Professional Guidelines for establishing an Open Nano Lab / a Nano Researcher Live area

Appendix:

List of Texts

This handbook and its appendices present professional guidelines on how to establish an Open Nano Lab or a Nano Researcher Live area in a science museum / science centre in cooperation with a local partner university.

Of course the construction of such areas requires individual planning depending on the local circumstances, and thus this work can not be seen as a complete set of instructions, but far more as a guidance manual containing the experiences gathered in the 'Open Research Laboratory' of the Deutsches Museum in a condensed form.

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nanotoTOUCH
nanosciences live in science centres and museums

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This Appendix

In this appendix are various texts taken from the Open Research Laboratory exhibition of the Deutsches Museum. This compilation of texts is meant to assist you in creating texts for your Open Nano Lab or Researcher Live Area. Apart from translation into your local languague, it will also be necessary to cooperate with the local university partner to create individual texts on the specific research conducted by the scientific group.

Please feel free to use these texts as they are, or to amend them to your requirements.

General Information

The 'Open Nano Laboratory':

Live research in the museum

Here in this laboratory you can observe scientists conducting nanoscopic research.
A scanning tunneling microscope is used to investigate and publicly present the nanoscopic world.

The goal of this installation is to present an insight into the processes and methods of a modern laboratory.
Additionally, it is possible to discuss current scientific questions with the scientists.

Nanosciences and Nanotechnology

Nanosciences investigate phenomena based on structures
in the dimension of approximately 1 to 100 nanometers
Physicists, chemists, microbiologists and material scientists
strongly collaborate in this field of research.

1 Nanometer (1nm) = 0,000000001 Meter (10-9m)
This is approximately the radius of the DNA double helix.

Nanotechnology is the development and production
of materials with structures in this dimension.
The resulting products exhibit special properties
such as self-cleansing surfaces.

The Concept of the Open Nano Laboratory

The Open Nano Laboratory is based on the concept of and the three-year experience gained in the Open Research Laboratory of the Deutsches Museum. In this laboratory 'live' science was publicly presented for the very first time. Nano-research is conducted in midst of the exhibitions, with students and scientists working at their scientific instruments whilst answering questions and engaging the visitors in discussion. This is where the often cited dialogue between scientist and layperson - including the next generation of researchers - actually takes place.

In the Open Nano Lab visitors to the museum are given an insight into the processes and methods of a current microscopic laboratory: they can observe how the scientists obtain data and images from their instrument, and how these are processed or discarded. At the same time they have the opportunity to discuss various aspects of nanotechnology with the scientists, such as future visions or ethical and social implications. In addition, this approach establishes new role models: young adults reflecting on a future in science will have the opportunity to meet with young researchers. These in turn will learn that communication of their research is a self-evident part of their professional identity.

The Elements of the Open Nano Laboratory

The Microscope

The central research instrument of the laboratory is a Scanning Tunneling Microscope (STM), which uses a very fine imaging tip to scan sample surfaces with atomic resolution.

The Demonstrations

The visitors are offered insights into the phenomena of the nano-world by means of regular experimental presentations in which various nano-effects are demonstrated.

The Periphery

In-depth information, media presentations and an exhibit of currently available nano-products augment the introduction of the visitors to nanotechnology.

Instruments

The Scanning Tunneling Microscope (STM)

The STM is an important device for the nano-scientist.
It “scans” the surface of a sample with an imaging tip
which measures a so-called tunneling current.
The electronics then transform the measured signals
into a 3D-image of the surface.

It is also possible to manipulate matter with a STM.
For this purpose the tip is moved closer to the sample
until a contact is established. By this means it is possible
to mechanically move atoms and molecules.

Gerd Binnig and Heinrich Rohrer invented the STM
in the year 1982. For this they were awarded
the Nobel Prize for Physics in 1986.

Applications of the STM

The STM can be used under ambient conditions in air,
in vacuum or in non-conductive liquids.
The maximum resolution is approximately 0,1nm,
enabling the atomic structure of a sample to be imaged.

In this lab we investigate the properties of surfaces
to which various molecules have been applied.
It is hoped that an understanding of these properties
will lead to specific future applications.

The Imaging Tip of an STM

The imaging tip of an STM is atomically sharp,
tapering to a point consisting of a single atom.
It is produced by electrochemical etching
of a tungsten wire or altenatively by cutting.
a platinum-iridium wire at a high incident angle.

A tube piezo moves the tip across the sample.
The piezo elements which are arranged as a tube
change in shape when a current is applied.
This enables a highly precise movement of the tip.

The Atomic Force Microscope (AFM)

The AFM generates a surface profile of a sample.
Like the STM it scans a surface line by line with a fine tip.
This tip is attached to a thin cantilever
similar to the needle of a record player.
A laser is used to detect the motion of the cantilever,
thus depicting the height profile.

The AFM measures forces between surface and tip.
A computer then generates an image from this data.
The fineness of the tip determines the resolution,
usually a few billionths of a meter (= nanometer).

Applications of the AFM

The AFM can image in air, vacuum and water.
A suitable sample can have any kind properties,
whether electrical or magnetic,
the sole requirement being sufficient smoothness

The AFM can image the surface of a sample in detail.
The tip, however, is also a versatile tool
for microscopic and nanoscopic manipulation.
It can be utilised as tweezers or as a force sensor,
as nano-scissors or as a molecular cutter.

Miscellaneous Texts

Research in the Open Nano Lab

The research group in the Deutsches Museum under Prof. Dr. W.M. Heckl uses Scanning Tunneling Microscopes to investigate the self-organisation of molecules on various surfaces. The aim of this basic research is to gain a better understanding of such molecular processes and how to influence and control them. This will provide the basis for the development of novel surface coatings or molecular electronics.

Specifically, organic pigments of the family of Quinacridones are one of the objects of study. When applied to a graphite surface, for example, these semiconducting molecules form molecular chains with a width of approximately 1,5nm. When these molecules are applied to the surface, specific bonding mechanisms lead to the creation of such regular molecular patterns. These in turn can be manipulated to generate custom-made structures.

The Tunneling Effect

The tunneling effect is a special phenomena of quantum mechanics, the physics of the smallest particles.
By this it is possible for a particle to overcome a barrier which would be insurmountable in classical physics.
The particle manages to “tunnel” through the barrier.

In the case of the STM, electrons tunnel through the gap between imaging tip and sample.
This current is referred to as the tunneling current.

Graphite

Graphite consists of honeycomb-shaped carbon layers.
The removal of an individual layer reveals
an atomically smooth, perfectly clean surface
which is ideal for STM investigations.

For this reason graphite is often used as a substrate.
Various molecules are applied to the graphite surface.
Their structure and properties are then investigated.

Market Value

The manifold applications of nanotechnology, in particular, offer an enormous potential for growth. The worldwide turnover is estimated to increase to 1,8 trillion Euros. This represents a more than tenfold increase compared to today. (Lux Research estimate)

However, the prefix 'nano' enjoys great popularity in the field of marketing, as the phrase implies high innovation potential and progress. Unfortunately, this leads to a number of products being advertised as 'nano' which do not contain any nanotechnology.

Manufacturing

In principle there are two ways to fabricate nano-sized systems for products featuring nanotechnology:

One method of fabrication is to scale down existing systems further in a so-called top-down approach.
Alternatively, a bottom-up approach enables the desired objects to be constructed from single atoms or molecules.

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