1 overview

- What is bionanotechnology
- Bionanomachines, How do they work?
- Structural and functuonal principles of bionanotechnology
- Modern bionanotechnology

1.1 Suggested reading

E. Gazit, Plentl of roo for biology at the bottom
Bionanotechnology lessons, Nature
Nanobiotechnology: Concepts, Applicatins and Perspectives.
Nanobiotechnology II: More Concepts and Applications.
Bionanotechnology: Proteins to Nanodevices

1.2 Grading scheme

- Final examination 50% (12 Dec. ?) - we need to pass it
- Final report (Due to Feb. 6 2017) 50%
- Physical chemistry knowlage is expected (free energy, gibbs free energy, helmholz free energy etc.)

1.3 Whorkshop - second part of the semester

1. constructing synthetic nanopores 2.solvatubg sukucib butrude nanopores 3.applying ... ...
We will be supplied with tutorial and all nececary files. In the tutorial there will be 3 tasks - those are nececery. There is also one Challenge that is nececary. If you do any other challenge you migth get extra points (5.5).

1.4 Grading seminar

- we start Nov. 28.
- List of all seminar topics is given on eportal.
- You have to declare time and topic of your speach on some blog.
- Oral presentation counts for 80% of grade.
- Parcipitation is 20%
- Presence is obligatory.
- Presentation should be based on recent papers. (up to 5 yr. old)

- Speach should last 30 min +- 5 min. Disscusion should last about 5-10 min.
- try to limit your presentation to 20-25 slides.
- presentation goal should be to enchant us.

Presentation goals:
1. deliver clear introduction and the purpose of the study 2. explain the necessarty methodology 3. present the result/discussion 4. conclude the topic 5. provide the comprehensive analysis of the strong and weak points of the study ¡¡ **very important** 6. make a personal constructive criticism 7. Once you have a draft of your speach go ask profesor if it is enough.

2 2 class

Nanoscale is everything up to 100nm
Top-down approach (Michael Angel craved his pieta in a big block. its about making something, starting with something bigger.
Nanotechnology (molecular nanotechnology) - a technology that manipulates matter at dimensins up to 100nm.
The study of nanotechnology includes molecular systems, molecula assembiles (such as quantum dots), and organized self-assemnled devices and machines.

Richard Feynman - nice physics lectures
Macro- vs nano-sacle Upon reducing the size and no change in substance, fundamental properites of material such as electrical conductivity, melting point, color etc. will can change.
For example something that is soft and malieable on the macro-scale may be 100 times stronger and 6 times lighter then steel at the nano-scale (nanotubes).
Biotechnology is technology that involves the use and manipulation of living organisms - genetic engeenring.
Nanobiotechnology - the use of nanosiciese for specific biological applications.
Bionanotechnolgoy - subset of nanotechnology where biolohu provides the inspitarion and or the ultimate goal.
Technology that uses biological assemblies for various applications that may not be directionaly associated with biology.

3 3 class - Natural bionanomachines

3.1 Examples of bionanomachines

This are examples of bionanomachines that working out side the cells: *pepsin *lysozume *amylaze They find thier use in industry like loundry specific, corn sugar thing (syrop kukurydziany)

When you start to look at the nanoscale the fundamental properties are changing, for example consider gravity. If you have huge building you need some kind of support for matirial to last. On the other hand when you go to microscale droples can stay on the leaf - that is becouse adhesion and random forces are greater than gravity meaning those small things do not obey gravity. Other example is moving bacteria once it will stop moving its flagelum? it will stop imeditely - on oposit side consider a boat.

3.2 More examples

Nanocar build of fulleren wheels and alkines axis. This car is placed on gold surface, once it is heated fulleren wheels starts to rotate couse there is very low bond-bond rotational boundary. Few years later there were proposed another nanocar with engine this time, build out of fotoactive compound that rotates under light. Structure of this motor is a bit harash oposite to real car, that is becouse you can't play with atoms as you like.

3.3 Examples summary

In nanoscale there is no smooth atomic-scale motion (transition from one rotatory state to tje mxt os utilized wjem tje a[[rp[iate chemical energu is applied.
Individual atmic properites (covalent bonds, steric interaction, electrostatic interactions, hydrogen bonds) are defined rather then bulk properties (e.g. viscosity, friction).
Natural biomachines operates in cellural space - that is very special conditions, that are very important to specific nanomachine
Individual parts interact through random motion and diffusion
Q: Is diffusive motion sufficient to allow interaction between the two bionanmachines in cell containing millions of other biomolecules. This may happen on the exam and should be answered with some equasions about diffusion.

3.4 Bionanomachines in water eviorment

*from and function of biological system are linked to chemical properties of individual components and water enbironment : hydrophobic effect is largely responsible for it * in water biomolecules are able to form a single form?? .. missed it
Hydrophobic effect narrows number of possible protein conformations * Carbon rich parts of the protein are hydrofobic Q: Think about hydrophobic effect in terms of termodynamic what you gains and loose in terms of entalpy, what about entropy? Final goal will be to tell what happens with Gibbs energy. This process is spontainous deltaG¡0.

3.5 Four 'molecules of life'

Q: Structures of proteins, lipids, polisacharydes and nucleic acids and impact of their structure on theirs properties. Q: 1st and 2nd low of thermodynamics. 3rd and 0th (thermomether)

3.6 Errors are natural part of protein synthesis

*In bacterial celss, the generic sequence is misread in about 1 in 2000 aa. tje pccasopma; errprs have often little efect on the function of the protein * sythesis of the protein may terminate early and produce a truncated chain due to processivity errors. More common * kolagen as an example of a protein

3.7 Characteristics of nuclec acids

*applied in nanoscale data sotrage and retrivial *every ....

3.8 Lipids

*Lipids are used for cellular infrastructure

3.9 Polysacharydes

Sacharoze what is the conformation of each unit D or L? Carbon-hydrogen bonds are resrvuars of energy. Becouse glucose or sacharoze is soluble in water it canot be used for storing energy. Glicogen is much more apropiate for this purpose becouse it is unsoluble, and more over there is simple access for enzymes to cut it down. * different linear and branched polymers are created for different needs * individual chains may associate withe large quantity of water forming gluttery gel * carbohydrate chains may associate tightly side by side creating strong fibers with almost ....

3.10 Limits imposed by evolution

* cells use a few sunthetic techniques and rely on a few simple molecular plans to build their different bionanomachines * Small steps are better - big evolutionary step might have disterious results — evolutions favors modification over innovation * biomolecules requite water enviormet, as well as proper temperature, pH and slanity. * Biomolecues are constrained by: * 20 aminoacids alphabet * ... * bionanomachines have short life span and are build to perform only one task.

3.11 Aims of bionanotechnology

* designing bionanomachinery from scratch. There is much problems with this task: * no reliable folded strucure of a protein from its chemical sequence *

tools that are avaible today are dont give us a insight into chemical activity of folded protein structure.

4 Methods in bionanotechnology

4.1 Recobinant DNA technology

* using recombinant DNA technology one can construct any required protein. * two natural enzymes: restriction enzymes and DNA ligase are utilizedd in technology. * Restriction enzymes types: 7 classes * Type I cleves DNA at random sites far from its recognition sequence * Then it gets better and more specific * Restriction enzymes might produce blunt or sitcky ends. * Chemical synthesis of DNA, there are troubles with lenghts of those.

4.2 Pros and cons of using bacteria

* easy to grow and cheap * may animal and plats proteins have carbohydrate groups attached to their surfaces to be active and bacteria do not ad these groups to engineered proteins. * proteins tend to aggregate when they reach high concetration formming incluson bodies. Theu are formed when new proteins associate randomly..

4.3 Cell-free methods of producing proteins

Why? It provides a controlled method for sunthesizing proteins are difficult in engineered bacteria such as: * membraine binding proteins * proteins with

This is done invitro

4.4 Site-directed mutagenesis

HOME WORK!

* may be used in determining the function of specific aa or regions within a protein * may improve the stability of proteins, by engueering in cross-linking resdues or improving the fitting of residues within the protein interior.

4.5 Fusion/chimeric proteins

Two proteins with different functions are combined creating a hybrid protein with both fuctions. For instance anticancer immunotoxins.

4.6 Antibodies

are intersting becouse there is a need for an effecitve methed for recognizing individual molecules. * Immune system produce high amount of different antibodies with hope that one will fit 10**15 * If we combine this natural library of molecues with modern method of synthesizng antibodies. * It is now routinely

possible to obtain antibodies capable of high-affinity recognition of virtaully any molecule. * Monoclonal and heteroclonal antybodies production. * antiboidies can be found in: pregnacy test, heart protein in blood - heart attack , test for HIV viruses, test for patient with Lupus (autoimmune desise). * Antibodies can be also used to treat desisesses: neturalize toxins (snake toxin), effective in treating some types of cancer (Hodgkin lymphoma).

5 X-ray crystallography

* X-ray technique provides the most detailed atimic structures * resolution of the structure depends on the quailtu of the ctstals * typical X-ray studoes of proteins are resolved within 1.5-3.0 A * at 3.0 A final coordinates must be taken with care * mobile regions of the structure may not be well resolved * X-ray structure is average structure * temperature factors (B-values) of the atomic positions are good indicators of the quality of coordinates. Large values 40 might mean 2 things: this amino acid is mobile or resolution of this part of the protein is low. * protein is bounded within oriented crystal latice - single conformation * to study functional aspects of proteins number of crystal obtained under varied conditions must be studied.