ANALYSIS OF THE HILL EQUATION IN THE EDUCATIONAL PROCESS

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Teaching of the discipline "Mathematical modeling of biological processes" to the students-biologists shows that the effectiveness of classes increases dramatically if after building a mathematical model its laboratory verification conducted immediately. The lesson could become especially effective if the model is not only adequate to the prototype, but also predicted the properties of the object which were not at all obvious.

As an example, we can cite the topic "Modeling of erythrocyte hemoglobin oxygenation (derivation of the Hill equation)." The effect studied is based on the phenomenon of a sharp simultaneous increase in both: oxygenation of hemoglobin and oxygen partial pressure in a closed vacutainer. This is the result of hemolysis after an incubation in an hour. We offer to conduct the lesson in 4 stages.

1st stage. Theoretical preparation. The derivation of the Hill equation:
$G = [pO_2]^n \times ([pO_2]^n + p50^n)^{-1}$, where: "***G***" is the relative fraction of oxygenated hemoglobin; "***p50***" is the oxygen partial pressure at which ***G*** = 0.5; "***n***" is the Hill coefficient (the average number of moles of bound oxygen per 1 mole of hemoglobin).

2nd stage. Laboratory part. In each of the 4 vacuum tanks (vacutainers of 2.5 ml each) students contribute 2 ml of venous blood of the experimental animal. In the first, it'll be necessary to determine the following: $\boldsymbol{pO_2}$; $\boldsymbol{HbO_2}$, %; hematocrit (***HCT***) and hemoglobin concentration [***Hb***] (you can use any gas blood analyzer). 0.5 ml of blood to be taken from the second vacutainer and replaced with 0.5 ml of air, after that mixed without sharp shaking. In this sample it is also necessary to determine $\boldsymbol{pO_2}$; $\boldsymbol{HbO_2}$, %. Similarly, manipulation is carried out and with the third vacuum tank, but 0.25 ml of blood to be replaced with 0.25 ml of air. All the 4 vacuum tanks are placed in the rotamix and then in a thermostat for 1.5 hours.

Stage 3. Analysis of the Hill equation. Based on the data obtained the students calculate the values of ***n*** and ***p50*** for tanks number 1 and 2. After that it is necessary to check the coincidence of the results with the values for vacutainer № 3. Next, for available blood samples a series of biophysical calculations of dissolved in plasma ***HCT*** and [***Hb***] are performed. The mass of 1 mole of hemoglobin is assumed equal to 66800 gr, the average value of the solubility coefficient ***K*** of oxygen in blood plasma is 1.25×10^{-6} M / (liter × Torr).

4th stage. Verification. The $\boldsymbol{pO_2}$ and $\boldsymbol{HbO_2}$, % in the vacuum tank № 4 to be determined. In the EXCEL application, students build tables and dependency charts. The table is constructed in the specified range of values from 0 to 160 Torr, in increments of 2–5 Torr. At the end of the laboratory practice, it is advisable to analyze: 1) how the changes in the amount of O_2-mols released during hemolysis will affect the values of the O_2 and ***Hb*** in a vacuum tanker; 2) O_2 moles in the vacuumizer plasma, and 3) the percentage of $\boldsymbol{HbO_2}$ (in the assumption of pronounced activity of hemoxidases in vacutainers). The results of the measurements are compared with the tabulated values.