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БИОХИМИЯ ПИТАНИЯ
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Резюме. Данное исследование представляет последние достижения в области нутрициологии и показывает, что сбалансированное и разнообразное питание, а также ежедневные физические упражнения и контроль веса могут помочь избежать проблем со здоровьем, стабилизировать психологическое и эмоциональное благополучие, улучшить физическое состояние и снизить риск появления широкого спектра заболеваний, таких как диабет, рак, сердечная недостаточность, атеросклероз, инсульт, болезнь коронарных артерий, СДВГ, тревожность, стресс, депрессия, биполярное расстройство, шизофрения и болезнь Альцгеймера.

Ключевые слова: питание, биохимия, избыточный вес, ожирение.

Resume. This research represents the latest achievements in nutritional science and shows that balanced and diverse nutrition as well as daily exercise and weight control can help avoid problems with health, stabilize psychological and emotional well-being, improve physical state and decrease the risk of appearance of wide range of diseases and health issues, such as diabetes, cancer, heart failure, atherosclerosis, stroke, coronary artery disease, ADHD, anxiety, stress, depression, bipolar disorder, schizophrenia and Alzheimer's disease.

Keywords: nutrition, biochemistry, overweight, obesity.

Topicality. According to the World Health Organization, 39% of women and 39% of men aged 18 and over, as well as 18% of children and adolescents aged 5-19 were overweight or obese in 2016. The main reasons for overweight are increased intake of high-calorie foods and low physical activity. Excessive weight, in its turn, is the reason for a number of diseases, such as type 2 diabetes, cardiovascular and oncological diseases, that may lead to the shortening of life. As long as nutrition and lifestyle also influence epigenome of a person they affect his/her lifespan.

Objective: to study what happens with food in human organism at the molecular level, to learn the reasons of weight gaining from biochemical point of view and how to prevent it.

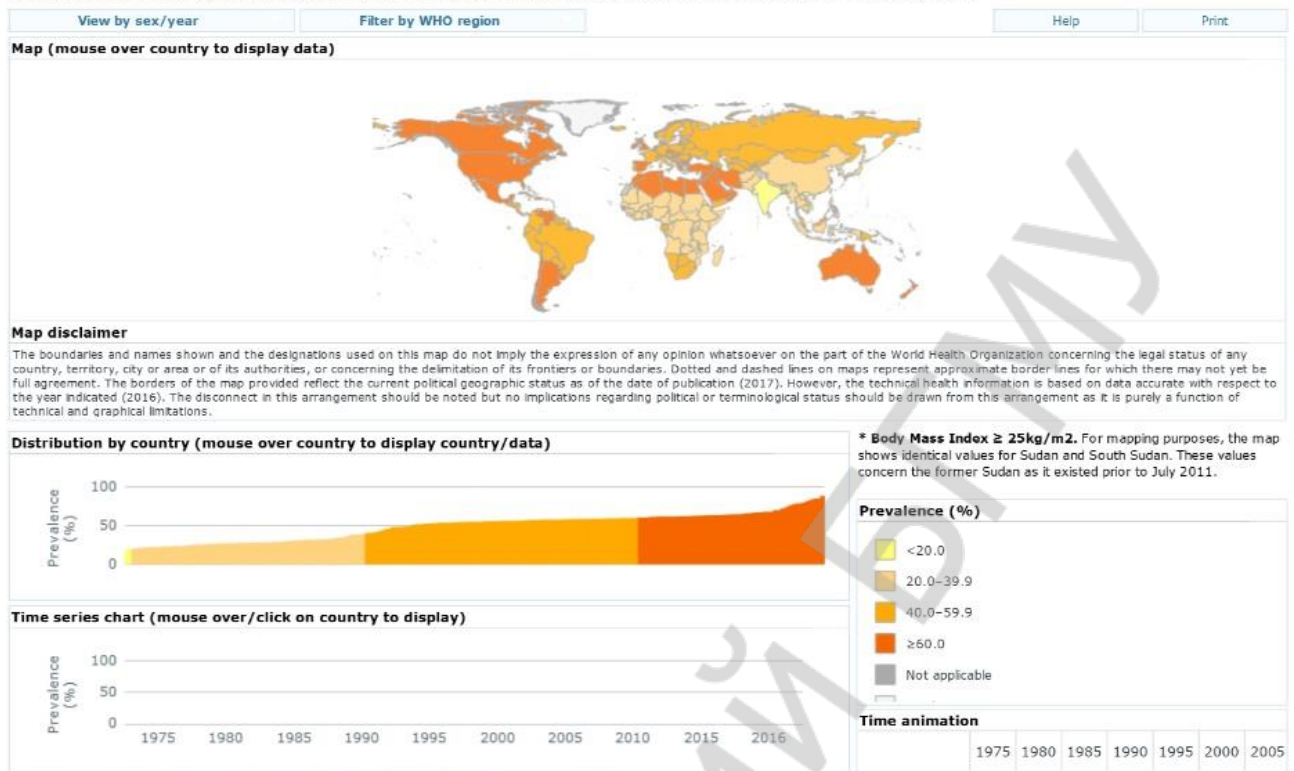
Tasks:

1. To find out the reasons for the increase in the number of people with obesity.
2. To analyze the problem of obesity from the biochemical point of view.
3. To review the biochemical processes associated with food.
4. To review the principles of rational consumption and expenditure of energy.

Materials and methods. Scientific articles, documentary films and the latest studies on biochemistry and physiology devoted to this problem have been assessed.

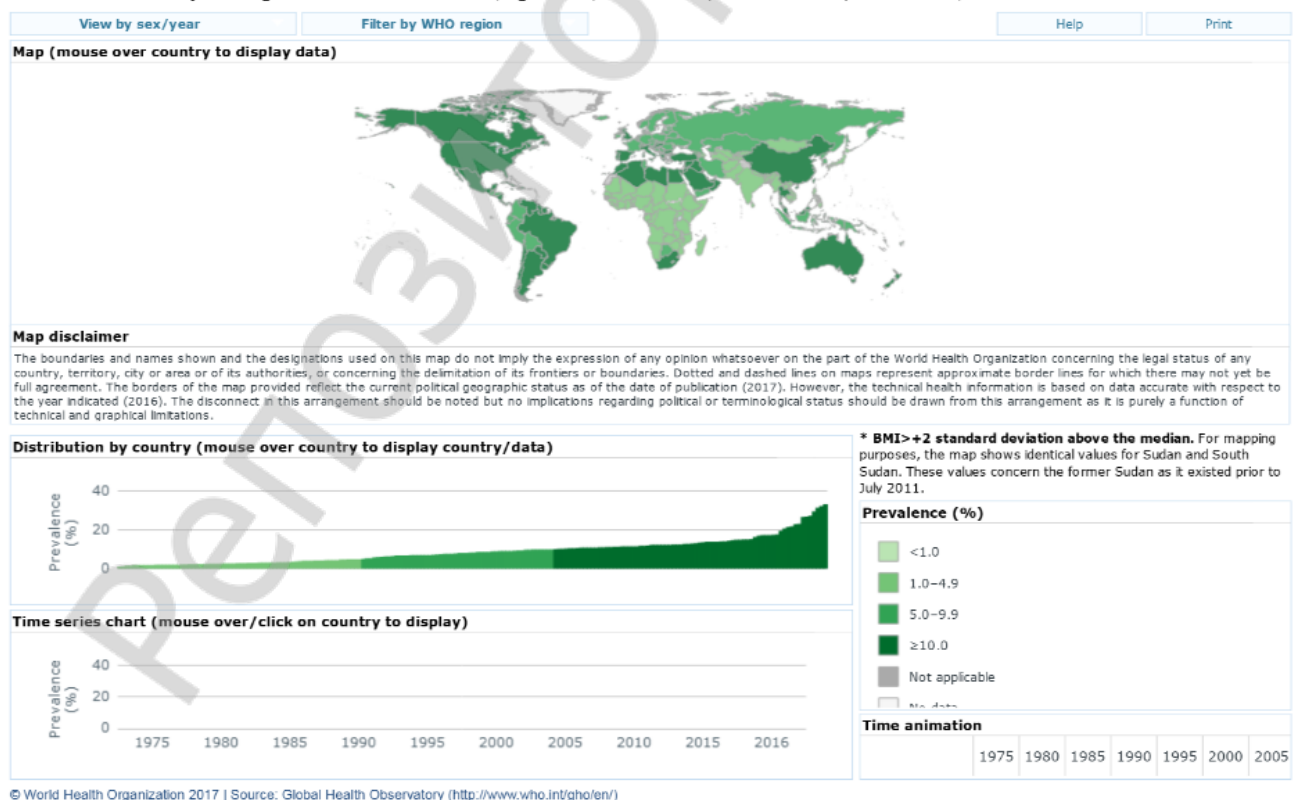
Results and discussion. Recently, there has been a tendency towards an increase in the percentage of the world's population suffering from obesity (pictures 1, 2). People are now consuming more foods high in energy because of the increased production of processed food, rapid urbanization and changing lifestyles that have led to a shift in dietary patterns. That is why it is especially important to understand what happens in human's organism with all food at the molecular level and what leads to the weight gaining.

Prevalence of overweight* among adults, ages 18+, 1975-2016 (age standardized estimate): Both sexes, 2016



Picture 1 – Prevalence of overweight among adults

Prevalence of obesity* among children and adolescents, ages 5-19, 1975-2016 (crude estimate): Both sexes, 2016



Picture 2 – Prevalence of overweight among children and adolescents

All food consists of proteins, fats and carbohydrates. During digestion these complex substances break down into simple (particularly proteins into amino acids, carbs into glucose and fats into fatty acids and glycerol) and then get absorbed into the bloodstream. By blood, they, together with inhaled oxygen, are delivered to the cells, where begins cellular respiration — the most important reaction in the body, because all the energy from the eaten food, basically in the form of adenosine triphosphate (ATP), is obtained due to it. Let's take a look at the scheme on an example of glucose. It includes three stages.

The first stage, called glycolysis, is anaerobic. Glucose breaks down into 2 pyruvates and at the same time are released 2 ATP molecules. Then each pyruvate transforms into Acetyl-CoA with the emission of CO₂. The last was preparation for the next stage called citric acid cycle or Krebs cycle.

It occurs in mitochondria. This stage is aerobic. Acetyl-CoA reacts with oxaloacetic acid with the formation of citric acid, which then turns back into oxaloacetate and everything is repeated again. During each cycle are released 1 ATP and 2 CO₂. In addition to these products, in the first two stages are formed helper molecules — NADH and FADH₂, which are received to the electron transport chain and are used in the last stage — oxidative phosphorylation.

NADH and FADH₂ are donors of protons and electrons, which energy goes to synthesis of 34 ATPs and a bit of water.

The total equation for cellular respiration is:



In other words, to convert 1 glucose molecule, it is needed to inhale 6 molecules of oxygen. In doing so, will be exhaled 6 molecules of carbon dioxide, excreted 6 molecules of water and emitted energy.

Each ATP contains 2 high-energy bonds. At their rupture, from each is released approximately 40 kJ/mol of energy. If we multiply 38 ATP on x 80 kJ/mol we'll receive 3040 kJ/mol that is equal to ~ 726 kcal/mol. As 1 mol of glucose contains 180g, we get that 1g of glucose contains 4 kcal of energy.

The ATP molecule is much more convenient to use as an energy source. The molecule of glucose contains a lot of energy, withal in not usable form. But ATP releases only the necessary amount of energy for the cell needs, thus ATP is commonly referred to as the "energy currency" of the cell. Its energy then is expended on physical exercises, brain work, biosynthesis of new substances, cell division and many other kinds of work.

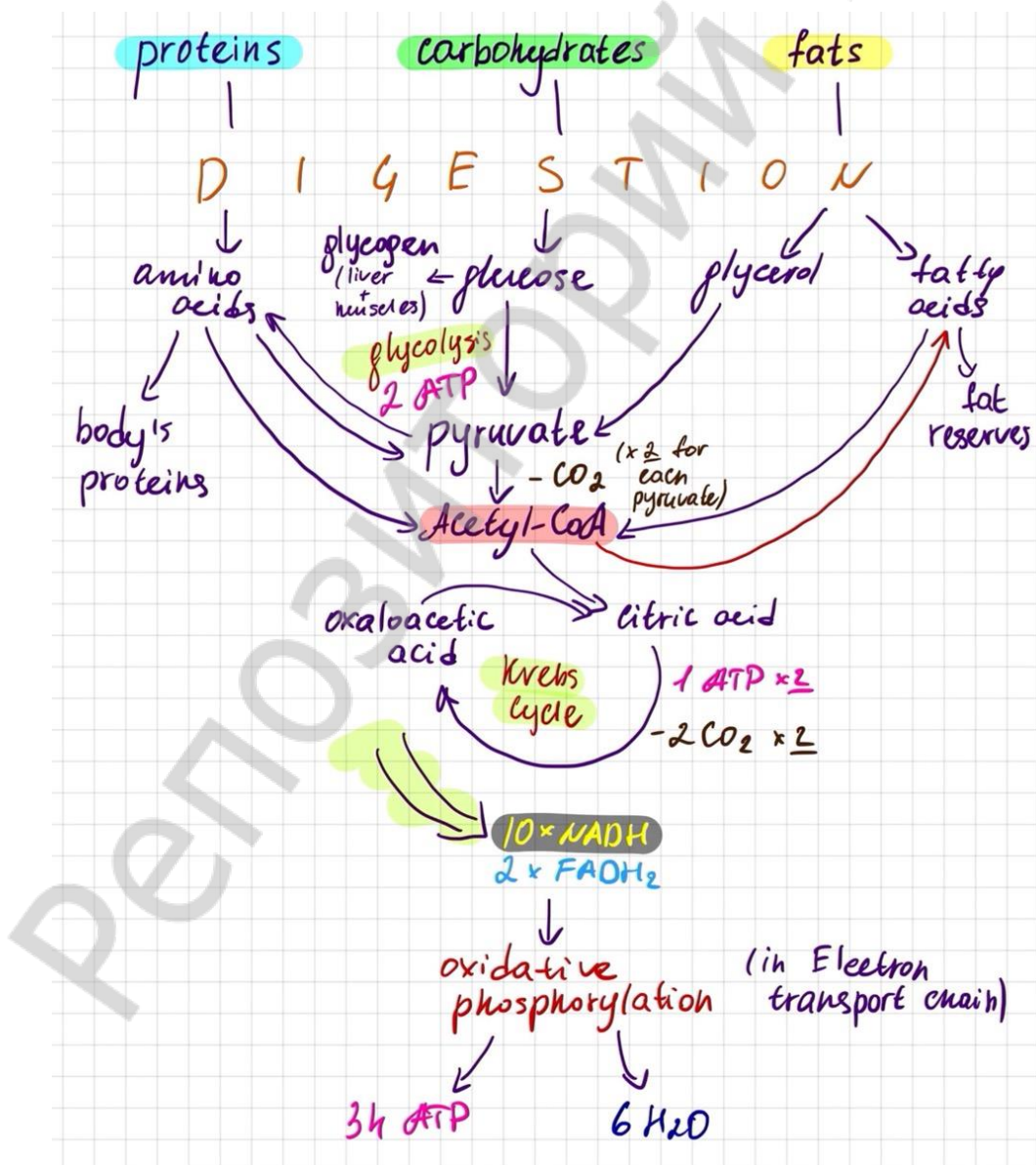
Most cells use just glucose for obtaining ATP. However, if with food is supplied excess protein or fat, they can also serve as a source of energy. In this case Acetyl-CoA is a common intermediary, which enters the Krebs cycle, no matter what was the starting substance, and the Krebs cycle is a starting point for catabolism of carbs, fats and proteins for their conversion into ATP.

Normally, amino acids are used for building body's proteins. Excess glucose is stored in the form of glycogen, consisting of chained glucose molecules. Fatty acids are stored in the adipocytes in the form of fat. A person with a normal weight has about 35 billion adipocytes. Accumulation of fat goes only by increasing the size of already existing fat cells. But if the amount of fat in the cell reaches critical mass, the precursor cells (also

known as preadipocytes) receive a signal and begin to multiply, giving growth to new adipocytes. A person with severe obesity has about 125 billion of adipocytes (that is 4 times more than in a person with a normal weight). Newly formed fat cells remain for all life and if a person loses weight, they only decrease in size.

All the unused in the previously discussed stages proteins and carbs are also stored in the form of fat. And here the intermediary is as well Acetyl-CoA. Fats are long-term energy reserves. Unlike glycogen, which holds a large amount of water, whereby it takes up much space and weighs a lot, fats are hydrophobic — they repel water and combine into droplets. On average the total stock of glycogen is 300-400g, and of fat — 15-20kg, that is more in 50 times. In addition, the energy value of fat is more than twice that of carbs or proteins. From an evolutionary standpoint, the ability to store huge amounts of energy in a very small space is a great advantage that helped human ancestors to survive when food was not enough.

The general scheme of biochemical processes associated with food is as follows (picture 3):



Picture 3 – Biochemical processes associated with food

Proceeding from all the above, to lose weight a person need to either reduce the amount of food intake, or spend more energy. And no new-fangled fad diets will help.

It's important to note, that to remove excess fat, the physical activity should be at least 30 minutes, as at the beginning of training energy is consumed by the breakdown of muscle and liver glycogen, as it's easier mobilized to get energy than fat. But if the intensity is high the muscles will quickly come to fatigue and stop working even before fat begins to burn. Recently, applications under the general title of "7-minute workout" have become very popular. In the description of the applications, the following is often written: «scientifically proven», «the fastest way to improve health and lose weight», «7 minutes a day keeps the belly away». But based on the above, these applications will not help get rid of excess fat. Furthermore using this 7-minute technique just for keeping body in shape may be harmful. Even professional sportsmen point out that it is really hard to do all these high-intensive exercises just in 7 minutes and that it may be more harmful than helpful, especially if a person is not a professional sportsman.

Conclusions:

- 1 Energy intake (calories) should be in balance with energy expenditure.
- 2 Unhealthy diet and lack of physical activity are leading global risks to health.
- 3 Food provides certain chemical substances called nutrients that are needed for good health. The key to good nutrition is a varied diet that includes every kind of nutrient.
- 4 A proper diet and physical activity help to prevent certain illnesses and aid in recovery from other diseases. Following a balanced diet is the best way to ensure that the body receives all the food substances it needs.
- 5 The level of biological and nutritional literacy among the Earth population should be increased.

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THE BIOCHEMISTRY OF FOOD

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