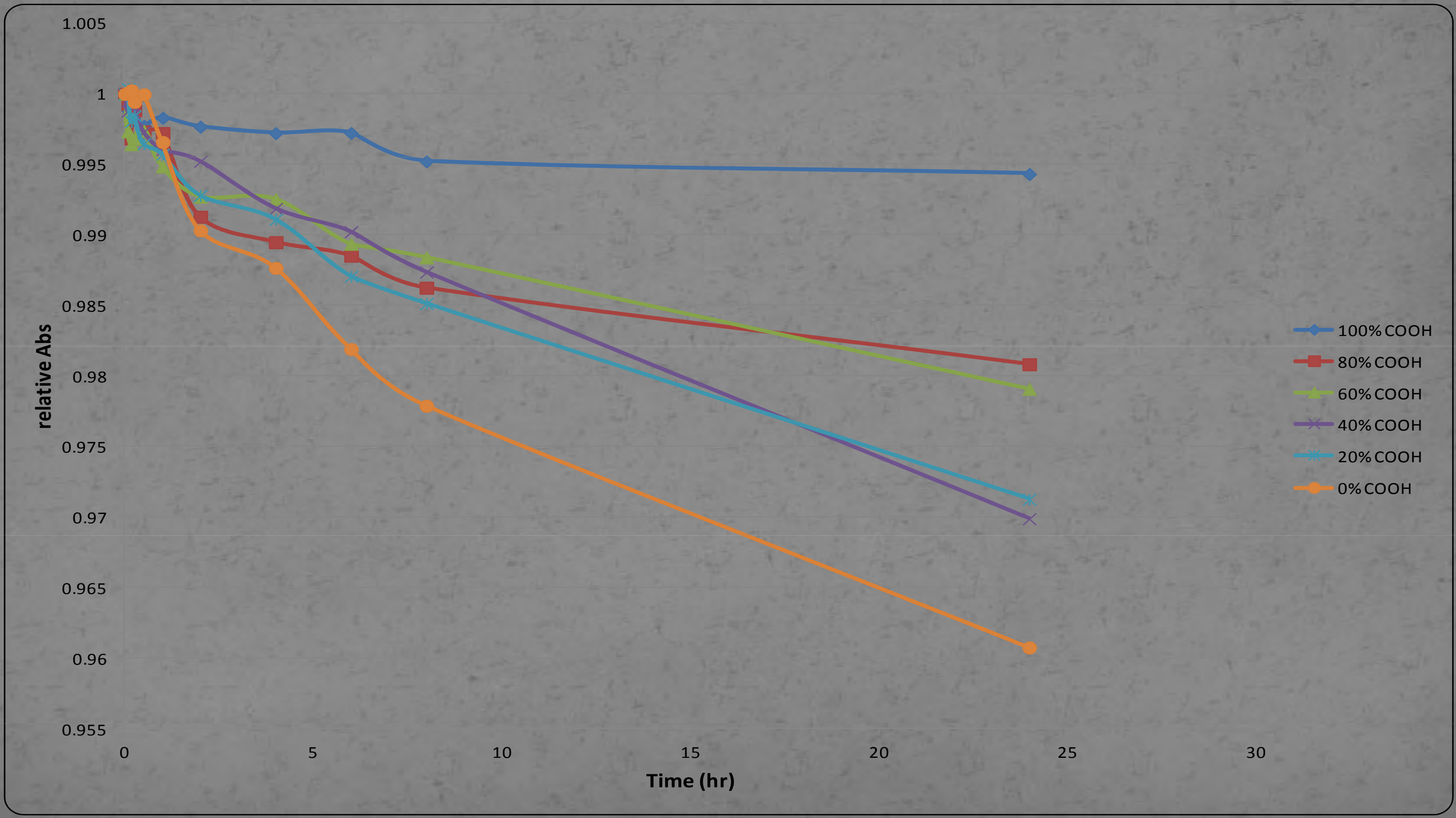
Biocompatibility

- MTT Assay



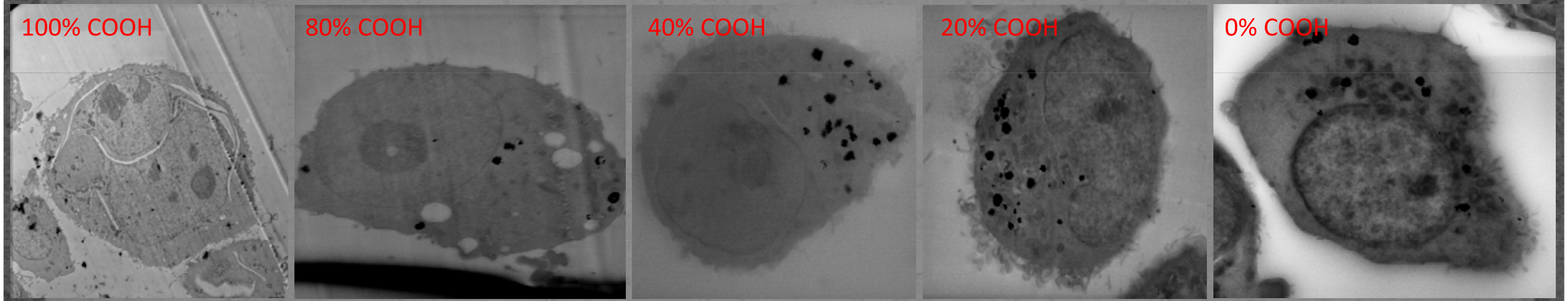
Cellular uptake

- UV-Vis spectroscopy



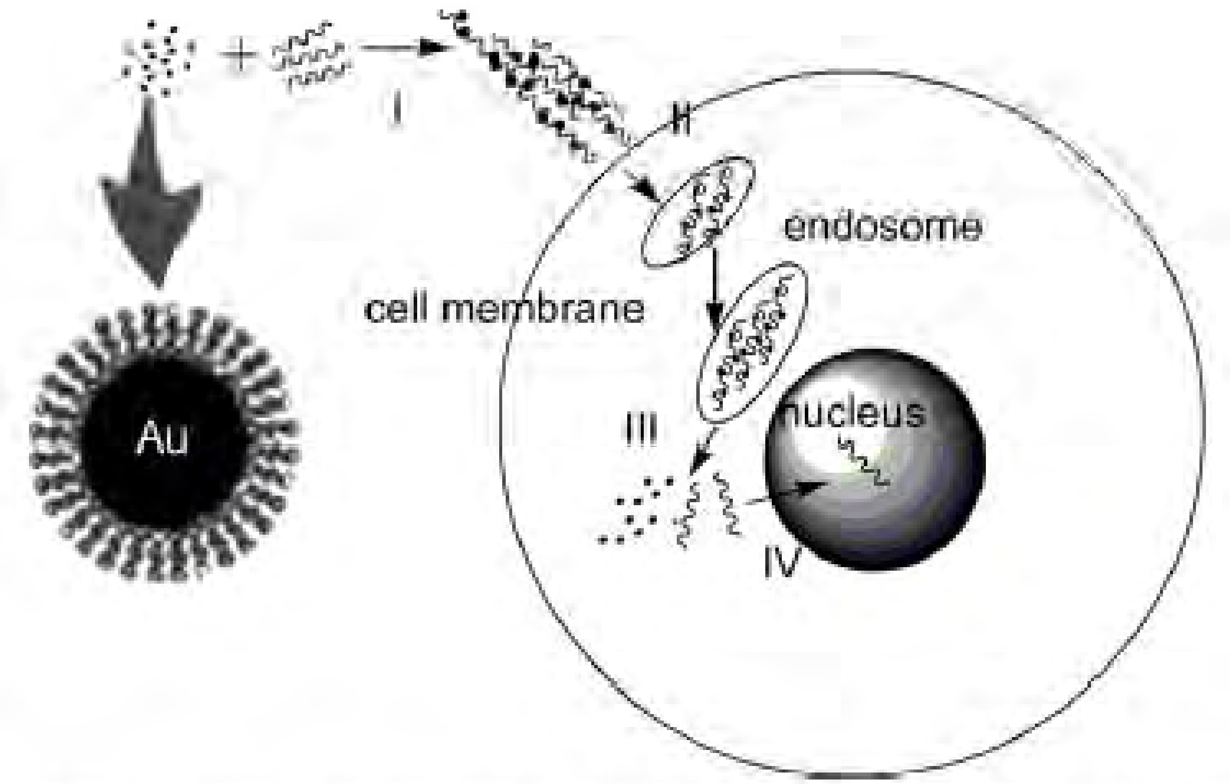
Cellular uptake

- STEM



Ability as carrier

- Gene expression after transfection



Scheme 1. Schematic illustration of the structure of AuNPs and the process of AuNPs mediated transfection. Four steps were supposed to involve in this procedure (see text for detail).

P. Li et al. / Biomaterials 29 (2008) 3617–3624

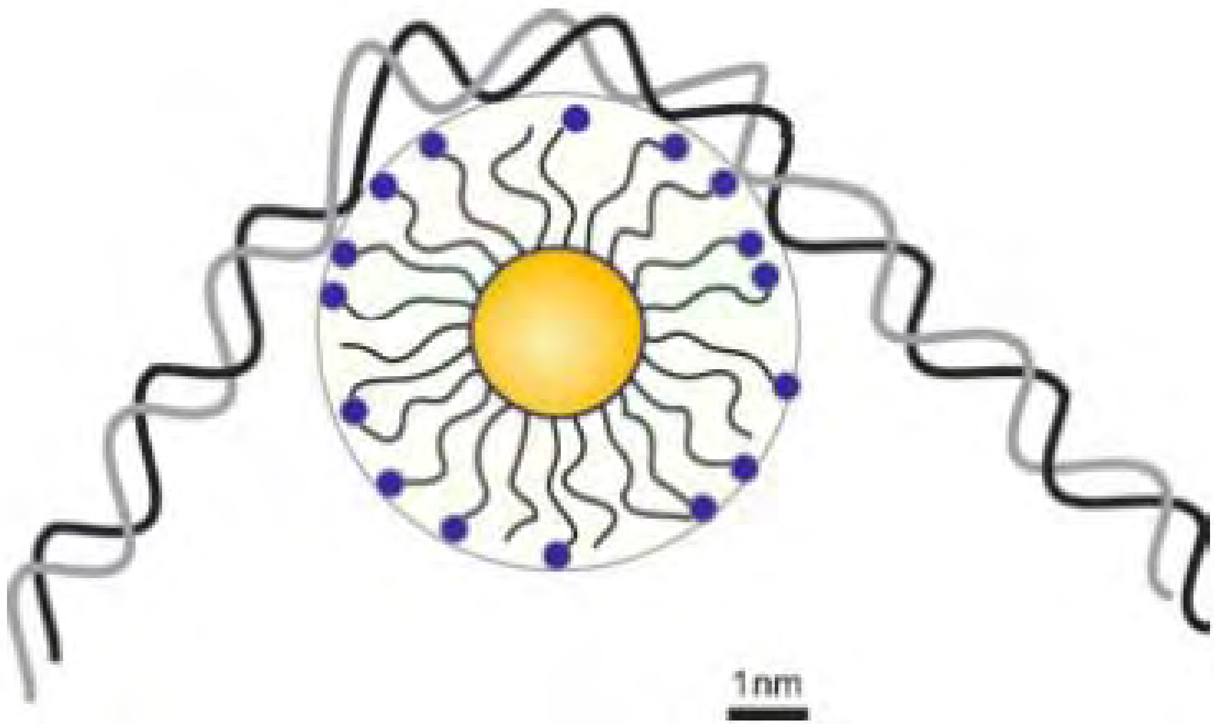


Figure 5: Schematic representation of 60-mer DNA bending on the surface of a cationic gold nanoparticle.

Chem Biol Drug Des 2006; 67: 78–82

SAM-AuNPs (100% COOH)

SAM-AuNPS (80% COOH)

SAM-AuNPs (60% COOH)

SAM-AuNPs (40% COOH)

SAM-AuNPs (20% COOH)

SAM-AuNPS (0% COOH)