

# **DNA - the whole nanoworld in one molecule**

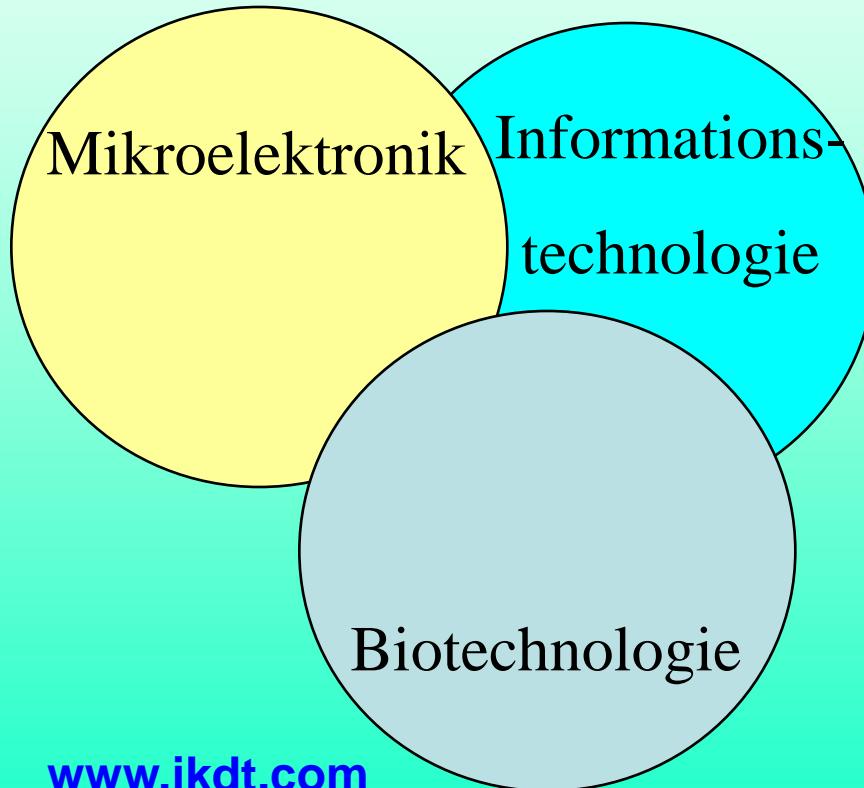
**Dirk Lassner**

**Nanoscience 2009, 15.10.2009**

[www.ikdt.com](http://www.ikdt.com)

## The 3 most important technologies

– End of 20th century





**IKDT**  
Institut Kardiale Diagnostik und Therapie

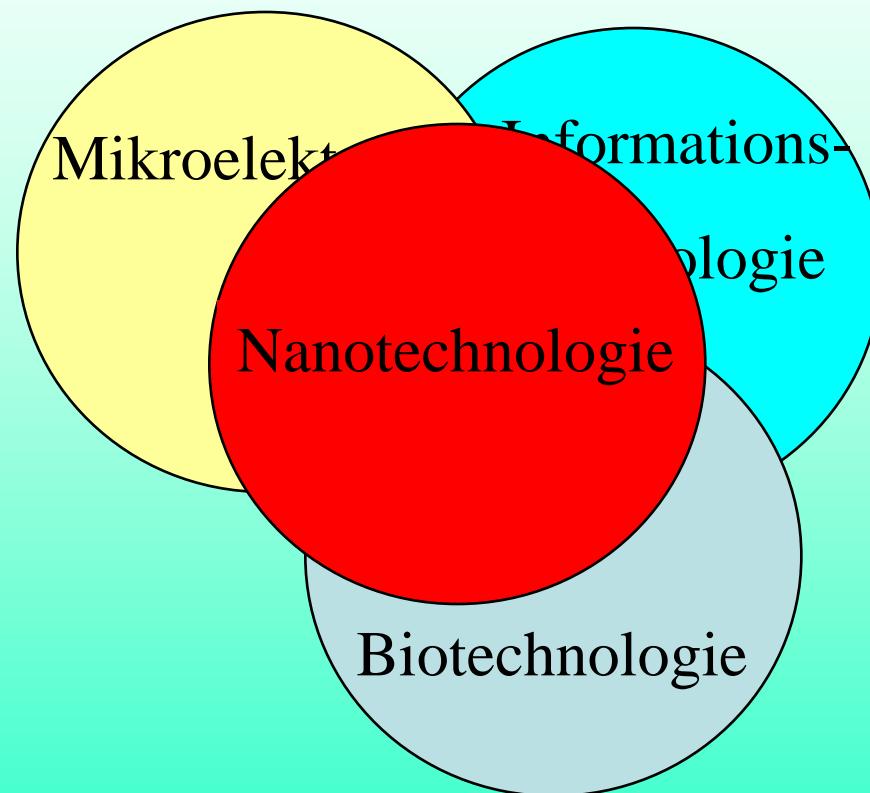
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

## The 4 most important technologies today



## Was ist Nanotechnologie?

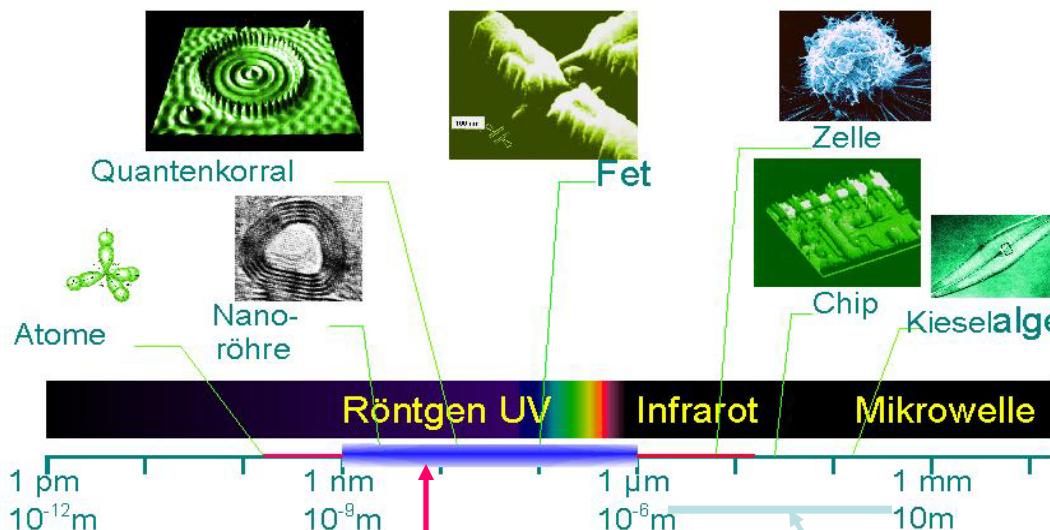
Nanotechnologie ist ein Sammelbegriff für eine weite Palette von Technologien, die sich mit Strukturen und Prozessen im Größenbereich der Nanometerskala befassen.

Ein Nanometer ist ein Milliardstel Meter ( $10^{-9}$  m) und bezeichnet einen Grenzbereich,

in dem die **Oberflächeneigenschaften** gegenüber den **Volumeneigenschaften** der Materialien

eine immer größere Rolle spielen und zunehmend quantenphysikalische Effekte berücksichtigt werden müssen.

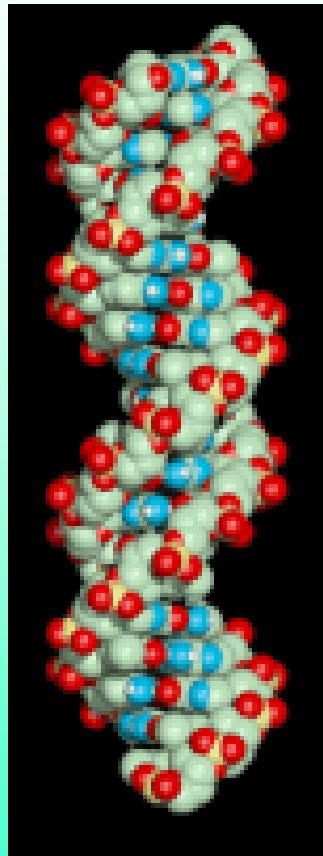
## Längenskalen



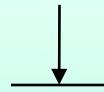
Bereich der Nanotechnologie

[www.ikdt.com](http://www.ikdt.com)

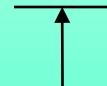
Mikrosystemtechnik



## Desoxyribonucleic acid (DNA)



10nm



- Basics of all living individuals

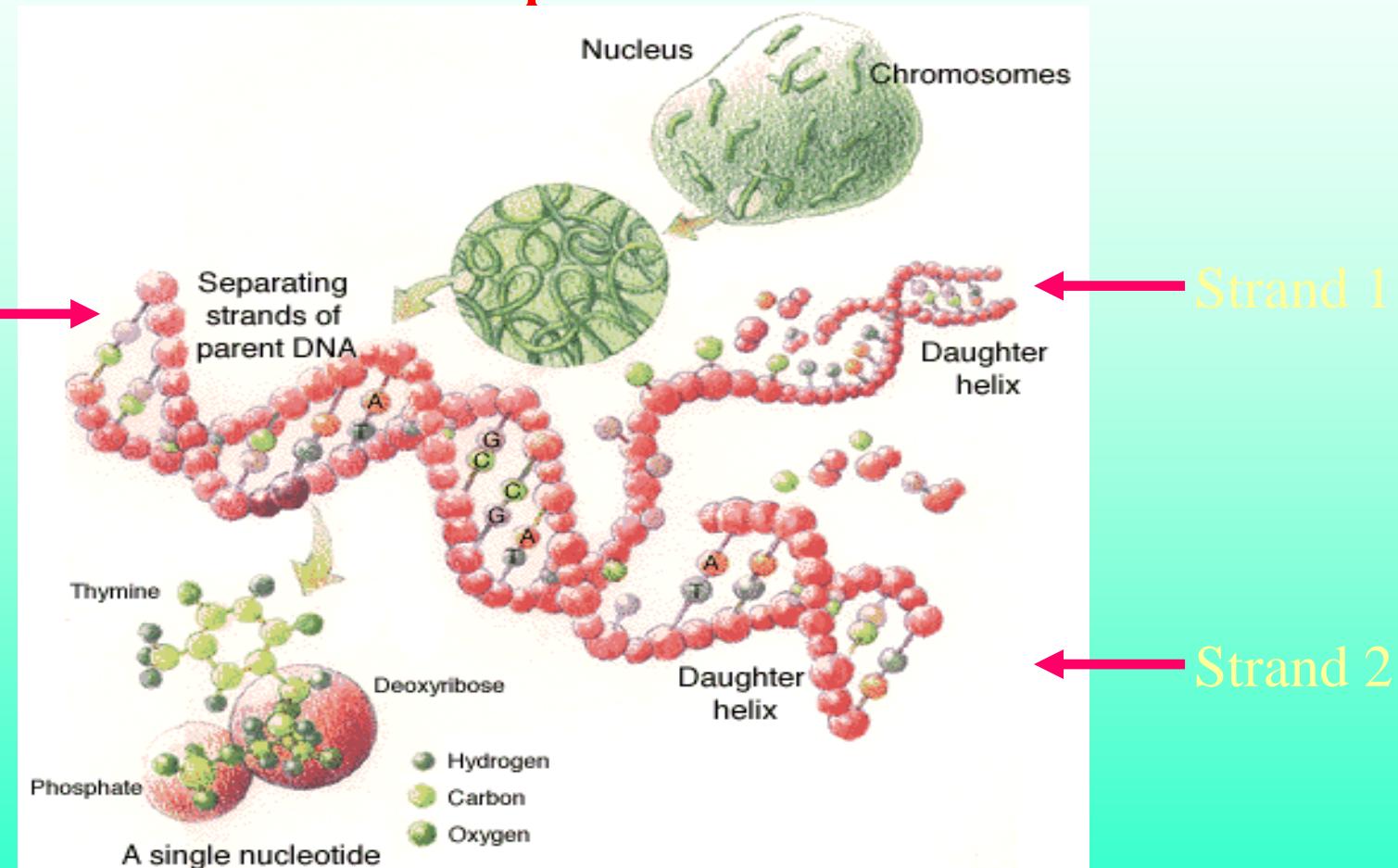
- largest existing hard disk

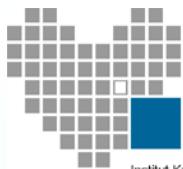
- Nanometer-Konstruktor

→ | 2 nm | ←

## Die identical replication of DNA

mature  
DNA





**IKDT**

Institut Kardiale Diagnostik und Therapie

**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



Advancing Excellence

# Teilgebiete der Nanotechnologie

## Nano-Werkzeuge

Mikroskope

Kalorimeter

Kernspinresonanzdetektor

## Nano-Elektronik

Quanteneffekte

Nano-Speicher

## Nano-Mechanik

molekulare Schalter

mechanische Quantenzustände

Nano-Motoren

## Nano-Chemie

molekulare Erkennung

Oberflächendesign

gezielte Synthese von Molekülen

## Nano-Optik

Licht-Materie-Wechselwirkung

Nano-Laser

## Nano-Biotechnologie/-Medizin

Kopie der biologischen Systeme

Nutzung und Modifikation von Biomolekülen

Selbstorganisation komplexer Systeme

[www.ikdt.com](http://www.ikdt.com)

Importance for human society,  
history, politics and so on???

## Nano Devices

Mikroscops

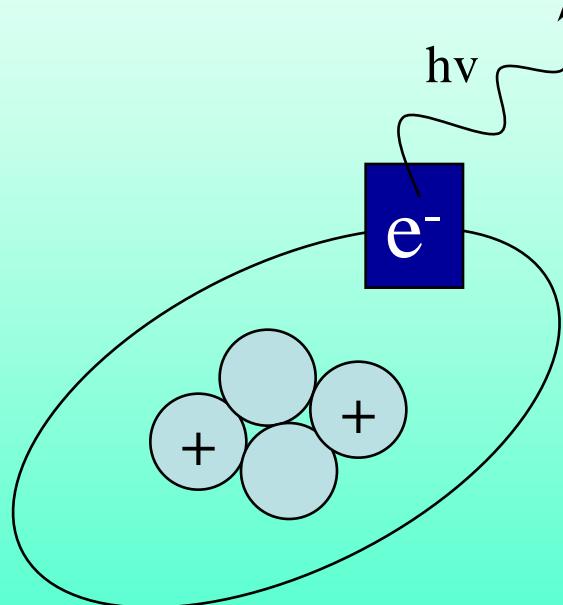
Calorimeter

Nuclear Spin Resonance detektor

# Was soll gemessen oder beeinflußt werden ?

**Was?**

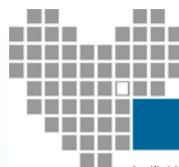
- Atome
- Moleküle
- Molekülschichten
- Strukturen



**Womit?**

- Licht
- Wellen
- Magnet
- Temperatur
- Milieu
- Druck
- Strom

*Welle-Teilchen-Dualismus*



**IKDT**

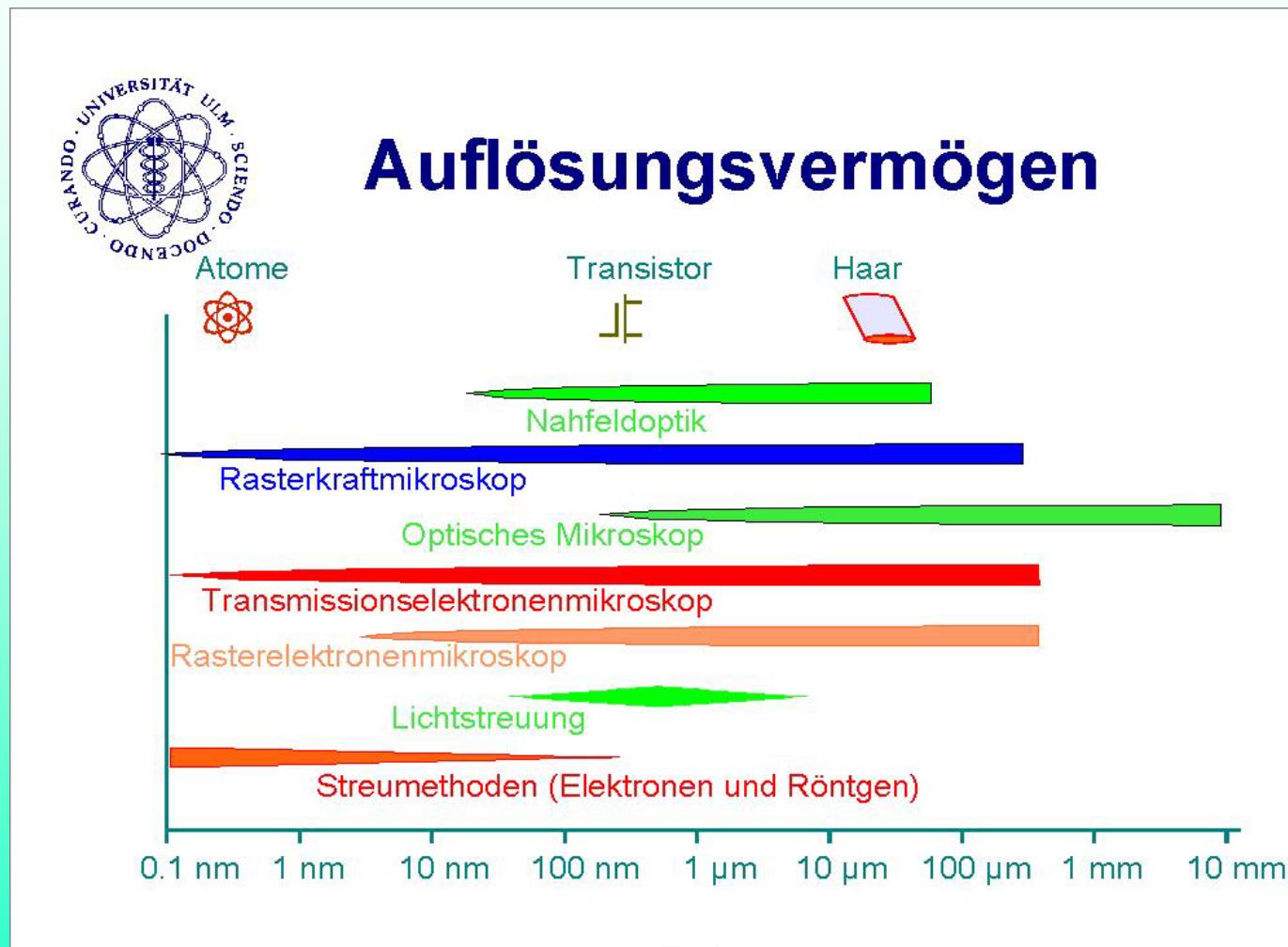
Institut Kardiale Diagnostik und Therapie

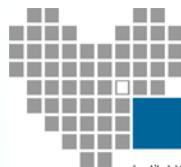
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**





**IKDT**

Institut Kardiale Diagnostik und Therapie

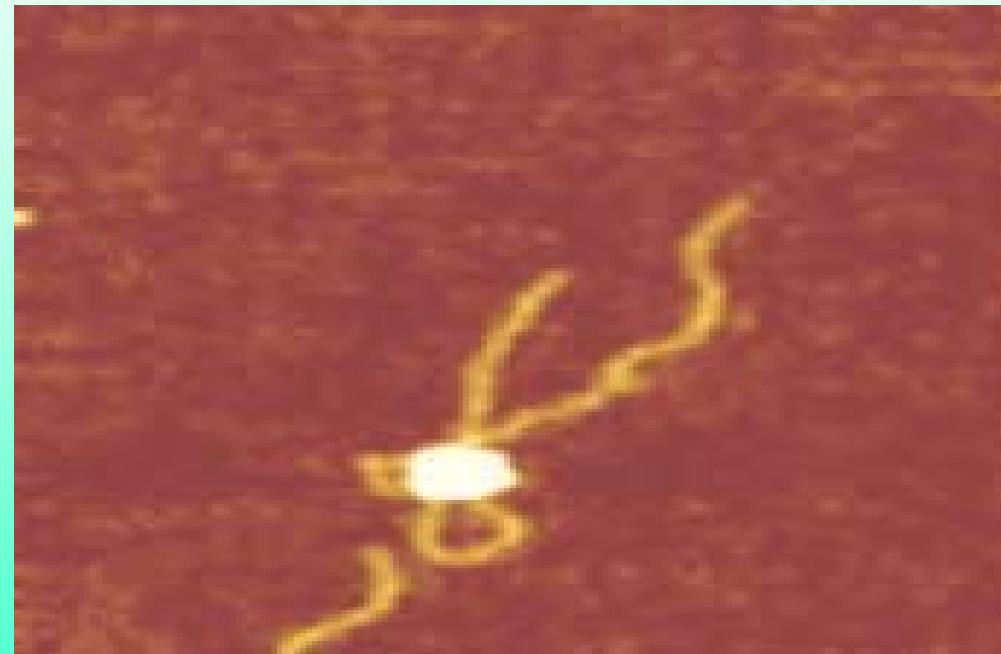
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

## AFM picture of DNA polymerase



[www.ikdt.com](http://www.ikdt.com)

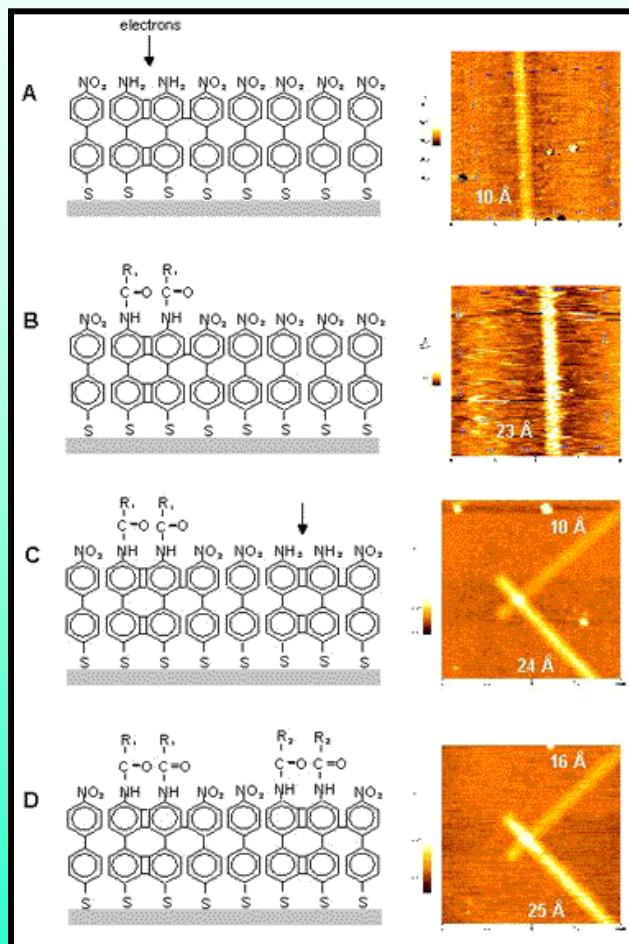
# Nano Chemistry

molecular recognition

Surface design

directed design of  
molecules

## Nanolithography by electron beam (part 1)



**A:** Durch Elektronenbeschuß wird die Nitrogruppe eines Nitrobiphenylthiol SAMs in eine Aminogruppe umgewandelt, während die aromatische Monoschicht vernetzt. Rechts sieht man die AFM Aufnahme einer 100 nm breiten Linie, die auf diese Weise geschrieben wurde. Ihre Höhe beträgt 10 Å.

**B:** An den bestrahlten Bereiche wird PFBA angebunden. Man erkennt die Höhenänderung auf 23 Å nach der Ankopplung der Moleküle.

**C:** Senkrecht zur ersten wird eine zweite Linie geschrieben. Wie in A) beträgt ihre Höhe wieder 10Å.

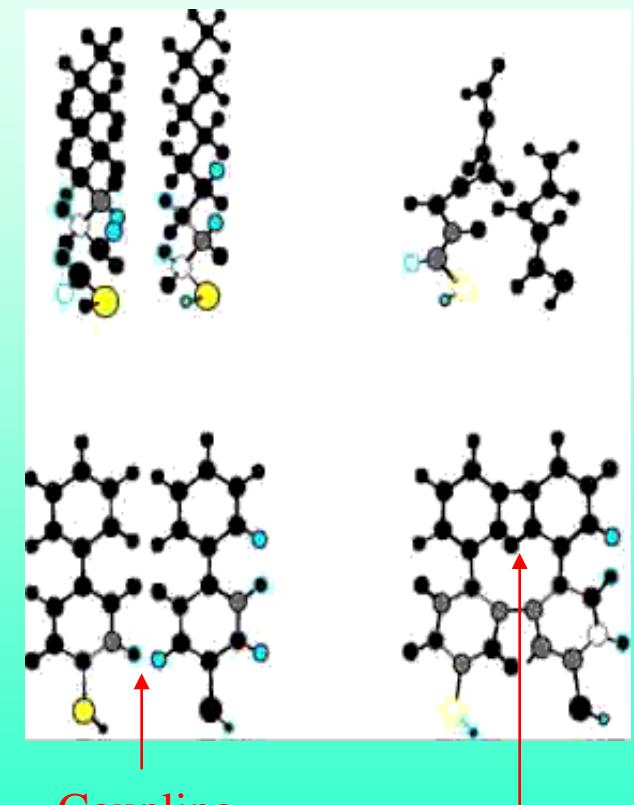
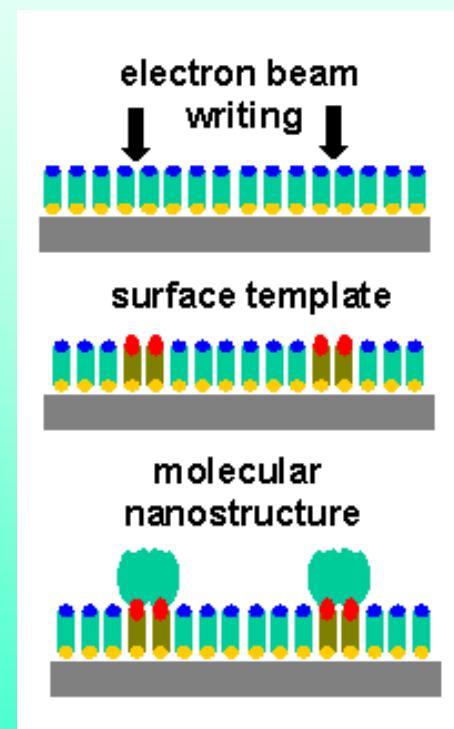
**D:** Im letzten Schritt wird die modifizierte Oberfläche aus C) in eine Lösung mit TFAA gegeben. Man erkennt, die Anbindung an die aktivierten Bereiche und die damit verbundene Höhenänderung auf 16Å. Die Höhe der Bereiche, die vorher mit PFBA beschichtet waren bleibt unverändert

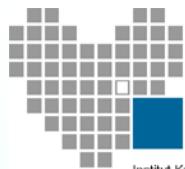
## Nanolithography by electron beam (part 2)

Beschuss durch  
Elektronen

Veränderung  
der Oberfläche

Aufbau neuer  
Schichten





**IKDT**

Institut Kardiale Diagnostik und Therapie

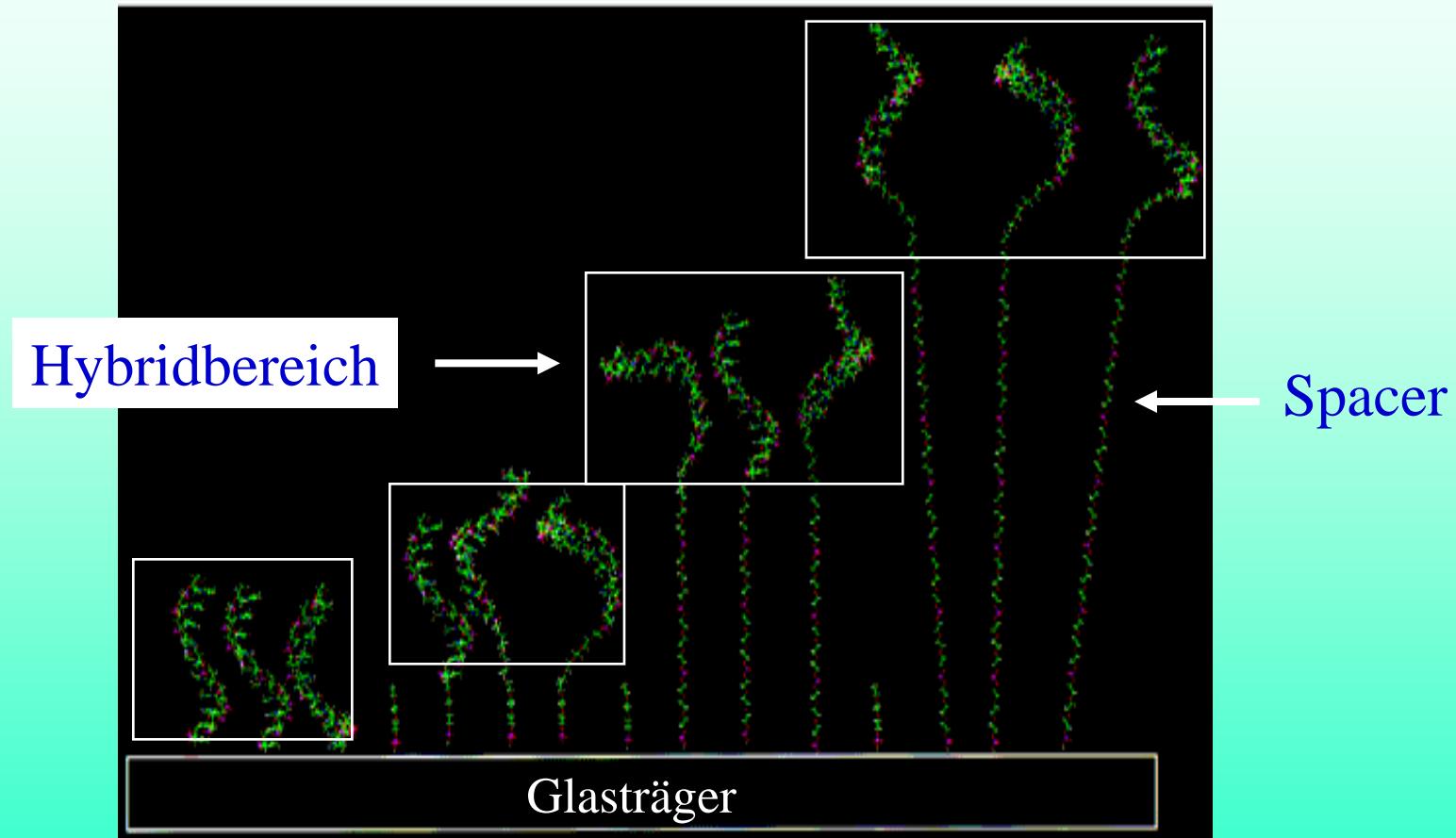
**Institut Kardiale Diagnostik und Therapie GmbH**

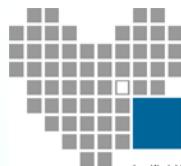
*accredited laboratory CAP Nr. 71828-02 since 2003*



Advancing Excellence

## DNA probes on a biochip





**IKDT**

Institut Kardiale Diagnostik und Therapie

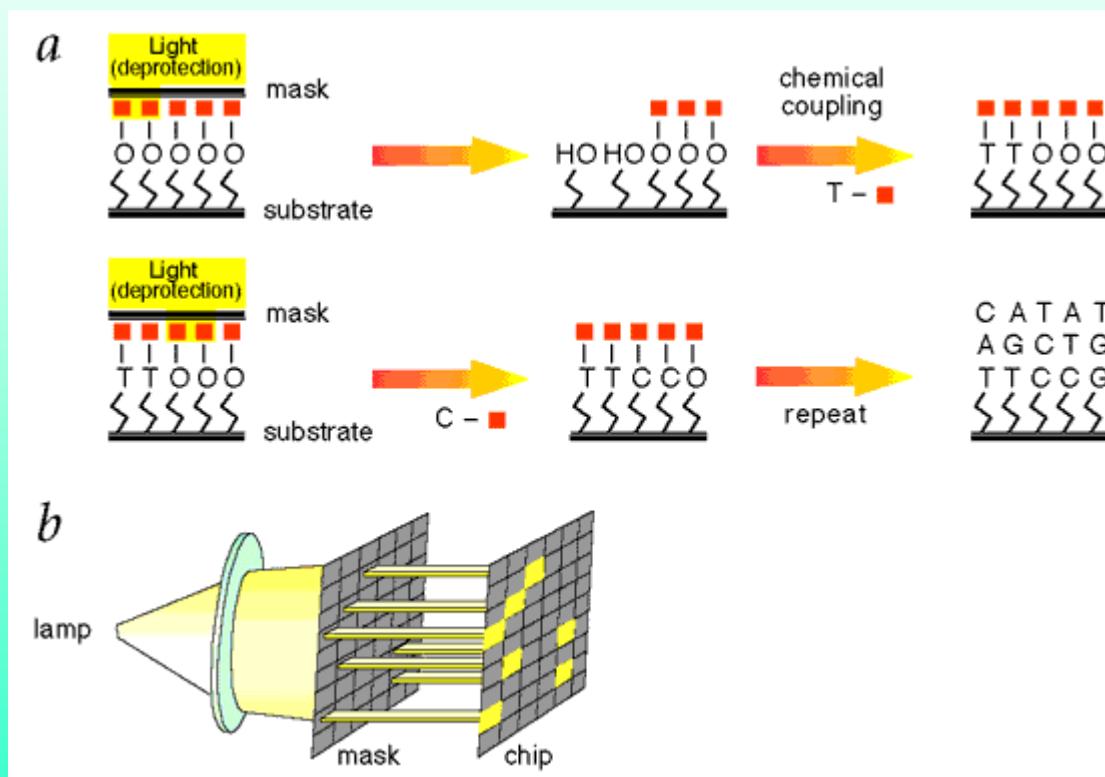
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

## Photolithographic Oligonucleotid Synthesis



## Nano Electronics

Nano Wires

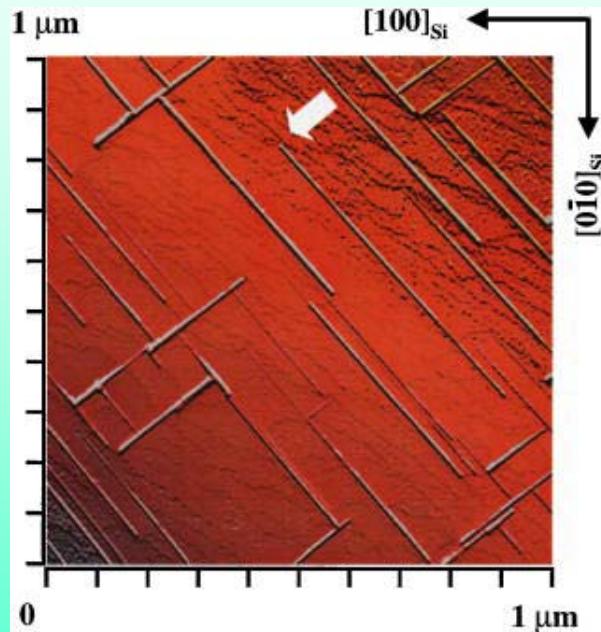
Nano Storages

Quanten effects

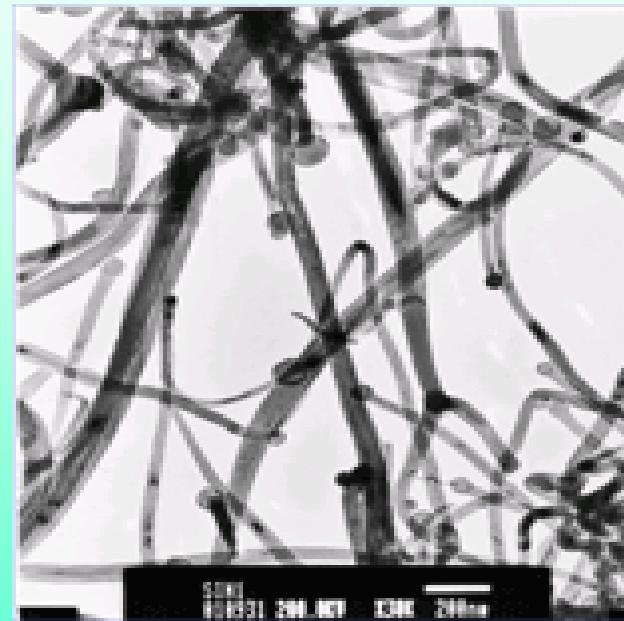
## Nanowires

- light or electricity
- Basics for Nanolaser
- Verlustfreie Stromleitung (Supraleitung)
- materials: gold, semiconductors, natural products, DNA
- Basics for nano storages (Goldwires, DNA based)
- Suitable as nanosensors, nanotransistors, LEDs

## Nanowires



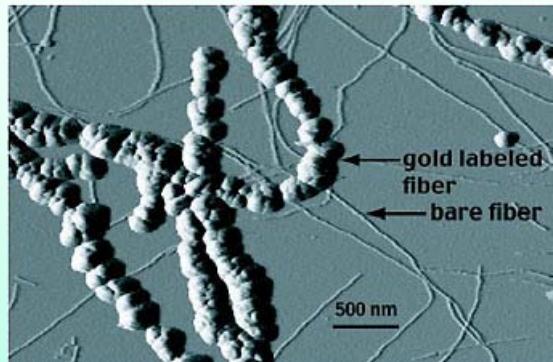
STM picture of  $\text{ErSi}_2$  Nanowire, grown  
on flat Si(001) substrat



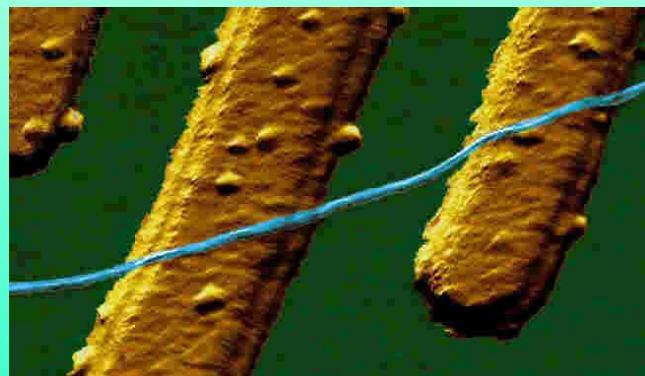
Si nanowire created by heating and  
currency

## Design of Nanowires

Advancing Excellence

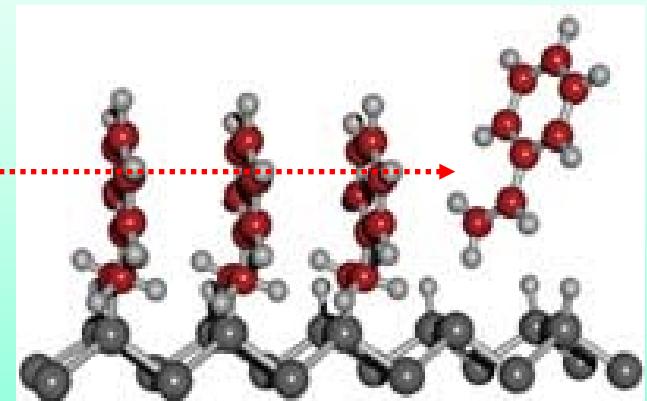


Mikroscopic picture of yeast fibres  
with or without gold covering



Nanowire between two electrodes

Neuer Nanodraht



The larger grey spheres and the bonds between them represent a silicon surface. The red spheres with small spheres around them represent styrene molecules. The small spheres represent hydrogen atoms. In this diagram, a gap in the hydrogen coating the silicon attracts a styrene molecule.

Source: National Research Council of Canada



**IKDT**  
Institut Kardiale Diagnostik und Therapie

**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



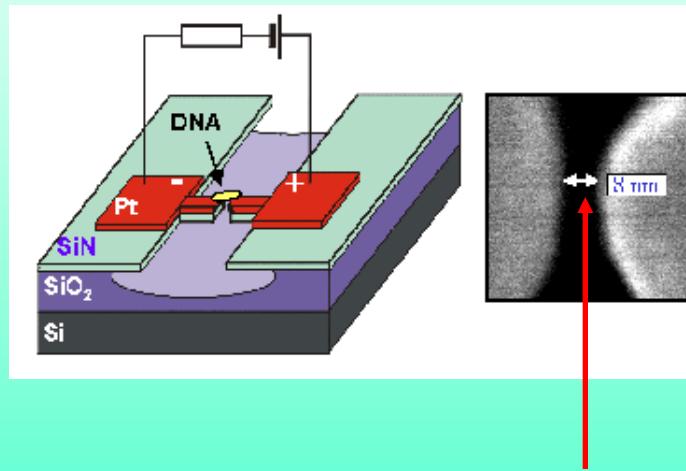
**Advancing Excellence**

## Application of DNA Nanowires

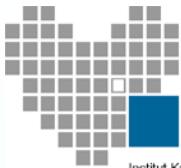


Fixed DNA

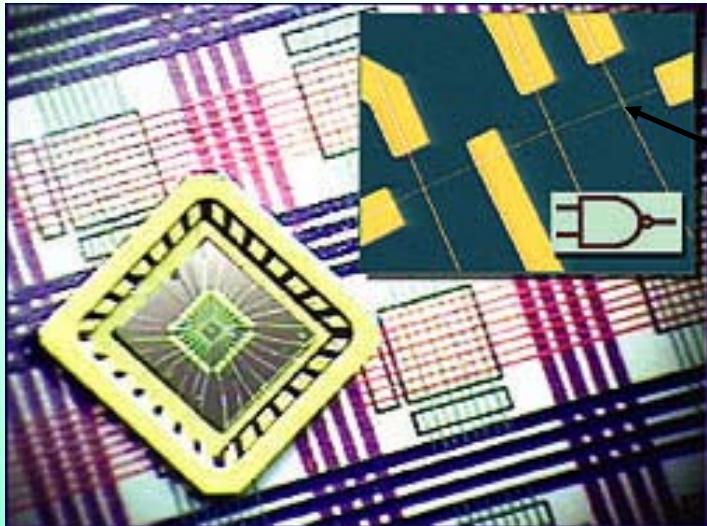
for conductivity measurement



Fixed DNA



## Storage made of nano wires



Cross point

Dieses Material ändert beim Anlegen einer spezifischen Spannung seine Leitfähigkeit – jeder Kreuzungspunkt der Nanodrähte repräsentiert eine Speicherzelle. Dass ein solches Design im Prinzip funktioniert, haben US-Wissenschaftler erst vor kurzem nachgewiesen, das Problem der Kontaktierung mit "makroskopischen" elektronischen Kontakten ist allerdings bisher ungelöst.



**IKDT**  
Institut Kardiale Diagnostik und Therapie

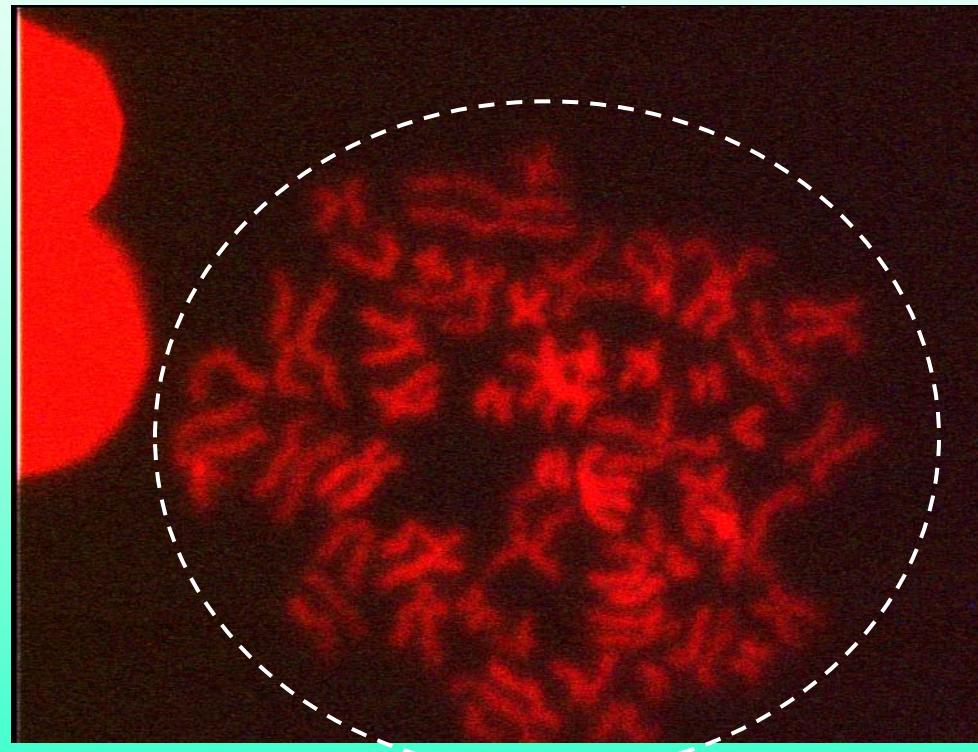
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

## Set of human chromosomes



[www.ikdt.com](http://www.ikdt.com)

## The human genome

- 46 Chromosomes      23 maternal, 23 paternal
- Of them 22 autosome pairs and 2 sex determining.
- one genome – 3 billion bases
- only 4 letters A, C, G, T

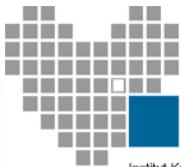
## DNA as largest hard disk

- DNA built of nucleotide pairing A-T or G-C
- one nucleotide pair conserve **2 Bit on ca. 1nm<sup>3</sup>**
- This data amount corresponds to **1 Gbit / 1μm<sup>3</sup>**

**or 10<sup>21</sup> bit / 1cm<sup>3</sup>**

**Currently existing hard disk: 10-100 Gbit / 1cm<sup>3</sup>**

**Humanes Genom: 1,5 Gbit / 5μm<sup>3</sup>**



## *The tallest book on earth*

### Chromosome 22

28 Mio bases corresponds to ca. 8898 pages (10-er signature) means to ca. 12500 pages Bible (10 St.)

### Human Genome

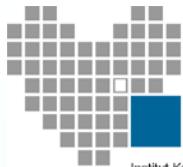
3 Billion Bases corresponds to ca. 1.250.000 pages Bible (1000 pieces.)



Gutenberg-Bible  
(42-Script, 1250 pages)

1 Gramm DNA contains

information of one trillion CDs !



**IKDT**

Institut Kardiale Diagnostik und Therapie

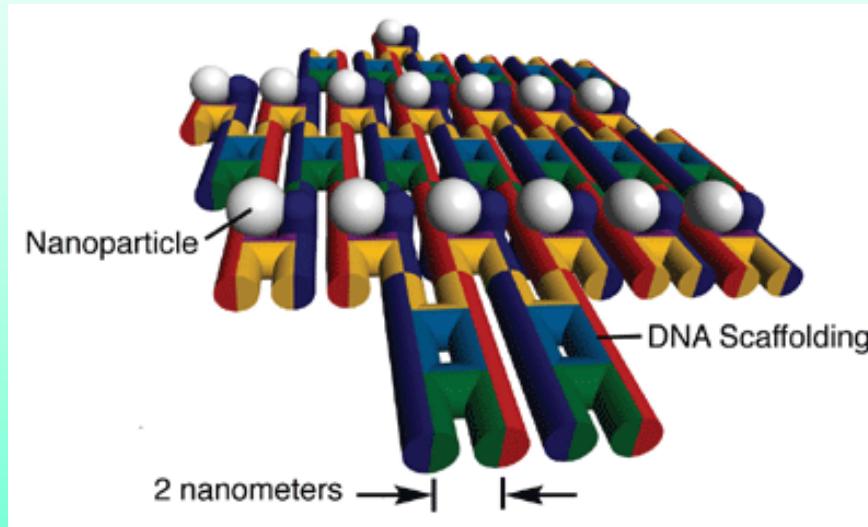
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

# DNA-assembly of nanotubes



On DNA cristals bounded beads



**IKDT**

Institut Kardiale Diagnostik und Therapie

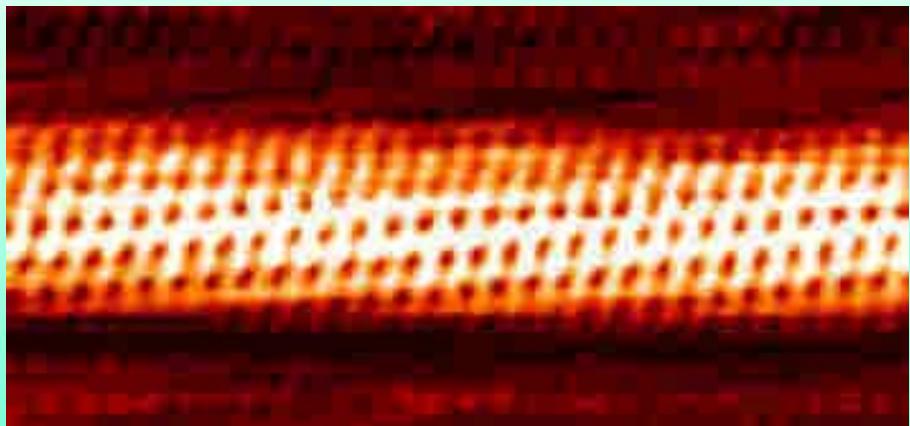
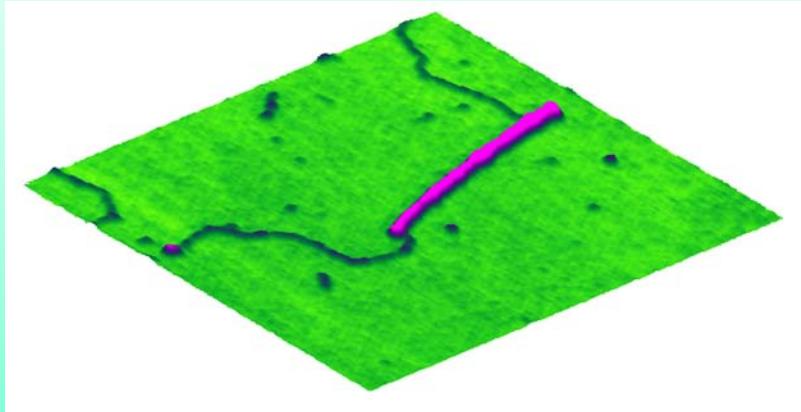
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



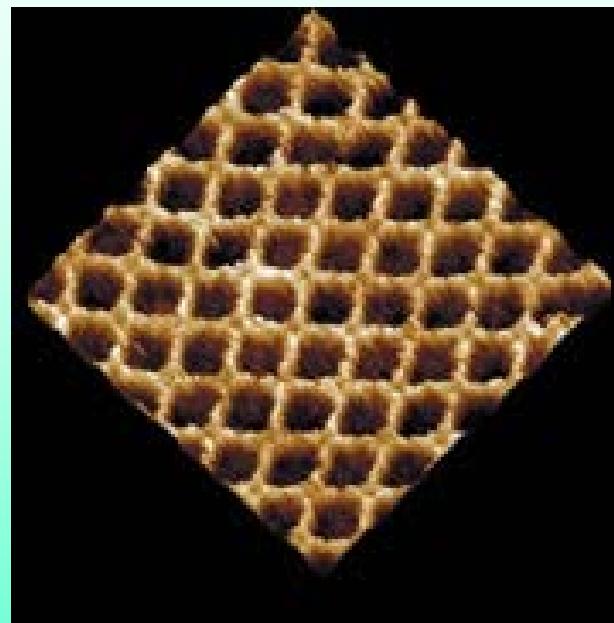
Advancing Excellence

# DNA-assembly of nanotubes



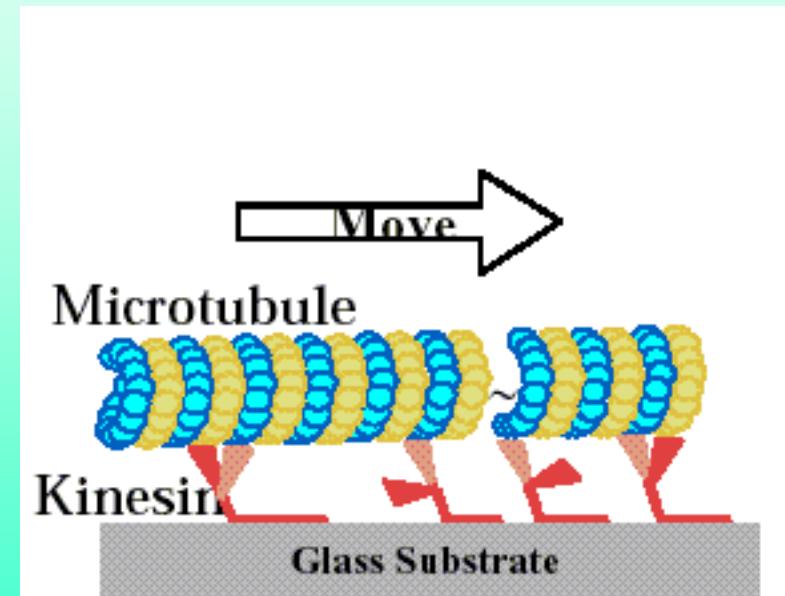
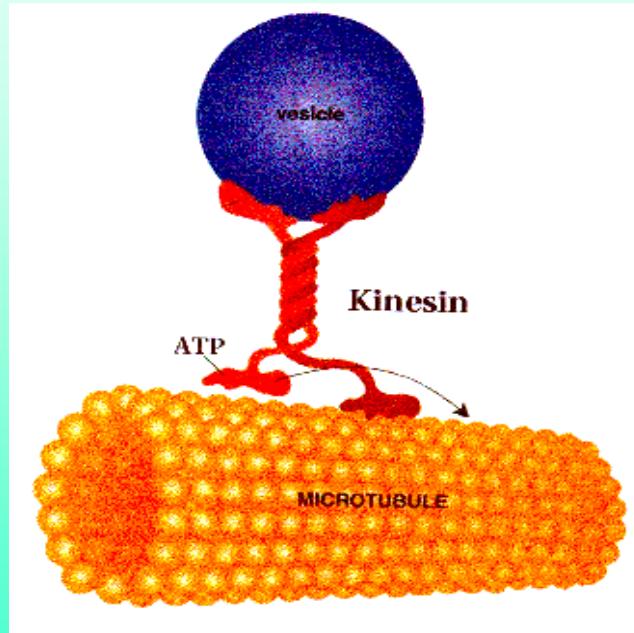
[www.ikdt.com](http://www.ikdt.com)

## DNA Nano-Net

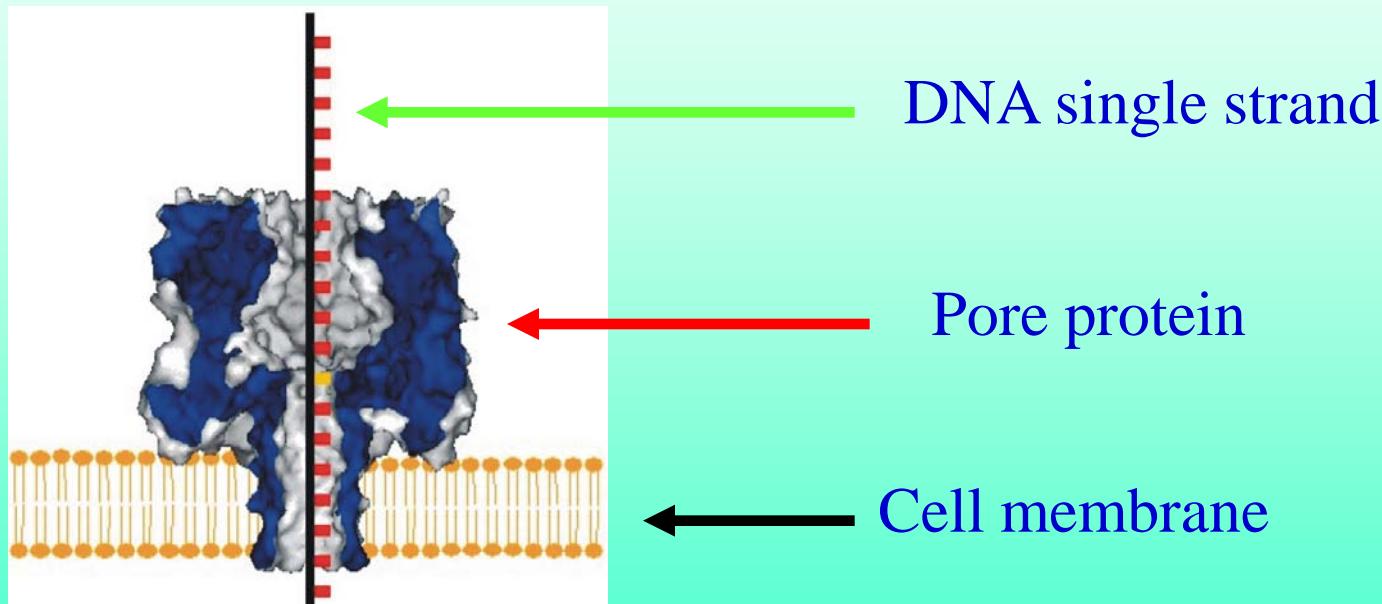


US researchers have woven DNA into a net that expands and contracts.  
It could be used as a nano-filter or in biological sensors.

## ATP-Kinesin driven nanomotor

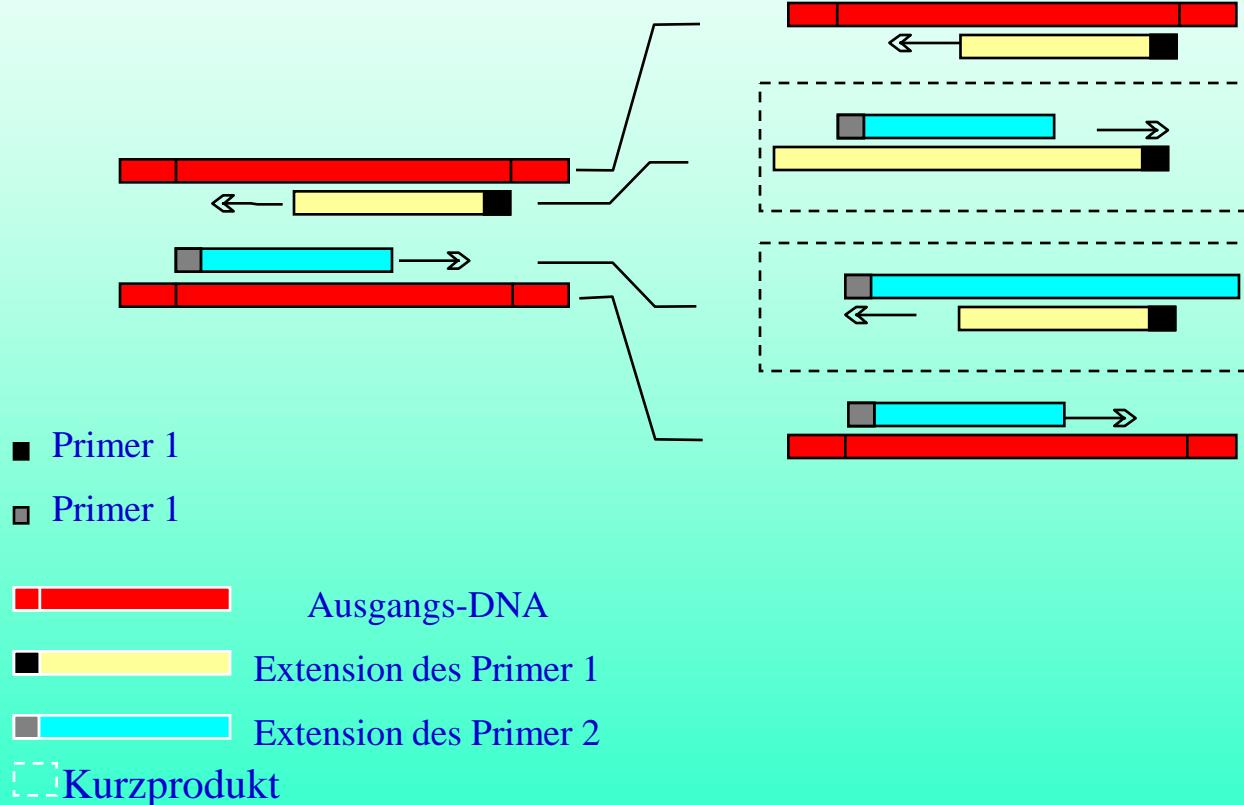


## Alpha-Hemolysin Nanopore



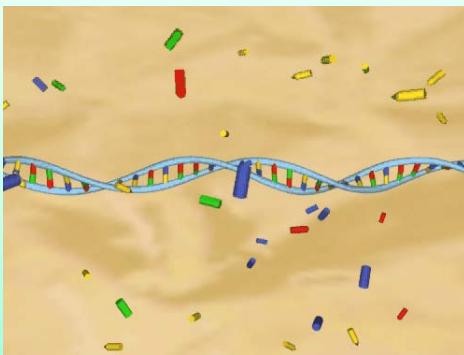
Transport of DNA single strand through membran pore

# Polymerase Chain Reaction (PCR)

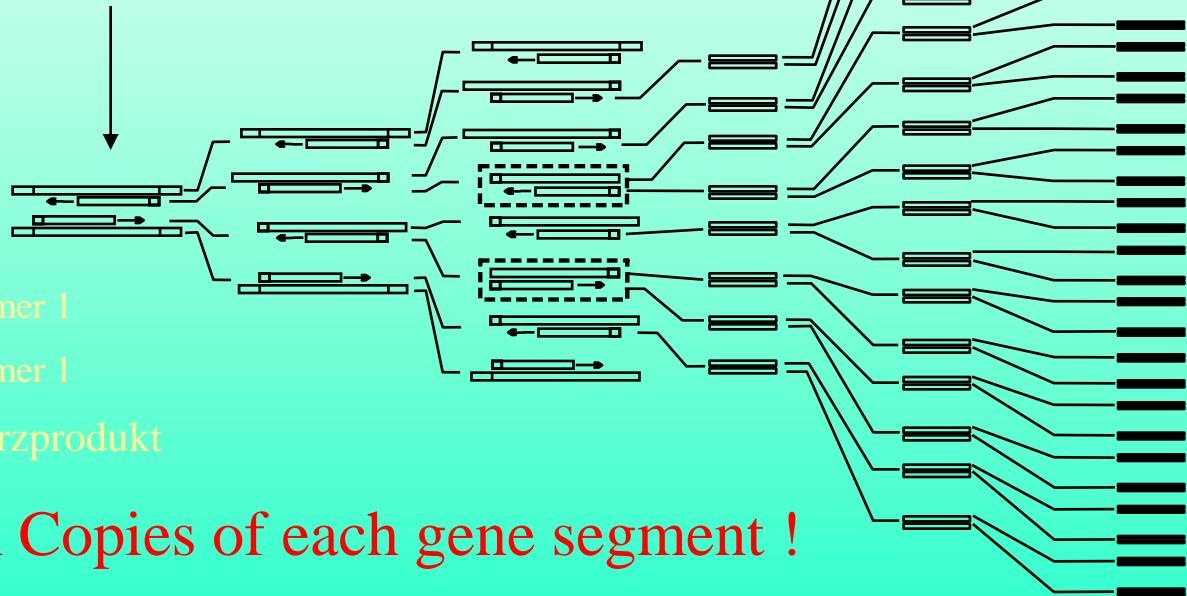


## Polymerase Chain Reaction (PCR)

Zyklus 1	Zyklus 2	Zyklus 3	Zyklus 4	Zyklus 5	Zyklus n
Kopien N = 1	N = 2	N = 4	N = 8	N = 16	N = 2 <sup>n-1</sup>



Starting point with one copy



In 20 min 1 Billion Copies of each gene segment !

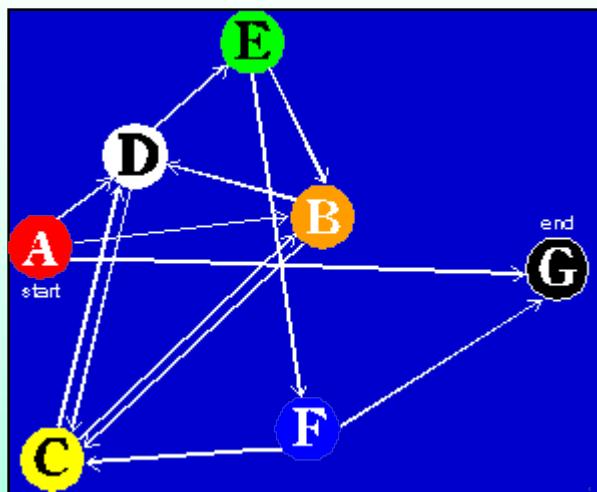
## Data processing during PCR

- die Taq Polymerase incorporates ca. 100 Nukleotide pro sec  
(200 Bit/s)

*moderne computers in GHz dimension (10<sup>7</sup> faster)*

- nevertheless in one PCR assay 10<sup>12</sup> bits in 20 min

$$= 1,66 \text{ Gbit pro second in } 10^{-2} \text{ cm}^3$$



## DNA Computing



The nanocomputer consists of DNA and DNA-processing enzymes, both dissolved in a liquid.

[www.ikdt.com](http://www.ikdt.com)



**IKDT**

Institut Kardiale Diagnostik und Therapie

**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



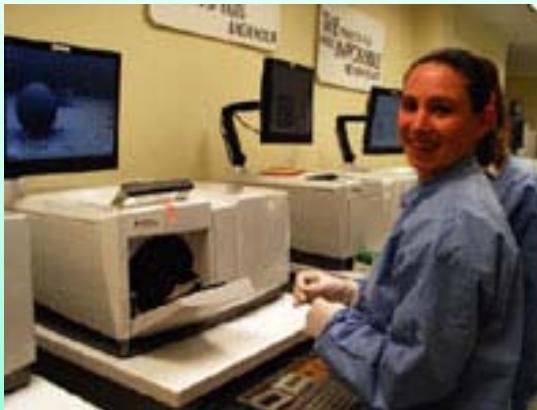
## Next Generation Sequencing

Method of the year 2007



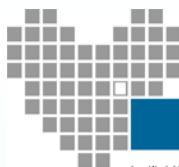
Sequencing centers producing the Sanger sequence data for mammalian genome projects are factory-like outfits with a large number of personnel.

*Maria Nemenuk, Broad Institute*



The latest next-generation sequencing instruments can generate as much data in 24 h as several hundred Sanger-type DNA capillary sequencers, but reoperated by a single person

[www.ikdt.com](http://www.ikdt.com)



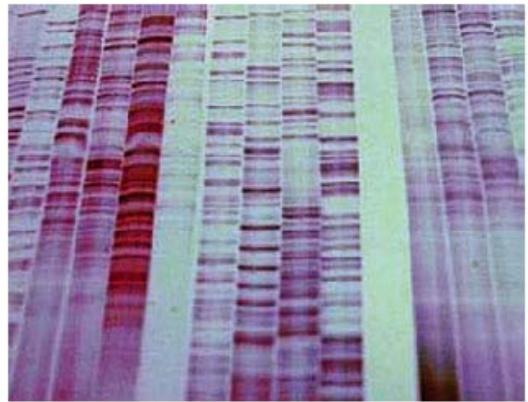
**IKDT**  
Institut Kardiale Diagnostik und Therapie

# Institut Kardiale Diagnostik und Therapie GmbH

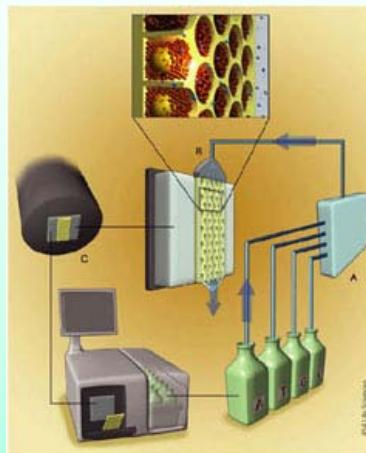
accredited laboratory CAP Nr. 71828-02 since 2003



Advancing Excellence

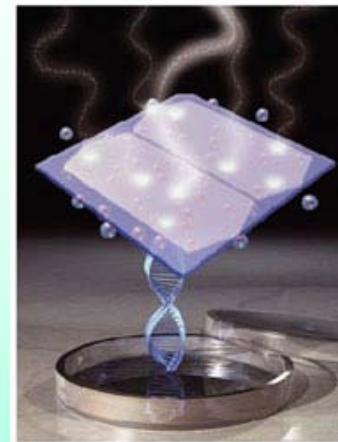


Sanger sequencing becomes  
the 'old' generation.



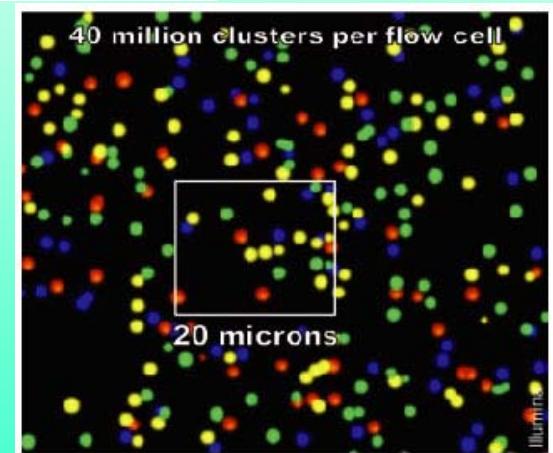
The inner workings of  
the 454 Life  
Sciences

sequencer ■



The concept of next-  
generation sequencing  
according to 454:  
fiberoptic flow cell and  
emulsion droplets.

454 Life Sciences



Color dots replace bands as a  
sequence is read with reversible  
terminators on a Solexa  
(Illumina) sequencer.

[www.ikdt.com](http://www.ikdt.com)

Importance for human society,  
history, politics and so on???

## Genetic Fingerprinting



Alec Jeffrey 1984

-Forensics

- paternity testing



**IKDT**

Institut Kardiale Diagnostik und Therapie

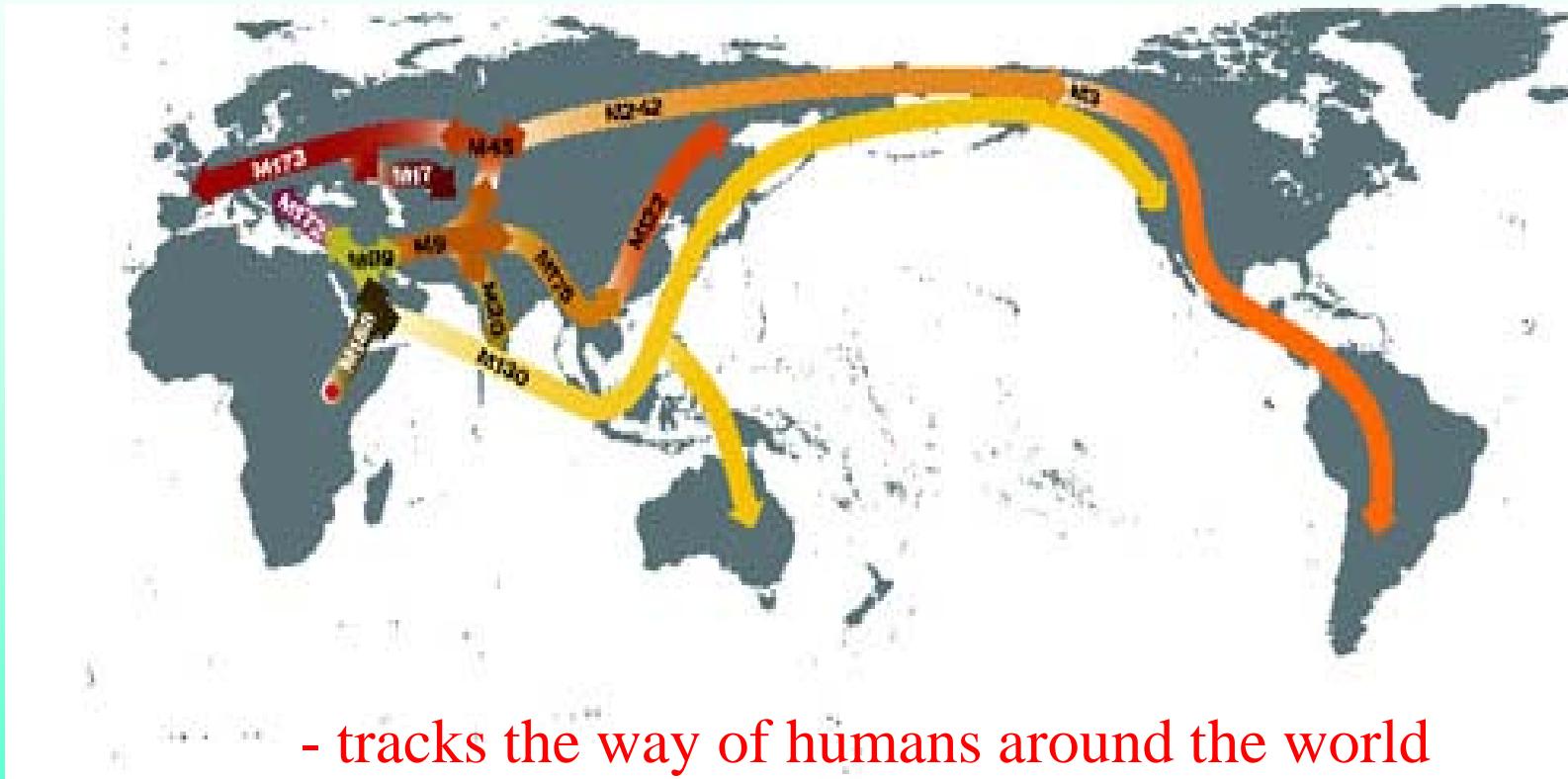
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



## Genographic Project

Advancing Excellence



# Our mother is an african!

[www.ikdt.com](http://www.ikdt.com)



**IKDT**

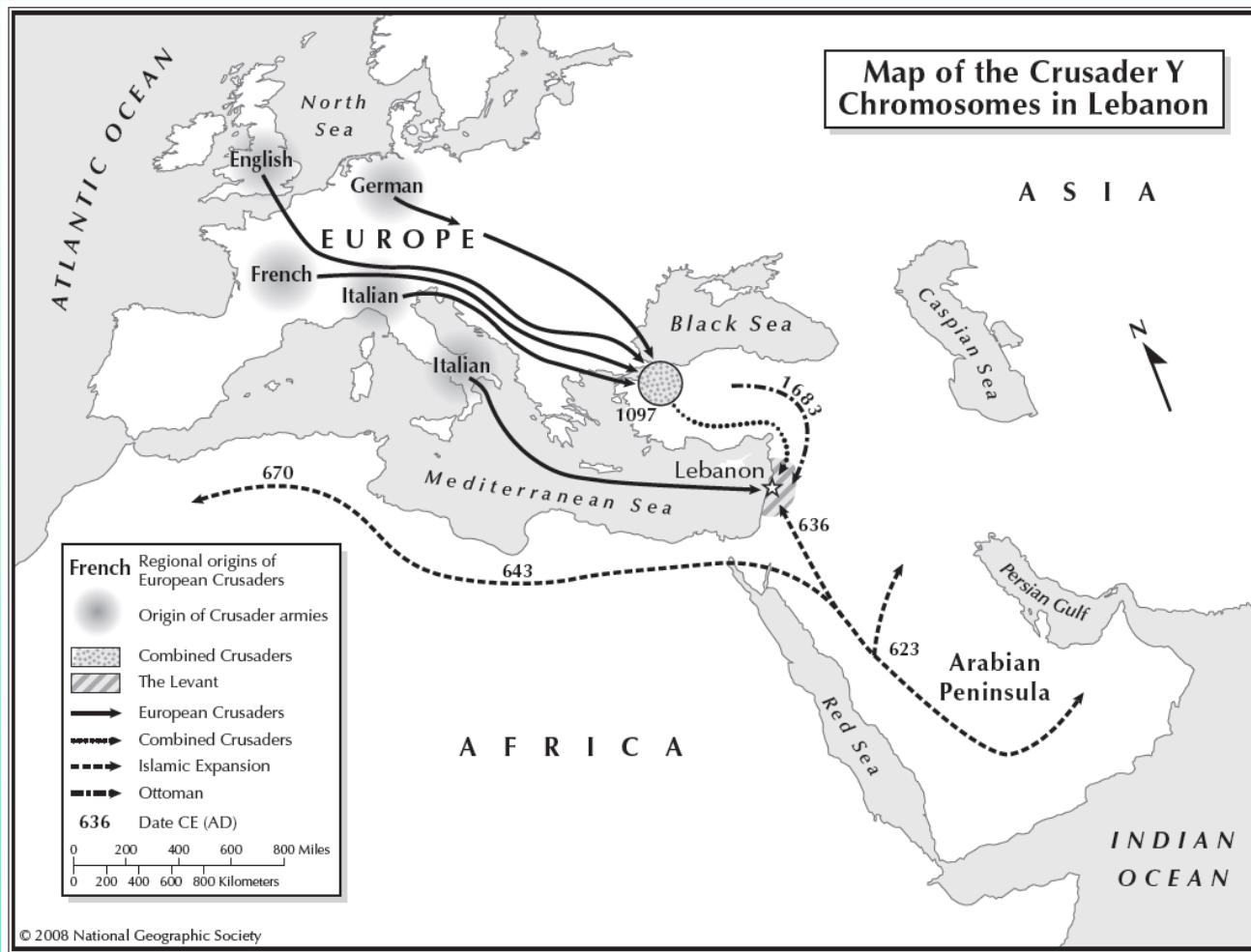
Institut Kardiale Diagnostik und Therapie

# Institut Kardiale Diagnostik und Therapie GmbH

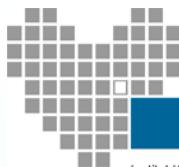
accredited laboratory CAP Nr. 71828-02 since 2003



Advancing Excellence



[www.ikdt.com](http://www.ikdt.com)



**IKDT**

Institut Kardiale Diagnostik und Therapie

**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*

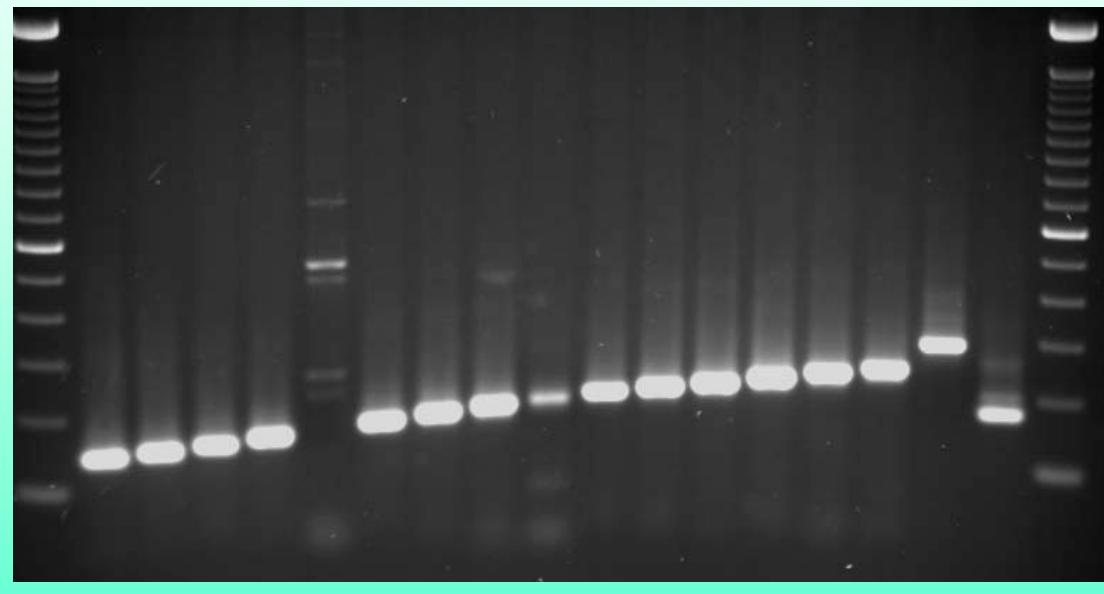


Advancing Excellence

# Erythrovirus-Fragment-PCR

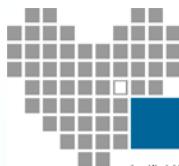
Amplification of single fragments

	Start PCR-Produkt (1-5500) J35	Product Size G1 (+37 bp)
PF1	4952	137
PF2	3728	144
PF3	1716	151
PF4	4468	158
PF5	123	165
PF6	1117	172
PF7	769	179
PF8	4170	186
PF9	161	193
PF10	2336	200
PF11	1961	207
PF12	3351	214
PF13	537	224
PF14	3097	233
PF15	2589	243



M 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 K K M

[www.ikdt.com](http://www.ikdt.com)



IKDT

Institut Kardiale Diagnostik und Therapie

Institut Kardiale Diagnostik und Therapie GmbH

accredited laboratory CAP Nr. 71828-02 since 2003



Advancing Excellence

# DNA art for customers

The screenshot shows the homepage of DNA Art's website. At the top, there is a navigation bar with links for 'About Us', 'Product Gallery', 'Buy Now', 'Deutsch', 'Español', 'Français', 'Customer Support', and 'United States'. A green button labeled 'DNA II' is visible. The main headline reads 'NEW DNA Mini Portraits™' followed by the subtext 'The Perfect Unique Gift Idea for the Person who has Everything!'. Below this, there is a photograph of a DNA portrait on a stand. To the right, a green box contains the text 'DNA Portraits™ Starting at \$199 USD' and buttons for 'Explore' and 'Purchase'. Below the main image, there are three categories: 'DNAPortraits™', 'FingerPrintPortraits™', and 'KissPortraits™'. At the bottom, there are four sections: 'Flat Fee Shipping', 'DNA Pet Portraits', 'Elijah Wood', and 'As Seen In'. The 'Flat Fee Shipping' section includes a note about one fee anywhere in the USA and a 10% discount on additional pieces. The 'DNA Pet Portraits' section features a photo of a dog. The 'Elijah Wood' section features a photo of Elijah Wood holding a DNA portrait. The 'As Seen In' section features a 'TODAY' logo.

About Us    Product Gallery    **Buy Now**

Deutsch • Español • Français  
Customer Support    United States

**dna II**

**NEW DNA Mini Portraits™**  
The Perfect Unique Gift Idea for the Person who has Everything!

DNA Portraits™  
Starting at \$199 USD

Explore • Purchase •

DNAPortraits™    FingerPrintPortraits™    KissPortraits™

Flat Fee Shipping • One fee anywhere in the USA and Save 10% on each additional piece you order.

DNA Pet Portraits • We can transform a DNA sample from your favorite pet and turn it into a meaningful masterpiece.

Elijah Wood • Elijah has partnered up with us to auction off his DNA for the charity *The Art of Elysium*.

As Seen In

TODAY

[www.ikdt.com](http://www.ikdt.com)



**IKDT**  
Institut Kardiale Diagnostik und Therapie

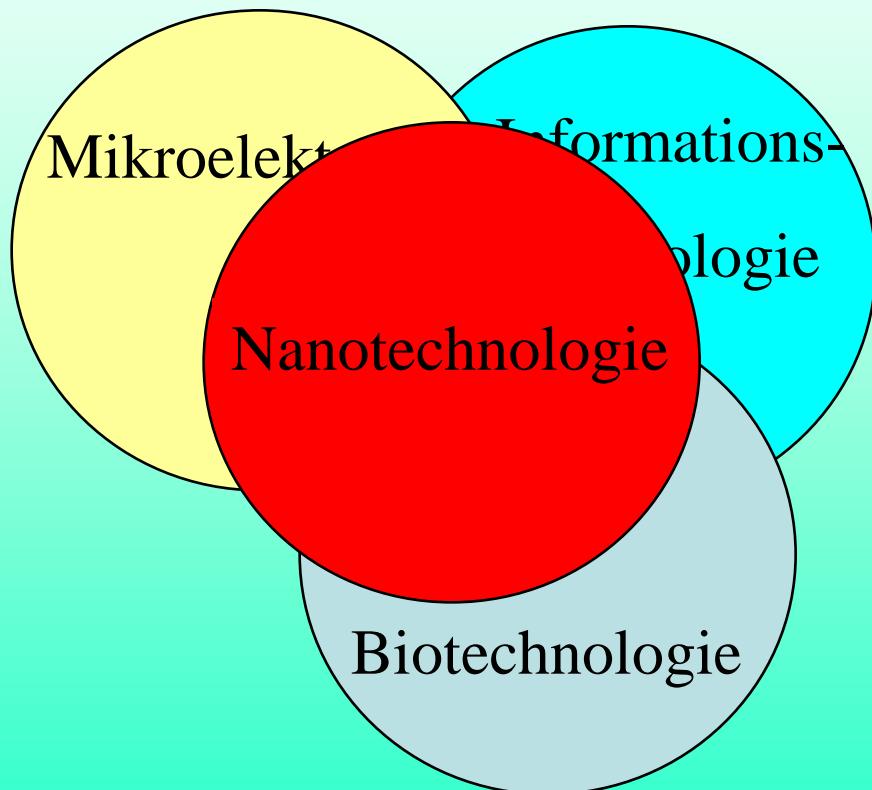
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*

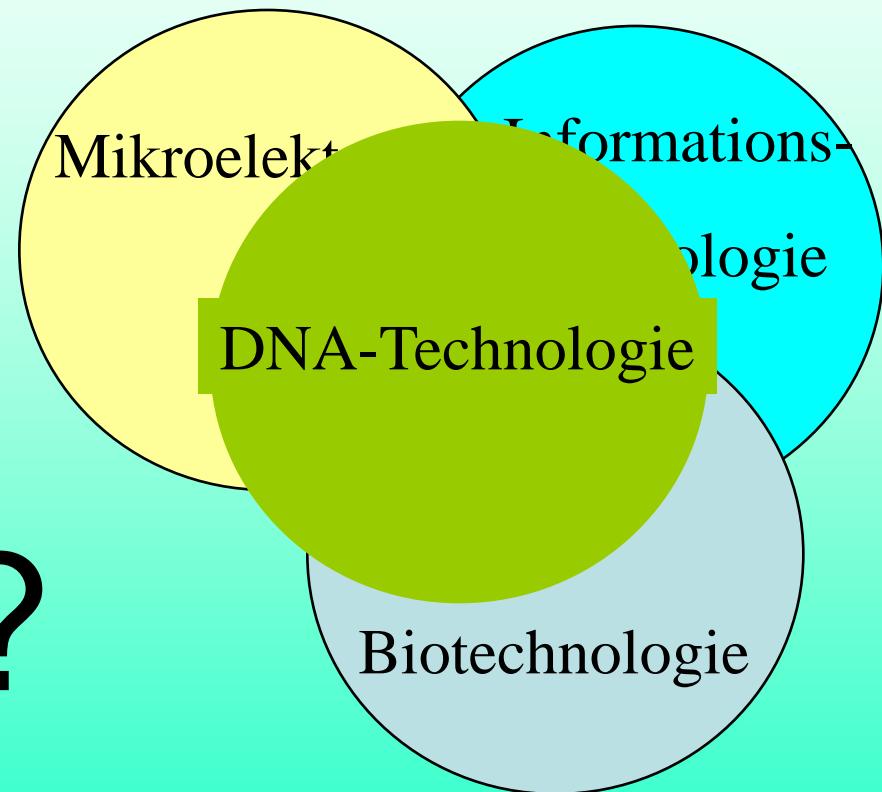


**Advancing Excellence**

**The 4 most important technologies today?**

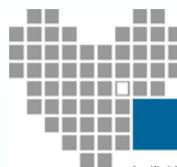


?



[www.ikdt.com](http://www.ikdt.com)

***Vielen Dank !!!***



**IKDT**

Institut Kardiale Diagnostik und Therapie

# Institut Kardiale Diagnostik und Therapie GmbH

*accredited laboratory CAP Nr. 71828-02 since 2003*



Advancing Excellence



[www.ikdt.com](http://www.ikdt.com)

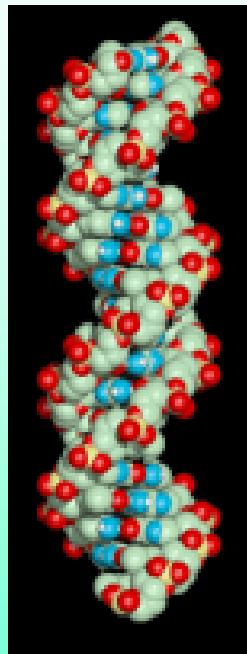
# *Das bisher größte Buch der Erde*

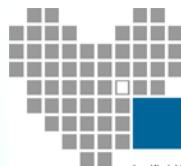
## **Chromosom 22**

28 Mio Basen entsprechen ca. 8898 Seiten (10-er Schrift)  
entsprechen ca. 12500 Seiten Bibel (10 St.)

## **Humanes Genom**

3 Mrd. Basen entsprechen ca. 1.250.000 Seiten Bibel (1000 St.)





**IKDT**

Institut Kardiale Diagnostik und Therapie

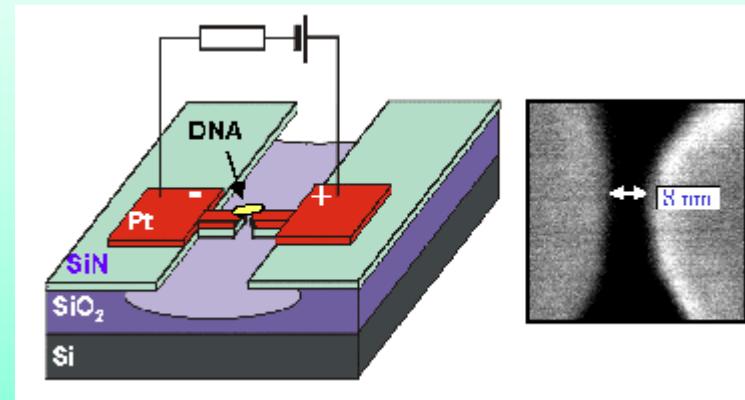
**Institut Kardiale Diagnostik und Therapie GmbH**

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

## Application of DNA Nanowires



[www.ikdt.com](http://www.ikdt.com)



# Institut Kardiale Diagnostik und Therapie GmbH

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

[www.ikdt.com](http://www.ikdt.com)



# Institut Kardiale Diagnostik und Therapie GmbH

*accredited laboratory CAP Nr. 71828-02 since 2003*



**Advancing Excellence**

[www.ikdt.com](http://www.ikdt.com)