**Methodological guidelines for the IWM on the discipline**

**Risk management of transgenes**

**Exercise 1**

*Genetic engineering methods Analysis of genes and genomes. Genome editing*

**Methods for producing GMOs**

## Ti-plasmid A. tumefaciens - gene transfer vector

## Genetically modified organisms acquire new properties, as a rule, due to the transfer of new genes into the genome.

## New genes can be taken from the genome of related species (cisgenesis) or, theoretically, from any organism (in the case of transgenesis).

## Genetically modified organisms are obtained by the transformation method using one of the following methods: agrobacterial transfer, ballistic transformation, electroporation or viral transformation. Most of the commercial transgenic plants are obtained by agrobacterial transfer or ballistic transformation.

## In most cases, for gene transfer, a plasmid is used that contains a gene whose work gives the body the desired properties, a promoter that regulates the inclusion of this gene, a transcription terminator, and a cassette that contains a selective gene for resistance to the antibiotic kanamycin or herbicide.

## Obtaining transgenic varieties of a new generation does not involve the use of a selective gene, the side qualities of which may be considered undesirable. On the other hand, a genetic construct can carry several genes that are necessary for the complex work of a genetic construct.

## *Purpose of genetic modification*

## *Цель генетического модифицирования*

Genetic modification can give the body and the food that is produced from it, a number of new properties. Most cultivated genetically modified plants are resistant to insect pests or herbicides. As a result, growing costs are reduced. Other properties obtained as a result of genetic modification of food crops are growth acceleration, improvement of food and technological properties of products, resistance to adverse conditions, resistance to pathogens such as viruses and fungi.

A number of cultivars contain more than one additional gene, for example, corn, approved in 2017, contains 3 genes that make it possible to treat it with the herbicides glyphosate, 2-4-D and glufosinate, as well as 6 genes responsible for the production of Bt-toxins and 1 for the destruction of the corn beetle [1].

**Exercise 1**

Modification of food and technological properties of the product

Existing modifications

**Increased production of lysine**

In plant fiber, the synthesis of certain amino acids stops if their concentration has reached a certain level. The bacterial cordapA gene from Corynebacterium glutamicum was transferred into the corn plant using genetic engineering methods under the control of the Glb1 seed promoter. This gene encodes the enzyme lysine-insensitive dihydropicolinate synthase, which is not recognized by plant inhibition systems. LY038 maize, developed by Monsanto, contains an increased amount of the amino acid lysine and is therefore more nutritious as animal feed. The LY038 corn line is commercial and approved for cultivation in Australia, Canada, Japan, Mexico, the Philippines and the USA. In Europe, a request for cultivation was made in the Netherlands, permission was obtained in 2007, but the permission was withdrawn in 2009.

**Suppression of amylose synthesis**

Potato tubers contain starch in two forms: amylose (20-30%) and amylopectin (70-80%), each of which has its own chemical and physical characteristics. Amylopectin consists of large branched polysaccharide molecules, while amylose molecules are composed of unbranched molecules. Amylopectin is soluble in water and its physical properties are more suitable for use in the paper and chemical industries. As a rule, production technologies include additional steps to separate or modify amylose and amylopectin by chemical, physical or enzymatic means.

The BASF campaign has developed a technical potato variety "Amflora", in which the gene of granulo-linked starch synthase, which promotes the synthesis of amylose, is genetically excluded [20]. Such potatoes accumulate only amylopectin in tubers, and therefore are technologically more adapted to processing.

Amflora has been approved by the European Union and in 2010 it is planned to plant 20 hectares in Germany, 80 hectares in Sweden and 150 hectares in the Czech Republic.

*Developed modifications*

**Changing the composition of fats and fatty acids**

The use of essential fatty acids is an important prerequisite for the prevention of prenatal and neonatal developmental defects, since they are necessary for the normal development of the tissues rich in molecular membranes of the brain, nervous and circulatory systems. Polyunsaturated fatty acids with a carbon chain of more than 16 atoms are found mainly in animal cells. For example, docosahexaenoic acid is not synthesized in the human body and must be ingested with food. The production of essential fatty acids is viewed by the food industry as a new and cheap source of nutritional components.

Under normal conditions, rape seeds do not contain such fatty acids as arachidonic, eicosopentaenoic and docosahexaenoic acids. But the seeds of a close Asian relative of rapeseed, the brown mustard Brassica juncea, contain linoleic and linoleic acids, which can be converted in three consecutive biochemical reactions into arachidonic and eicosopentaenoic acids. Transgenic lines of brown mustard have been created, into which whole blocks have been transferred (from three to nine genes that encode enzymes for converting linoleic and linolenic acids into arachidonic, eicosopentaenoic and docosahexaenoic acids).

The yield of these plants is low, these experiments show that, in principle, it is possible to transform lipid metabolism so that polyunsaturated fatty acids are produced in oil crops.

## Allergenicity reduction and detoxification

## A significant proportion of people are allergic to certain food products. Soybean allergen is particularly problematic as soy products are increasingly used in food production due to the high nutritional value of soy proteins. This means that it is increasingly difficult for people with soy allergies to obtain non-allergenic foods. In addition, soy-fed pigs and calves also experience allergic reactions. Natural proteins are almost always food allergens. One of the highly allergenic soybean seed proteins is Gly-m-Bd-30-K, which makes up about 1% of the total seed protein. It is to this protein that more than 65% of allergy sufferers react. It is possible to block the gene for this protein and develop soybean lines that will not contain this allergen.

## Cotton yield for every kilogram of fiber gives about 1.6 kg of seeds, which contain about 20% oil. After soybeans, cotton is the second largest source of oil, the food use of which is limited by the high content of gossi-pol and other terpenoids. Gossypol is toxic to the heart, liver, reproductive system. In theory, 44 megatons of cotton seeds annually could provide oil for 500 million people. Using conventional methods, it is possible to obtain cotton without gossypol, but in this case the plant remains unprotected from insect pests. Using genetic engineering methods, it is possible to purposefully interrupt one of the first steps in the biochemical synthesis of gossypol in seeds. In this case, the content of gossypol in the seeds decreases by 99%, while the rest of the plant's organs continue to produce it, which protects the plant from insects.

## Allergenicity reduction and detoxification by genetically engineered methods are at the stage of scientific development.

## *Using genetically modified foods*



#### Agricultural cultivation areas GMO 1997-2009

#### In early 1988, in Ireland, experiments began to change the genetic structure of salmon (in order to increase the productivity of these fish, copies of the gene encoding the production of growth hormone were introduced into salmon eggs).

#### Some food products (yoghurts, dietary supplements, enzyme preparations) may contain live or non-viable genetically modified microorganisms (GMM). Genetically modified food can also include products containing components obtained using GMM, for example, cheeses produced using rennet from genetically modified bacteria (this technology produces more than 50% of hard cheeses).

#### Agricultural crops

## *Status for 2019]*

## A total of 134 million hectares were sown with genetically modified plants (both food and forage and industrial crops) in the world. This corresponded to 9% of all cultivated fertile land (1.5 billion hectares). GM crops were officially cultivated in 25 countries. In addition, the import of food and feed GM crops of 24 species was allowed in 32 countries that do not grow such crops on their own.

## In 2015, the area occupied by GM crops (both food and forage and technical) increased to 180 million hectares. This corresponded to 12% of all arable land, 1.5 billion hectares.

## Genetically modified plants are grown in 28 countries, especially in the USA, Brazil, Argentina, Canada, India. Since 2012, production of GM varieties by developing countries has exceeded production in industrialized countries. Of the 18 million GM farms, over 90% were smallholders in developingcountries.

## *The largest areas were occupied by GM crops in the following countries:*

## *Assignment 3*

*Methods for checking for GMOs*

As a rule, testing for the presence of GMOs is carried out using the polymerase chain reaction (PCR). Such a test involves three main steps:

1. Sample preparation, consisting in the isolation of DNA from the test food;

2. Setting up PCR with isolated DNA and with a pair of primers, which are complementary to the region of the inserted gene. Sometimes one of the primers can be complementary to the border region between the chromosomal DNA of the "host" and the inserted DNA. During PCR, a DNA region specific for an inserted gene or an insertion event is repeatedly amplified.

3. Identification of the amplified PCR product using different devices. If the product is found, it is evidence that the DNA of a genetically modified organism has been detected in the sample.

Quantification for GMOs: The exact number of GMOs in a product cannot be quantified. For a long time, only the presence of GMOs in a product was determined: whether the product contains GMOs or not. Quantification methods have recently been developed - real-time PCR, in which the amplified product is labeled with a fluorescent dye and the radiation intensity is compared with calibrated standards. However, even the best devices still have significant margin of error.

Quantification for GMOs is only possible when sufficient DNA can be isolated from the product. If difficulties arise with the isolation of DNA, which is rather unstable, degrades and is lost during product processing (purification and refining of oil or lecithin, thermal and chemical treatment, pressure treatment), then quantitative determination is impossible.

DNA extraction methods in different laboratories may be different, so the quantitative values ??may also differ, even if the same product is being tested.

Regardless of whether a qualitative or quantitative determination is used for the analysis of food products for GMO content, the disadvantage of this method is a large number of false positive and false negative results. The most accurate results can be obtained by analyzing raw plant materials.

Standardized chip verification systems are sometimes used to qualitatively determine GMO content. Methods for determining DNA in different laboratories may differ, therefore, the quantitative values ??may also differ, even if the same product is being analyzed. Chip systems are based on the principle of complementary DNA hybridization with a tag applied to the chip. Efficient DNA extraction is also a limiting factor in this method. However, such verification systems do not cover the entire variety of GMOs and are difficult to define.

## Assignment 4

## Ways to commercialize GMOs

## Each country has a different path to commercializing GMOs. The procedures for marketing and cultivation are different, but they are based on the same principles.

## Safety: the product must be safe and not pose a threat to the health of people or animals. Also, it must be safe for the environment. Safety is determined according to developed tests, which are based on the latest scientific knowledge and are applied using modern technological means. If a product does not meet the above requirements, it does not receive permission for cultivation or distribution. If, over time, hazardous properties are identified in a product, it is excluded from the market.

## The right to choose: even if GMOs receive permission to cultivate or distribute, consumers, farmers and businesses should have the right to choose whether to use it or not. This means that in the long term it should be possible to manufacture products without the use of genetic engineering.

## Ensuring the principle of the right to choose is possible provided that two rules are observed:

## Marking: the most important way to ensure the right to choose. Wherever and how GMOs are used, they must be clearly labeled. In this case, the consumer has the opportunity to make an informed choice.

## Tracking: labeling is also necessary, even if GMOs cannot be traced in the residual product. This applies to manufacturers and suppliers of products. In this case, they undertake to inform consumers by issuing responsible documentation regarding raw materials.

## The tolerance for one genetically modified crop in one country is estimated from 6 to 15 million US dollars, this includes the costs of preparing the request, assessment of molecular characteristics, composition and toxicity of the product, animal studies, characterization of proteins for allergenicity, assessment of agronomic qualities, development of testing methods, preparation of legal documents for the organization of export. The costs are paid by the person applying for admission.

*Risks associated with GM foods*

*Main article: Studies of the safety of genetically modified organisms*

Health risk

It is scientifically impossible to establish 100% safety of any foodstuff. However, genetically modified products undergo detailed research based on modern scientific knowledge.

There have been no reports of harmful effects in the human population from genetically modified foods.

There is a scientific consensus that currently available foods derived from GM crops do not pose a greater risk to human health than conventional foods, but each GM product must be tested on a case-by-case basis prior to introduction.

## Assignment 5

Food Allergies that may be Associated with GMOs

These products on the market today have not been found to have allergic effects.

One of the possible risks of eating genetically modified food is its potential allergenicity. When a new gene is inserted into the genome of a plant, the end result is the synthesis of a new protein in the plant, which may be new in the diet. Therefore, it is impossible to determine the allergenicity of a product based on past experience. In theory, each protein is a potential trigger for an allergic reaction if there are specific binding sites for the IgE antibody on its surface.

Antibodies that are specific for a particular antigen are produced in the body of the individual mind that is sensitive to the allergen. Sensitivity to allergens often depends on genetic predisposition, so calculations of allergic potential cannot be done with 100% accuracy. New potential allergens are also formed in varieties of conventional breeding, but it is very difficult to track such allergens, in addition, the procedure for admitting conventional varieties to the analysis for allergenicity is not provided.

Each genetically modified variety, before reaching the consumer, undergoes an assessment of its allergenic potential. Tests include comparison of the protein sequence with known allergens, protein stability during digestion, blood tests from allergen-sensitive individuals, and animal tests.

In the event that a product demonstrates allergic properties during development, the request for commercialization may be withdrawn. For example, in 1995, Pioneer Hi-Bred developed a feed soybeans with a higher content of the amino acid methionine. For this, the Brazil nut gene was used, which, as it turned out over time, demonstrated allergic qualities. Product development has been halted because there is a risk that feed soybeans may accidentally or as a result of vendor misconduct end up on the consumer's table.

Another example of a potentially allergenic product is the "Star-Link" Bt corn feed variety developed by Aventis Crop Sciences. US regulators have authorized the sale of StarLink seeds with the caution that the crop should not be used for human consumption. The limitation was based on tests that demonstrated poor digestive qualities of the protein. Despite the restriction, Star-Link corn seeds have been found in food. 28 people went to medical institutions with suspicion of an allergic reaction. However, the US Centers for Disease Control studied the blood of these people and concluded that there is no evidence of an increased sensitivity to the Bt-corn protein "StarLink".

Since 2001, the cultivation of the variety has been discontinued. Monitoring has shown that since 2004 no traces of cultivation of the variety have been observed.

In 2005, the Australian company CSIRO developed pea by inserting a gene for resistance to insect pests isolated from beans. Experimental studies have shown allergic lung lesions in mice. Further development of this variety was immediately stopped. At the same time, the allergic reaction was presumably due to the fact that the protein synthesized in the peas was not identical to the protein synthesized in the beans, due to post-translational modification. Experiments in 2013 by other researchers showed that both transgenic legumes and non-transgenic beans caused allergic reactions in some species of mice.

## Assignment 6

*Toxicity that may be associated with GMOs.*

1. Certain gene products that are genetically engineered into the body can be harmful. In 1999, an article by Árpád Pusztai was published concerning the toxicity of genetically modified potatoes to rats. The lectin gene from the snowdrop Galanthus nivalis has been inserted into the potato to improve its resistance to nematodes. Feeding potatoes to rats demonstrated the toxic effect of the genetically modified cultivar. The publication of the data was preceded by a loud scandal, as the results were presented before peer review by other scientists. The explanation proposed by Empty that the toxic effect was most likely caused not by lectin, but by the gene transfer method, is not supported by most scientists, since the data presented in the article are insufficient to formulate just such conclusions. The development of a transgenic potato with a lectin gene has been discontinued.
2. The modern methodology for the admission of transgenic plants to use provides for a chemical analysis of the composition in comparison with conventional products and research on experimental animals. A separate subject of discussion is the design of animal experiments. Russian researcher Irina Ermakova conducted a study on rats, which, in her opinion, demonstrates the pathological effect of genetically modified soybeans on the reproductive qualities of animals. Since the data were widely discussed in the world press, without being published in peer-reviewed journals, the scientific community considered the results more carefully.

A review of six independent world-class experts led to the following conclusions regarding this experience:

Irina Ermakova's results contradict the standardized results of other researchers who worked with the same soybean variety and did not reveal any toxic effect on the body [62].

3. In her work, Ermakova noted that she had received transgenic soybeans from the Netherlands, although the noted company does not supply genetically modified soybeans.

4. Used GMO products and control samples are a mixture of original varieties.

5. There was no evidence that the control samples did not contain material with modified genes, nor was it shown that the modified soybean was 100% transgenic.

6. There is no description of diets and components of the diet of rats.

7. There are no data on the nutrition of individual individuals, the data shown concern only groups of individuals.

8. Mortality in the control group was significantly higher than the normal mortality of rats of this laboratory strain. Also, the reduced weight in the control group indicates insufficient inspection or insufficient nutrition of the rats, which makes the researcher's conclusions irrelevant.

In 2009, Eric Séralini's studies were published concerning the assessment of the toxic effect of transgenic corn varieties NK 603, MON 810, MON 863 on the health of rats. The authors recalculated the results of feeding rats obtained by Monsanto for varieties NK 603 and MON 810 in 2000 and Covance Laboratories Inc for varieties MON 863 in 2001 using their own statistical methods. The findings indicate that the use of these genetically modified varieties is hepatotoxic, and therefore attracted close attention of the regulatory authorities.

EFSA GMO Panel выдвинула ряд критических замечаний к выбранному статистическому методу вычисления и выводам, приведённых в статье:

1. The results are presented solely as a percentage of difference for each variable, and not in their actually measured units.

2. The calculated values ??of the toxicological test parameters are not related to the normal distribution range for the investigated species.

3. The calculated values ??of toxicological parameters were not compared with the normal distribution in experimental animals that were fed different diets.

4. Statistically significant differences are not dose related.

5. Inconsistencies between Séralini's statistical arguments and the results of these three studies of animal feeding related to organ pathology, histopathology and histochemistry.

The EFSA concluded that the results demonstrated by Séralini do not warrant a revision of previous food safety findings for transgenic maize varieties NK 603, MON 810 and MON 863.

A 2013 review of 1,783 studies carried out between 2003 and 2013 and dealing with various aspects of the safety of GM crops concludes that there is no scientific evidence of the toxicity of GM crops.

Gilles-Eric Séralini study on the dangers of GMO corn in 2012

In 2012, Séralini published an article in Food and Chemical Toxicology that highlighted the long-term effects of feeding on GM round-resistant corn on rats. The article argued that rats that ate GM corn were more likely to develop cancer [66]. The publication drew very serious criticism. Before publication, Séralini called a press conference, while journalists were only allowed access if they signed a confidentiality agreement and could not include reviews from other scientists in their articles. [67] This drew sharp criticism from both academics and journalists, as it excluded the possibility of critical comments in journalistic publications reporting on this study. Research methods were also criticized. Experts noted that Spreg-Dawley rats are not suitable for such long-term studies, since even under normal conditions they have an almost 80% incidence of cancer.

Serious questions were also raised by the methods of statistical processing of the results and the lack of data on the amount of food fed to the rats and their growth rates. Also, experts noted the absence of dose-effect relationship and undefined mechanisms of tumor development. Six French national academies of sciences issued a joint statement criticizing the study and the journal that published it . The magazine "Food and Chemical Toxicology" published 17 letters from scientists that criticized Séralini's work. The result of the criticism was that in November 2013 the magazine withdrew the publication of Séralini's article.

On June 24, 2014, the article was republished without peer review in the journal Environmental Sciences Europe, which is not included in the largest scientometric databases.

## Assignment 7

*Horizontal gene transfer from product to consumer]*

* Experiments on mice demonstrate that undigested food DNA is unable to enter the bloodstream. Similar studies have been carried out on chickens and calves. Not a single case of insertion of pieces of foreign DNA into the genome of the offspring was observed.
* Risk to the environment
* One of the problems associated with transgenic plants is the potential impact on a range of ecosystems.
* Migration of genes due to cross-pollination
* The transgenes can affect the environment if they enter wild populations and persist there.

*This also applies to conventional breeding. The following risk factors should be considered:*

• whether transgenic plants are able to grow outside the cultivated area;

• whether the transgenic plant can pass on its genes to local wild species and whether the hybrid offspring will be fertile;

• whether transgenes give their carriers a selective advantage over wild plants.

Many domesticated plants can interbreed with wild relatives when they grow in close proximity, and in this way the genes of the cultivated plants can be passed on to the hybrids. This applies to both transgenic plants and conventional breeding varieties, since in any case we are talking about genes that can have negative consequences for the ecosystem after being released into the wild. This is usually not a major concern, despite concerns about “mutant superstorms” that could overwhelm local wildlife. Although hybrids between domesticated and wild plants are far from uncommon, in most cases these hybrids are not fertile due to polyploidy and do not persist in the environment for a long time after the domesticated plant variety is withdrawn from cultivation. However, this does not exclude the possibility of negative impact.

* The pollen of domesticated plants can spread for miles with the wind and fertilize other plants. This can complicate the assessment of the potential loss from cross-pollination, since potential hybrids are located far from the test fields. To solve this problem, systems are proposed that are designed to prevent the transfer of transgenes, for example, terminator technologies and methods of genetic transformation of chloroplasts exclusively so that pollen is not transgenic.
* With regard to the first direction of terminator technology, there are prerequisites for the unfair use of technology, which can contribute to greater dependence of farmers on producers. The genetic transformation of chloroplasts does not have such features, but it has technical limitations that still need to be overcome. To date, there is still not a single commercial cultivar of transgenic plants with a built-in anti-pollination system.

***There are at least three possible pathways that can lead to the release of transgenes:***

• hybridization with non-transgenic crops of the same species and variety;

• hybridization with wild plants of the same species;

• hybridization with wild plants of closely related species, as a rule, of the same genus.

However, a number of conditions must be met for such hybrids to form:

• transgenic plants must be cultivated close enough to wild species for pollen to physically reach them;

• wild and transgenic plants must bloom at the same time;

• wild and transgenic plants must be genetically compatible.

In order for the descendants to survive, they must be viable and fruitful, as well as contain the transferred gene.

Studies show that the release of transgenic plants is most likely to occur through hybridization with wild plants of related species.

It is known that some crops are capable of interbreeding with wild ancestors. Moreover, according to the basic principles of population genetics, the distribution of transgenes in the wild population will be determined by the rate of gene inflow into the population and the selective advantage they provide. Beneficial genes will spread rapidly, neutral genes can spread through genetic drift, non-beneficial genes will only spread through constant influx.

The ecological impact of transgenes is not known, but it is generally accepted that only genes that improve the degree of adaptation to abiotic factors can give hybrid plants a sufficient advantage to become aggressive weeds. Abiotic factors, such as climate, mineral salts or temperature, make up the non-living part of the ecosystem. Genes that improve adaptation to biotic factors can disrupt the (sometimes very sensitive) balance of an ecosystem. For example, wild plants that have received an insect resistance gene from a transgenic plant may become more resistant to one of their natural pests. This could increase the presence of this plant, and at the same time, the number of animals that are above the pest, as sources of food in the food chain, can decrease. However, the exact consequences of transgenes with selective преимуществом в естественной среде почти невозможно точно предугадать.

#### Gene Migration Through Horizontal Gene Transfer]

#### A separate note of ecologists is the use of the gene from nptII of Escherichia coli, which gives resistance to the antibiotic kanamycin, as a selective marker. Most commercial transgenic plants contain it. It is believed that this gene can get into the soil with the remains of plant DNA, and from there into the genome of soil bacteria. As a result, this will lead to fixation of antibiotic resistance in the bacterial population and its transfer to pathogenic bacteria.

#### The DNA of transgenic plants does indeed remain in the soil for some time, although it degrades at the same time. In addition, bacteria are able to “import” foreign genes into their own genome.

#### The frequency of such an event in vivo on Acinetobacter bacteria was determined: transfer of a circular plasmid 1.9 x 10-5 into the bacterial genome, a linearized molecule 2.0 x 10-8, transfer of DNA from transgenic residues - less than the sensitivity limit measurements 10-11.

*Experimental data from environmental studies*

As of 2007, 14 million hectares were sown with transgenic cotton in the world, of which 3.8 million hectares were in China. The cotton bollworm is one of the most serious pests, the larva of which infects not only cotton, but also cereals, vegetables and other cultivated plants. In Asia, she gives four generations per season. Wheat is the main host for the first generation of the scoop, while cotton, soybeans, peanuts and vegetables are hosts for the next three generations. The main agrotechnical measure of the pest control was intensive, 8 times per season, treatment of fields with insecticides. This control method, however, led to the emergence of insecticide-resistant moths and, as a result, an outbreak of the pest in 1992. This, accordingly, later led to an increase in the intensity of the treatment of crops with insecticides.

In 1997, the first transgenic cotton plant containing the Bt toxin gene was launched on the market. Its cultivation made it possible to achieve an increase in yield and a decrease in the need for treating fields with insecticides - up to two times per season. The results of the ten-year monitoring of the ecological situation indicate that since 1997, the density of damage by the moth larva has decreased and continues to decrease. In addition, the population of moths has decreased not only on transgenic cotton, but also on other cultivated plants. This is due to the fact that cotton, as a host plant for the secondthe seasonal wave of reproduction of the moth significantly weakens this second wave, which leads to a decrease in the number of individuals of the third and fourth waves.

Simultaneously with a decrease in the population of moths in cotton fields, the number of another pest, bedbugs from the Miridae family, slightly increased. This fact is explained by a decrease in the intensity of the use of insecticides, which creates more favorable conditions for the development of other pests [95].

Fusarium proliferatum is a phytopathogenic fungus that damages corn and produces the cytotoxin fumonisin, neuro- and pneumotoxic and carcinogenic for humans, and therefore its content is strictly controlled. The results of ecological monitoring of conventional cultivars and genetically modified Bt maize demonstrated an unexpected effect of reducing the infection of genetically modified cultivars by this fungus. Obviously, the fungus mainly infects plants damaged by insects, while insect-resistant transgenic plants are not affected by fusarium.

### Caterpillar Danaida monarch (Danaus plexippus)

### In 1999, the first experimental study of the risk assessment of the impact of transgenic plants on the environment was carried out. Possibility and influence of toxic contamination with Bt-corn pollen of flowers of Syrian Asclepias syriaca, the monarch butterfly Danaus plexippus feeds on pollen. It has been established that, under laboratory conditions, feeding Bt-maize pollen to a butterfly caterpillar leads to a slowdown in its growth and an increased mortality of larvae. More recent studies regarding risk assessment, taking into account the level of exposure and contamination with transgenic pollen, the use of pesticides and other potential toxic substances, showed that the impact of Bt-maize pollen on the monarch butterfly population remains low.

### A similar laboratory study was carried out on the larvae of the caddis flies Hydropsyche borealis. Artificial feeding of larvae with Bt-maize pollen showed an increase in mortality by 20%. The same authors reproduced the experiment in vivo in order to verify the results obtained in laboratory conditions. Caddisflies were cultivated in containers placed next to fields sown with Bt corn. Under natural conditions, no influence of transgenic pollen on the viability of caddisflies was observed.

### The cultivation of Bt crops has long been considered the cause of the mass mortality of honey bees, which peaked in the United States in 2007 and is called “collapse of bee colonies”. Later it was found that the cause of the death of bees was a viral infection, and not GMOs.Конфликты интересов и исследования безопасности

According to the 2011 study, in cases where the risks of using a particular culture were investigated either at the expense of the manufacturer or with the participation of scientists affiliated with the manufacturer, the results of the study were unfavorable only in 2% of studies, in the absence of a conflict of interest, the result was unfavorable in 23% of work

Regulation of the admission, trade and labeling of GM foods

*Russian Federation*

### Until 2014, GMOs could only be grown in Russia in experimental plots, and the import of some varieties (not seeds) of corn, potatoes, soybeans, rice and sugar beets (22 plant lines in total) was allowed. From July 1, 2014, the Resolution of the Government of the Russian Federation of September 23, 2013 No. 839 “On state registration of genetically engineered organisms intended for release into the environment, as well as products obtained using such organisms,” comes into force or containing such organisms ”, which are allowed to sow genetically modified crops [103] [104].

### On February 3, 2015, the Russian Government proposed to the State Duma a bill establishing a ban on the cultivation and breeding of GMOs on the territory of the Russian Federation, with the exception of their use for expert examinations and research work. In July 2016, the President of the Russian Federation signed a law banning the use of genetically modified organisms except for research purposes. One of the main lobbyists for the law was the OAGS (All-Russian Association for Gene Safety) under the leadership of E. A. Sharoikina.

*Kazakhstan Law of GMO*

*US law of GMO*

The approval of genetically modified foods is regulated by three federal agencies, the Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA).

US Laws

Department of Agriculture (APHIS)

7 CFR Part 340: Introduction of Organisms and Products Altered or Produced Through Genetic Engineering Which are Plant Pests or Which There is Reason to Believe are Plant Pests. those about which there is reason to believe that they are plant pests) [111].

Department of the Environment (EPA)

40 CFR Parts 152 and 174: Pesticide Registration and Classification Procedures.

40 CFR Part 172: Experimental Use Permits.

40 CFR Part 725: Reporting Requirements and Review Processes for Microorganisms.

Food and Drug Administration (FDA)

Statement of Policy: Foods Derived From New Plant Varieties [115].

Supplement: Consultation Procedures under FDA's 1992 Statement of Policy.

The register of genetically modified plants admitted for cultivation and sale in the world, as well as those awaiting admission to commercialization, can be found on the website of the Bio-technology industry organizations [117]. The list applies to products manufactured by BASF Plant Science, Bayer CropScience LP, Dow AgroSciences LLC, Monsanto Com-pany, Pioneer, Dupont Company, and Syngenta Seeds Inc.Дополнение: Consultation Procedures under FDA’s 1992 Statement of Policy.

*European legislation**of GMO*

## In the European Union, GMO approval is regulated by two legislative acts:

## 1. Directive on the Deliberate Release into the Environment of Genetically Modified Organisms (2001/18) [119]. This law regulates the rules for the commercial release of GM plants (capable of propagation) and the release of such plants into the environment.

## 2. Regulation on Genetically Modified Food and Feed (1829/2003). This law regulates the admission to the market of food and feed that are manufactured or contain GM plants.

## In addition to these two laws, there are a number of clarifying regulations. A complete list of transgenic plants that are approved for commercialization in Europe can be found on the GMO compass website [121].

## Other worldwide regulations

## The Food and Agriculture Organization of the United Nations, together with the World Health Organization, have developed an appendix to the Codex Alimentarius - "Foods derived from modern biotechnology", regulating safety rules for genetically modified foods.

## Problems of harmonization of legislation

## The laws that govern the admission of GM products to the market are similar, but there are discrepancies in their implementation. The United States declares a free trade policy, while Europe allows free trade with certain restrictions, which is based on the principle of caution. In 2003, the United States [123], Canada [124] and Argentina [125] filed a complaint with the World Trade Organization regarding European restrictions. In 2005, the WTO satisfied most of the points of the complaint.

## There is also asynchronous admission of GM products across countries, causing an artificial substitution of trade priorities [clarify]. For example, according to European legislation, products of crossing of a previously approved and commercialized genetically modified variety with conventional varieties are considered a new GM product and are subject to a new approval procedure. In the United States, such products do not require a separate authorization.

## The overwhelming majority of GM approvals in Europe relate to permits for the import of raw materials, not cultivation. Europe imports transgenic raw materials, the content of which in the finished product should not exceed 0.9%. As a result of asynchronous tolerances, either a restructuring of trade markets is expected, or Europe will abandon the principle of zero tolerance [126].См. также

1. [Brookes, G. and P. Barfoot. 2009. GM Crops: Global Socio-economic and Environmental Impacts 1996-2007. P.G. Economics Ltd, Dorchester, UK](http://www.pgeconomics.co.uk/pdf/2009globalimpactstudy.pdf). [Архивировано](https://www.webcitation.org/6EEnHb7rR?url=http://www.pgeconomics.co.uk/pdf/2009globalimpactstudy.pdf) 6 февраля 2013 года.
2. ↑ [Перейти обратно:](https://ru.wikipedia.org/wiki/%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8_%D0%BC%D0%BE%D0%B4%D0%B8%D1%84%D0%B8%D1%86%D0%B8%D1%80%D0%BE%D0%B2%D0%B0%D0%BD%D0%BD%D0%B0%D1%8F_%D0%BF%D0%B8%D1%89%D0%B0%22%20%5Cl%20%22cite_ref-%D0%B0%D0%B2%D1%82%D0%BE%D1%81%D1%81%D1%8B%D0%BB%D0%BA%D0%B01_5-0)***[1](https://ru.wikipedia.org/wiki/%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8_%D0%BC%D0%BE%D0%B4%D0%B8%D1%84%D0%B8%D1%86%D0%B8%D1%80%D0%BE%D0%B2%D0%B0%D0%BD%D0%BD%D0%B0%D1%8F_%D0%BF%D0%B8%D1%89%D0%B0%22%20%5Cl%20%22cite_ref-%D0%B0%D0%B2%D1%82%D0%BE%D1%81%D1%81%D1%8B%D0%BB%D0%BA%D0%B01_5-0)*** [***2***](https://ru.wikipedia.org/wiki/%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8_%D0%BC%D0%BE%D0%B4%D0%B8%D1%84%D0%B8%D1%86%D0%B8%D1%80%D0%BE%D0%B2%D0%B0%D0%BD%D0%BD%D0%B0%D1%8F_%D0%BF%D0%B8%D1%89%D0%B0#cite_ref-%D0%B0%D0%B2%D1%82%D0%BE%D1%81%D1%81%D1%8B%D0%BB%D0%BA%D0%B01_5-1) [Bonny S. Genetically Modified Herbicide-Tolerant Crops, Weeds, and Herbicides: Overview and Impact.](https://www.ncbi.nlm.nih.gov/pubmed/26296738)
3. [↑](https://ru.wikipedia.org/wiki/%D0%93%D0%B5%D0%BD%D0%B5%D1%82%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8_%D0%BC%D0%BE%D0%B4%D0%B8%D1%84%D0%B8%D1%86%D0%B8%D1%80%D0%BE%D0%B2%D0%B0%D0%BD%D0%BD%D0%B0%D1%8F_%D0%BF%D0%B8%D1%89%D0%B0#cite_ref-ISAAA_6-0) [Global Status of Commercialized Biotech/GM Crops](http://www.isaaa.org/Resources/publications/briefs/39/executivesummary/default.html). [Архивировано](https://www.webcitation.org/6EEnIAQhI?url=http://www.isaaa.org/Resources/publications/briefs/39/executivesummary/default.html) 6 февраля 2013 года.

Ibrahim, M. A., Griko, N., Junker, M., & Bulla, L. A. (2010). Bacillus thuringiensis: a genomics and proteomics perspective. Bioengineered bugs, 1(1), 31-50. *Ronald P.* Plant genetics, sustainable agriculture and global food security (англ.) // Genetics : journal. — 2011. — May (vol. 188, no. 1). — P. 11—20. — [doi](https://ru.wikipedia.org/wiki/Doi):[10.1534/genetics.111.128553](https://dx.doi.org/10.1534/genetics.111.128553). — [PMID 21546547](https://www.ncbi.nlm.nih.gov/pubmed/21546547?dopt=Abstract).