Nucan: Nucleic Acid Based Nanostructures (STRP 013775)

Publishable executive summary

Objectives

The central objective of the NUCAN project is to develop the technology for the handling and construction of nanometre sized basic building blocks and of **n**ucleic **a**cid **b**ased **nano**structures (*Nabnanos*) built from these as a basis technology for the production of nanostructures for various applications (Fig. 1).

Getting smaller is a goal in technological areas as different as electronics and pharmaceutics, in order to increase computing power or faster drug screening systems, respectively. Therefore nanotechnology is recognized as an upcoming technology in a multitude of fields.

The bio-molecular approach is of special interest because of the biotechnological promise of cheap production facilities using bioreactors and because of the highly evolved capabilities of bio-molecules. Moreover, optimization strategies are inherent to nucleic acids and may be transferred to artificial systems, as has been demonstrated for aptamers and ribozymes in recent years.

This overall aim will be reached by the following steps:

1. construct basic building blocks from DNA, PNA (peptide nucleic acid), proteins, nanotubes and metallic nanoparticles
2. find rules, how to find and construct basic building blocks
3. form nucleic acid based nanostructures (*Nabnanos*) by directed self-assembly of the basic building blocks
4. guide the development by well defined applications
5. show the usefulness of *Nabnanos* in the context of three different areas of research and development, namely in:
   Nano- and bio-electronics (sub-micro- and molecular electronics)
   Bioanalytics (e.g. surface bound ligands for single molecules and single cells)
   Pharmascreening (drug target screening)

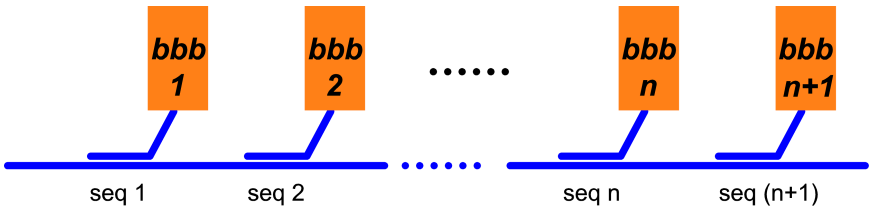

Fig. 1. Basic structure of *Nabnanos* (**n**ucleic **a**cid **b**ased **nano**structures). Basic building blocks ("*bbb*") of, possibly, different type 1, 2, ..., n couple to a nucleic acid strand at specific sites (sequences seq 1...seq n) according to their base sequence.

At the end there will be a nanometre scale "toolbox" consisting of basic building blocks and of protocols for their assembly. Its applicability will be demonstrated in such diverse fields like electronics, bioanalytics and drug screening.

Participants

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Work performed and results achieved

A first set of basic building blocks has been defined and synthesized. It consists of a carrier DNA strand of 103 nucleotides, 4 DNA-peptide conjugates and a PNA-clamp. All building blocks are available now to all members of the consortium. Further PNA-clamps have been synthesized for nore complicated nanostructures. First nucleic acid based nanostructures have been assembled. Another type of building blocks had to be prepared: conjugates from nucleic acids and inorganic nanoparticles like metals and nanotubes. Nanotubes have been conjugated to DNA by avidin-biotin and covalent coupling. Metallic nanoparticles have been coupled to DNA by thiol-gold and by avidin-biotin coupling. First *Nabnanos* have been assembled from the mentioned building blocks. Further *Nabnanos* have been prepared from self-assembling

DNA-parallelograms. First steps in the assembly of universal anchors from basic building blocks for high throughput receptor screening have been taken. In order to contact nucleic acids to surfaces, protocols for chemical surface modifications have been developed, especially for electrodes and semiconductors. AFM tips are ready for functionalization. Nanowires have been prepared by DNA templated polypyrrole and by metallization of DNA with palladium, gold and silver. Characterization of building blocks and their assemblies has been performed, preferentially by atomic force microscopy, but also by fluorescence and electron microscopy.