Nanobiotechnology

Place: 5F, First Meeting Room New building of Institute of Physics
Time: 9:30-12:10

Nanobiotechnology, edited by C.M. Niemeyer, C.A. Mirkin, Wiley-VCH, 2004

Grade: 30% midterm, 30% oral presentation, 40% final report

Oral Presentation

1. 30 minutes each person
2. Five references (2004-2007)
3. At least, one from Nature, Science, Nature Biotechnology
4. Other journals: Nano Letter, Advanced Materials, PNAS, JACS, PRL

What is nanobiotechnology

Nano + Bio

Nano-fabrication => nanofluidic, nanowire

Nanomaterials => Q-dots, SERS, Plasmon

Nano-imaging => AFM, optical tool, EM

Nano-manipulation => optical, electrical, magnetic, mechanical

What is nanobiotechnology

Bio + nano

DNA assembly

Cell factory

Molecular motor

Energy

Nanotechnolgy

Top-Down Approach

Lithographic, Manipulation, Industrial process

Bottom-Up

Self-assembly, natural process

Building Block

Log, Brick

High energy physicist –quark

Physicist-proton, neutron, electron

➔periodic table

Chemist- molecule

Biologist- cells

How to assemble them

Thermodynamic

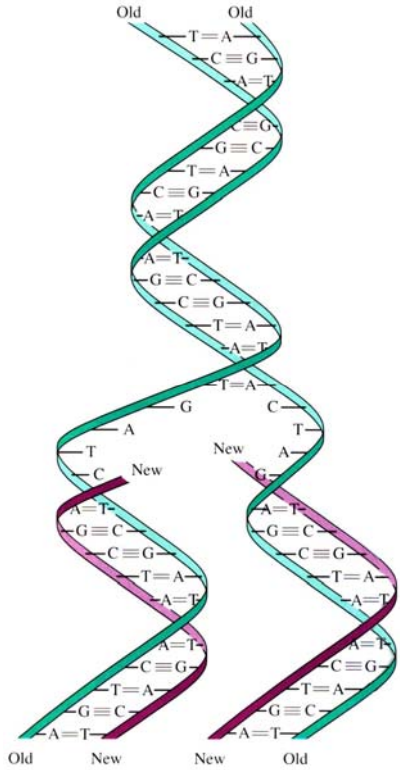
Strong-Weak interaction

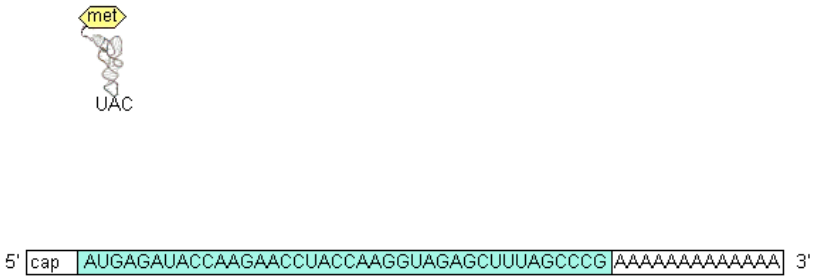
Chemical bond

Hydrogen bond

Other interaction

Self-Assembly Process in Nature

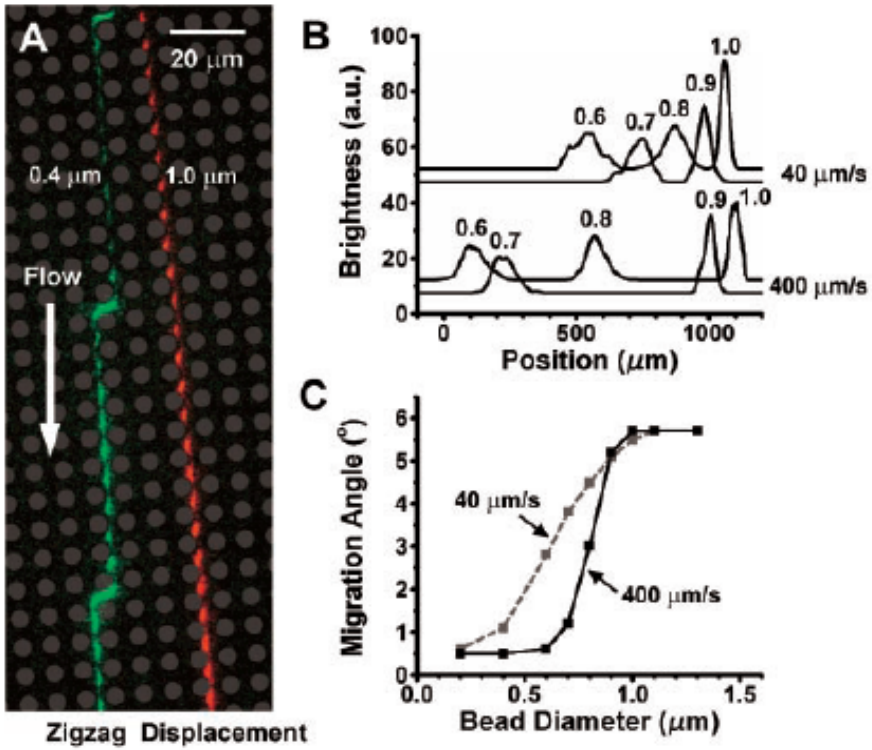


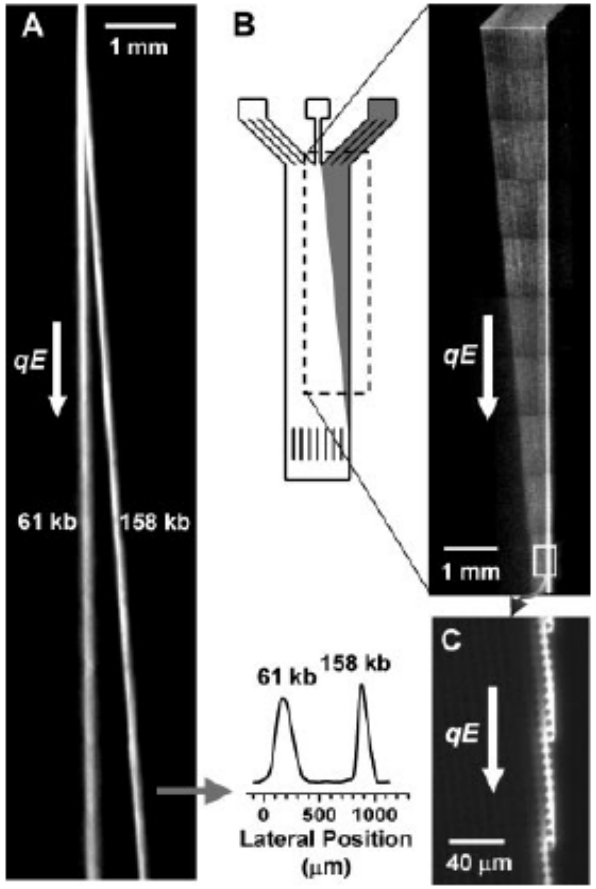


Continuous Particle Separation Through Deterministic Lateral Displacement

Lotien Richard Huang,[1] Edward C. Cox,[2]
Robert H. Austin,[3] James C. Sturm[1]

SCIENCE VOL 304 14 MAY 2004

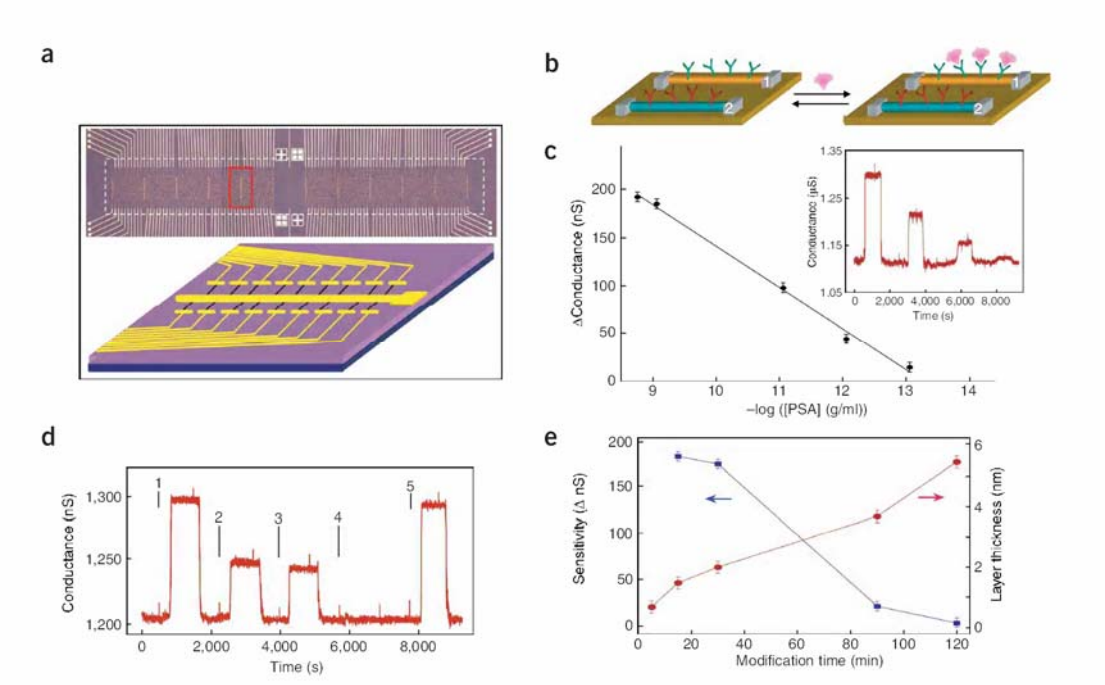


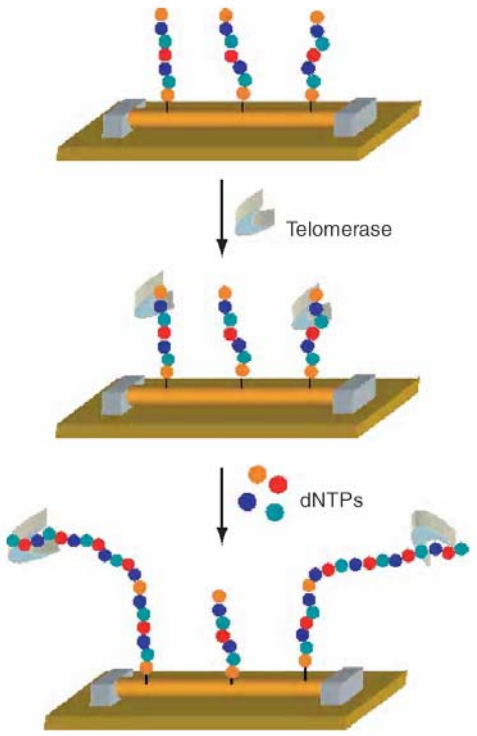


Multiplexed electrical detection of cancer markers with nanowire sensor arrays

Gengfeng Zheng[1,4], Fernando Patolsky[1,4], Yi Cui[1], Wayne U Wang[1,2] & Charles M Lieber[1,3]

VOLUME 23 NUMBER 10 OCTOBER 2005 NATURE BIOTECHNOLOGY

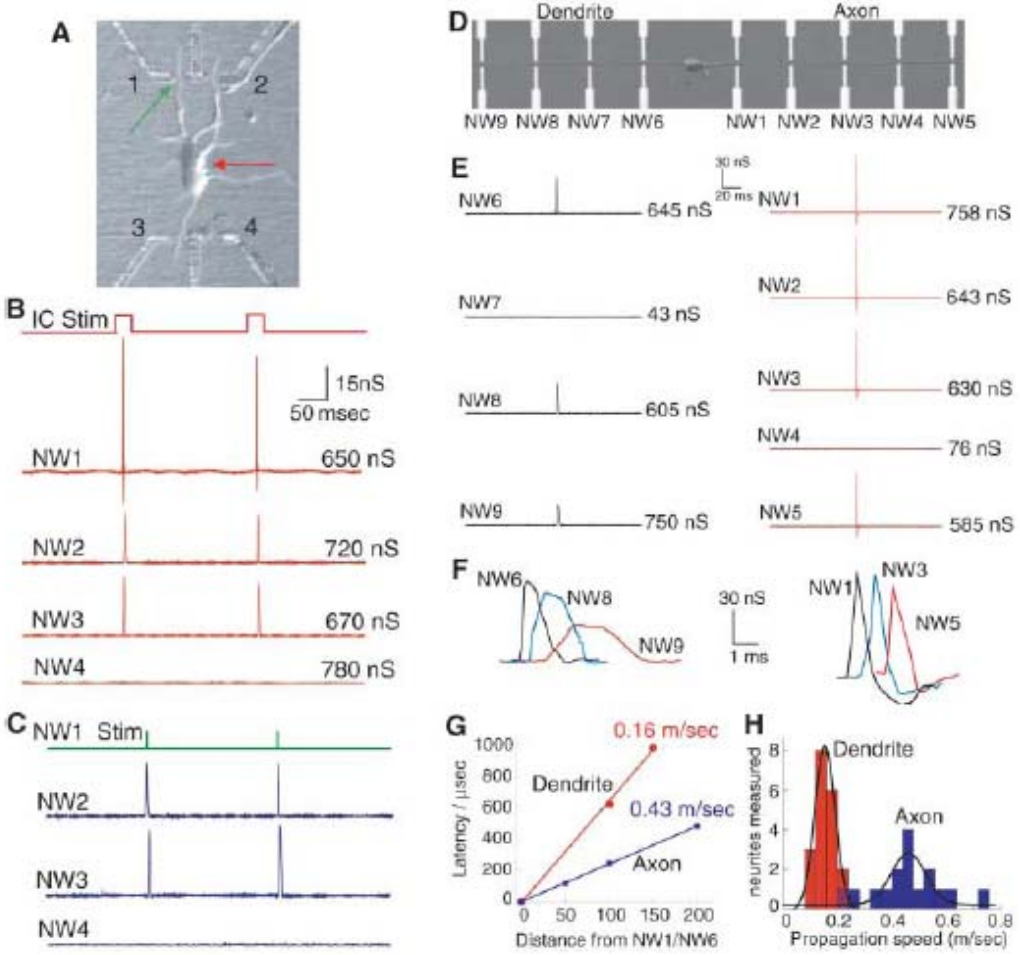




Detection, Stimulation, and Inhibition of Neuronal Signals with High-Density Nanowire Transistor Arrays

25 AUGUST 2006 VOL 313

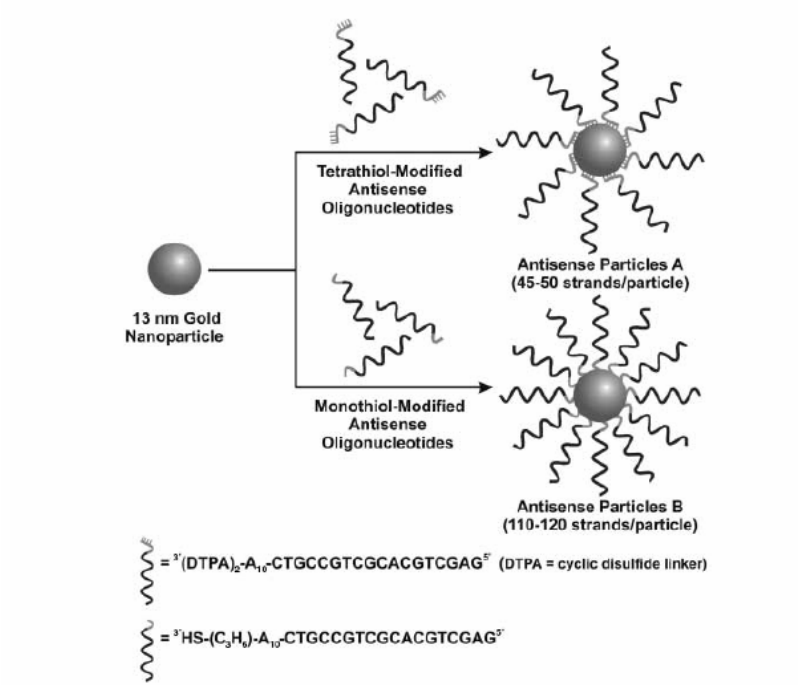
Fernando Patolsky,[1*] Brian P. Timko,[1*] Guihua Yu,[1] Ying Fang,[1] Andrew B. Greytak,[1] Gengfeng Zheng,[1] Charles M. Lieber[1,2]†

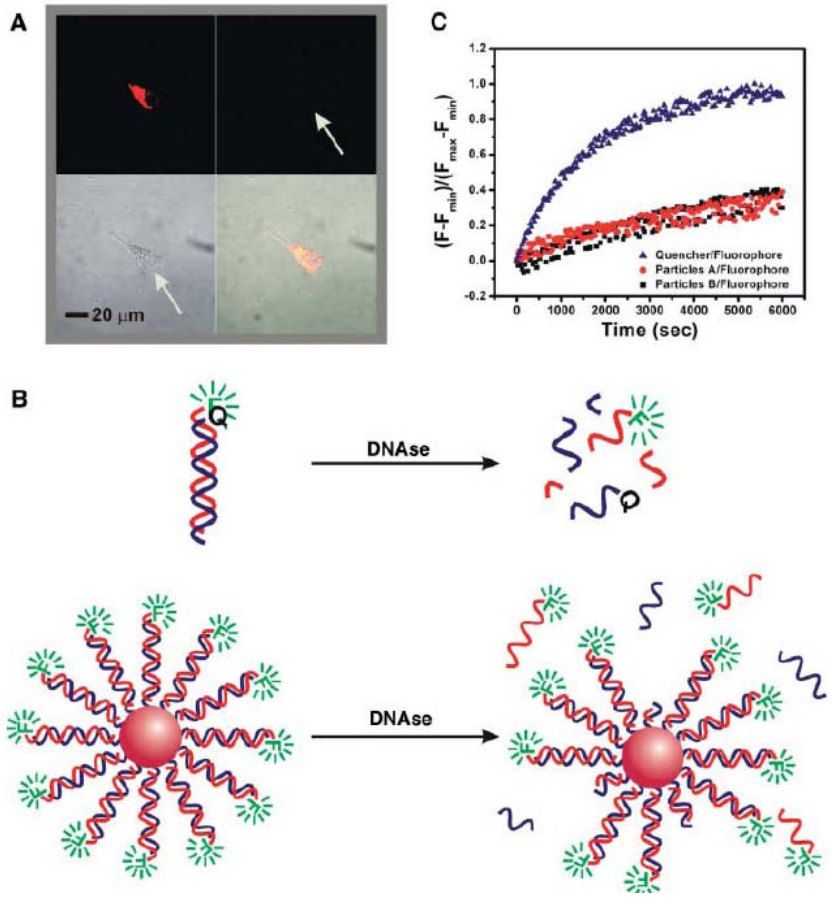


Oligonucleotide-Modified Gold Nanoparticles for Intracellular Gene Regulation

SCIENCE VOL 312 19 MAY 2006

Nathaniel L. Rosi,* David A. Giljohann,* C. Shad Thaxton, Abigail K. R. Lytton-Jean, Min Su Han, Chad A. Mirkin†





Nanoparticle-Based Bio–Bar Codes for the Ultrasensitive Detection of Proteins

26 SEPTEMBER 2003 VOL 301 SCIENCE

Jwa-Min Nam,* C. Shad Thaxton,* Chad A. Mirkin†

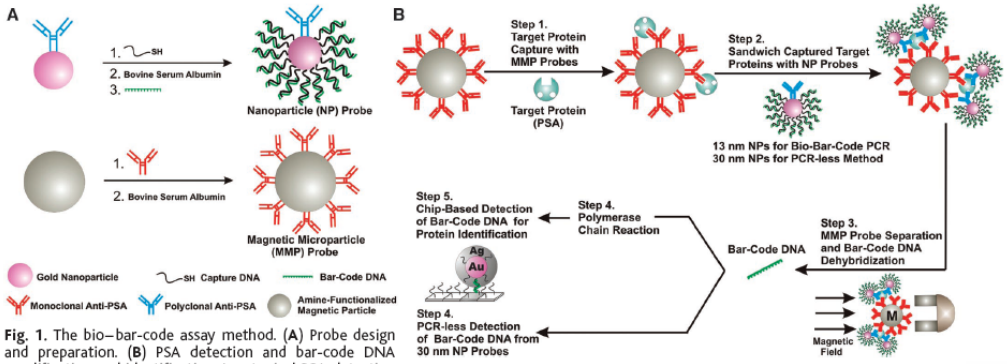
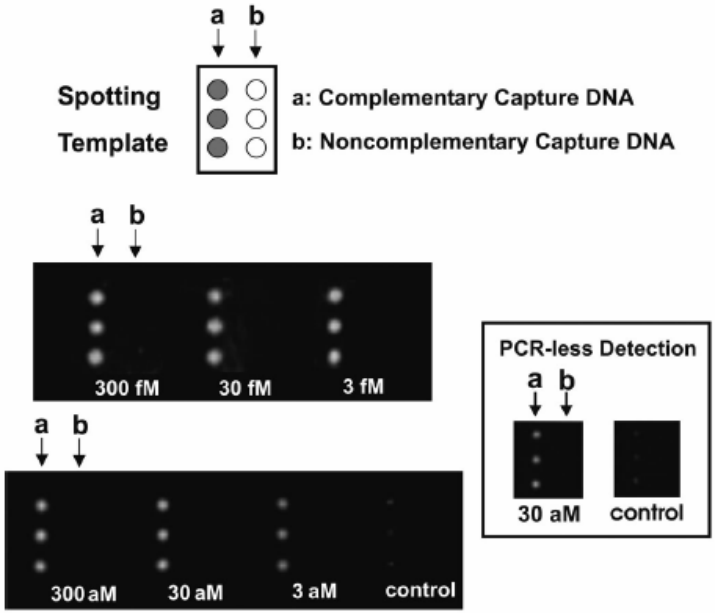


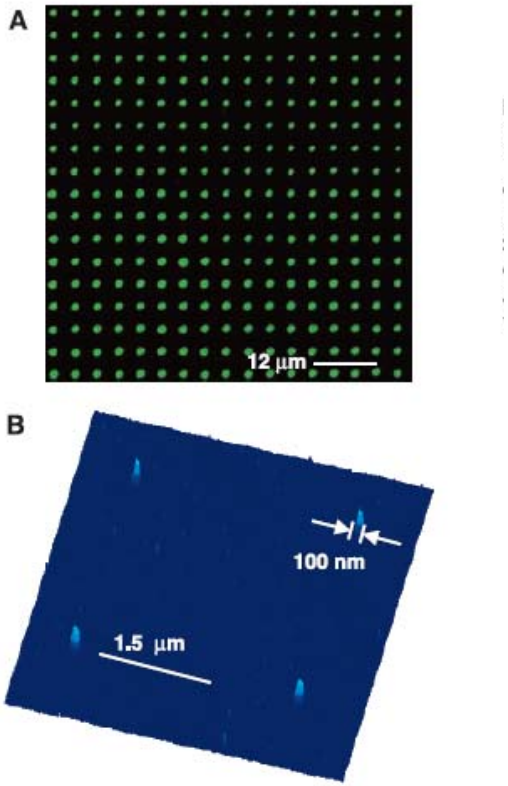
Fig. 1. The bio–bar-code assay method. (**A**) Probe design and preparation. (**B**) PSA detection and bar-code DNA amplification and identification. In a typical PSA-detection

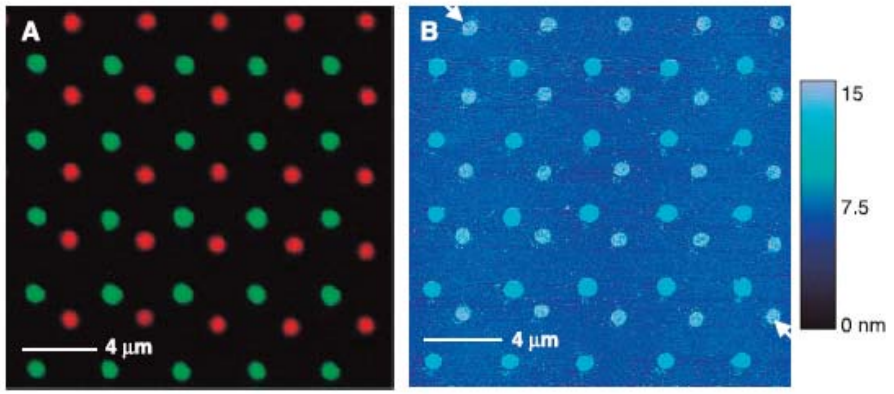


Direct Patterning of Modified Oligonucleotides on Metals and Insulators by Dip-Pen Nanolithography

L. M. Demers,* D. S. Ginger,* S.-J. Park,
Z. Li, S.-W. Chung, C. A. Mirkin†

7 JUNE 2002 VOL 296





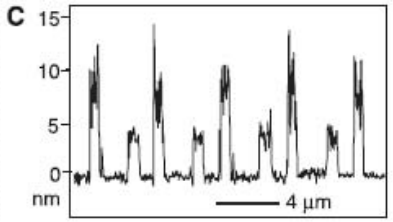
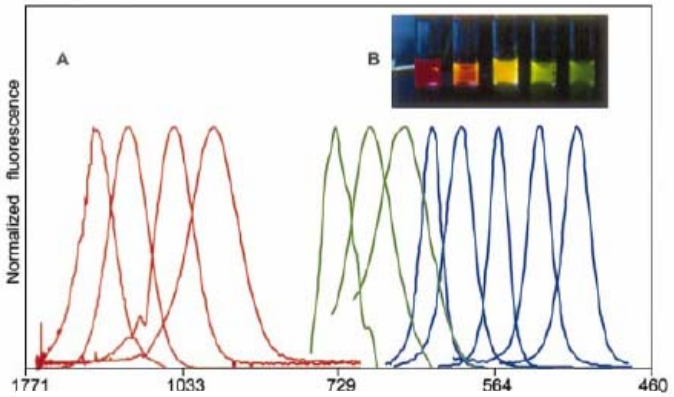


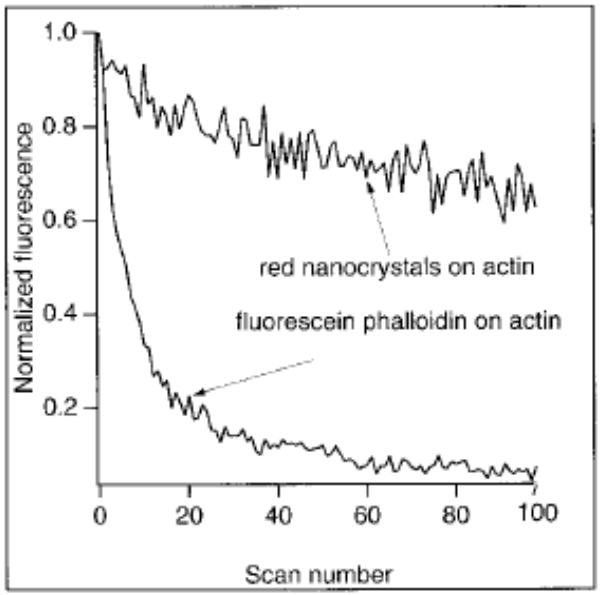
Fig. 4. Direct patterning of multiple-DNA inks by DPN. (**A**) Combined red-green epifluorescence image of two different fluorophore-labeled sequences (Oregon Green 488-X and Texas Red-X) simultaneously hybridized to a two-sequence array deposited on an SiO_x substrate by DPN. (**B**) Tapping-mode AFM image of 5 (dark)- and 13 (light)-nm–diameter gold nanoparticles assembled on the same pattern after dehybridization of the fluorophore-labeled DNA. The scale bars represent 4 μm. (**C**) The line plot was taken diagonally through both nanoparticle patterns, and the start and finish are indicated by the arrows in (B). The scale bar represents 4 μm.

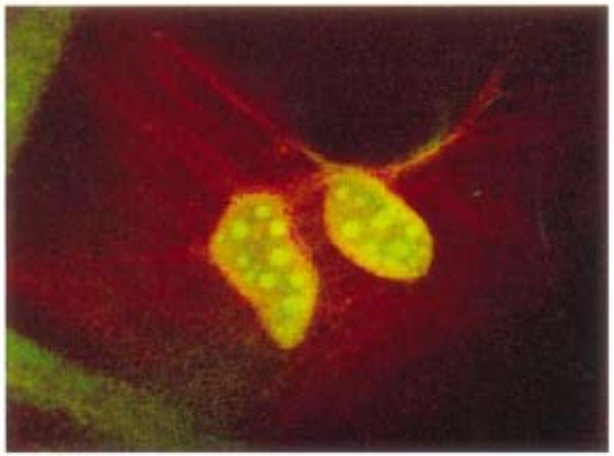
Semiconductor Nanocrystals as Fluorescent Biological Labels

Marcel Bruchez Jr., Mario Moronne, Peter Gin, Shimon Weiss,*
A. Paul Alivisatos*

25 SEPTEMBER 1998 VOL 281 SCIENCE



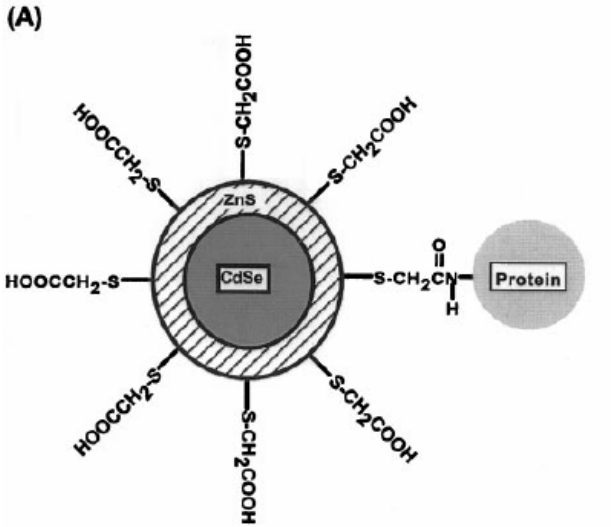


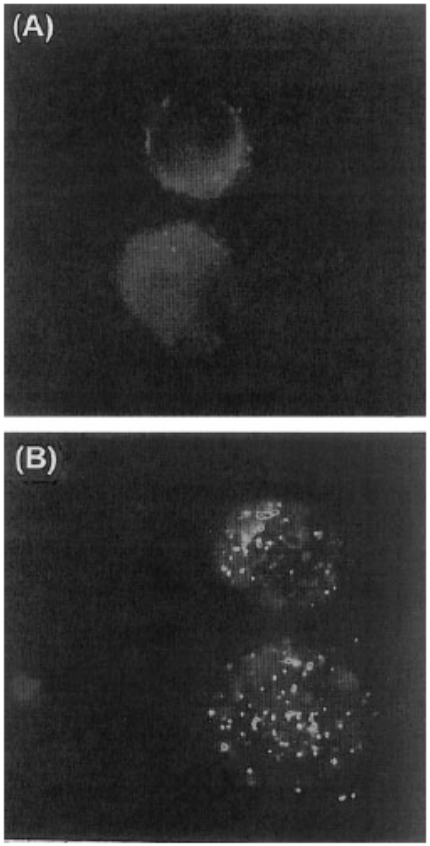


Quantum Dot Bioconjugates for Ultrasensitive Nonisotopic Detection

25 SEPTEMBER 1998 VOL 281 SCIENCE

Warren C. W. Chan and Shuming Nie*

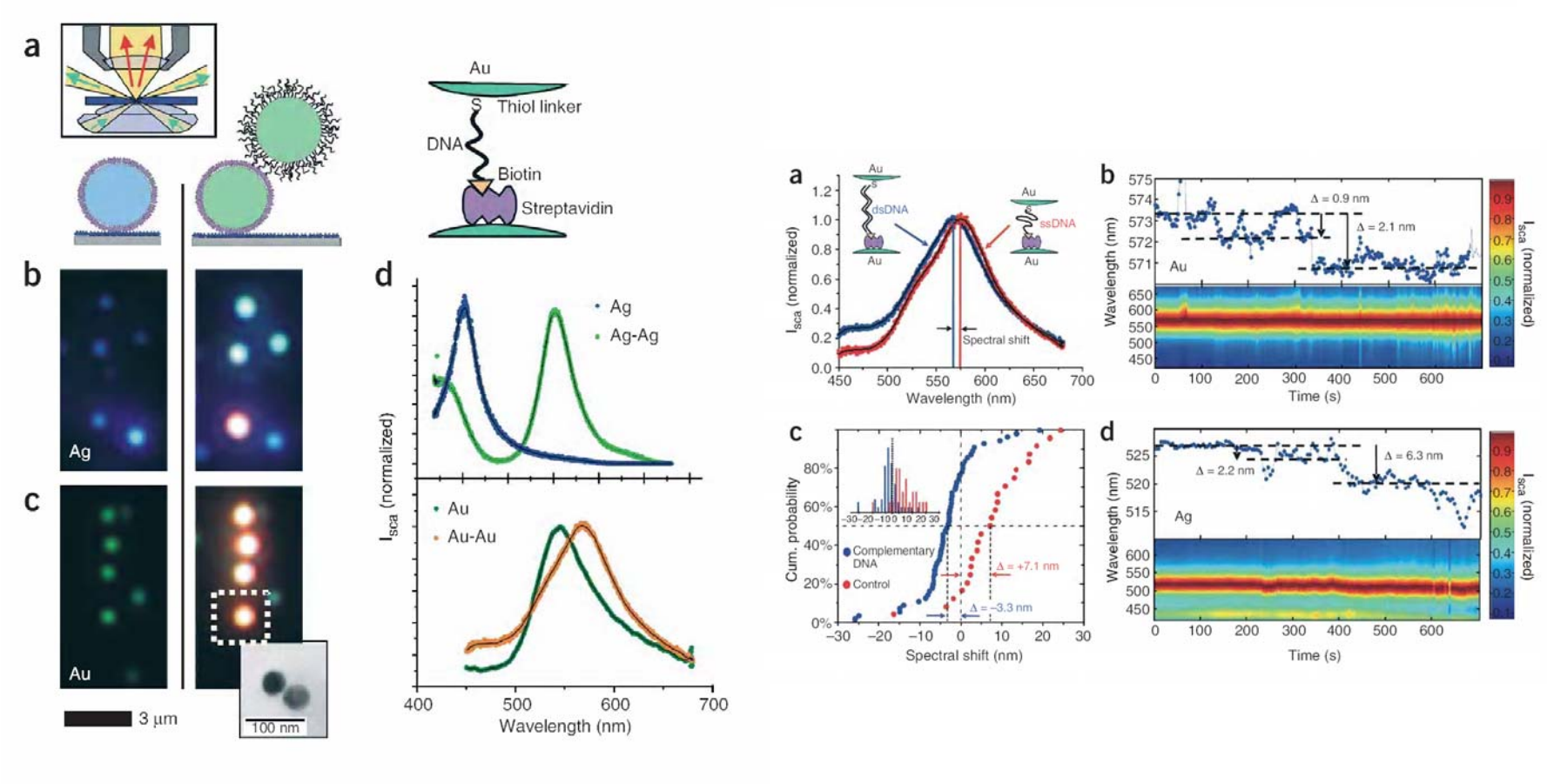




A molecular ruler based on plasmon coupling of single gold and silver nanoparticles

Carsten Sönnichsen[1,3], Björn M Reinhard[2,3], Jan Liphardt[2] & A Paul Alivisatos[1]

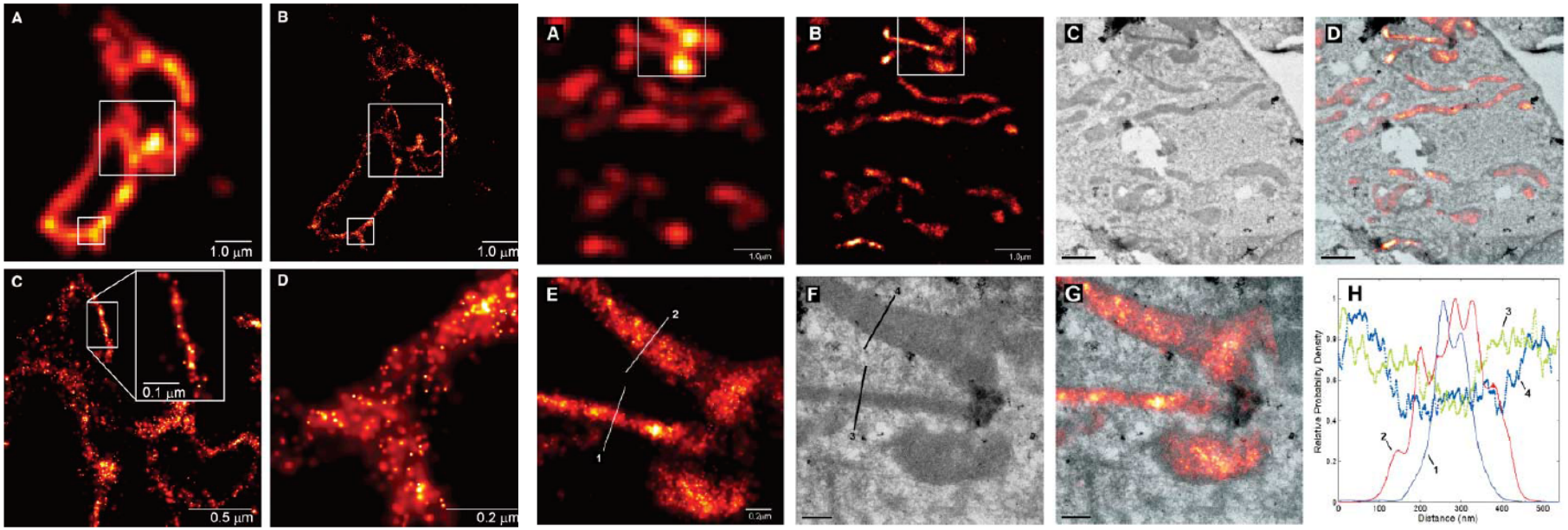
NATURE BIOTECHNOLOGY VOLUME 23 NUMBER 6 JUNE 2005



Imaging Intracellular Fluorescent Proteins at Nanometer Resolution

Eric Betzig,[1,2*]† George H. Patterson,[3] Rachid Sougrat,[3] O. Wolf Lindwasser,[3] Scott Olenych,[4]
Juan S. Bonifacino,[3] Michael W. Davidson,[4] Jennifer Lippincott-Schwartz,[3] Harald F. Hess[5*]

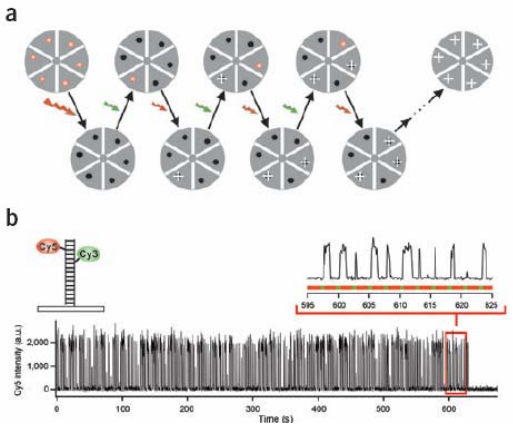
15 SEPTEMBER 2006 VOL 313 SCIENCE



Sub-diffraction-limit imaging by stochastic optical reconstruction microscopy (STORM)

NATURE METHODS | VOL.3 NO.10 | OCTOBER 2006 | 793

Michael J Rust[1,5], Mark Bates[2,5] & Xiaowei Zhuang[1,3,4]



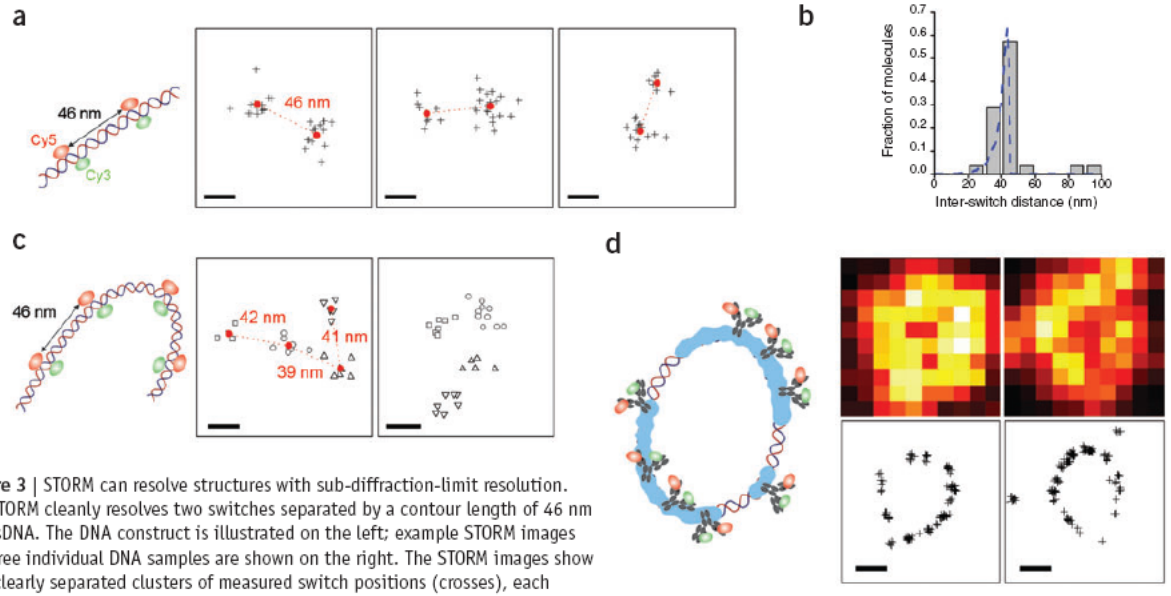
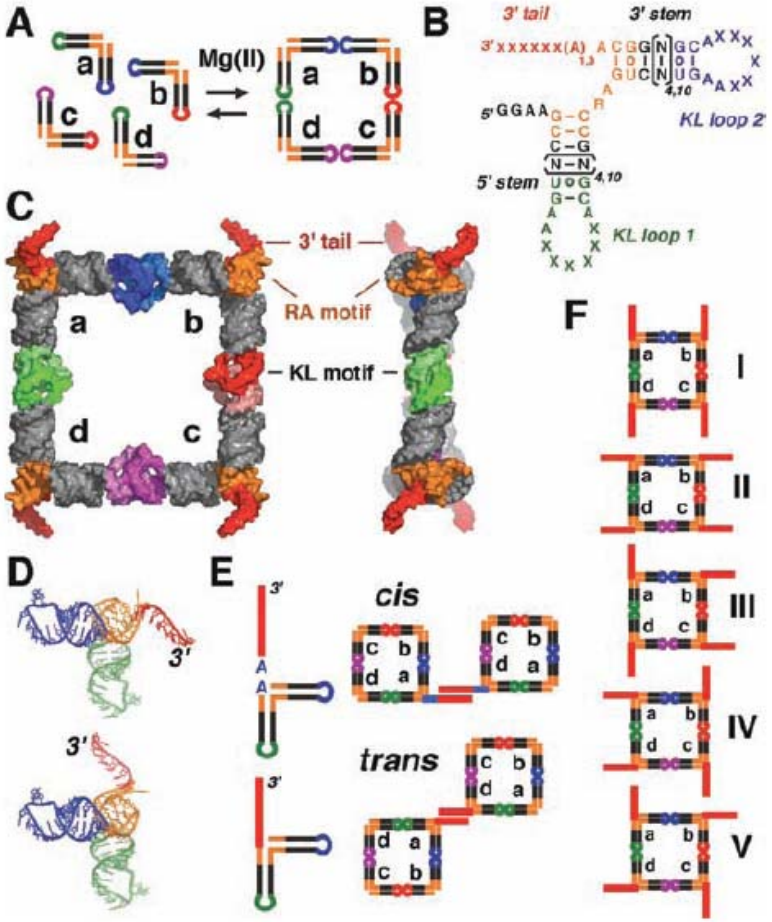


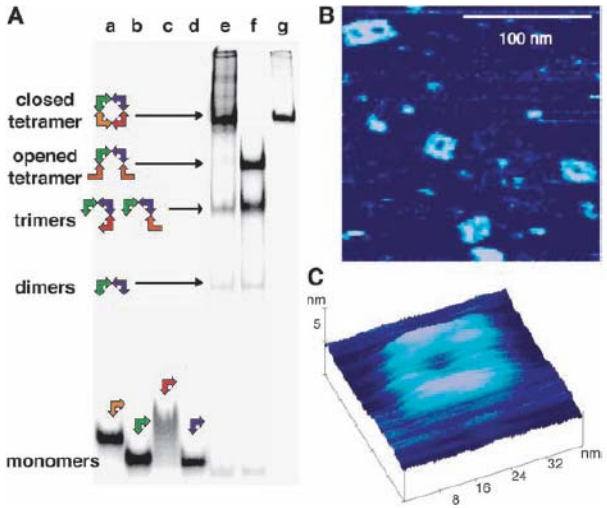
Figure 3 | STORM can resolve structures with sub-diffraction-limit resolution. (**a**) STORM cleanly resolves two switches separated by a contour length of 46 nm on dsDNA. The DNA construct is illustrated on the left; example STORM images of three individual DNA samples are shown on the right. The STORM images show two clearly separated clusters of measured switch positions (crosses), each corresponding to a single switch. The center-of-mass position of each cluster is marked by a red dot. The inter-switch distances are 46 nm, 44 nm and 34 nm for these three examples. Scale bars, 20 nm. (**b**) Comparison between the inter-switch distances measured using STORM (columns) and the predicted distance distribution considering the flexibility of DNA (dashed line). (**c**) STORM images of four switches attached to a dsDNA, pair-wise separated by a contour length of 46 nm. The measured switch positions are clustered by an automated algorithm and different clusters are indicated by different symbols. Scale bars, 20 nm. (**d**) STORM images of RecA-coated circular plasmid DNA. Indirect immunofluorescence images with switch-labeled secondary antibody taken by a total internal reflection microscope (top); the reconstructed STORM images of the same filaments (bottom). Scale bars, 300 nm.

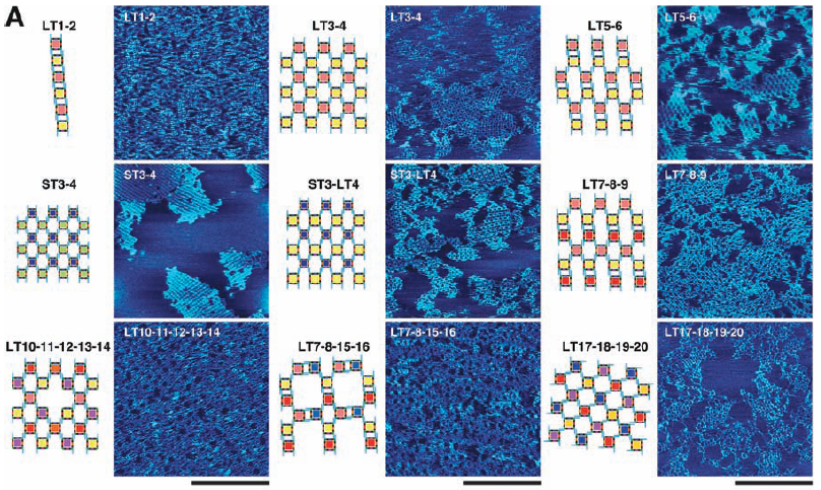
Building Programmable Jigsaw Puzzles with RNA

17 DECEMBER 2004 VOL 306 SCIENCE

Arkadiusz Chworos,[1] Isil Severcan,[1] Alexey Y. Koyfman,[1,2] Patrick Weinkam,[1,4] Emin Oroudjev,[3] Helen G. Hansma,[3] Luc Jaeger[1,2]*



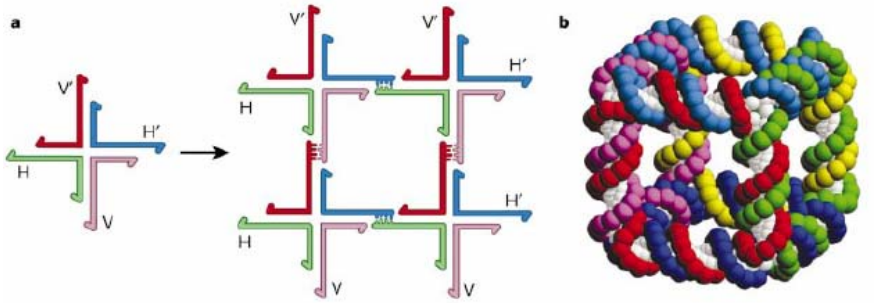


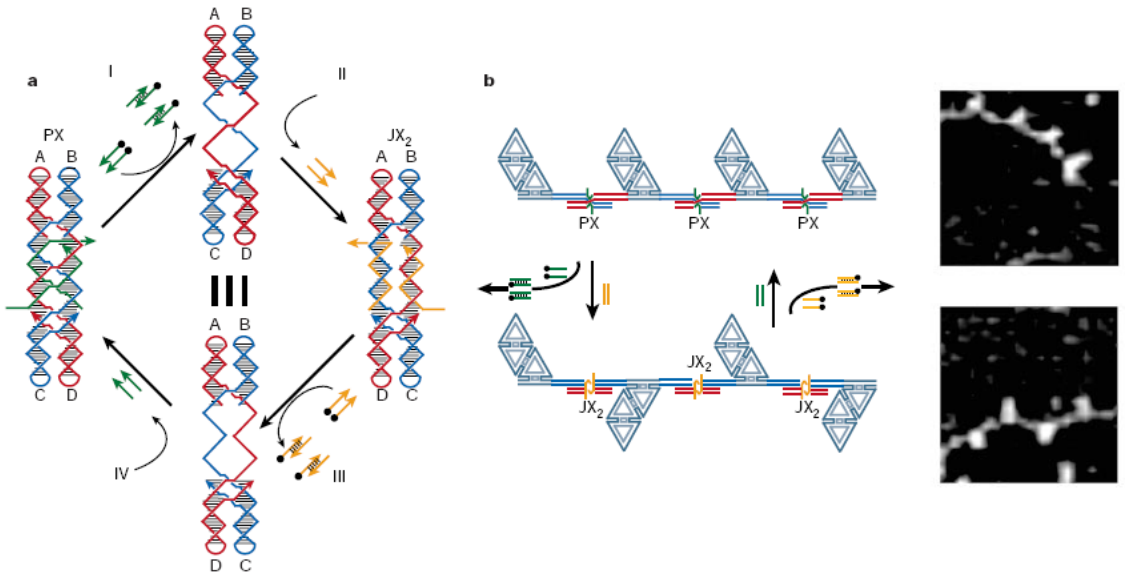


DNA in a material world

NATURE | VOL 421 | 23 JANUARY 2003 | www.nature.com/nature

Nadrian C. Seeman

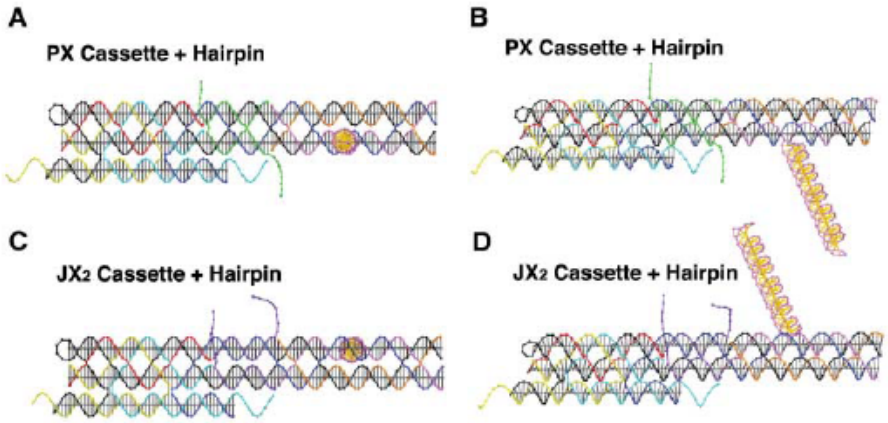


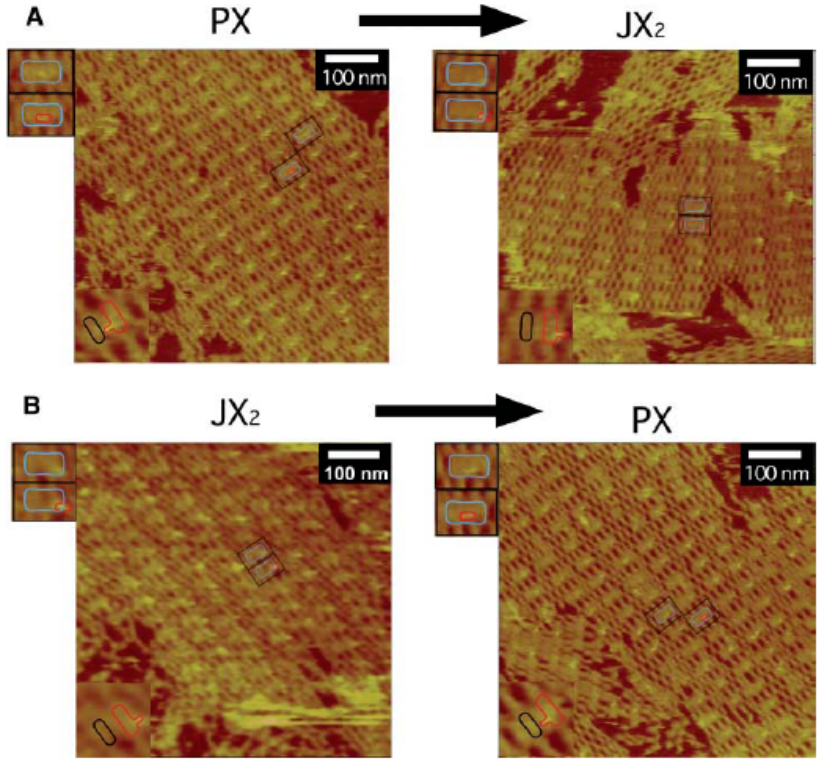


Operation of a DNA Robot Arm Inserted into a 2D DNA Crystalline Substrate

Baoquan Ding and Nadrian C. Seeman*

SCIENCE VOL 314 8 DECEMBER 2006

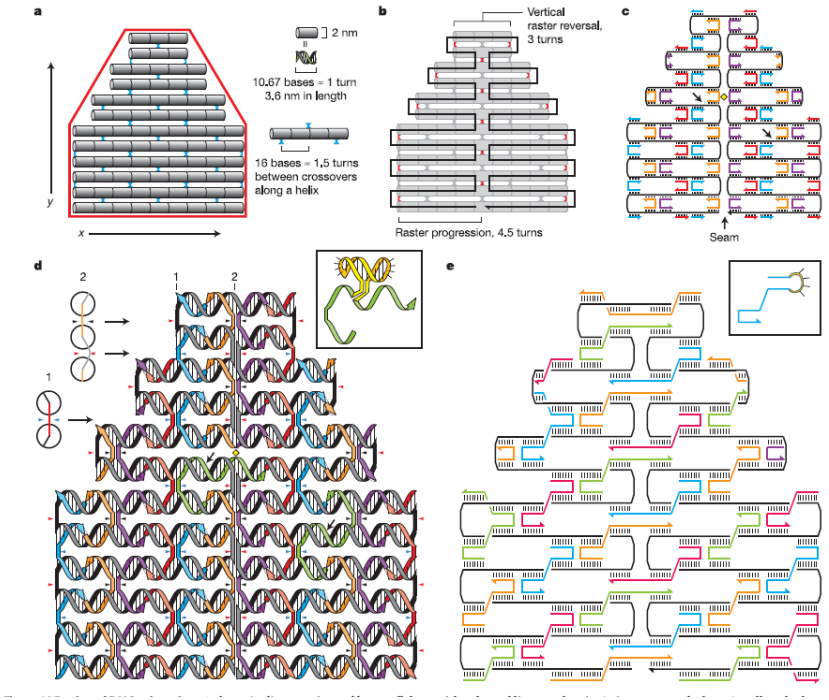


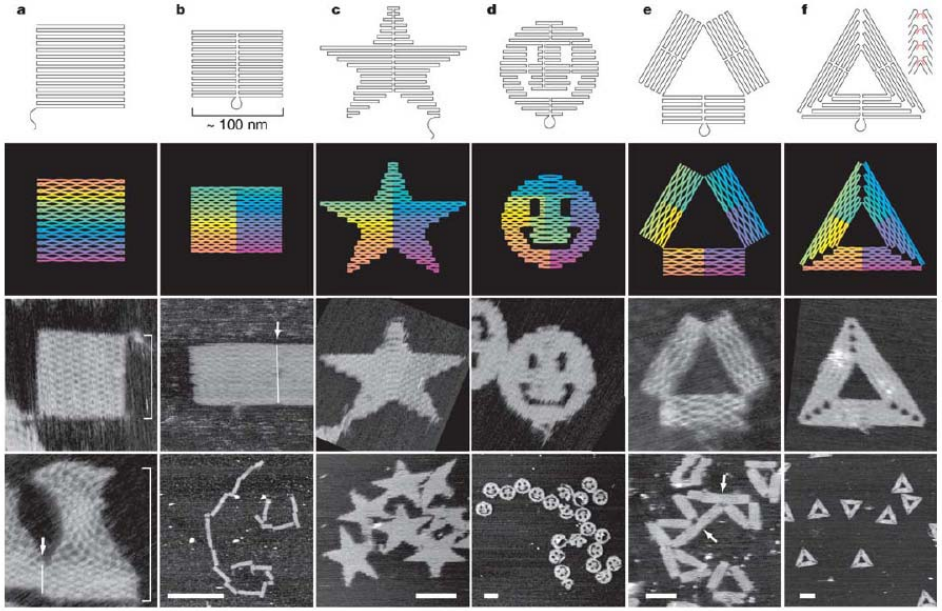


Folding DNA to create nanoscale shapes and patterns

NATURE|Vol 440|16 March 2006

Paul W. K. Rothemund[1]





Molecular Sorting by Electrical Steering of Microtubules in Kinesin-Coated Channels

12 MAY 2006 VOL 312 SCIENCE

Martin G. L. van den Heuvel, Martijn P. de Graaff, Cees Dekker*

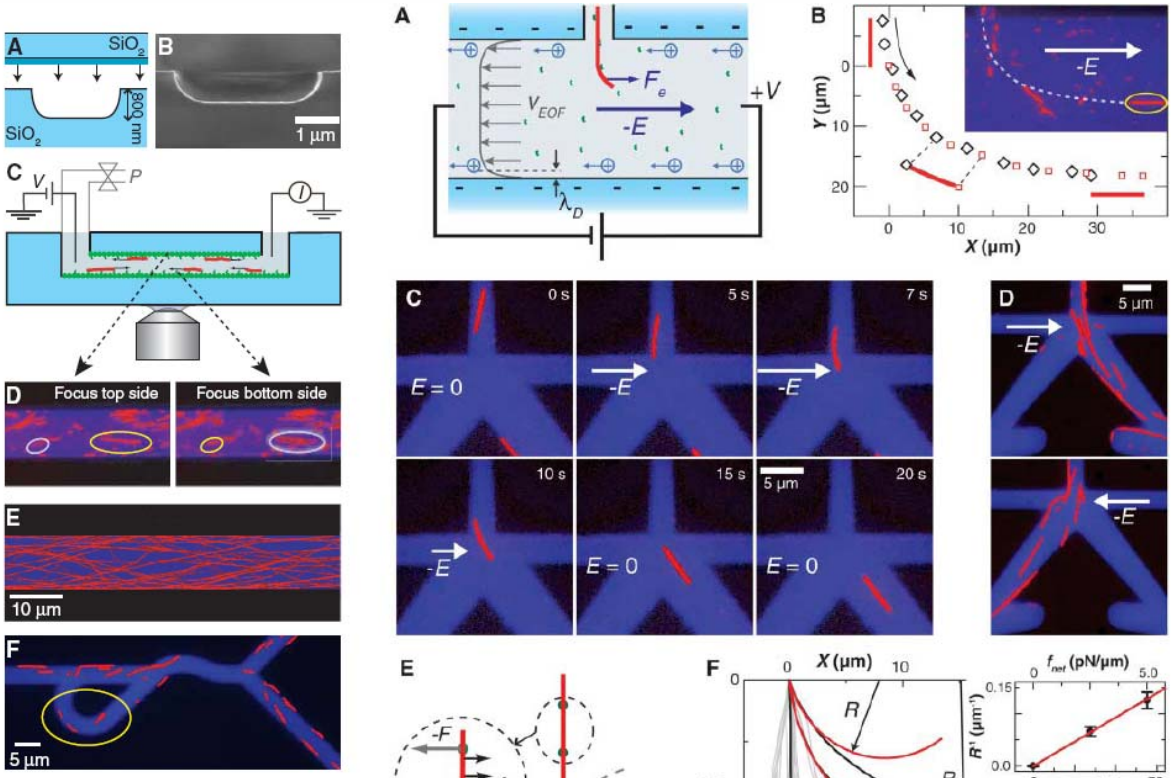
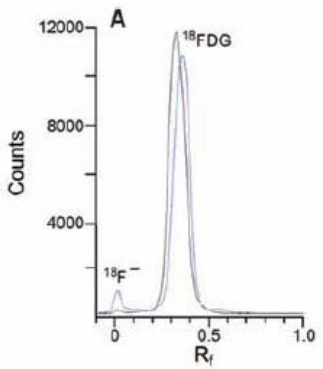


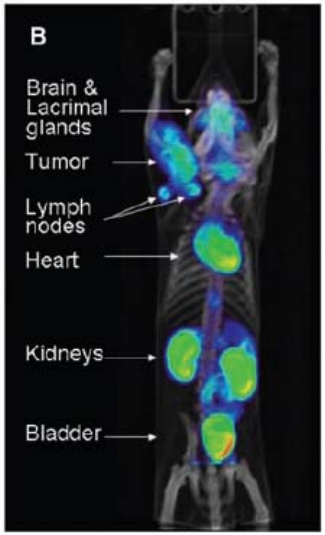
Fig. 1. Enclosed submicron channels allow for full confinement of microtubules. (**A**) E-beam lithography and wet etching create 800-nm-deep trenches in SiO_2 substrates. A coverslip coated with a sodium-silicate solution (dark blue) seals the channel after annealing. (**B**) Scanning electron microscopy image of a cross section of a nanochannel. (**C**) Schematic cross section along

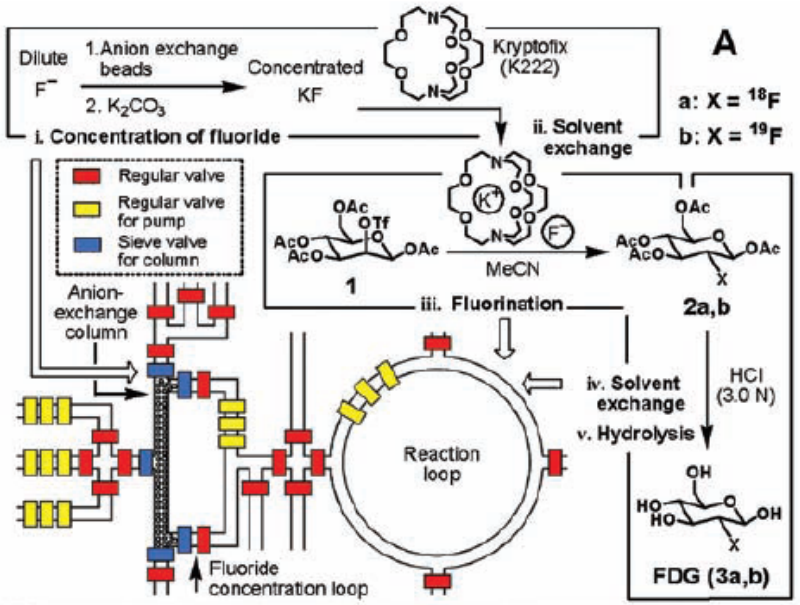
Multistep Synthesis of a Radiolabeled Imaging Probe Using Integrated Microfluidics

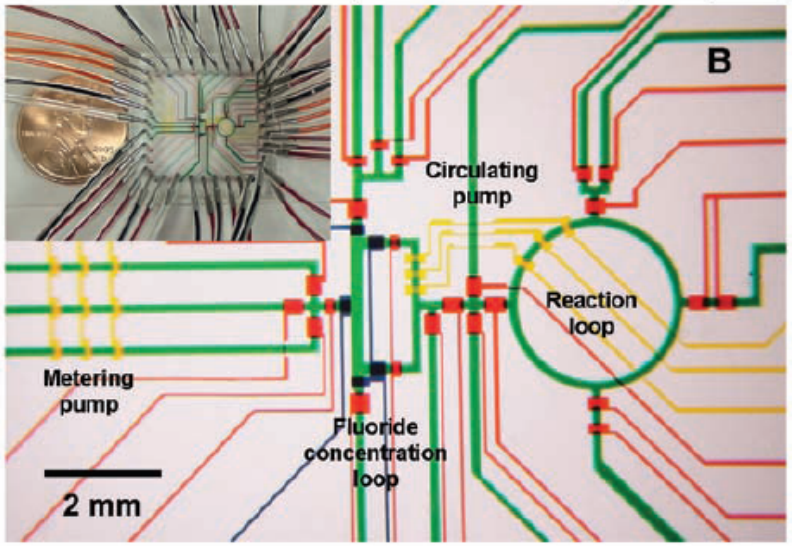
Chung-Cheng Lee,[1*] Guodong Sui,[3,4*] Arkadij Elizarov,[2*]
Chengyi Jenny Shu,[5] Young-Shik Shin,[2] Alek N. Dooley,[6]
Jiang Huang,[8] Antoine Daridon,[8] Paul Wyatt,[8]
David Stout,[4] Hartmuth C. Kolb,[3,9] Owen N. Witte,[3,5,7]
Nagichettiar Satyamurthy,[3] James R. Heath,[2,3,4]
Michael E. Phelps,[3,4] Stephen R. Quake,[1,10]† Hsian-Rong Tseng[3,4]†

SCIENCE VOL 310 16 DECEMBER 2005





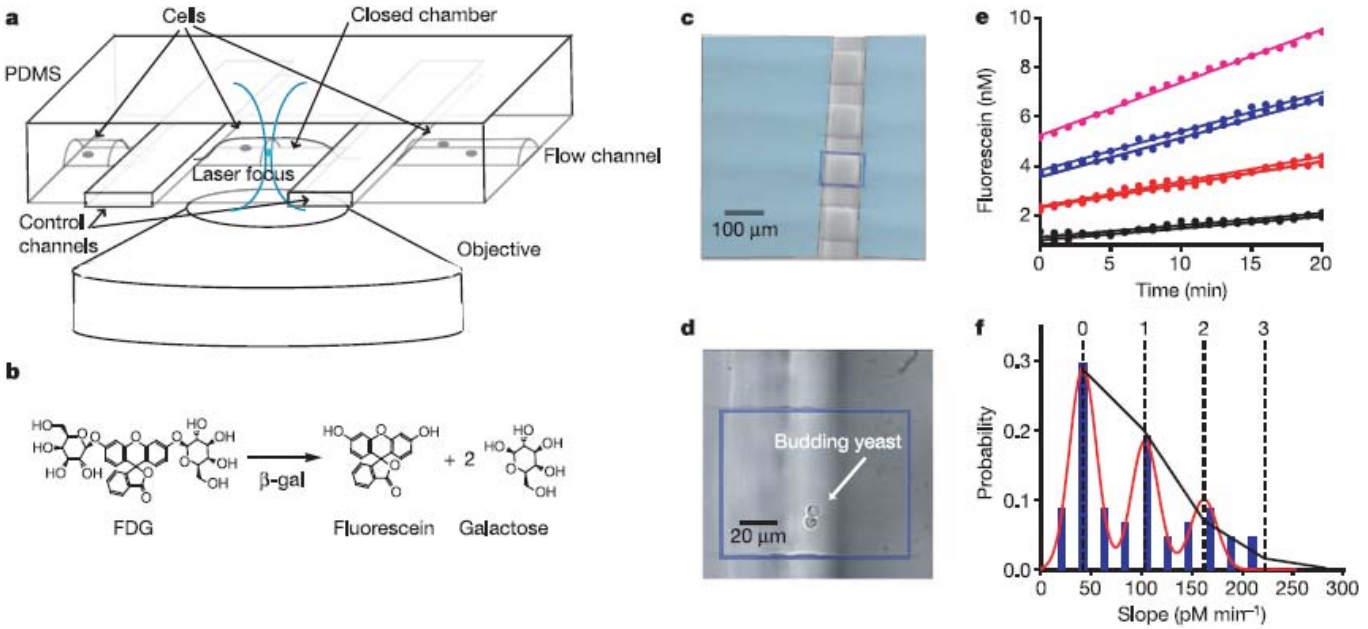




Stochastic protein expression in individual cells at the single molecule level

Long Cai[1]*, Nir Friedman[1]* & X. Sunney Xie[1]

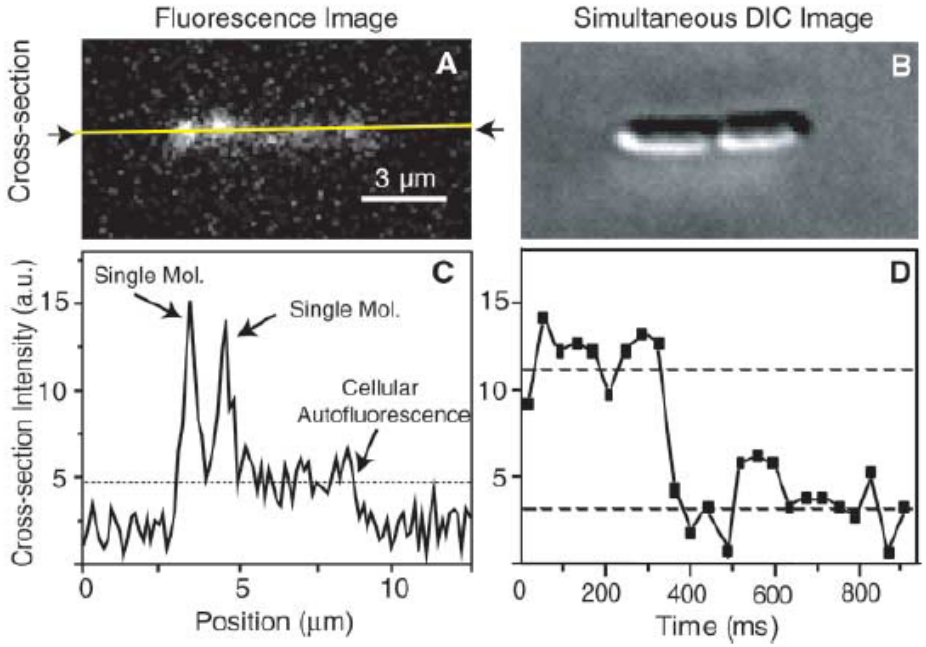
NATURE|Vol 440|16 March 2006



Probing Gene Expression in Live Cells, One Protein Molecule at a Time

Ji Yu,[1*] Jie Xiao,[1*] Xiaojia Ren,[1] Kaiqin Lao,[2] X. Sunney Xie[1]†

17 MARCH 2006 VOL 311 SCIENCE



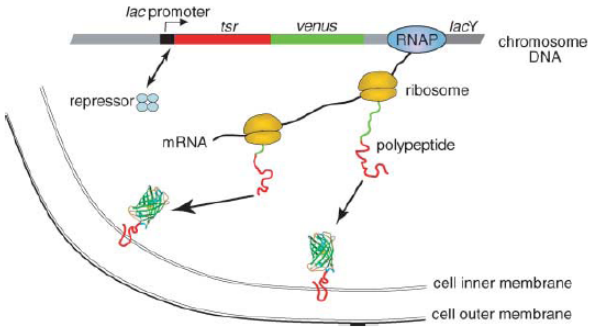


Fig. 2. Experimental design for live-cell observations of gene expression. Tsr-Venus is expressed under the control of *lac* repressor, which binds tightly to the *lac* operator on DNA. Transcription of one mRNA by an RNA polymerase results from an infrequent and transient dissociation event of repressor from DNA. Multiple copies of protein molecules are translated from the mRNA by ribosomes. Upon being assembled into *E. coli*'s inner membrane, Tsr-Venus protein molecules can be detected individually by a fluorescence microscope.

Topics

Engineering:
- Micro- and Nanofluidic
- Nanofabrication
- Microarray
- Cell-surface interaction

Physics:
- Single molecular behavior (Optical and AFM)
- Optical properties of Q-dot
- SERS
- Surface plasmon

Chemistry:
- Nanomaterials: Q-dot, nanoparticle, DNA assembly
- Surface functionalization
- Drug delivery
- DNA, Protein, Cell interactions