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THE EMERGENCE OF A NEW SCIENTIFIC DISCIPLINE IN TURKEY: GENETICS AT ISTANBUL UNIVERSITY AFTER THE 1933 UNIVERSITY REFORM

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At the beginning of the 20th century, the science of heredity made a remarkable progress, and its impact manifested itself first in Western Europe and the United States of America and later in the other parts of the world. In the wake of this progress, genetics has become a primary discipline among the biological sciences. In Turkey, however, studies in genetics started later than in other Western countries. In the context of the establishment of the nation-state in Turkey, during the 1920s and 1930s, the government of the newly founded Turkish Republic initiated a number of structural reforms in higher education and scientific research. The University Reform of 1933 paved the way for the creation of a more organized and institutionalized structure in scientific pursuits. Within this period, numerous German scientists who had left their country due to the rise of Nazism, came to Turkey upon the official invitation of the Turkish government, and greatly contributed both to the inception of scientific research and the education of young scientists in Turkey.

Among these German scientists were also geneticists. Some of them were the earliest geneticists being active in Turkey and having contributed to the education of the novice local researchers in this discipline. The period between the implementation of the Atatürk University Reform of 1933 and the 1960s saw the rising of the first two generations of geneticists who contributed to the emergence of genetics as a new scientific discipline in Turkey. This period has come to an end at the beginning of 1960s when German geneticists retired from Turkish Universities and went back to post-WWII Germany. These three decades may also be seen more specifically as a period that witnessed the first scientific investigations on classical genetics in Turkey. After the discovery of the molecular structure of DNA in 1953, studies in molecular genetics started to draw more and more attention, and they constituted a discipline growing alongside classical genetics in 1960s. This development provides another reason for considering these years as an endpoint for the prominence of classical genetics.

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Scientific research made in this new branch of science was not the only way of its emergence as a discipline in academic institutions. Education was another important factor for its development. Accordingly, the first courses on genetics began to appear in the curricula of several university departments and publishing textbooks on genetics became a necessity in this period. It fell to these first geneticists in Turkey to offer the first courses and start writing textbooks on the subject.

Genetics at Istanbul University after 1933

It is fair to say that almost all of the first genetics researches in Turkey were undertaken within the Faculty of Science of Istanbul University.[1] After the 1933 University Reform, biological sciences were being pursued at the Zoological Institute and the Botanical Institute, both located at Zeynep Hanım Mansion, in the Beyazıt neighborhood. However, this building constructed in 1864, suffered from poor conditions and lacked the laboratory facilities. Therefore the university administration decided to launch the construction of a new building in Süleymaniye district. After the building was completed in 1935, both institutes moved in and carried on their scientific and educational activities.[2] After a short period the Botanical Institute became divided into two sections, the Institute of Pharmacobotany and Genetics, and the Institute of General Botany. Genetics studies were generally pursued in the Institute of Pharmacobotany and Genetics, and the Zoological Institute. Together with a group of assistants and students, Alfred Heilbronn, the director of the Institute of Pharmocobotany and Genetics, and Curt Kosswig, the director of the Zoological Institute, conducted numerous researches on various issues of genetics.

The most noteworthy studies in the Institute of Pharmacobotany and Genetics were conducted on the sexual characters of the plant genera *Bryonia* and *Digitalis*. As for the Zoological Institute, these studies were on tumor formation and sex determination mechanisms in *Cyprinodontiformes,* an order of ray-finned fish, and investigations on giant chromosomes of several species of *Diptera*, the order of two winged insects. In addition to these systematical

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1 Research in genetics was also made in the Higher Institute of Agriculture in Ankara. While Osman Tosun conducted research on wheat and rye hybrids, Salahattin Batu and Kadri Bilgemre wrote textbooks or published lecture notes on the livestock farming and animal breeding. These scholars provided detailed information on the uses of genetics in these fields. The German zoologist and geneticist Richard Woltereck who was in the faculty of the Higher Institute of Agriculture between 1933-37, published mainly on marine biology and Turkish fishery, but not on genetics.

2 A. Baytop, "Ord. Prof. Dr. Alfred Heilbronn'un (1885-1961) İstanbul Üniversitesi'ndeki Bilimsel Faaliyetleri," *Marmara Üniversitesi Eczacılık Dergisi,* vol. 10 (1). 1996, pp. 51-66 (p.54).

studies there were other research projects of short-term nature on various subjects. Beside doing these researches, scientists both from the Institute of Zoology and the Institute of Botany wrote a significant number of textbooks for their respective fields.

Genetics in botany

Research on plant genetics was mainly carried out at the Institute of Pharmacobotany and Genetics, which was one of the two institutes working on botany at that time. The director of this institute was the German scientist Alfred Heilbronn. The director of the other institute, the Institute of General Botany, was Leo Brauner who was one of the immigrant scientists that had come to Turkey in 1933. He and other scientists at the Institute of General Botany mainly researched in the fields of plant physiology and plant systematics.[3]

At the Institute of Pharmacobotany and Genetics, researchers used in their experiments plant genera like *Bryonia* and *Digitalis*. The secondary sexual characters and sex determination mechanisms in the crossings of some species of these genera were their main research topics. *Bryonia* was the plant genus studied by Heilbronn in his experiments. These studies were a continuation of former studies that Heilbronn had begun when he was in Germany.

The first scientist who studied the genetics of the sex determination in crossings of *Bryonia* was Carl Correns. Correns was also one of the three scientists who played a significant role in the re-discovery of Mendel's Laws in 1900, together with Hugo de Vries and Erich von Tschermark.[4] He had made crossing experiments between dioecious *Bryonia dioica* and monoecious *Bryonia alba.* According to him, there were two different kinds of systems in the pollen germ cells of *Bryonia dioica* that have an effect on sex determination in *B.dioica* x *B.alba* hybrids and these two different systems might generate different sex characters, besides different sex forms.[5] The results of his experiments in 1903 showed for the first time the Mendelian inheritance of dioecy and an example of the XY sex determination system.[6]

Heilbronn was a doctoral student of Carl Correns at the University of

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3 For a detailed survey of the activities of these institutes between 1933-1946 see S. İshakoğlu Kadıoğlu, *İstanbul Üniversitesi Fen Fakültesi Tarihçesi (1900-1946)*, İstanbul Üniversitesi Publ., No. 4106, İstanbul, 1998, pp.136-143.

4 R. Moore, "The 'Rediscovery' of Mendel's work", *Bioscene*, vol. 27(2), 2001, p.16.

5 H.J. Rheinberger, "Mendelian inheritance in Germany between 1900 and 1910. The case of Carl Correns (1864-1933)", *Comptes Rendus de l'Académie des Sciences - Séries III - Sciences de la vie*, vol. 323(12), Décembre 2000, pp.1089-1096 (p.1093).

6 S.M. Volz, S.Renner, "Hybridization, polyploidy and evolutionary transitions between monoecy and dioecy in *Bryonia,*" *American Journal of Botany,* vol. 95 (10), October 2008, pp. 297-1306 (p.1297).

Münster and his studies followed the same path as Correns'. After completing his PhD in 1913, he stayed at the University of Münster and became the Director of the Genetics Institute until his emigration to Turkey in 1933. Genetics studies he conducted in Germany were generally focused on subjects like apogamy, polyploidy, the function of the nucleus and genetic localization.[7] His first article on the genetics of *Bryonia* in Turkey was published in 1935.[8] This paper was also presented to The Turkish Society of Physical and Natural Sciences[9] and it was a survey of the theories about the different ways of sex determination, especially in plants and animals. In this article, he also mentioned Correns' numerous studies, including those on *Bryonia* and *Melandrium*, and offered a conclusion on the possibility of controlling the sex determination mechanisms and creating organisms –including humans- that have the desired sexual characteristics.

Heilbronn wrote his second article on *Bryonia* with his assistant Mehpare Başarman in 1939.[10] The authors focused especially on the secondary sexual characters of *Bryonia dioica, Bryonia alba* and their hybrids. According to their findings, some particular physiological and morphological characters were always seen in particular sexes of *B.dioica,* thus they were accepted as the secondary sexual characters. However, in the crossings with *B.alba,* they can be found in both sexes, so they can not be deemed as sexual characters anymore. Heilbronn and Başarman argued that this could be an evidence pointing that the genes of these characters were located on autosomal chromosomes and their phenotypical development might be determined by the existence of two X chromosomes in the hybrids. In another article written three years later in 1942,[11] Heilbronn and Başarman claimed to have proved the existence of male (M) "Realisators" on autosomal chromosomes and female (F) "Realisators" on the gonosoms. They admitted that there is a bisexual potential in the idiotypes of both *Bryonia* species, while there are no (M) or (F) "Realisators" in the

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7 A. Baytop, *Ibid.* p.54.

8 A. Heilbronn, "Die Geschlechtsbestimmung, ein Problem der Vererbungswissenschaft," *Compte Rendu Annuel Société Turque des Sciences Physiques et Naturelles*, vol. 3, 1935, pp.44-51.

9 Türk Fiziki ve Tabii İlimler Cemiyeti / Société Turque des Sciences Physiques et Naturelles was established in 1934 in Istanbul by a group of emigré German scientists and their Turkish colleagues including Mazhar Osman Usman, Akil Muhtar Özden, İbrahim Hakkı Akyol and Hamit Nafiz Pamir. All of these founding members were also academics at different faculties of Istanbul Universtiy. See E.K. Unat, "Türk Fiziki ve Tabii İlimler Cemiyeti Tarihçesi," *Tıp Tarihi Araştırmaları*, no.12, 2004, pp.306-313.

10 A. Heilbronn, M. Başarman, "Über sekundäre Geschlechtscharaktere bei *Bryonia dioica* und ihren Bastarden mit *Bryonia alba*", *Compte Rendu Annuel et Archive de la Société Turque des Sciences Physiques et Naturelles*, 1939, pp. 68-73.

11 A. Heilbronn, M. Başarman, "Über die F2 der Bryoniabastarde und ihre Bedeutung für das Problem der Geschlechtsrealisation", *Revue de la Faculté des Sciences de l'Université d'Istanbul, Série B*, 7 (1-2) 1942, pp.138-144.

genotype of the *B.alba.* According to their theory, the sterility as in the case of the *B.alba* x *B.dioica* hybrids was a result of the incompatibility between *B.alba*'s plasma and the "Realisators" of *B.dioica*.

Studies on Bryonia were not carried on after 1942 and during the remaining years of the decade. It was only in 1953 that Heilbronn published another study on the subject. In this study, he explained the role of plasma in detail. He used two dioic species, *B.dioica* and *Bryonia multiflora.* When he crossed the *B.dioica* female and *B.multiflora* male, he only obtained monoecious offsprings, but in reciprocal crossings, he observed male and female individuals. After these results he constructed a theory arguing that this kind of sex determination is a result of the antagonisms created by the realisators and bisexual plasma primordia of the parent species. The sex determination of *Bryonia* species occurs due to an interaction between bisexual plasmatic systems and "Realisator" genes, and this interaction, depending on the relative strengths of both systems, reproduce monoecious or male and female offsprings.[12]

It seems that Heilbronn did not carry on any research on *Bryonia* after 1953. He retired from his position at Istanbul University in 1955 but continued to work as adjunct professor in the same institute for five more years. In 1960, he went back to Germany and was appointed as honorary professor of genetics and botany at the University of Münster until his death.[13] Emine Bilge, a young scientist in the institute and one of Heilbronn's doctoral students continued to research on *Bryonia.* Her doctoral thesis was a detailed study on *Bryonia macrostylis,* which was a plant species newly discovered in Gümüşhane, in northeastern Anatolia. In her thesis, also published as an article, she described the sexual characters and fertility of the hybrids of *B.macrostylis* and various *Bryonia* species like *B.dioica, B.alba* and *B.multiflora.* [14]

In his first years in Turkey, Alfred Heilbronn had also undertaken research on mutations, but his pursuit did not last for long. In one of these studies, he used ferns, considering the mutation levels in specific environmental conditions. In his article of 1935, he emphasized the diversity of the forms created by mutations and their importance as evolutionary mechanisms. According to him, every new mutated form was genetically instable. Reproduction of this instability by any intervention will increase the number of new characteristics and thus, natural selection can find even more tools for

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12 A. Heilbronn, "Über die Rolle des Plasmas bei der Geschlechtsbestimmung der Bryonien", *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 18 (3-4), October 1953, pp.205-206.

13 A. Baytop, *Ibid*., p.54.

14 E. Bilge, "Recherches morphologiques, anatomiques et génétiques sur *Bryonia macrostylis,*" *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 20 (1-2), Avril 1955, pp.121-146.

making an elimination among them. [15]

Heilbronn also worked with the mathematician William Prager on the question of mutation. Prager was another German immigrant scientist in Turkey and a member of the Institute of Mathematics of the Faculty of Science. Together, they calculated the probabilities of mutations that could be the cause of albinism.[16] According to their results, in an equilibrium state, there is a certain mathematical ratio between the probability of mutability and interaction level of homozygous and heterozygous types. They argued that their research allowed solving three important problems. First, it established how new species emerged from an equilibrium state as mentioned above. Second, the convergence of a newly emerged species to the equilibrium state can be explained easily. Thirdly, these calculations helped to determine the critical point that causes to the evolution of a genetic trait during the phylogenetic alterations.

Digitalis was another important plant genus that was studied at the Institute of Pharmacobotany and Genetics. Nebahat Yakar, a doctoral student of Heilbronn's, worked on *Digitalis* species and they jointly published an article in 1942. [17] After this first publication about gynodioecy and intersexuality occurring after the hybridization between hermaphroditic individuals, Yakar became the only person working in this area. She generally used species like *Digitalis purpurea* and *Digialis lutea* in her experiments and generally focusing on sexual characters and some special cases like pseudogamy in these species. Her research on *Digitalis* was only one part of her studies on genetics. She also produced other works concerning the effects of certain dyes, such as methyl green and pyronin used for staining nucleic acids.[18] Her studies at the end of 1950's, indicates her interest in nucleic acids that she developed during her stay at Milislav Demerec's Laboratory in Carnegie Institute, Washington between February 1951 and March 1952.[19] In the same institute, she also contributed to Berwind P. Kaufmann's research on the shrinkage [20] of chromosomes by

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15 A. Heilbronn, "Über die Mutabilität mono- und digenomatischer Farne", *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 1(1), Oct. 1935, pp. 56-60.

16 A. Heilbronn, W. Prager, "Beiträge zum Mutationsproblem (Erste Mitteilung)", *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 1 (3), Avril 1936, pp.37-43.

17 A. Heilbronn, N. Yakar, "Gynodiöcie und Intersexualität als Folge der Bastardierung zwittriger Species", *Rev. Fac. Sci. Univ. Istanbul, Sér. B***,** 7 (4), 1942, pp.317-342.

18 N. Yakar-Olgun, "Methyl-green and pyronin specificity for deoxyribonucleic acid after acid hydrolisis", *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 22 (1-2), April 1957, pp.45-51; N. Yakar-Olgun, "Methyl-green stainability of nucleic acids," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 22 (3), Juillet 1957, pp.155-162.

19 *Carnegie Institution of Washington - Year Book No. 51 (July l, 1951— June 30, 1952)*, The Lord Baltimore Press, Baltimore, 1952, p.220.

20 *Ibid.*, p.185.

solutions of pepsin[21] and made experiments on the nature of the changes occurring in cellular proteins and nucleic acids induced by chemicals.[22] She also wrote short articles on nucleic acids and the nucleolus for *Türk Biologi Dergisi*.[23]

Sara Akdik had also produced important research worth mentioning here. She was one of the senior assistants of Alfred Heilbronn at the Institute of Pharmacobotany and Genetics. However she conducted part of her significant studies at the University of Lund between 1947 and 1948. During her stay in Sweden, she also attended the International Congress of Genetics which was held in Stockholm in 1948.[24] In Lund, she worked on ryes at the laboratory of the geneticist Arne Muntzig and made some cytological analyses on their chromosomes, especially during meiosis state. The three articles that she and Arne Muntzig co-authored were published in *Hereditas*.[25] The first one, dated 1948, was about the effects of the accessory chromosomes (or B-chromosomes) on cell sizes of several plant species. The results showed that even if this type of chromosomes had no genetic effect on the plant cells, there was a relationship between their existence in the nucleus and the volume of cell. Their second article, also published in 1948, was a statistical analysis of chromosomal abnormalities observed in the meiosis of some lines of rye (*Secale cereal*). They co-authored another article in 1949, in which they examined the chromosomes of two varieties of *Secale cereale* that were grown in Sweden and Ecuador and their F1 crossings during crossing over and meiotic division. In this study they especially emphasized the importance of Akdik's participation in the laboratory group for carrying out the cytological investigations on these experimental subjects.

Genetics in zoology

After the French zoologist André Naville, who had joined Istanbul University during the 1933 University Reform, had died of typhoid in 1937, Curt Kosswig, a geneticist and zoologist at the Berlin-Dahlem Institut für Vererbungsforschung, was invited to Turkey to become the director of the Zoological Institute. In the first years of his career, Kosswig had studied the

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21 *Ibid.*, p.185.

22 *Ibid.*, p.223.

23 N. Yakar, "Nüklein asitlerin hücrelerdeki lokalizasyonları ve rolleri," *Biologi*, 3 (4), Oct.1953, pp.182-207 ; N. Yakar, "Nükleolus," *Türk Biologi Dergisi*, 11 (4), Oct. 1961 pp.97-105.

24 "Havadisler", *Biologi,* 1 (1), July 1950, p. 44.

25 A. Müntzing, S. Akdik, "The effect on cell size of accessory chromosomes in rye," *Hereditas*, 34 (1-2), 1948, pp. 248-250; A. Müntzing, S. Akdik, "Cytological disturbances in the first inbred generations of rye," *Hereditas*, 34 (4), 1948, pp.485-509; S. Akdik, A. Müntzing, "New cases of segmental interchange and some other meiotic irregularities in rye," *Hereditas*, 35 (1), 1949, pp. 67-76.

genetic patterns of color in Dutch rabbits. After 1924, he researched on the genetics of *Cyprinodontiformes* at the Zoological Institute of the University of Münster and then at the Zoological-Biological Institute of the Technical School of Brunswick. Cosswig arrived to Istanbul in 1937. He had brought his research and laboratory material along. Thus, genetics studies on *Cyprinodontiformes* were became part of the research program of Istanbul University's Zoological Institute. While Curt Kosswig continued to research on *Cyprinodontiformes* in his first years in Istanbul, his assistants and doctoral students including Atıf Şengün, Melekper Öktay, Recai Ermin, Bedia Bozkurt and Nezihe Öztan examined the various genetic aspects of this order of freshwater fishes.

Although Kosswig started to work as the director of the Zoological Institute in 1937, it was not easy for him to conduct his research. The insufficiency of laboratory equipment –especially of aquarium equipment for keeping different fish varieties separate- and lack of competent technicians made him give up genetic research and direct his attention to systematical studies on Turkish fauna.[26] Nevertheless, he published a number of articles on the genetics of *Cyprinodontiformes*.

Kosswig's research was specifically focused on genes playing a role in tumor formation and sex determination mechanisms in *Cyprinodontiformes* fishes. The first scientist to have studied on *Cyprinodontiformes* genetics was the German geneticist, M. Willy Gerschler.[27] His work on the crossings of *Platypoecilus maculatus* and *Xiphophorus helleri* in 1914 had paved the way for the following studies.[28] In the beginning of the 1930s, studies on these genera had already started to gain wide attention in the scientific world. Kosswig was among the prominent members of the scientific community and his theories had already started to be discussed by other scientists in the USA and Europe.

The year after his arrival in Turkey, Kosswig published two articles on tumor formation in *Cyprinodontiformes* in 1938.[29] One of these articles was about the genetic basis of melanophores emerging in the offsprings of *Platypoecilus maculatus* and *Xiphophorus helleri* crossings and the other one on

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26 C. Kosswig, "1937 yılından bugüne kadar Türkiye'deki hatıralarımdan bazıları," *Proceedings of the Second Turkish-German Medical Relations Symposium*, ed. Arslan Terzioğlu, FGV Publ., 1981, p. 24.

27 C. Kosswig, "The role of fish in research on genetics and evolution," *Genetics and Mutagenesis of Fish: Dedicated to Curt Kosswig on his 70th Birthday*, Ed. Johannes Horst Schröder, Springer Science & Business Media, Dec 6, 2012, p.3.

28 M.W. Gerschler, "Über alternative Vererbung bei Kreuzung von Cyprinodontiden-Gattungen," *Zeitschrift für induktive Abstammungs und- Vererbungslehre*, 12(2), 1914, pp.73-96.

29 C. Kosswig, "Über die Erzeugung erblicher Tumoren nach Artkreuzung", *C. R. Soc. Turque Sci. Phys. Nat*., 5-6, 1938, pp.209-223; Curt Kosswig, "Über einen neuen Farbcharakter des Platypoecilus maculatus," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 3 (4), Oct. 1938, pp. 395-402.

a new color gene of *P. maculatus* called *fuligonosus,* some alleles of which can cause sterility and weaknesses in tumor-bearing fishes. By publishing these first articles, Kosswig wished to present his former research to the Turkish scientific community. Just as Heilbronn did before, he presented his first article mentioned here in a meeting of the Turkish Society of Physical and Natural Sciences in 1938.

Recai Ermin, one of Kosswig's assistants, published on the tumor formation in *Poecilidae.* At that time, Ermin was a young scientist who had studied zoology, botany, and geology in Bonn and Leipzig.[30] After receiving his doctoral degree, he continued his scientific career in Turkey. Ermin and Kosswig worked together for many years at the Instiute of Zoology and the Hydrobiological Research Institute of Istanbul University in Baltalimanı. One of Ermin's articles, which was published in 1946 revealed the role of several genes on the X chromosome responsible for tumor formation in *P.maculatus-X.helleri* crossings. In this article, Ermin investigated the tumors that are formed in the bodies of *P.maculatus-X.helleri* crossings and in a different species, *Mollinesia velifera* (the currently accepted name *Poecilia velifera*). This investigation mainly focused on the tumor morphology and histology. However, Ermin's conclusions were closely related with genetic factors. According to him, tumors can be found in many forms but the emergence of these forms are of secondary importance; tumor formation in *Cyprinodontiformes* is not a result of the excess chromatophore formation, but of a disharmony that affects the whole tissue. This disharmony is caused by genes that normally need to be in separate genotypes but come together in a single organism due to these crossings.

It seems that the studies on tumor formation in *Cyprinodontiformes* came to an end in 1950. The last publication on this issue is a Turkish translation made by Curt Kosswig from a lecture of the American fish geneticist Myron Gordon, who was famous for his research on some *Cyprinodontiformes* species found in Mexico. In July 1950, Gordon came to Turkey and gave a seminar about the tumor formation in fishes. The translation of his seminar text was then printed in *Türk Biologi Dergisi,* the official publication of the Turkish Biological Society that had been newly established at that time.[31]

Tumor formation studies were only one aspect of the genetic researches conducted on *Cyprinodontiformes*. Another long-lasting project regarded sex determination mechanisms. The first studies on this topic, were again made by

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30 Suzan Gülfirat, "geb. 1913. Recai Ermin," *Der Tagesspiegel*, 12.09.2013, http://www.tagesspiegel.de/wirtschaft/unternehmen/geb-1913/447470.html (Accessed 24.10.2015)

31 Myron Gordon, "Irsi tümörler", Trans. Curt Kosswig, *Biologi*, 1(2), Oct. 1950, pp. 66-73.

Curt Kosswig. His two articles published in 1939,[32] in which he responded to the criticisms held by Richard Goldschmidt and Joachim Hammerling against his theories about sex determination, were also somewhat polemical. In another article published in 1941, he showed some of the differences seen in sexual characters and genetic factors that cause sterility in the F_2 and F_2R offspring of *P.maculatus-X.Helleri* crossings. He argued that, contrary to formerly held views, the role of autosomal chromosomes is more important for sex determination than the role of gonosomes.[33]

Studies on sex determination mechanisms in *Cyprinodontiformes* continued throughout the 1940s and 1950s with contributions from other researchers in the Institute of Zoology. Atıf Şengün's studies on several sex-determination genes and their effects [34] and Neziha Öztan's studies on abnormalities in sterile fish[35] are some examples. Nezihe Öztan also studied the effects of certain hormones on some sexual behaviors of fishes with specific genes and chromosomes. Bedia Bozkurt was another researcher studying causes of sterility in fishes. She was one of the students who had been sent to Germany for doctoral education alike Recai Ermin and Atıf Şengün. She studied the crossings of two different species of the *Cyprinodontiformes* order: *Aphyosemion bivittatum* and *Aphyosemion splendopleuris*. Like Recai Ermin's former study on tumors, her work approached the problem from a morphological point of view, but her conclusions emphasized the role of the specific genetic mechanisms in these species.

One of Koswig's assistants, Melekper Öktay, also undertook a long-term investigation on the sex determination mechanisms of *P.maculatus* in the 1950s, publishing her results in three articles. In a study published in 1954, she focused on the effects of the *fuligonosus* gene on sex determination. In her studies, she observed that there are no male individual that are homozygous for *fuligonosus* gene; thus she investigated if these allels disappear at the pre- or post-fertilization stage. She then concluded that this phenomenon occurs just before fertilization due to a disharmony between *fuligonosus*-carrying egg and sperm

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32 C. Kosswig, "Die Geschlechtsbestimmungen Kreuzungen zwischen Xiphophorus und Platypoecilus", *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 4(1-2), Oct. 1938 - Jan. 1939, pp. 91-144; C. Kosswig, "Die Geschlechtsbestimmungsanalyse bei Zahnkarpfen," *Rev. Fac. Sci. Univ. Istanbul, Sér. B,* 4 (3-4), Avril 1939, pp.239-270.

33 C. Kosswig, "Mitteilungen zum Geschlechtsbestimmungs Problem bei Zahnkarpfen," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 6 (1-2), Juin 1941, pp. 1-32.

34 A. Şengün, "Ein Beitrag zur Geschlechtsbestimmung bei Platypoecilus maculatus und Xiphophorus helleri," *Rev. Fac. Sci. Univ. Istanbul, Sér. B,* 6 (1-2), Juin 1941, pp. 33-48.

35 N. Öztan, "Cytological investigation of the sexual differentiation in the hybrids of Anatolian Cyprinodontids," *Rev. Fac. Sci. Univ. Istanbul, Sér. B,* 19 (4), Oct. 1954, pp. 245-277.

cells.[36] Another research of her, published in two separate articles, she examined a sexually exceptional variety of *P.maculatus* that has XX-gonosomes both for male and female individuals. She made a number of crossing experiments between these individuals and domestic varieties. According to her results, the X chromosome of these individuals still had a potency of feminization. However, sex determination on this exceptional variety did not depend on a gonosomal mechanism but instead on an autosomal and polygenic one.[37]

In addition to these experimental studies on fish genetics, the group also published some theoretical works, especially on the species problem. In 1945, Curt Kosswig and Atıf Şengün wrote an article about the concept of species.[38] This work put great emphasis on several factors that play a role in the mating of individuals from one or from different species. They claimed that all spermatozoids of an individual have different success rates of insemination because of their genotypic diversities and these differences are even more explicit between two species. First, they made some comments on intra-species diversification of chromosomal configurations. They scrutinized if there was a difference with regard to reproduction between spermatozoids that carry an X chromosome or a Y chromosome and concluded that there is nothing that causes such a difference to increase or decrease the chance of insemination. However, they also added that female individuals used in experiments can also change this possibility. As for mating between two different species, Kosswig and Şengün claimed that in some instances, a chromosome can make a difference for a spermatozoid, while in some other cases, it may not have any effect at all. Moreover, in some cases a spermatozoid can carry a gene that might reduce the success of insemination or, by contrast, might be more successful when crossed with other species as was the case in *P.maculatus-X.helleri* crossings.

According to Kosswig and Şengün, in inter-species breeding, usually one sexual type can emerge and therefore it is not possible for the offspring to continue reproducing. In some cases, sterile individuals that may not have any developed gonad structure could be found. Besides, some genes – i.e. *N* and *Sp* genes, which trigger tumor formation in *P. maculatus-X. helleri* crossings – can reduce the chance of survival while still, others can slow down or even stop

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36 M. Öktay, "Über Besonderheiten der Vererbung des Gens *fuligonosus* bei Platypoecilus maculatus", *Rev. Fac. Sci. Univ. Istanbul, Sér. B,* 19 (4), Oct. 1954, pp. 303-327.

37 M. Öktay, "Über Ausnahmemännchen bei Platypoecilus maculatus und eine neue Sippe mit XX-Männchen und XX- Weibchen," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 24 (1-2), 1959, pp.75-91; M. Öktay, "Weitere Untersuchungen über eine Ausnahme (XX-) Sippe des Platypoecilus Maculatus mit polygener Geschlectsbestimmung," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 24 (3-4), 1959, pp. 225-233.

38 C. Kosswig, A. Şengün, "Über arttrennende Mechanismen," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 10 (3), July 1945, pp.164-213.

body development and sexual maturation. When the growth process is slowed down or accelerated, some extreme body shapes like dwarfism or gigantism may occur and these conditions may eventually restrain the breeding and mixing of different species.

Another study by Atıf Şengün, also considered the effects of the structure of sexual organs in speciation.[39] This study especially focused on the gonopodia of some *Cyprinodontiformes* species and some hereditary factors that have an effect on the formation of these organs. To measure this effect Şengün observed the gonopodia of *P.maculatus-X.helleri* offsprings, concluding that different gene groups are influential in the development of different organ parts. The excess number of genes that act on the development of these parts creates different results in different species. Even if more or less the same genes involved in the same developmental processes, there can be some other genes that differentiate the structure and prevent the individuals from mating with each other. This abundance of genes also makes it impossible to determine the Mendelian rules behind the process. Therefore, investigating each part of the gonopodium separately is becoming more important for our understanding of the hereditary mechanisms which otherwise show an intermediate state.

Fish genetics was not the only important research area in the Zoological Institute. Beginning from the second half of the1940s, Atıf Şengün began his studies on giant chromosomes, which are very common in the cells of some *Diptera* species. These chromosomes are generally formed by repeated DNA replication without any cell division, and in the end, they assume a large, banded form. Şengün's studies were specifically dealing with the structure and development of these chromosomes. The first studies on the giant chromosomes, carried out jointly by Kosswig and Şengün were published in 1947.[40] After the first study, Şengün started to work on his own on the subject with different approaches until the 1970's. Some of his studies were also published in international journals such as *Nature.*[41] In his work, Şengün used different genera like *Chironimus*, *Culex, Aedes, Simulium*, *Drosophila* and *Ascaris.* Throughout his career, he investigated and compared the chromosomes found in the different tissues of these organisms. He also made several experiments revealing the effects of various environmental conditions to their structure. In the 1960s, he started to use radioactive elements to label the

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39 A. Şengün, "Beitrage zur Kenntnis der erblichen Bedingtheit von Formunterschieden der Gonopodien lebendgebärender Zahnkarpfen," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 15 (2), Avril 1950, pp. 110-133.

40 C. Kosswig, A. Şengün, "Vergleichende Untersuchungen über die Riesenchromosomen der verschiedenen Gewebearten verschiedener Dipteren," *C. R. Soc. Turque Sci. Phys. Nat*., 13, 1947, pp. 93-101.

41 Atıf Şengün, "Difference in structure between the same giant chromosomes from the same larvae of *Drosophila replete*," *Nature*, 163 (25), June 1949, p. 1002.

specific parts of chromosomes and analyze the content of metabolic DNA in these structures.[42] The establishment of the Çekmece Nuclear Research and Training Center (ÇNAEM) in 1958 had a substantial impact on his scientific work especially after 1961. Among the research groups at ÇNAEM there was a radiobiology group studying histology and the medical use of radioisotopes, Atıf Şengün was a member of this group and carried out a good number of his researches at ÇNAEM, in addition to those pursued at the Zoological Institute.[43]

Genetics textbooks

As genetics flourished in Istanbul University as a scientific discipline, the first genetics textbooks also began to appear. The earliest textbooks saw the press in 1940s, and they were used in the genetics courses given at the biology departments. These textbooks were also used in biology courses at the medical faculty, the school of pharmacology and the departments of physics and chemistry of Istanbul University.[44] The first genetic courses were given as part of the curricula of the Zoological Institute and the Botanical Institute at Istanbul University. Alfred Heilbronn in the academic year 1941-1942; Alfred Heilbronn and Sara Akdik in 1944-1945 gave lectures they had titled "Genetics".[45] These lectures were not only for the students of botany but also for students in medicine, pharmacy and natural sciences.

Not only the first courses of genetics were given by Alfred Heilbronn and Sara Akdik; these two scientists also wrote the first course book dealing with some aspects of genetics: *Botanik ve Genetik'e Giriş*[46] *(Introduction to Botany and Genetics)*. First published in 1943, the book saw two more editions in 1946 and 1950. Nebahat Yakar contributed to the book with botanical illustrations and drawings. According to a review written in 1951 by Hüsnü Demiriz, who was a professor of botany at Istanbul University and one of the assistants of Alfred Heilbronn, it was the best botany and genetics textbook ever written up

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42 See Atıf Şengün "Incorporation of tritiated thymidine into the giant chromosomes of larvae of *Chironomus*." *Pathologie et Biologie*, vol.10, 1961, pp.753-755; A. Şengün, "The incorporation of H^3-Thymidine into the homologous giant chromosomes of *Simulium*-larvae," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 27 (1-2), 1962, pp.129-134; A. Şengün, A. Özalpan, D. Anıl, E. Üçer, "The occurence of metabolic deoxyribonucleic acid in giant chromosomes (I)," *Rev. Fac. Sci. Univ. Istanbul, Sér. B*, 27 (1-2), 1962, pp. 151-157; A. Şengün, "The existence of two kinds of deoxyribonucleic acid (DNA) and chromosomal secretion as demonstrated by mean of autoradiography using tritiated thymidine," *Pathologie et Biologie*, 10, 1962, pp.1701-1705.

43 Kaan Ata, *Barış İçin Atom Programı'nın Türkiye'de Çekirdek Fiziğinin Kurumsallaşmasına Etkisi*, Unpublished doctoral thesis, Istanbul University, p.118.

44 Beside the mentioned textbooks there were also pamphlets on eugenics and human heredity, compiled by the professors of the Istanbul University's Faculty of Medicine, such as Sadi Irmak, Fahrettin Kerim Gökay, and Mazhar Osman Usman.

45 S. İshakoğlu-Kadıoğlu, *ibid*., pp.141-142.

46 A. Heilbronn, S. Akdik, *Botanik ve Genetiğe Giriş*, Adnan Kitabevi, İstanbul, 1946.

to those years.[47] The book consisted of three sections dealing with morphology, genetics and physiology. Heilbronn and Akdik, in the foreword of the book's second edition emphasized that, in contrast to similar books published in other European countries, they gave more room to genetics. Bearing in mind that the book will be used by those studying various disciplines – i.e. by students in medical or agricultural sciences – the authors also gave examples from human and animal genetics in order to show that the laws of genetics apply to all living beings. Along the eighty pages reserved for genetics, they treated almost all main subjects of this discipline, such as the basic concepts of inheritance, Mendel's experiments, chromosomal theory of heredity, Thomas Hunt Morgan's studies, sex-linked characters, twin research and mutation. Fifteen years after this first book, Sara Akdik wrote in 1961 another botany textbook titled *Genel Botanik (General Botany)*.[48] The content and the arrangement of this book were very similar to *Botanik ve Genetik'e Giriş* that Akdik had jointly published with Heilbronn. As a matter of fact Akdik acknowledged Heilbronn's permission to use their earlier joint volume as a template for her own course book.

The first book published in Turkey dealing exclusively with genetics was the Turkish ~~a~~ translation of *Principia Genetica* co-authored by Alfred Heilbronn and Kurt Kosswig.[49] The book had been previously published in Germany as an article.[50] Sara Akdik translated it to Turkish. As Heilbronn and Kosswig pointed out in the Turkish edition, the book has been translated after the first German edition has been reviewed and supplemented. After that, another new German edition of the book also came in 1961.[51] The book consists of 231 numbered paragraphs arranged according to the principle of progression, that is from simpler to more complex theoretical knowledge on genetics. So to say, it functioned both as a course book and, with its short and simple explanations, as a reference book for any individual interested in genetics. Another significant feature of the book was that it contained a table of 47 terms and their equivalents in Turkish. Prepared by Sara Akdik, the table was a first attempt at rendering genetics terms into Turkish. Heilbronn and Kosswig acknowledged Akdik's hard work and pointed out that she was the first to coin these Turkish

47 H. Demiriz, "Heilbronn, A. ve Sara Akdik: Botanik ve Genetiğe Giriş, 3. Baskı, İstanbul 1951, Adnan Bookstore 7+379 s.", *Biologi*, 1 (4), April 1951, p.209.

48 S. Akdik, *Genel Botanik,* Şirketi Mürettibiye Matbaası, İstanbul, 1961.

49 A. Heilbronn, C. Kosswig, *Principia Genetica: Kalıtım Biliminin Temel Anlamları ve Temel Vakıaları*, Transl. Sara Akdik, Kenan Matbaası, İstanbul, 1947, 31 pp.

50 A. Heilbronn, C. Kosswig, "Principia Genetica: Grundbegriffe und Grundtatsachen der Vererbungswissenschaft," *The Journal of Unified Science (Erkenntnis),* 8 (1), April 1939, pp.229-252.

51 A. Heilbronn, C. Kosswig, *Principia Genetica: Grunderkenntnisse und Grundbegriffe der Vererbungswissenschaft*, Hamburg, Parey, 1966.

terms and they were used for the first time in the Turkish translation of *Principia Genetica,* a book which bridges the boundaries of biology and philosophy.

Concluding remarks

The publications that have been examined in this paper, revealed that almost all the works on genetics in Turkey made during the first three decades that followed the 1933 University Reform, were produced by scientists at the Faculty of Science of Istanbul University. Scientists who fled Germany due to Nazi oppression and took refuge in Turkey played a very significant role both in the import of knowledge and in starting researches in genetics. Alfred Heilbronn, who had arrived in Turkey in 1933, initiated research in genetics in 1935 at the Institute of Pharmacobotany and Genetics. Subsequently genetics researches were undertaken at the Zoological Institute from 1937 on under the directorship of Curt Kosswig. Thus, the arrival of both scientists should be considered as a milestone for the beginning of genetics research in Turkey. As a matter of fact almost all studies on genetics at that time can be traced back to the scientific work that Kosswig and Heilbronn had undertaken before coming to Istanbul University.

As the academic staff of the above mentioned institutes was also charged with the teaching of botany and zoology as well as the penning of Turkish textbooks for students, genetics first became included in the books on botany. *Botanik ve Genetiğe Giriş* and *Genel Botanik* by Alfred Heilbronn and Sara Akdik included considerable information on genetics although both of them approached the subject within a broader context. The Turkish translation of *Principia Genetica* by Alfred Heilbronn and Curt Kosswig was an important step in the publication of books dealing exclusively with genetics. In the 1960s, this trend followed different path and several new books were published, especially by the staff of agricultural and veterinary faculties, and the newly founded faculties of science.[52] In contrast with the previous books, these new

[52] Among these authors were Orhan Düzgüneş and Yusuf Vardar from Ege University and Emin Arıtürk from Ankara University. Upon returning from his post-doctoral studies in the USA, Düzgüneş started to work at the Faculty of Agriculture of Ankara University and after 1955 at Ege University as a staff member at the Chair of Agricultural Genetics and Statistics. At that time, he was also giving lectures on genetics, biometry, and animal husbandry. In 1960, he wrote a book entitled *Genetik (Genetics)*, which he described as a collection of his lecture notes that he had started to pen in 1954. Düzgüneş pointed out that his primary aim in writing this book was to fill a gap in the field of genetics in Turkish academic literature and to promote new research in genetics by drawing interest to this field. See Orhan Düzgüneş, *Genetik*, Ege University Faculty of Agriculture Press, Izmir, 1963; Another scientist at Ege University who wrote a genetics textbook was Yusuf Vardar. Vardar was a doctoral student of Leo Brauner at Istanbul University and had moved to Ege University in 1959. His book *Genetik'e Başlarken (Getting started with Genetics)* was first published in 1961 and reprinted many times until 2011. See Y. Vardar, *Genetik'e Başlarken*, Ege University Press, İzmir, 1961; Emin Arıtürk from Ankara University also wrote a book in 1963, entitled *Genetiğin Başlıca İlkeleri (The Main Principles of Genetics).* The book was

textbooks were completely dedicated to genetics. The increasing number of this kind of books produced during 1960s, was also a sign of the increasing number of genetics courses offered at the faculties of science, medicine and agriculture of the newly established universities, namely Ankara University and Ege University.

Geneticists at Istanbul University also played an important role in making scientific activities in Turkey known internationally. The multi-lingual (German, French, English) scientific journal of the Faculty of Science (*İstanbul Üniversitesi Fen Fakültesi Mecmuası / Revue de la Faculté de Sciences de l'Université d'Istanbul)* played a significant role for the recognition of genetics research carried out at Istanbul University. On the other hand, the presence of scientists alike Alfred Heilbronn and Curt Kosswig in Turkey and their publications in this journal helped greatly the American and European researchers to follow up the genetic researches made in Turkey. The study of fish genetics was already given particular importance in many universities in the world, and as an authority in this field, Curt Kosswig held a major role on the recognition of Turkish researches by publishing his articles in this journal. His polemical discussions with other scientists and the criticism he received from eminent geneticists like Richard Goldschmidt and Joachim Hammerling, as mentioned above, put Istanbul University at the center of attention of a number of biologists in the world.

The professional network of these two scientists in Europe, and especially in Germany also provided a good opportunity for their Turkish assistants to make their researches known outside Turkey. For instance, in one of his article about the historical development of zoology in Istanbul University, Atıf Şengün expressed his gratitude to Curt Kosswig, for sending his works to a number of the German scientists and thus awakening their interest in his studies, of which otherwise no one could ever been informed. [53]

Moreover, Atıf Şengün and Sara Akdik, assistants to Alfred Heilbronn and Curt Kosswig, contributed to the recognition of genetics at Istanbul University through their publications in Turkey and other countries. Şengün's articles, which were published in several European and American journals, and

published in 1968 under a different title, *Genetik (Genetics).* Arıtürk was a member of the Veterinary Faculty, and his main interest laid in animal breeding. As Orhan Düzgüneş had done before, Arıtürk emphasized that genetics is a relatively new field but the results of researches made so far are of striking significance. He stressed the importance of genetics studies in animal breeding because all characters of animals and other living beings were determined jointly by genetics and environmental conditions. Therefore it was not possible to achieve success without using its findings. See E. Arıtürk, *Genetiğin Başlıca Prensipleri*, Ankara University Veterinary Faculty Press, 1963.

53 Atıf Şengün, "İstanbul Üniversitesi'nde 1933 Reformundan sonra zoolojinin gelişmesi", *İstanbul Üniversitesi Fen Fakültesinde Çeşitli Fen Bilimi Dallarının Cumhuriyet Dönemindeki Gelişmesi ve Milletlerarası Bilime Katkısı,* Ed. A. Y. Özemre, İstanbul Univ. Publ. No. 3042, p. 93.

Akdik's studies co-authored with Arne Müntzig in Sweden, had been important for enhancing their reputation in the western world. In addition to these two important names, Nebahat Yakar also prepared significant studies in the United States between 1951-1952, during her stay an the Carnegie Institute of Washington. Her work in Milislav Demerec's laboratory provided her a great chance to see the significant scientific progress in various research topics in genetics. During her time at the Carnegie, scientists such as Alfred Hershey, Martha Chase and Barbara McClintock were conducting their famous experiments in the same department. Therefore, she had the opportunity to become acquainted with the work of these highly reputable scientists. After returning to Istanbul University, she published several articles on nucleic acids and also on her researches in molecular biology and genetics in *Türk Biologi Dergisi*. In this way, she made an important contribution to the recognition of genetics, this emerging science in Turkey.

These first geneticists at Istanbul University contributed greatly to the establishment of this new research field as a scientific discipline in Turkey. Their effort created awareness on genetics within the Turkish universities and paved the way for further studies. However much of their studies did not continue at the same pace and ceased after 1960s when Kosswig and Heilbronn left the Institute and returned to Germany. Local geneticists who had studied under their supervision or collaborated with them tended to research in other fields such as physiology or histology. This first experience, however, greatly effected the establishment of more Turkish institutions researching in genetics. Genetics research continued in different research fields both in basic and applied sciences such as medicine, agriculture or veterinary science.

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Türkiye'de yeni bir bilim dalının doğuşu: 1933 Üniversite Reformu'ndan sonra İstanbul Üniversitesi'nde genetik araştırmaları

Üniversite Reformu'nun ilan edildiği 1933 yılından 1960'lı yıllara uzanan dönem, Türkiye'de ilk genetik araştırmalarının yapılmaya başlandığı ve genetiğin bir bilim dalı olarak kurulduğu ve kurumsallaştığı yıllardır. Bu ilk genetik araştırmalarının hemen hepsi İstanbul Üniversitesi Fen Fakültesi'nde yapılmıştır. Nazilerin iktidara gelmesiyle birlikte Türkiye'ye gelen bazı Alman

genetikçiler, İstanbul Üniversitesi'nde genetik araştırmalarının başlatılmasına ve genetik alanında ilk araştırmacıların yetiştirilmesine önemli katkıda bulunmuşlardır. İlk genetik çalışmalar 1935 yılında, Farmakobotanik ve Genetik Enstitüsü'nde Alfred Heilbronn tarafından başlatılmıştır. Daha sonra, 1937 yılında Curt Kosswig'in Zooloji Enstitüsü'nün başına geçmesiyle zooloji alanında da genetikle ilgili çeşitli araştırmalar yapılmaya başlanmıştır. Bu iki bilim insanı, asistan ve öğrencileriyle birlikte cinsiyet belirleme mekanizmaları, ikincil cinsiyet karakterleri ve tümör oluşumunun genetik mekanizmaları gibi birçok farklı konuda araştırma yapmış, genetik üzerine dersler vermiş ve bu konuda Türkiye'de ilk ders kitaplarının yazılmasına ve basılmasına öncülük etmişlerdir.

Anahtar kelimeler: Türkiye'de genetik, 1933 Üniversite Reformu, Alfred Heilbronn, Curt Kosswig, Atıf Şengün, Sara Akdik, Melekper Öktay, Nebahat Yakar, Recai Ermin, Nezihe Öztan.

The Emergence of a new scientific discipline in Turkey: Genetics at Istanbul University after the 1933 University Reform

The years between 1933 when Istanbul University was fundamentally reformed and the 1960s, constituted the period when the first geneticists in Turkey carried out their research and contributed to the formation and institutionalization of a new scientific discipline. Almost all of this first genetics research in Turkey was conducted at the Faculty of Science, Istanbul University. After the University Reform, German geneticists who came to Turkey due to Nazi oppression, made important contributions to scientific research as well as to the training of the first researchers in genetics. The first researches were launched by Alfred Heilbronn in 1935 at the Institute of Pharmacobotany and Genetics. Subsequently, research at the Zoological Institute begun in 1937 when Curt Kosswig came to Turkey as the director of the institute. These scientists, together with their local assistants and students, undertook numerous studies on several questions of genetics such as sex determination mechanisms, secondary sexual characters and genetic mechanisms of tumor formation. Alongside their scientific studies, they also gave lectures on genetics and they wrote some of the first genetics textbooks in Turkey.

Key words: Genetics in Turkey, 1933 University Reform, Alfred Heilbronn, Curt Kosswig, Atıf Şengün, Sara Akdik, Melekper Öktay, Nebahat Yakar, Recai Ermin, Nezihe Öztan.

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