

VIII International Natural Sciences Tournament

(Jan 29 – Feb 3, 2018, Agra India)

Problems of the intramural round

Unit 1, Jan 31, 2018 (cycle #1, cycle #2)

1. Phagocytosis

Alzheimer's disease is a neurodegenerative medical condition that primarily leads to memory loss, depriving the afflicted person of the capability to work, communicate with other people and live on his own in society. Every year, the number of people that suffer from Alzheimer's disease increases, and there is still no cure for this disease, while the current treatment methods have a number of shortcomings (low effectiveness, side effects).

However, there is some evidence of the possibility to treat Alzheimer's by increasing the number of cells in brain, which are capable to active phagocytosis. To implement this technique, it is possible to increase the number of phagocytes in the brain, or to increase the activity of existing phagocytes.

Propose and justify your own method of treating Alzheimer's disease, based on the mechanism of phagocytosis, which will have minimal obvious risks to the patient's health. What kind of difficulties will you encounter introducing the proposed approach into medical practice in your country?

2. 21st Century Physicist

School physics experiments are remembered for life. For a physicist in the 21st century, a smartphone is not just a gadget, but also a set of numerous sensors: a high-resolution camera, an accelerometer, a compass, a microphone. Modern computing platforms such as Apple AR SDK and Google Tango allow the smartphone to determine its position in space with an accuracy of up to several millimeters.

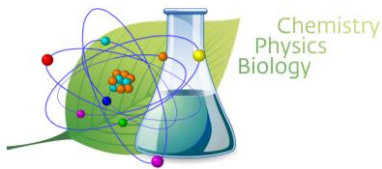
Come up with some interesting physics experiments that will involve the capabilities of smartphones. The proposed experiments are evaluated by the following criteria: spectacularity, educational value and how easily the science behind the experiment is explained to a layman.

The company plans to include the experiments in physics science kits for children of ages 6 to 15 y.o.. The experiments will be conducted at home under parent supervision.

3. 42 ("forty-two")

The task of any synthetic chemist is to obtain the target molecule using one of the possible synthetic pathways. The choice of the synthesis scheme depends on various factors: the availability of the reagents, their quality and cost, the implementation complexity of individual stages of the synthesis. Furthermore, the matters of isolation and purification of the product require particular attention.

Propose a formula or algorithm for calculating the numerical complexity index of a synthesis. The index should designate the complexity of the synthesis taking into account the laboratory



parameters of the synthesis, as well as the project priorities (costs, performance time, substance purity requirements, etc.)

People who are not familiar with chemistry should be able to use your complexity index.

Provide a calculation example of your index for various synthesis schemes of one active pharmaceutical substance.

Do not consider scalability of the synthesis, focus on laboratory syntheses only

4. Consumer electronics

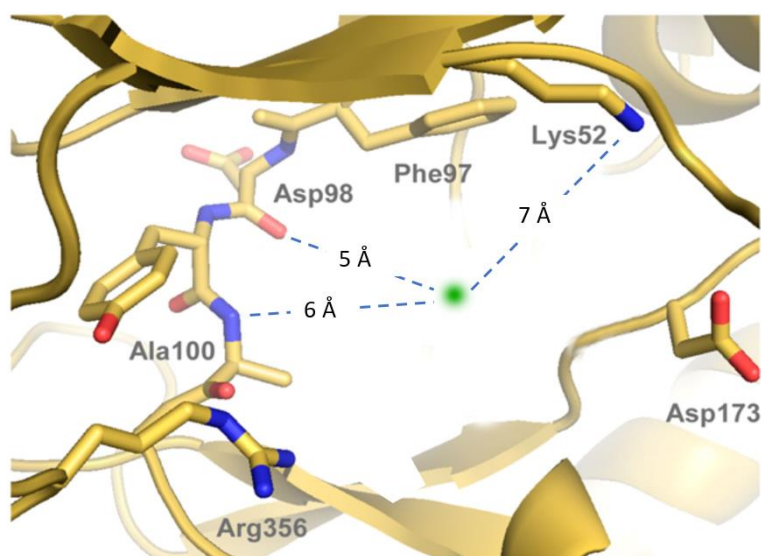
Putting up at hotels, frequent travelers wish to maintain the comfort they are accustomed to at home without paying extra money for the hotel service level.

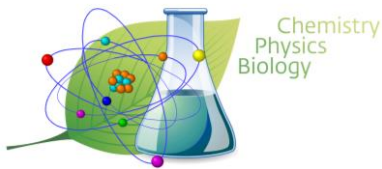
Propose a device for travelers, which would include the functions of a hair dryer, a kettle, a shoe dryer and a heater.

The device should operate off mains power supplies. The ability of one or several functions to operate afield from a car cigarette lighter or a solar cell would be of advantage.

5. Conformation

Recently, a group of scientists has determined the structure of some oncogenic intracellular protein, localized in the nucleus. It has been established that the inhibition of this protein can be used to treat various types of malignant tumors. The figure below shows the distances from the conventional center of the groove to the chemical groups, the interaction with which is expected to make the main contribution to the interaction energy of the ligand and the target. The groove of the active center of the protein is an ellipsoid with an approximate size of $15\text{\AA} \times 6\text{\AA} \times 5\text{\AA}$ and the coordinates: Center (0,0,0), Ala100 (-6,0,0), Asp98 (-4,3,1), Lys52 (5,5,-1). Propose the structure of a potential oral drug, which acts as an inhibitor of this protein. The proposed molecule should be stable, soluble in water, able to penetrate through the cell membranes and should not be metabolized too quickly in the human body.





Unit 2, Jan 31, 2018 (cycle #3)

6. Clothes of the future

One of the drawbacks of various portable electronic devices is low accumulator capacity, while charging with the help of the power grid is not always available. Currently, clothes, which transform energy from the human body (movement, heat) and alternative energy sources (wind, sun) into electric energy, are being actively developed. Propose your own concept of clothes or accessories, which would effectively transform the energy of human heat or movement or any other sources of energy resulting from human activities, into electricity. The proposed clothes must be comfortable, should have a reasonable price and should be able to charge the accumulators of any common portable electronic devices.

7. Love potion

Every year more species of animals comes to the edge of extinction. For example, at the moment there exist only three living representatives of such species as northern white rhinoceros: one male and two females. The attempts of breeding such animals in captivity often fail, and the living couple of animals may not want to breed for any reason. Not only preserving of species is important, but also preserving of natural behavioral features of each species during breeding. Propose a nonviolent general approach, which could make possible natural breeding of rare species.

8. Taj Mahal

Contemporary India is a blend of unique culture, centuries-old traditions, and modern technologies. However, as any rapidly developing country, it has some unsolved problems. In the city of Agra, stands the oldest cultural monument -- the Taj Mahal. In recent years, yellow pollution stains started to develop on the snow-white cupola and the upper part of facade.

Currently, government approaches the problem using a so-called “mud-pack” method, which has significant disadvantages. Propose a new method for removing this yellow staining from the Taj Mahal building envelope, as well as a long-term staining protection method.

9. Artificial pancreas

Diabetes mellitus type 1 (DM1) is caused by inadequate insulin production.

Unlike the natural production of insulin by the pancreas, the insulin injection treatment of DM1 does not support accurate maintenance of normal glucose levels in the blood, leading to hypoglycemia or hyperglycemia conditions.

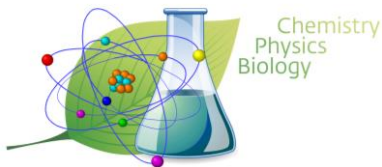
Over the recent years, the so-called glucose-responsive insulin (GRI) systems are actively being developed. These systems maintain the necessary concentration of insulin in the blood, depending on its sugar content, replacing the insufficiently working natural mechanism of the human body

Propose your own GRI system or an improvement on an existing system. Mechanical systems, such as an insulin pump with a glucometer, are not allowed.

In your literature search focus on the following review article, but do not limit yourself to it:

Curr Opin Endocrinol Diabetes Obes. 2017 Aug;24(4):267-278.

doi:10.1097/MED.0000000000000345., <https://www.ncbi.nlm.nih.gov/pubmed/28509691>



10. Save the shells

Collecting seashells is a popular hobby. However, a good collector's shell must have the color, typical for its species and no defects, visible to the naked eye. Therefore, practically all the shells are obtained from live mollusks and, before use, the shells must be cleared from sponges, barnacles, algae and other biofouling. For this, rough mechanical processing or chemical treatment with acids or bleaching agents is used. It leads to damage of lots of the obtained shells, and as a result, to the necessity of more fishing in order to compensate the loss. Propose a method of seashell treatment, which would allow the producers to clear them from biofouling, preserving their color and shape. Prove the working efficiency experimentally. The method must be maximally cheap and simple, applicable for the treatment of a large amount of shells in the production countries (for example, Philippines).

The final of the Tournament is played by the tasks from both Units. Each team-finalist personally chooses which task to report, in order of their ranking in the qualifying rounds. It is forbidden to choose any of the tasks that the team has previously reported or that have been chosen by other teams.