Educating students to boost innovation

.....and high-tech entrepreneurship

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WHY innovation?

...a growth engine

- Creates **new** jobs: Start-up companies
- Maintains **jobs**: Strengthening the competitive position of existing companies
Innovation is not a choice

.....it is really a matter of survival
Todays talk

• Discovery of PNA
  - Some reflections from an innovation perspective

• The innovative research environment
  - University-industry collaboration is key

• The “go it alone” decision
  - We need more high-tech entrepreneurs – what is missing?

• Patents – important commercial instruments
  - Lessons learned
PNA – discovery of artificial DNA

BIG surprise!...almost by accident

*Science* (1991)

University of Copenhagen
Michael Egholm
Peter E. Nielsen
Ole Buchardt

Risø National Laboratory
Rolf Henrik Berg
"The new molecules [PNA], brainchildren of chemists Michael Egholm, Peter Nielsen, Ole Buchardt, and Rolf Berg ... has spurred a flurry of activity at biotech companies"

From research to business

>3,500 papers

• >25,000 US patents (is./pend.),
• 7 new companies
• >15 corporate licenses
• >10 products have received FDA clearance

.....2016
The good idea

[Diagram of DNA and PNA structures]
Motivation

...to obtain some level of "control" of gene expression

Watson-Crick base pairs

dsDNA

mRNA

Protein

A

T

G

C
The plan

...to find a structure that showed some hint that it worked

Our wildest dream

If PNA could form a triplex with DNA

...and then spend the next 20-30 years optimizing the structure
BINGO!!

*Science* (1991)
Biology Offers Nanotech's A Helping Hand

Rather than building tiny devices atom by atom, nanoscientists are raising biology's molecular toolbox in hopes of revolutionizing sensors, medical diagnostics, and electronics.

BOSTON, MASSACHUSETTS—When it comes to nanotechnology, physicists, chemists, and materials scientists can't hold a candle to the simplest bacteria. Billions of years of evolution have outfitted organisms of all stripes with a wealth of nanomachines—from the information-storage medium of DNA to the proteins that capture sunlight and copy DNA during cell division. Early nanotech visionaries dreamed of crafting their own versions of nanomachinery and even went so far as to draw up molecular specs for tiny gears and motors. But at the Materials Research Society meeting here earlier this month,” it was clear that as nanotechnology begins to leave its infancy and find its feet, most nanobuilders are looking to biology not just for inspiration but also a little practical help.

In labs around the globe, researchers are working to marry biology and nanotechnology, fiction nanomanufacturing tools. “There are a lot of ideas emerging right now,” says Günter Schmid, a chemist at the University of Essen, Germany.

One of the biggest drivers behind nanotechnology’s enthusiasm for biological systems revolves around an organism’s impressive ability to manufacture complex molecules such as DNA and proteins with atomic precision. Chemists create molecules up to hundreds of atoms in size without too much trouble, controlling the position of every atom. But beyond that, traditional synthetic schemes become unwieldy and too infel.

Complex biological machines also show an uncanny knack for holding in on and binding to molecular targets amid a sea of other molecules. “Biomachinery is a powerful way of bringing organization into a system,” notes Keith Williams, a physicist and nanotech expert at the Delft Institute of Technology in the Netherlands. By contrast, engineered nanosized objects such as carbon nanotubes and tiny spherical metal and semiconducting particles lack any guidance mechanisms. That makes it extremely difficult to put those tubes and particles where you want them to go. “As materials become so small, they become difficult to handle with traditional methods such as lithography,” the technique used to pattern computer chips, says Williams.

As a result, until researchers learn to construct complex nanostructures from the ground up, they have little choice but to become small-time thieves. “Instead of trying to build [nanostructures] from scratch, let’s just steal them from biology,” says Jacob Schneid, a bioengineer at the University of California, Los Angeles. A handful of nanotech research groups has been perpetrating such thefts in recent years. Makino and others say, but now the nano field is in the midst of a kleptomania epidemic.

Bioelectronic assembly

At the meeting, for example, Williams described an emerging effort to harness the selective binding capabilities of a chemical relative of DNA called peptide nucleic acid (PNA) to assemble carbon nanotubes into molecular-scale electronic
PNA - what happened?

...an innovative research environment?

Research environment
- Fruitful research environment
- Visionary leader
- Close collaboration with industry

The good idea
- Went for something interesting
- Driven by: perhaps it could be used
- BINGO! – lucky, accidentally, it was great

high ambitions & chasing luck
WHAT is innovation?

...one of the most widespread buzzwords

Definition(s)

• OECD: “Product development”

• DTU: Research-based renewal of an external party’s product, technology or process – aimed at creating added value in companies and society

...definition probably reflects where you are

...must result in (salable) product or service
HOW do you stimulate innovation?

.....perhaps easy to define – but in practice?

Begins with: The good idea (or discovery)

• Can come from anywhere

• Often very simple

• Often requires more ... advanced technology/knowledge
The innovative environment

.....perhaps more relevant to define

- Since everybody can get a good idea
- About the *probability* of getting a good idea
- Can you create an environment which generates the good idea?
What does not work?  

.....innovation “killers”

- Easily goes wrong if you try to manage it too much
- **Administrators and micro management** too early in the process easily results in innovation in a “straitjacket”

....it is about being excited about something

....straitjacket OK when you “smell blood”...now innovation is fun
Keep it simple

.....first link in the food chain

Invention disclosures (DTU Nanotech)

...and 35 in 2015
Keep it simple

You know who to talk to....

...your good idea or discovery... *perhaps it is useful!*

...the sooner the better
The *innovative* research environment

*Besides the desire to report good ideas.....HOW?*

- Putting (the "right") people together
- Create a cross-disciplinary "melting pot" of strong basic scientific skills/competences
- Building a "talking to each other" culture
- Leadership & visions
- Not *too* result-oriented research, but *animated* to think commercially
A culture promoting innovative thinking

...industry-university collaboration is key

Can you create a research environment/culture that
1) educates the **innovative** engineer/scientist
2) generates the **good** idea?

It is about maximizing the **probability**

---

Industry

**collaboration**

University

High-tech entrepreneurs

Animates you to think commercially

**Innovative**

research environment

**The good idea**

Innovations

= brought to the ”market”

**Creative**

research environment
HTF: NanoPlast – a technological platform

Vision
Revolutionize the way you provide functionality to "daily life" plastic products – by nanotechnology

Enhancement of competitive edge for Danish injection moulding industry

Budget
91 MDKK (50 MDKK from HTF)

Platform Leader
DTU Nanotech
The "go it alone" decision

Industry

University

Collaboration

High-tech entrepreneurs

Animates you to think commercially

Innovative research environment

Innovative engineers & scientists

The good idea

Innovations

Creative research environment
Creating the initial phase

...turning on entrepreneurial ...

... "fiery souls"

**VENTURE CUP**

All-over winner 2013

Category winner 2012

All-over winner 2011

All from DTU Nanotech
Start-ups from DTU Nanotech

...since 2013

2. SBT Aqua IVS (2013)
7. Monta Biosciences IVS (2014)
11. AK Diagnostics IVS (2015)

...and two more start-ups, i.e., 15 in total
We need more - what is missing?

- What is driving "be your own boss" entrepreneurs?
- Special challenges for high-tech entrepreneurs?
- Could the "go it alone" decision be made more attractive?
Getting people to do this

...what are the drivers?

1. They must be able to see an upside:
   - eg. that they can make some money

   &

2. That they do not risk being ruined.

...simple behavior
We live in an "employee culture"

...OK, yes it is difficult to say:

"Now I start a company!"

BUT: Special challenge in HIGH-TECH start-ups

Even you have the "entrepreneurial DNA"

- in practice, there is another big problem: MONEY!

It easily costs DKK 10M to develop a product

It is expensive!
What to do in the initial phase?

...if you want to be a "your own boss" high-tech entrepreneur?

Your are **prepared** to:

- Work 24/7
- "Live on a stone"

But you **don’t** want to:

- Take a loan in your parents’ house (high-risk)
- Be an employee hired by investors
  - because you are quickly diluted, and not in control
You need to “buy” yourself time

...for example, in order to:

- Establish the company
- Understand the market
- Learn book-keeping
- Make a “bird’s nest” model
- Write a business plan
- Make the first contact to a company
  - a potential customer
- Try making a development agreement with a customer
  - customer-based financing (no equity dilution)

Learn something and get something clarified

Easily takes two years

HOW??
Relaunch of an alternative “Danish” model?!

... in style with the ”Innovative Entrepreneurs” programme in the 90’es

The “Prepared” Entrepreneur

The good Idea → Your savings

"Soft" money from government?

DKK 1.1M
Half grant
Half loan (if successful)

Allowed you to “buy” yourself time

Family & Friends

Investors

Co-financed funding (eg. EU)

Successful

VCs in later - not to found the company, but to found the growth of the business
...think you be surprised how many would “come out” based on university inventions
Patents – lessons learned
Why patents?.... expensive

• Protection of an invention often required before investing in product development (e.g. millions of US dollars)
• Grants the patent owner(s) the right to exclude others from "make, use and sell" products based on the invention
• The patent owner(s) can license "make, use and sell" rights under the patent

Note that:

A patent is a right granted on a country-by-country basis
The PNA story

1991 – PNA priority application filed 24 May
1991 – First preliminary (“T”) public disclosure 17 Jun
1991 – First exclusive license granted

1992 – PNA Diagnostics A/S
1992 – More exclusive licenses granted

...so far so good
27 Nov 1992.....A little worried

Glaxo *Science* paper:
"A" works!
Fortunately, "ATCG" *Nature* paper accepted!

BUT...24 Jun 1993...Extremely worried!!

Glaxo PCT application:
"A" reduced to practice

Priority date:
18 Dec 1991!!
...and stating the following:

At the Twelfth American Peptide Symposium at the Massachusetts Institute of Technology in Cambridge, Massachusetts on June 17, 1991, Rolf Berg of the Risø National Laboratory in Roskilde, Denmark presented work on modified peptides with nucleoside side chains which were called peptide nucleic acids (PNAs). However, only PNAs from the T monomer could be made. Presentations by this
PCT

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(72) Applicant and Inventors: BUCHARDT, Ole [DK/DK]; Sandegardstræde 73, DK-2350 Værløse (DK); EGHOLM, Michael [DK/DK]; Sindsdalsvej 5, 3. tv., DK-2000 Frederiksberg (DK); NIELSEN, Peter, Eng.

(48) Abstract

A novel class of compounds, known as peptide nucleic acids, bind complementary ssDNA and RNA strands more strongly than a corresponding DNA. The peptide nucleic acids generally comprise ligands such as naturally occurring DNA bases attached to a peptide backbone through a suitable linker.
So, public disclosure

- not only when, but WHAT

1991 – PNA priority application filed 24 May
1991 – First preliminary (“T”) public disclosure 17 Jun
1991 – Science paper (“T”) published 6 Dec
1992 – PCT published 26 Nov
1992 - Glaxo’s Science paper (“A”) published 27 Nov
1993 - Glaxo’s PCT published (“A” reduced to practice) 24 Jun

Priority date: **18 Dec 1991!!**

1993 – Nature paper (“ATGC”) published 7 Oct
1993–1998: Interference proceedings at USPTO
1998 – Settlement (cross-license)
THANKS!

Really appreciate your time!
Invited speakers and guests
1. Anders Bjarklev, President of DTU and co-founder of Crystal Fibre in 1999.
2. Attila Súkósó, CTO and co-founder of Airturn in 2013, when he was a student at DTU. He raised more than 10 MDDK via crowd-funding.
3. Kasper Reck, CEO and co-founder of CKEO Sensors in 2015, following PhD and postdoc positions at DTU Nanotech, together with co-founder and CTO Christian Østergaard.
4. Eva Kühne, MSc from DTU Elektro and CEO for Applied Medico Technologies.
5. Filippo Bosco, CEO and co-founder of Blusense Diagnostics following his postdoc position at DTU Nanotech.
7. Peter Følmer Nielsen, CTO and Co-founder at Capres, which is based on inventions from DTU Nanotech.
9. Rasmus Davidsen, PhD student and winner of Venture Cup 2011 with Black Silicon Solar, while he was writing his BSc project at DTU Nanotech.
10. Gustav Skands, Winner of Venture Cup 2013 with SBT Aqua, while he was writing his MSc project at DTU Nanotech.
11. Theodor Nielsen, CEO and co-founder of NIL Technology in 2006, following his employment at DTU Nanotech.
12. Bjørne Henning Jensen, CEO at Syddansk Teknologisk Innovation, which invests in innovative business ideas in the start-up phase.
13. Kristian Hertz, Professor at DTU Byg and recipient of DTU’s innovation award.
15. Preben Kjar Kristensen, Senior IPR Consultant at DONG Energy and former Senior business developer from DTU AIS.
16. Carsten Gaarm-Larsen, CEO at CLEAN, President for the Danish Academy of the Technical Sciences and former managing director of the Danish National Advanced Technology Foundation.
17. Pål Simon Fornwall (project leader) from DTU Skylab and Claus Voigt Andersen (team leader) from DTU AIS.
18. Martin Vigild, Senior Vice President and Dean of Undergraduate Education and Student Affairs at DTU.
Entrepreneurs of tomorrow

In August 2015 a brand new course in high tech entrepreneurship rooted at DTU Nanotech was held for the first time. During three intensive weeks, bachelor students teamed up with innovation experts and met with high-tech entrepreneurs.

Developing a high-tech product is often capital- and time-intensive before generating any income. These are some of the biggest challenges you face as a high-tech entrepreneur - and among them the financing approach is vital. How do you (the founding team) maintain control of your start-up business when you do not yourself have the required capital it takes to develop your product? To illustrate these points, the students on the course were presented with a large number of real life innovation cases.

The course is a cross departmental collaboration. The team behind the course consists of Rolf Henrik Berg, Professor in Nanotechnology and Innovation at DTU Nanotech, co-founder of PNA Diagnostics (acquired by Thermo Fischer) and co-inventor of more than 40 issued or pending US patents. Lotte Bjerregaard Jensen, Associate Professor at DTU byg and Head of studies (Byg DTU Architectural Engineering bachelor programme), and Timothy John Hobley, Associate Professor at DTU Food.

Networking and real life experiences
The list of business cases was comprehensive, ranging from brand new start-up companies such as CEMeo Sensors, established in 2015, to well-established companies as ChemoMetec which was founded in 1996 and listed on the stock exchange in 2006. Almost all cases are based on research performed at DTU and the case owners almost all have a DTU background, e.g. a master’s or a PhD degree from DTU. Apart from this, the business cases differed significantly being based on different technologies and run by different persons at different times of their careers.
"It was incredibly inspiring to hear the various talks from non-university people".

"One of the best courses I've had".

"I was very positively surprised by the effective and easy process of idea-generation and group formation".

Rolf Henrik Berg says that "to pique their interest, introducing the students to different high tech entrepreneur role models who all share the same background as the students themselves is a key aspect of the course. There are many ways to start up a new high-tech business and many ways to be an entrepreneur and we try to give the students the possibility of seeing themselves as possible players in this game."

The course also included a visit at the company, Capres, which is based on inventions from DTU Nanotech. Here the students had a closer impression of the perspectives of making a start-up company.

**How can I realise my idea?**

Throughout the course the students worked in cross-disciplinary teams generating technical project ideas. They analysed and evaluated the commercial potential of their technical projects and through phone calls to potential customers, they expanded their knowledge of the market and learned about the customers' opinions. As their background knowledge grew during the course, the analysis of each project was further developed and fine-tuned.

Furthermore, the students trained their presentation skills at pitching sessions and received feedback from the other students and from the teachers.

Educational consultant, Pernille Hammar Andersson from DTU Learning Lab interviewed the students after the course. "The students have seen many examples of the process from the birth of an idea to the establishment of
Would you like to hear what inspired other entrepreneurs from DTU to start up their own high-tech business? Then sign up for this course (www.kurser.dtu.dk/33480)

Please e-mail any questions you may have to innovation@nanotech.dtu.dk

Please note that the course is taught in Danish.

a start-up company and their horizon has been broadened. They are truly open-minded towards the idea of starting up their own business - they have adopted the entrepreneur spirit.

DTU Nanotech emphasises a culture promoting innovative thinking and entrepreneurial activity. More than 175 invention disclosures have been submitted during the past five years. And 13 start-up companies have been established during the past three years - all with promising prospects. At the department an Innovation team provides support for the researchers in relation to IP protection and the development of their business ideas.

Rolf Henrik Berg says that “we have experience in helping the researchers bring their ideas into the real world. Our objective in the new course is to light a fire in every student and to help them understand the process - and maybe their good ideas will form the basis for future high-tech start-up companies”.

The course was run and developed with valuable contributions from Erik V. Thomsen, Professor at DTU Nanotech, Flemming Larsen, Business Developer at DTU Nanotech, Yutaka Yoshinaka, Associate Professor at DTU Management, Perinille Hammar Andersson, Educational Consultant and Louise Hindenburg, Academic Officer both from DTU Study Programmes and Student Affairs.

The course is scheduled to be held next time in August 1st until August 19th. The course was developed with support from The Danish Industry Foundation (Industriens Fond)
### Højteknologisk Iverksætteri (kursusnummer 33480)

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*Note: The table includes various activities and sessions for each day, such as lectures, group work, and breaks.*