SABINA VITALIIVNA CHEBOTAR

PROFESSOR HONORIS CAUSA

UNIVERSITATIS

STUDIORUM NATURALIUM

LUBLINENSIS

DIE XXVIII MENSIS IUNII ANNO DOMINI MMXXIII

SABINA VITALIIVNA CHEBOTAR

PROFESSOR HONORIS CAUSA UNIVERSITATIS

STUDIORUM NATURALIUM LUBLINENSIS

Q.F.F. F.Q.S.

IN NOMINE UNIVERSITATIS RERUM NATURALIUM LUBLINENSIS E SENTENTIA
CONSILII DISCIPLINAE AGRICULTURAE ET HORTORUM CULTUS FACULTATIS
AGROBIOINGENIARIAE
NOS

CHRISTOPHORUS KOWALCZYK
DOCTOR HABILITATUS, SCIENTIARUM AGRARIARUM PROFESSOR
IN UNIVERSITATE RERUM NATURALIUM LUBLINENSI PROFESSOR ORDINARIUS
ET EIUSDEM HOC TEMPORE RECTOR MAGNIFICUS

BARBARA KOŁODZIEJ
DOCTOR HABILITATUS, SCIENTIARUM PROFESSOR
IN UNIVERSITATE RERUM NATURALIUM LUBLINENSI PROFESSOR ORDINARIUS
HOC TEMPORE FACULTATIS AGROBIOINGENIARIAE DECANUS SPECTABILIS

IN
REVERENDISSIMUM DOMINUM

SABINAM CHEBOTAR

SCIENTIARUM AD GENETICAM ET BIOLOGIAM MOLECULAREM PERTINENTIUM PROFESSOREM

ACADEMIAE NATIONALIS SCIENTIARUM AGRARIARUM UCRAINICAE SOCIAM
IN INVESTIGATIONIBUS GENETICIS MOLECULARIBUSQUE DE TRITICO AESTIVO
ET EIUS VARIIS COMPOSITIONIBUS DOMINAM DOCTRINA ERUDIOTIONEQUE EXCELLENTEM
QUAE MERITA VALIDA AD COOPERATIONEM INTERNATIONALEM PROMOVENDAM INTULIT
SOCIETATUM MULTARUM ET CONSILIORUM SCIENTIARUM PRAESIDEM ET SOCIAM
IN REBUS AD SCIENTIAS DOCTRINASQUE PERTINENTIBUS
MODERATRICEM EXCELLENTEM COOPERATORUM EDITIONUM PERIODICORUM
SCIENTIFICORUM EDITOREM PRINCIPALEM ATQUE SOCIAM

IN EANDEM MULIEREM DOCTAM MULTA OBSERVANTIA REVERENTIAQUE GRANDI DIGNAM
EX DECRETU FACULTATIS AGROBIOINGENIARIAE AMPLISSIMIQUE SENATUS

PROFESORIS HONORIS CAUSA

UNIVERSITATIS RERUM NATURALIUM LUBLINENSIS

NOMEN ET DIGNITATEM, IURA ET PRIVILEGIA CONTULIMUS

IN EIUSQUE REI FIDEM HOC DIPLOMA SIGILLO UNIVERSITATIS NOSTRAE ET PROPRIIS NOSTRIS
SUBSCRIPTIONIBUS SANCIENDUM CURAVIMUS

PROF. DR HAB. BARBARA KOŁODZIEJ
DECANUS

PROF. DR HAB. CHRISTOPHORUS KOWALCZYK
RECTOR

DATUM LUBLINI, DIE VICESIMO OCTAVO MENSIS IUNII ANNO DOMINI BIS MILLESIMO TERTIO

RECTORIS MAGNIFICI ORATIO

The calendar of academic celebrations includes special days in which we especially appreciate and honor outstanding people: meritorious for the development of science and cooperation between research centers. One of such celebrations is awarding the title of professor honoris causa. Awarding the title of honorary professor is also an expression of gratitude to the distinguished person for their scientific work and cooperation on many levels with a given academic center. Appreciating the long-term cooperation with our University and the great merits in the field of research and teaching, as well as the great personality of Professor Sabina Chebotar, the University of Life Sciences in Lublin awarded the Professor with the title of professor honoris causa.

Professor Sabina Chebotar, is the Head of the Department of Molecular Biology, Biochemistry and Genetics of Odesa I. I. Mechnikov National University and taking secondary employment as a Lead Research Scientist in the Department of General and Molecular Genetics of the Plant Breeding and Genetics Institute – the National Centre of Seed and Cultivar Investigation in Odesa city, Associate Member of the National Academy of Agrarian Sciences of Ukraine, the member of international platform "The European Cereals Genetics Co-Operative" EWAC. Moreover she is the wife, mother, grandmother and daughter who is experiencing the terrible drama of the war, caused by the aggression of Russian troops against Ukraine, especially since Odesa was the target of invasion from the first days of the war, remaining under the constant threat of attack from sea and air.

Professor Sabina Chebotar was born in 1966 in Potsdam. After graduating from secondary school, she began studying at the Odesa I. I. Mechnikov National University and graduated with a degree with distinction in biology. In 1995, she defended her doctoral thesis entitled "Molecular genetic analy-

sis of introgression of *Aegilops* genome segments into the bread wheat genome". After obtaining a doctoral degree she worked as a Senior Researcher at the Department of Genetic Engineering of the Institute of Plant Breeding and Genetics of the Ukrainian Academy of Agricultural Sciences, and then she was the Deputy Director for Science of the Southern Center for Plant Biotechnology of the Ukrainian Academy of Agricultural Sciences. She completed three internships in scientific centers abroad. At the Department of Genetics at the University of Regensburg and at the Leibnitz Institute of Plant Genetics and Crop Research in Gatersleben and at the Cereal Genetics and Genomics Laboratory at the Blaise Pascal University in Clermont-Ferrand in France. In 2009, she obtained a postdoctoral degree in molecular genetics based on her scientific achievements and work entitled "Molecular-Genetic Analysis of Ukrainian Bread Wheat Gene Pool". In 2019, based on the Resolution of the Graduate Council of the Ministry of Education and Science of Ukraine, she was awarded the academic title of professor.

Since 2003, she has been working at the Mechnikov National University in Odesa, initially at the Department of Genetics and Molecular Biology of the Faculty of Biology. In the years 2013–2022 she was the head of the Department of Genetics and Molecular Biology. Currently she has been working as the Head of the Department of Molecular Biology, Biochemistry and Genetics of the Mechnikov National University in Odessa. In addition, since 2003, she has also been working as a Lead Research Scientist at the Department of General and Molecular Genetics of of the Plant Breeding and Genetics Institute – the National Centre of Seed and Cultivar Investigation in Odesa.

Application for granting prof. Sabina Chebotar with the title of professor honoris causa of the University of Life Sciences in Lublin, submitted by the Faculty of Agrobioengineering, was supported by the Agriculture and Horticulture Discipline Council and the academic community from other faculties of our University. Fully appreciating the greatness of merits in the field of research, implementation and organization, as well as cooperative with the University of Life Sciences in Lublin.

By awarding this honorable academic title, our University expresses its thanks and gratitude to prof. Sabina Chebotar. Dear Honorable Professor

Honoris Causa of the University of Life Sciences in Lublin, on this important and solemn day, please accept the best wishes for all prosperity, health and success in further research work, and a lot of satisfaction and joy in your personal and family life. But the most important wishes for you Sabina, your family, staff from your University and all of Ukraine are a quick end to the war and desired- peace after the Russian aggressors are driven out.

prof. dr hab. Krzysztof Kowalczyk

Rektor Uniwersytetu Przyrodniczego
w Lublinie

COMMEMORATIVUM DECANI ORATIO

Today, an eminent person joins the esteemed group of Honorary Professors of University of Life Sciences in Lublin - Professor Sabina Vitaliivna Chebotar. This honorary title is awarded to the people, who have contributed to our University, outstanding scholars, who have devoted their professional lives to scientific work and cooperation on many levels.

Professor Sabina Chebotar has a rich academic, didactic and organizational achievements. In 1983 she graduated from Odessa I. I. Mechnikov National University, where she gained further academic career, defended her PhD thesis in 1995, DSc in biology in 2010, and obtained the academic title of Professor of Genetics and Molecular Biology in 2019. She is a Head of the Department of Molecular Biology, Biochemistry and Genetics of Odessa I. I. Mechnikov National University and a Lead Research Scientist in the Department of General and Molecular Genetics of PBGI – NCSCI in Odessa city. Professor Chebotar is an Associate Member of the National Academy of Agrarian Sciences of Ukraine.

Professor Chebotar is a specialist in genetics of bread wheat. She has done extremely important work in the field of molecular genetics, being the author of more than 300 scientific papers, many monographs and also instructional and methodical guides.

Professor Chebotar is a member of Ukrainian Society of Geneticists and Plant Breeders; the international platform 'The European Cereals Genetics Co-Operative'; the working group 'Adaptation of Wheat to Abiotic Stresses' of the International organisation 'Wheat Initiative', and the International Wheat Genome Sequencing Consortium (IWGSC). She also serves as an Academic Secretary of the Scientific Council section 'Biology, Biotechnology and Topical Issues in Medical Sciences' of the Ministry of Education and Science of Ukraine. Moreover, Professor Chebotar is a member of the editorial boards of important academic journals (a.a. Odessa National Uni-

versity Herald. series: Biology, Cytology and Genetics, Plant Varieties Studying and Protection).

Professor Chebotar cooperates with many research centres a.a. in Germany, France and Poland. She has conducted her scientific research in The Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) at Gatersleben in Germany and in the Laboratory of Genetics and Genomics of Cereals of the UMR1095-INRA – Blaise Pascal University in Clermont-Ferrand, France (within the ECO-NET project). Besides, she cooperates closely with scientists from the Institute of Plant Genetics, Breeding and Biotechnology of our University, which results in participation in joint conferences, publications and presentation of papers within the Open Seminar – for which we thank you very much.

Dear Honorary Professor,

On the occasion of awarding the title of Honorary Professor of the University of Life Sciences in Lublin, please accept the heartfelt congratulations and expressions of appreciation for the scientific and didactic achievements so far, for perseverance in passing on knowledge to the next generations of students and young scientists, who have the honour to learn and gain experience under the guidance of the Professor. First of all, I would like to thank you for your impressive achievements in professional work, numerous publications, and admirable diligence resulting from the genuine passion of a scholar for whom acquiring knowledge and passing it on to others has become a lifelong vocation. Congratulations on all these achievements.

Let the title of Honorary Professor of University of Life Sciences in Lublin be an expression of deep appreciation for the enormity of your work and gratitude for it.

Optime tibi eveniant omnia!

Dean
Faculty of Agrobioengineering

Prof. dr hab. Barbara Kołodziej

LAUDATIO

Your Magnificence Rector, High Senate,
Venerable Excellencies,
Highly Honorary Professor honoris causa
Ladies and Gentlemen!

I have a great privilege and honour to present professor Sabina Chebotar, who is to receive today the title of Professor honoris causa of University of Life Sciences in Lublin.

Professor Sabina Chebotar is a researcher at the I. Miecznikov University in Odessa, who devoted her scientific life to plant genetics and biotechnology. She is known to the dignified assembly, gathered today in the Congress Hall of the University of Life Sciences in Lublin, not only from conferences and speeches, but above all from many publications of which the honorary professor is the author or co-author. Professor's commitment to scientific work and achievements should be a model for many scientists, including doctors who receive their diplomas today.

Sabina Vitaliivna Chebotar was born on January 31, 1966 in Potsdam, in the German Democratic Republic, in the family of a military surgeon. In 1988, she graduated from the State University of I. Mechnikov in Odessa with a degree with honors in biology as a Biology and Chemistry Teacher.

Immediately after the graduation, she began working as a Senior Lab Assistant at the Department of Genetic Engineering of the All-Union Institute of Plant Breeding and Genetics. She developed her interests in the field of genetics and plant breeding by undertaking postgraduate studies at the All-Union Plant Breeding and Genetics Institute. After graduation, in 1994, she began scientific work at the Department of Genetic Engineering of the Institute of Plant Breeding and Genetics of the National Center for Seed and Cultivar Investigation in Odessa. A year later, she defended her doctoral dissertation entitled “Molecular genetic analysis of introgression of Ae-

gilops genome segments into the bread wheat genome". As a young scientist, she started working at the Plant Breeding and Genetics Institute of the Ukrainian Academy of Agrarian Sciences, initially as a Senior Research Associate and then as the Deputy Director for Science and Lead Research Scientist. There, she headed the work related to the study of the common wheat genome.

In 2003, she took a second job in the Department of Genetics and Molecular Biology of the Faculty of Biology of Odesa I. I. Mechnikov National University, where she gave lectures, conducted laboratory and other practical classes, supervised semester and Master's theses.

In 2009, she successfully defended habilitation thesis in molecular genetics entitled Molecular-Genetic Analysis of Ukrainian Bread Wheat Gene Pool.

Further scientific career of prof. Sabina Chebotar was inextricably linked with the University, where she worked initially as a Professor in the Department of Genetics and Molecular Biology and then as a Head of the Department. In 2019, based on the Resolution of the Graduate Council of the Ministry of Education and Science of Ukraine, she received the title of a professor.

The scientific work of prof. Sabina Chebotar mainly concerns issues related to the genetics and biotechnology of common wheat, both in terms of the analysis of genetic diversity of various wheat genotypes as well as the analysis and identification of dwarfism genes, genes related to the photoperiod and genes determining the baking quality of wheat.

Prof. Sabina Chebotar broadened her scientific interests through the implementation of national and international grants and research projects that gave her the opportunity to cooperate with numerous foreign research centres, such as the University of Regensburg, Germany, Leibniz Institute of Plant Genetics and Crop Plant Research at Gatersleben, Germany. Blaise Pascal University in Clermont-Ferrand, France. Among these centres there is also the University of Life Sciences in Lublin, which Professor Chebotar visited several times. She actively participated in conferences organized by our University, where she presented the results of her scientific work and

chaired scientific sessions. She also gave a lecture as a part of an open seminar.

Professor Sabina Chebotar has also impressive didactic and organizational activity. Her dedication to science and educating young people is confirmed by the courses and lectures she conducts in the field of molecular biology, genetics, genomics and transcriptomics or genetic engineering. She was the promoter of many master's theses, two doctoral theses and supervised post-graduate students.

Since 2016, she has been the academic secretary of the section of the Scientific Council "Biology, biotechnology and current issues in medical sciences" of the Ministry of Education and Science of Ukraine. She is also the scientific editor of the specialized scientific journals.

Prof. Sabina Chebotar actively participates in numerous scientific conferences, where she presents the results of her research both in the form of lectures and posters.

Prof. Sabina Chebotar is a co-author of over three hundred publications, including many scientific papers published in international and national peer-reviewed specialist journals, instructional and methodological guides. She is the author of chapters in several collective monographs. She is also a co-author of two utility models concerning method for determining the level of isogenicity of wheat analogue lines and method for determining the short-stem alleles of Rht-B1e in soft wheat genotypes. Scientific achievements and scientific indicators place her among the best scientists dealing with genetics and wheat breeding.

Prof. Sabina Chebotar is a member of numerous scientific associations, including the National Academy of Agricultural Sciences of Ukraine, the Ukrainian Society of Geneticists and Plant Breeders; working group “Wheat adaptation to abiotic stresses”, the international organization “Wheat Initiative” and the international wheat genome sequencing consortium (IWGSC) or the international EWAC “The European Cereals Genetics Co-Operative”. Platform. It was the EWAC group that made it possible to start her scientific cooperation with scientists from the Institute of Genetics, Breeding and Plant Biotechnology of the University of Life Sciences in Lublin. I remember very clearly my first meeting with prof. Chebotar and other members of

this organization during the EWAC conference in Novi Sad, Serbia, a very nice welcome of a group of young scientists to the group of collaborators, good advice on scientific work, willingness to help and a great atmosphere that allowed us to feel at ease in the company of such excellent scientists.

Highly esteemed Honorary Professor!

On behalf of myself and the entire community of the University of Life Sciences in Lublin, I would like to thank you for all your initiatives and activities related to the development of science and the education of young generations of researchers, especially now, in such a difficult period for Ukraine. Dear Honorary Professor, on this solemn and special day of honouring you with the highest decoration and scientific title, I wish you many further successes in your scientific and organizational work in the field of agricultural and biological sciences, prosperity and further development of a wonderful scientific environment, career and a lot of health and satisfaction in your personal life, especially during this very difficult time for Ukraine, caused by Russian aggression.

Lublin, 28.06.2023

Dr hab. Sylwia Okoń, Associate Professor

PROFESSOR HONORIS CAUSA LECTIO

DNA Technologies for the Investigation and Conservation of Genetic Resources of Plants

Sabina Chebotar

DSc (Biology), Prof., Cor. Mem. of the National Academy of Agrarian Sciences of Ukraine,
Department of Molecular Biology, Biochemistry and Genetics, Odesa I. I. Mechnikov National University,
Plant Breeding and Genetics Institute – National Center of Seed and Cultivar Investigations

Molecular-genetic characteristics of the gene pool of Ukrainian bread wheat varieties

Ukraine is one of the leading producers of wheat grain in the world; at the same time, our country has its own type of soil and specific climatic conditions, and as the genetic nature of the germplasm of Ukrainian bread wheat varieties is maximally adapted to such conditions, it requires studying at the molecular genetic level.

Fundamental and applied studies of the bread wheat genome have been carried out over the past 20 years and have become the basis for the development of DNA technologies, which are involved in crop breeding practice for the creation of new wheat varieties of improved quality with resistance to biotic and abiotic stresses and for the efficient use of the genetic potential of wheat germplasm.

Studies of bread wheat gene pools of various ecological and geographical regions using molecular marker analysis have been extensively developed worldwide; in particular, microsatellite analysis of diversity of bread

wheat varieties was performed by scientists from European Union (including Poland), UK, USA, China, Argentina, Israel, and other countries.

In Odesa, our efforts have been directed towards characterizing the gene pool of Ukrainian bread wheat varieties at the molecular genetic level. To this end, we applied DNA molecular markers as microsatellite and allele specific markers to genes, SNP-markers, KASP-markers, storage proteins, etc. We used molecular markers linked to genes responsible for agronomically important traits. Analysis of dwarfing genes is one of the directions of our study.

"Pyramids" of dwarfing genes in Ukrainian bread wheat varieties

Dwarfing or reduced height (*Rht*) genes have been associated with large increases in the yield potential of cereals and reckoned as a key component of the Green Revolution since they were introduced in wheat and rice breeding programs in 1950–1960s (Evans 1998). Since the 1960s, dwarfing genes have been used in breeding programs in the South of Ukraine. Also, the *Rht8* gene from Akakomugi was introduced into Ukrainian wheat cultivars in breeding programs aimed at the development of semi-dwarf and non-lodging wheat varieties. In the 1980s, different sources of dwarfing genes – namely, Red River 68 (USA), Ciano 79, Lerma Rojo, Veery S5 (CIMMYT) and Zlatna Dolina (Bulgaria) – were involved in crosses with the adapted Ukrainian varieties. We have shown the changes in allele distribution of molecular markers, linkage with dwarfing genes among wheat varieties developed in Ukrainian breeding programs during 1912–2002 and revealed the fact that the *Rht8c* gene is present in 98% of modern wheat varieties from the Plant Breeding and Genetics Institute (PBGI – one of the main plant breeding center in Ukraine, located in the Southern region). Allele-specific PCR has shown that *Rht-D1b* allele is present in 82% of modern bread wheat from the Institute, but it has not detected *Rht-B1b* with a high frequency in the tested genetic pool. Varieties from the V. M. Remeslo Myronivka Institute of Wheat (Kyiv region) do not carry gibberellin-insensitive genes (*Rht-B1b* and *Rht-D1b*); moreover, we have detected *Rht8c* in only 50% of the tested genotypes. Aiming to answer the question:

which advantages do wheat genotypes with *Rht8c* have in the southern steppe region, we have performed analysis of special genetic material – RILs F_5 from the crossing of contrasing wheat lines (*Rht8a*) x (*Rht8c*). The South of Ukraine is a risky agriculture area due to snowless winters, temperature variations from above zero to –15°C and often to –22°C within a short period of time, wherein plants are damaged by frost. The summer season is characterized mostly by high temperatures and low humidity (with the total spring/summer precipitation of about 100 mm). There was a point of view that the introduction of dwarfing genes into Ukrainian wheat varieties impaired their winter hardiness and frost resistance. However, we did not reveal a decrease in frost tolerance among the examined RILs due to the *Rht8c* allele. We have also used analogue lines created on the background of well known "old" varieities, such as Kooperatorka, Odeska 3, Stepnyak and Odeska 51, which differ in dwarfing alleles (e.g. there are no such dwarfing genes as *Rht8c*, *Rht8c* + *Rht-B1e*, etc.) and proved that the presence of dwarfing genes in a genotype does not lead to a decrease in frost resistance (at –13 ^{0}C) in rolls (Chebotar et al. 2015).

The *Rht* and *Ppd-D1* genes in Ukrainian winter bread wheats: effects and distribution

Wheat grain yields increased following the widespread incorporation of reducing height (*Rht*) and photoperiod insensitive (*Ppd*) alleles into wheat breeding programs to produce semi-dwarf early flowering wheat (Chapman et al. 2007). *Ppd-D1a* (2D) is closely linked to the *Rht8* (20.9 cM) gene; it reduces height through conferring photoperiod insensitivity and hence time to jointing in short days (Addisu et al. 2009) due to a 2.089 bp deletion upstream of the coding region, which is associated with mis-expression of the 2D pseudo-response regulator gene (Worland et al. 1998 a, b; Beales et al. 2007; McIntosh et al. 2008). Owing to its mode of action, *Rht8c*/*Ppd-D1a* is predominantly used in wheat genotypes introduced by CIMMYT and in varieties from the Southern and Southeastern Europe, as well as from the Southern Ukraine. The *Rht-B1b* and *Rht-D1b* alleles encode transcription factors, which belong to the DELLA proteins that act as plant growth repressors insensitive to GA (Peng et. al. 1999). The point mutations of *Rht-*

B1b and *Rht-D1b* lead to the introduction of a stop codon into a conserved region known as the DELLA domain, which is predicted to be in the N-terminus of the protein. Peng et al. (1999) proposed that translation might restart after the introduced stop codon, resulting in shortened proteins, which are resistant to GA-induced degradation. Accumulation of the mutant DELLA protein causes continuous growth inhibition and, accordingly, leads to agronomically advantageous dwarfed plant height and improved straw strength by inhibition of stem cell elongation (Flintham et al. 1997; Peng et al. 1999). The presence of *Rht8*, *Rht-B1*, *Rht-D1* dwarfing and *Ppd-D1* photoperiod insensitive alleles have been extensively investigated (Ganeva et al. 2006; Knopf et al. 2008; Gulyas et al. 2011). According to numerous studies (Worland et al. 1998 a,b; Rebetzke et al. 2001; Ellis et al. 2004; Kowalczyk et al. 2006; Gasperini et al. 2009; Addisu et al. 2009; Kolev et al. 2010; Voss 2010), the presence of dwarfing and *Ppd-D1* genes in wheat genotypes affects the rate of development, winter hardiness, drought tolerance, resistance to Fusarium head blight, nitrogen use efficiency, coleoptile length, seed viability, leaf elongation, and yield. These investigations have shown the importance of several alleles under specific climatic conditions. We investigated the effects of alleles of *Rht8*, *Rht-B1*, *Rht-D1*, *Ppd-D1* genes and their complexes on agronomically important traits (such as plant height, kernel size, WTK, coleoptile length, and *in vitro* androgenesis) of winter bread wheat under conditions of the Southern Ukraine and detected alleles of *Rht8*, *Rht-B1*, *Rht-D1* and *Ppd-D1* genes in genotypes of Ukrainian wheat varieties. As a material we used analogue lines created on the genetic background of varieties adapted to the steppe region – namely, Kooperatorka, Odesskaya 3, Odesskaya 51 and Stepnyak – that differ in plant height and dwarfing genes and varieties from different Ukrainian breeding centers, such as MIW (Myronivka); IASR (Kherson); IPPG (Kyiv); IPP (Kharkiv); DIAP (Donetsk); LIAP (Luhansk) and PBGI (Odesa). The complexes of dwarfing and *Ppd-D1a* alleles reduced plant hight to a greater extent as compared to individual genes. Thus, according to the data for 2008-2010, the complex of alleles *Rht8c+Ppd-D1a+Rht-B1e* decreased plant hight by an average of 47.6% while the complex *Rht8c+ Ppd-D1a+Rht-B1b* – by 39.2%, as compared to tall and photoperiod sensi-

tive plants under conditions of the Southern Ukraine. The complex of alleles *Rht8c+Ppd-D1a* increased WTK (weight thousand kernals) by 17% as compared to plants that carry *Rht8a+Ppd-D1b* alleles. On the other hand, the combination *Rht8c+PpdD1a+RhtB1e* reduced WTK by 15% as compared to the *Rht8a+Ppd-D1b* plants. In general, the breeding program in the Southern Ukraine steppe region has resulted in the presence of *Rht8c* and *Rht-D1b/Rht-B1b* dwarfing (*Rht-B1b* is present in genotypes of Ukrainian wheat varieties less frequently than *Rht-D1b*) and *Ppd-D1a* genes in the most modern winter wheat varieties. However, such a distribution was not observed in the other territory of Ukraine. Among varieties produced in the Eastern Ukraine, the frequency of *Rht-D1b* is 54.5%. Winter wheat varieties from the Central Ukraine are characterized predominantly by the alleles of wild type *Rht-B1* and *Rht-D1* genes. A different pattern of distribution is observed in spring wheat varieties. In general, the plant-breeding program in the Southern Ukraine steppe region has resulted in the *Rht8c* and *Rht-D1b/Rht-B1b* dwarfing and *Ppd-D1a* genes in the most modern winter wheat varieties. In spring wheat breeding programs, dwarfing alleles are more rarely used. Besides, dwarfing and *Ppd-D1a* genes lead to the reduction of plant height, life cycle (earlier heading), coleoptile length, WTK (except for *Rht8c+Ppd-D1a*), kernel size (except for *Rht8c+Ppd-D1a*), length of the main ear (compactisation), as well as to the induction of haploid potential and hence increased number and weight of kernels from secondary ears.

The aim of the next stage of the study was to determine a characteristic that would clearly reflect the negative impact of variations of environmental conditions on wheat plant growth and development and to reveal the best genotype in terms of *Rht* and *Ppd-D1* allelles for growing under conditions of the Southern Ukraine. Analogue lines, parental and recurrent forms that differ in alleles of dwarfing (*Rht*) and photoperiod sensitivity gene (*Ppd-D1*) were studied. In many cases, it is unfeasible to investigate and compare pure effects of genes with a full-factor plan, which contains all allele and gene combinations in the same genotype. Moreover, different growth conditions over the years gave rise to another well-known permanent problem. In a bad year (with water and temperature stress), *Rht8c Rht-B1b Rht-D1a*

Ppd-D1a appeared to be the most adapted genotype. The genotype *Rht8c Rht-B1e Rht-D1a Ppd-D1a* was the least adapted to the stress. We can see that *Ppd-D1b* has a negative effect on weight of grains per plant (WGP) as compared to *Ppd-D1a*. It may be efficient to find the objective indicator, which can reflect to the greatest extent the interaction between genotype and environment. A detailed data analysis has shown that only one of biometric traits – NSs (number of sterile spiklets) – varies under the influence of all sources of variation: year, gene background and their interaction. On the other hand, NSs is negatively correlated with all the other biometric traits. For instance, simple linear models of NSs show that NSs is closely related to main productive characteristics of wheat – WGP and productive tillering (PT): WGP = (11,10 ±0,07) – (2,00 ±0,03) × NSs; R2 = 0.999; SEE = 0.097; PT = (8.35 ±0.08) – (1.00 ±0.03) × NSs; R2 = 0.996; SEE = 0.10. It enables us to consider NSs as quite suitable for a quantitative estimation of how successful allele combinations are on environment and genetic background. *Rht8x* has a negative effect while *Rht8c* – a positive effect on any allele combination. Frequency distributions of sterile spikelets in main ear correspond to allele combinations. If the environment is close to optimal for realization of the productive potential of a given genotype, then NSs should be smaller and tend to zero (complete fertility). The presence of sterile spikelets in the main ear is indicative of suboptimal conditions for realization of the genetic potential at early (II–IV) and late (V–VII) stages of ontogenesis, which are the critical periods for formation of plant productivity. When excluding the NSs and PT variation, we cannot estimate the allele combination effects on the whole plant productivity, except for the most part of the year or parent effects. So, the NSs estimation can be used as an express (and prognostic) not destructive indicator of harvest.

PCR – analysis of genes that control grain quality has been performed for Ukrainian wheat varieties

Among genes that control grain quality, we analysed the presence of puroindolin *a* (*Pina*) and puroindolin *b* (*Pinb*) genes at the *Ha* locus of 5DS chromosome. Puroindolines a and b determine grain texture – hard grain / soft grain. Grain hardness grading is determined by the combination of

different alleles of *Pina-D1* and *Pinb-D1* genes and effect on the bread making quality.

We have revealed that the combination of *Pina-D1a* and *Pinb-D1b* alleles occurs in 95% of bread wheat varieties, so these varieties have hard structure of endosperm; soft wheat varieties with *Pina-D1a Pinb-D1a* alleles include Mirleben, Myronivska 33, Oksana and B16pp (Chebotar et al. 2012). By applying introgression from wild relatives, plant breeders increase the variability of grain texture characteristics and create varieties with special technological characteristics, such as a modern cultivar "Oksana" developed from hybridization with *Triticum palmovae* and reckoned as "supper soft".

We participated in a breeding program for creation wheat variaties with low amylose content for frozen food products. Modern Ukrainian varieties of winter wheat contain a functional *Wx-A1a* (7AS) allele and do not contain null alleles – *Wx-B1b* (4AL) and *Wx-D1b* (7DS) (Petrova et al. 2007a). Using marker-assisted selection, we selected wheat lines with null alleles (Petrova et al. 2007b).

One of the parts of our research was focused on the examination of gliadin polymorphism at *Gli-1* loci via PCR method (Chebotar et al. 2008) and evaluation of molecular markers suitable for identification of allelic variants of gliadin proteins as it is difficult to differentiate allelic variants of gliadins for wheat varieties. In cooperation with E. Metakovsky, taking into account genetic diversity of gliadins in 900 wheat varieties in the world, we found a clear correlation of protein allelic variants of gliadins with alleles detected with allele-specific primers, developed by Zhang et al. (2003), and *Taglgap* microsatellite alleles at *Gli-B1* (Popovych et al. 2020, 2021; Metakovsky et al. 2021) and *Gli-A1* loci, but not at *Gli-D1*.

With the use of molecular-genetic and cytological analyses, (1B)1R wheat-rye chromosome substitution or 1BL.1RS translocation were detected in original introgression stocks. Pairing between 1RS and 1BS chromosomes was detected with a very low frequency. Three and two genes responsible for resistance to leaf and stem rust, respectively, were revealed; among those, *Lr26* and *Sr31* were identified and reckoned as somewhat effective. Genes were identified using molecular markers *Xrems1303*,

SR1R003, ω-*sec*-P3 + ω-*sec*-P4, contributed by cv. Avrora and originated from Petkus rye (Motsnyy et al. 2012).

Microsatellite analysis of a gene pool of Ukrainian wheat varieties

We performed microsatellite analysis to test genetic diversity in a gene pool of Ukrainian wheat varieties at the level of DNA. Traditionally, this kind of analysis is used for forensic investigation and criminalistic DNA expertise to identify individuals. We used microsatellite markers that are generally neutral and, as we assume, they are not under evolutionary pressure in the genome. Microsatellite analysis of wheat varieties developed in Ukraine within the framework of plant-breeding programs over the past 100 years has revealed changes in allele frequencies of microsatellites and reduced genetic diversity in Ukrainian wheat genetic pool; at the same time, we have detected an introduction of new alleles in the genetic pool (Chebotar et al. 2003).

For example, changes in distribution of alleles at *Xgwm533.2* locus that is linked to cluster of resistance genes *YrnS-B1*, *FHB* and *Sr2* reflected the selection pressure on this region in plant-breeding programs in Ukraine (Chebotar et al. 2006).

DNA technologies for the conservation of genetic resources of plants

In the IPK Gatersleben Genebank, where plant seeds are stored and propagated, the seeds from the last regeneration are held in cold storage to maintain germination. Grain samples and whole spikelets from each sample registered in the Genebank had been stored in the herbarium at room temperature for many years and hence had lost their viability. After many years of regeneration and 40-50 years of storage in the Genebank, there was a need to find out whether the stored genetic material remained the same since it had entered the Genebank or changed. Was the genetic diversity lost during the storage period?

For crop plant genetic resources, most conservation efforts have been concentrated on *ex situ* conservation. It has been estimated that existing *ex situ* collections throughout the world contain approximately 6 million accessions. Over 40% of all the accessions in genebanks are cereals (FAO 1998).

In the Gatersleben genebank, about 100,000 accessions are maintained, including cereals, legumes, vegetables, oil and fibre plants, medicinal herbs, spice plants, forages and tubers (potatoes). Depending on the storage conditions and frequency of providing genebank materials to users, regeneration becomes a necessity. To this end, different procedures have to be applied to the pollination systems of particular crops. Cross-pollinating species especially need extensive efforts in order to maintain the genetic integrity of the germplasm accessions. However, a contamination by foreign pollen or incorrect handling during multiplication may affect the genetic identity of self-pollinating species as well.

In order to get some information about the integrity of germplasm maintained in the Gatersleben collection, randomly selected accessions of one self-pollinating (*Triticum aestivum* L.) and one cross-pollinating (*Secale cereale* L.) species were investigated by employing DNA-technology with microsatellite markers.

- For wheat varieties (*Triticum aestivum* L.) the analyses of the stocks multiplied up to 24 times showed a high degree of identity according to the results of microsattelite analysis (Börner at al., 2000).
- No contamination due to foreign pollen or incorrect handling during the multiplication cycles was discovered.
- For one accession (TRI 4599), genetic drift was observed, whereas for TRI 249 a heterogenous situation for two markers was maintained over the years.
- Therefore, our results indicated a high level of maintaining self-pollinating genebank accessions in Gatersleben for more than 50 years (Börner at al. 2000; Khlestkina at al. 2006).
- For rye (*Secale cereale L.* (2n = 14; RR)), which has been a major crop in the Northern and Eastern Europe for many years, the situation is complicated. We need to take in account that classical rye variety is

a panmictic population of hundred thousands individual plants. Random mating is the result of a strong system of self-incompatibility and wind pollination. The effective size for maintaining the genetic structure of a given rye population should be not less than 100 plants. A high level of heterozygosity and heterogenity is typical for classical rye varieties and landraces.

We employed DNA-technology PCR microsatellite-analysis to examine six accession of rye from the Genebank.

Table 1. The Genebank (IPK) rye accessions that have been analyzed using microsatellite markers

Catalogue number	Variety	Origin	Subspecies	Years of first and last multiplication	Size of population	Regeneration frequency
R 52	'Lungauer Tauern'	Austria	subsp. *cereale*	1963 1998	36 60	8
R 78	'Waldstauden Roggen'	Germany	subsp. *cereale*	1954 1956 1958 1993	36 36 36 60	12
R 200	'Universal'	Germany	subsp. *cereale*	1954 1956	36 60	12
R 197	Landrace	Italy	subsp. *Cereale*	1953 1993	36 60	14
R 784	Landrace	–	subsp. *cereale*	1986 1996	36 60	3
R 793	Esto	Germany	subsp. *Cereale*	1988 1995	36 60	2
Total					648	

We revealed changes in allele frequencies at microsatellite loci, along with appearance of new alleles and disapearance of alleles earlier revealed in original populations (Chebotar et al. 2003).

- What is the reason for the detected differences?
- Changes in allele frequencies could be caused by a sharp decrease in the population size, for example due to winter damage or diseases.

- The reason for the appearance of new alleles may be cross pollination during regenerations in the field.

Our investigations resulted in improved management of open-pollinated species in the gene bank. Because of the climate change and its effect on the conditions of plant growth in Ukraine, we are now searching for the sources of drought resistance originated from Ukrainian breeding material and their possible use in marker-assisted breeding of Ukrainian varieties.

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CURRICULUM VITAE

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Education & academic degrees

- **Professor of Genetics and Molecular Biology (since 2019).** The academic title was given based on the Resolution of the Graduate Council of the Ministry of Education and Science of Ukraine dated 15 October 2019 at the request of the Academic Council of Odesa I. I. Mechnikov National University, the respective Professor Certificate series AP No 001235.
- **DSc in Biology (since 2010).** The DSc thesis entitled Molecular & Genetic Analysis of the Winter Bread Wheat Gene Pool of Ukraine (specialty 03.00.22 - Molecular Genetics) was defended in the Specialised Scientific Council D26.237.01 of the Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine. The respective Doctor of Science Diploma series DD No 008054 was issued on 10 February 2010.
- **Senior Research Fellow (2004).** The academic rank (specialty 03.00.22 – Molecular Genetics) was given based on the Resolution of the Academic Council of the Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine, the respective Senior Research Fellow Certificate series AC No 003586 was issued on 10 March 2004.
- **PhD (Candidate of Sciences) (1995).** The PhD (Candidate of Sciences) thesis entitled Molecular & Genetic Analysis of Introgression of the Aegilops Genome Segments into the Bread Wheat Genome (specialty 03.00.03 – Molecular Biology) was defended in the Specialised Scien-

tific Council of the Institute of Molecular Biology and Genetics of the National Academy of Sciences of Ukraine. The respective Candidate of Science Diploma series KH No 008127 was issued on 20 June 1995.

- **All-Union Plant Breeding and Genetics Institute (1990 – 1993).** Post-graduating course.
- **Odesa I. I. Mechnikov State University (1983 – 1988).** Graduated with a degree with distinction in biology, Diploma of Biologist. Biology & Chemistry Teacher.

Employment & traineeships

- **1 September 2022 till the present time (Primary employment)** Head of the Department of Molecular Biology, Biochemistry and Genetics of Odesa I. I. Mechnikov National University.
- **2012 till the present time (Secondary employment)** Lead Research Scientist in the Department of General and Molecular Genetics of the Plant Breeding and Genetics Institute – the National Centre of Seed and Cultivar Investigation in Odesa city.
- **1 September 2013 – 1 September 2022 (Primary employment)** Head of the Department of Genetics and Molecular Biology of the Faculty of Biology of Odesa I. I. Mechnikov National University
- **1 September 2012 – 1 September 2013 (Primary employment)** Professor in the Department of Genetics and Molecular Biology of Odesa I. I. Mechnikov National University
- **2 September 2011 – 1 September 2012 (Primary employment)** Associate Professor in the Department of Genetics and Molecular Biology of Odesa I. I. Mechnikov National University
- **3 October 2005 – 2012 (Primary employment)** Lead Research Scientist in the Department of Molecular Genetics of the South Plant Biotechnology Centre of Ukrainian Academy of Agrarian Sciences. Also performed duties of the bread-wheat genome study group leader.

- **2003 – 2012 (Secondary employment)** Lecturer (including delivery of laboratory and other practicals), Director of term and Master's theses in the Department of Genetics and Molecular Biology of the Faculty of Biology of Odesa I. I. Mechnikov National University
- **2001 – 2002** Work placement and conducting scientific research in the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) at Gatersleben, Germany.
- **2000 – 2005 (Primary employment)** Deputy Director for Science of the South Plant Biotechnology Centre of Ukrainian Academy of Agrarian Sciences.
- **1998** Traineeship at the Department of Genetics of the Institute of Biochemistry, Genetics and Microbiology of the University of Regensburg, Germany, within the framework of the German Academic Exchange project.
- **1996 – 1999 (Primary employment)** Senior Research Associate in the Department of Genetic Engineering of the Plant Breeding and Genetics Institute of Ukrainian Academy of Agrarian Sciences.
- **1994 – 1995 (Primary employment)** Research Associate in the Department of Genetic Engineering of the Plant Breeding and Genetics Institute – the National Centre of Seed and Cultivar Investigation.
- **1988 – 1990** Post-graduate student in the Department of Genetic Engineering of the All-Union Plant Breeding and Genetics Institute.
- **1988 – 1990 (Primary employment)** Senior Lab Assistant in the Department of Genetic Engineering of the All-Union Plant Breeding and Genetics Institute.

Participation in competitive scientific projects

- **2016 – 2020** – Executive in Charge of the project "Genetic principles of qualitative and quantitative economic and valuable traits, development of modern biotechnologies for the creation and evaluation of source ma-

terial and increase the effectiveness of methods to improve plant genotypes" (State Record No 0116U000682) in the Plant Breeding and Genetics Institute – the National Centre of Seed and Cultivar Investigation.

- **2017 – 2019** – Supervisor of the research project "Polymorphism of loci of photoperiodic sensitivity of wheat and soybean varieties and the dependence of plant development on their allelic composition, according to PCR analysis", funded by the Ministry of Education and Science (State Record No 0117U001114).
- **2015 –** a participant in the BILAT-UKRAINA FP7 project, in particular in the "In-house training on biotechnologies", held on February 18-19, 2015; "Advanced Innovative Approach" in Paris, France, and "Workshop: Identification of research topics for further research cooperation between the EU and Ukraine in the field of Biotechnology" (February 20, 2015), within the program "Enhancing the bilateral S&T partnership with Ukraine.
- **2011 – 2015** – Executive in Charge of the project of PBGI-NCSCI NAAS 23.01 / 30-06 (State Record No 0111U006101) "Development of DNA technology for selection of genotypes - carriers of certain genes of economically valuable traits of wheat" and 23.01 / 28-04 (State Record No 0111U00610) "DNA technologies for identification of varieties, lines, hybrids of agricultural crops, development of molecular genetic passports and replenishment of the database of DNA typing".
- **2010 – 2011** – Executive in Charge of the State Fund for Basic Research project "F40 / 94-2011" Molecular genetic analysis of polymorphism of genes that control the growth, development and sensitivity to the photoperiod, among Russian and Ukrainian varieties of bread wheat" (with funding of about UAH 150,000).

Research grants & scholarships

- **2004 – 2007** – a personal grant for research in the Laboratory of Genetics and Genomics of Cereals of the Blaise Pascal University (within the

ECO-NET project; UMR1095-INRA – Blaise Pascal University in Clermont-Ferrand, France).

- **2001 – 2002** – a grant for the work placement and conducting scientific research in the Genetics Bank and the Laboratory of Genetic and Genomic mapping of the Leibniz Institute of Plant Genetics and Crop Plant Research at Gatersleben, Germany.
- **2000 – 2001** – scholarship of the Cabinet of Ministers of Ukraine for young scientists for accomplishing research in the genetics of bread wheat during 2000-2002 on a competitive basis (as per Resolutions of the Cabinet of Ministers of Ukraine No 2 dated 26 October 2000 and No 2 dated 2 November 2001).
- **1998** – a personal grant DAAD (within the framework of the German Academic Exchange project) for a traineeship at the Department of Genetics of the Institute of Biochemistry, Genetics and Microbiology of the University of Regensburg, Germany.

Innovative activity

The total number of patents and utility models recorded over the last 10 years is eight, including:

1. Utility Model by Chebotar S.V., Popovich Y.A., Chebotar G.O. "Method for determining the level of isogenicity of wheat analogue lines". Bull. No 11 dated 10.06.2020.
2. State Register of Patents of Ukraine for Utility Models. Utility model No 69103 "Method for determining the short-stem allele Rht-B1e in soft wheat genotypes". Bull. No 8 dated 25.04.2012 - 4 p.

Organisation of international conferences

- **2019 – 2022** – an organiser and manager of Biological Sections "The Importance of G. Gamow's Ideas for Biology of the 21st Century" with-

in the framework of the annual Gamow International Conference-School at Odesa I. I. Mechnikov National University.

- **2021** – an organiser and manager The 7th International Conference Drosophila in Experimental Genetics and Biology at Odesa I. I. Mechnikov National University.
- **2016** – a co-host of the XI International Scientific Conference "Factors of Experimental Evolution of Organisms", held at Odesa I. I. Mechnikov National University.

Academic & expert activity

- Since 2016 – Academic Secretary and Expert of Scientific Council Section No 15 "Biology, Biotechnology and Topical Issues in Medical Sciences" of the Ministry of Education and Science of Ukraine.
- A member of the Scientific and Technical Council of Odesa I. I. Mechnikov National University.
- Since 2019 – a member of the Specialised Council K.41.363.01 for the defence of PhD (Candidate of Science) theses in specialty 03.00.15 – Genetics.
- Since 2018 – a member of the Specialised Council K.41.051.06 for the defence of PhD (Candidate of Science) theses in specialties 03.00.04 – Biochemistry; 03.00.20 – Biotechnology.

Membership in specialised organisations

- A member of Ukrainian Society of Geneticists and Plant Breeders.
- Associate Member of the National Academy of Agrarian Sciences of Ukraine (since 2010)
- Since 2002 – a member of the international platform "The European Cereals Genetics Co-Operative" (formerly "The European Wheat Aneuploid Co-Operative").

- Since 2017 – a member of the working group “Adaptation of Wheat to Abiotic Stresses” of the International organisation “Wheat Initiative”.
- Since 2020 – A member of the International Wheat Genome Sequencing Consortium (IWGSC).

Membership in the editorial boards of scholar journals

- Academic Editor of the specialised scientific journal “Odesa National University Herald. Series: Biology” (which is included in the Index Copernicus International Journals Master List).
- A member of the editorial boards of the Scopus indexed peer-reviewed journal “Cytology and Genetics.
- A member of the editorial board of the ICI indexed specialised journal of applied research “Plant Varieties Studying and Protection”.

Educational & training activity

Managing the Scholar School “Genetic Polymorphism and Adaptation Mechanism” in Odesa I. I. Mechnikov National University.

Delivering the following lecture courses in the Department of Biology of Odesa I. I. Mechnikov National University: “Molecular Biology”, “General Cytology”, “Genomics and Transcriptomics”, “Genetic Engineering”, “Epigenetics” and “Molecular Genetic Analysis”.

Supervisor of habilitation, PhD, MSc/diploma and BSc theses PhD theses

1. **Bakuma, A. O.:** Genetic polymorphism of *Ppd* loci and photoperiod sensitivity of modern Ukrainian bread wheat varieties. (PhD Theses) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2021). 185 pp.
2. **Zharikova, D. O**.: Polymorphism at loci associated with *E* genes in Ukrainian soybean (*Glycine max* (L.) Merr.) varieties and lines (PhD Theses) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2021). 230 pp.

MSc & specialist's theses

1. **Ishchuk, I. M**.: Molecular genetic analysis of the allelic status at the *Ppd* loci in a series of modern Ukrainian common wheat varieties (*Triticum aestivum* L.). (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2020). 63 pp.
2. **Okhrymovych, O. V**.: Morphological analysis and identification of the *Ppd* alleles in wheat isogenic lines, created on the genetic background of Odeska 267 variety. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2020). 62 pp.
3. **Krasnytska, D. A**.: The polymorphism in soybean varieties at microsatellite loci linked to *E* genes. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2019). 63 pp.
4. **Kuku, N. M**.: Identification of genetic polymorphisms in dolphins, representing the Black Sea population, using molecular markers. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2019). 61 pp.
5. **Chubyk, I. Yu**.: Microsatellite analysis of bottlenose dolphins in order to create biometric passport. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018). 69 pp.
6. **Voitkova, V. S**.: Determination of the allelic status of the E1 gene in soybean varieties CG1 – NCSCI (the National Centre of Seed and Cultivar Investigation) using microsatellite markers. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018). 77 pp.
7. **Petrova, I. S**.: Characterisation of disomic addition lines of winter bread wheat with a *Elymus sibiricus* chromosome. (Master's thesis)

Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018). 75 pp.

8. **Popovych, Yu. A**.: Polymorphism analysis of ɣ-gliadin genes in bread wheat varieties using allele-specific PCR markers. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018).78 pp.

9. **Afinohenov, O. A.:** Markers of the *AHAS1* gene to identify the original genetic material in selective breeding of sunflower for herbicide resistance. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018). 62 pp.

10. **Kholostenko, O. H**.: Polymorphism analysis of photoperiod-sensitivity genes in bread wheat varieties in eastern Ukraine. (Master's thesis) Department of Genetics and Molecular Biology, Faculty of Biology, Odesa I. I. Mechnikov National University (2018). 64 pp.

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