

**International Natural Sciences Tournament**

February 1-6, 2019

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## **Problems of the Intramural round of IX International Natural Sciences Tournament**

### **Unit X**

#### **T-1000**

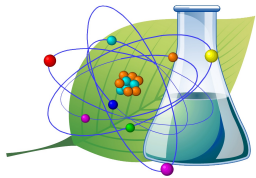
In nature, there are insects, the color of which is not based on pigments, but on the surface morphology. Recently, scientists were able to apply a similar approach to metals, as a result of which the surface acquired superhydrophobic properties and became almost completely black. Suggest your own methods for creating different solid colors of metals only by modifying the surface structure of the metal or alloy itself. Assess the thermal, chemical and mechanical stability of such a surface, depending on what color is created. Suggest applications for the metal products with such a surface.

#### **Char Ecosystem**

The StarCraft series of computer games features the planet Char – a volcanic world with a high temperature, due to which the lava does not freeze even on the surface, and a complete lack of vegetation. However, it is inhabited by a huge number of alien creatures – zergs. Judging by their appearance, all zergs, even the weakest and most numerous of them, are predators. How could the Char ecosystem be arranged then? What serves as food for so many predators if there are no traces of autotrophs on the surface of the planet? Your solution should not contradict to the known laws of biology and ecology. You can find more information about this fictional planet [here](#).

#### **The Chinese study**

In the summer of 2018, some batches of the drug valsartan, for which the active substance was produced by the Chinese company Zhejiang Huahai Pharmaceuticals, were recalled from the pharmaceutical market. The reason of the recall was the presence of a dangerous impurity N-nitrosodimethylamine (NDMA) in the active pharmaceutical substance. NDMA is highly hepatotoxic and is classified as a proven carcinogen. Its presence in valsartan is believed to be caused by the changes in the production method of the active substance. What do you suppose was the source of N-nitrosodimethylamine in the active pharmaceutical substance? How should the way it is produced be modified to avoid the appearance of this



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impurity? Is it possible to effectively purify the supplied substance from NDMA? If this is possible, suggest an alternative production scheme which excludes the appearance of N-nitrosodimethylamine in the substance.

### **Shake, but do not mix**

Check out this [video](#). If you look at the tape in polarized light through a polarizing filter, it will become colored. Furthermore, the observed color will depend on the number of layers of scotch tape and the rotation angle of the polarizing filter. Investigate this phenomenon, create a theoretical prediction model of the spectral line shape of such 'colored' light, and check experimentally whether the model you propose is consistent with the taken spectrum.

### **Breakthrough Starshot**

„Breakthrough Starshot“, announced in 2016, is a program that aims to send micro probes to the Alpha-Centauri star system. This will be the first interstellar flight of an object developed by man. The probe used in the program is a set of measuring instruments weighing 1 gram equipped with a solar sail. An array of lasers is supposed to be used to accelerate the entire structure to 20% of the speed of light. One of the unsolved problems of the project is the material of the solar sail: since it is accelerated to high speed, the sail can suffer from star dust or overheat by reflected light. Suggest a physical model of the solar sail and your material options, which would have a high light reflection factor, be heat-resistant, lightweight, and durable.

Unit Y will be published later. Please, be careful to work through every problem. Remember that you may refuse to solve any one problem in this unit.

No extended solution (\*.doc) is needed. If you have any questions in regard to the presented information, please do not hesitate to contact us again via:

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