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RADIOISOTOPE LABORATORY OF TIMIRYAZEV ACADEMY

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RADIOISOTOPE LABORATORY OF TIMIRYAZEV ACADEMY

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Timiryazev Agricultural Academy was the first educational and scientific institution in our country to apply isotopes in agriculture and animal husbandry (1945). Three prominent Soviet scientists, D. D. Ivanenko (chair of physics) K. R. Viktorov (chair of animal physiology), V. M. Klechkovskiy (chair of agrochemistry), were initiators of this work. Under their leadership a group of young co-workers, Ye. I. Luferova, V. B. Bagayev, N. V. Kashirkina, G. N. Zherdetskaya, T. P. Yevdokomova and V. V. Rachinskiy, conducted the first investigations with labeled atoms.

The Biophysics Laboratory of the Academy was established in 1947. The experiments use of isotopes have been continued at the chairs of physics, animal physiology and agrochemistry. Under the direction of I. I. Gunar, the experiments with isotopes were started in the newly established Laboratory of Artificial Climate at the chair of plant physiology in 1950. This laboratory assisted in the introduction of isotopes at the chairs of plant culture, genetics and selection, and forestry.

Development of techniques in the experimental work with isotopes, perfection of the industrial hygiene requirements for safety measures in work with radioactive substances, the training of experts capable of applying atomic techniques in agriculture -- all these prerequisites led to the decision for a well equipped laboratory to deal with radioactive substances. Such a laboratory was organized by the end of 1957 at the chair of inorganic and analytical chemistry and was named the Radioisotope Laboratory of the Academy. The establishment of this laboratory was a large-scale undertaking in the introduction of atomic techniques in educational and scientific work of the Academy. The wide experience and knowledge of the academy scientists and of other educational and scientific institutions were used in the organization of the laboratory and in its educational and scientific work.

The direct organizational work in the establishment of the laboratory was carried out by the Biophysics Laboratory (S. P. Tselishchev) and by the special chemical laboratory at the chair of inorganic and analytical chemistry (F. P. Platonov) of the Academy.

Layout and Equipment of The Laboratory

The general safety principles in work with radioactive materials were applied in laboratory layout and equipment. The laboratory occupies rooms of the auxiliary offices of the Academy located in right wing of the ground floor in the sixth educational building (chemistry). It was not an easy task to lay out these rooms according to the safety principles required in work with radioactive materials. The establishment of a laboratory of such a kind can be reasonably compared with scientific research. The layout of the laboratory is shown in Fig. 2. Complicated construction is connected with the establishment of this laboratory. It was necessary to conceal all plumbing and electric wiring, to round the junctures of ceilings and walls as well as corners, and to paint them with oil paint.

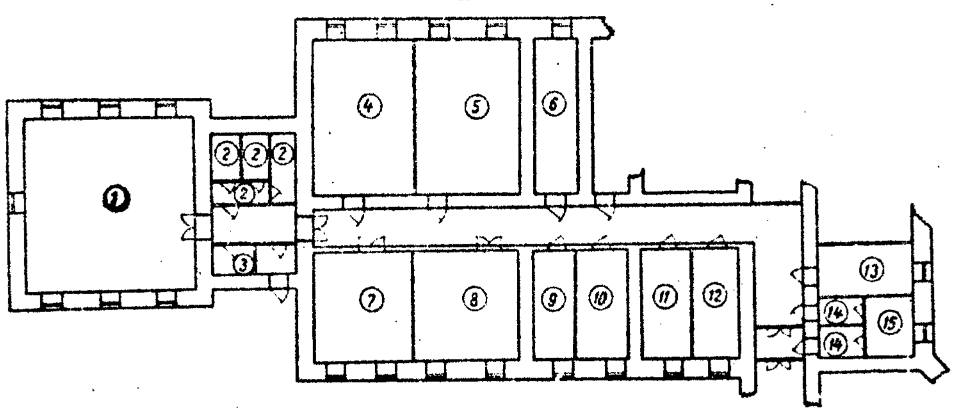

Fig. 1. The plan of the Radioisotope Laboratory: 1 - radiometric and lecture room; 2 - photographic room; 3 - distillation room; 4 - radiochemical room; 5 - forced-growth room; 6 - repair shop; 7 and 8 - radiochemical rooms; 9 - isotope storage; 10 and 11 - weighing rooms; 12 - teachers' room; 13 - washroom; 14 - dressing room; 15 - shower room.

Isotope storage. The isotope storage room (Fig. 1, 9) is equipped with deep (two meters) vertical drains in the floor, in which the lead containers with gamma-active substances are kept (Fig. 2). Each drain is covered with a lead cover. The heavy drain covers and lead containers are lifted and lowered with an electric hoist. There are also wall safes for storage of the beta-active material. The exhaust hood installed in the isotope storage room is equipped with devices for opening and unloading containers and ampules, containing radioactive materials, devices for dilution and distribution of these materials (an electrical device for opening of the ampules, a wall made of lead bricks, lead glass; remote control instrument, tongs and manipulators).

The isotope storage room is also equipped with dosimetric instruments controlling the radioactivety level in it, and which check contamination of equipment and personnel.

The Forced Growth Room. The forced growth room (Fig. 1, 5) is designed for the forced growth of plants with the use of radioactive substanced. The daylight fluorescent lamps, secured on frames, are used as a source of light. The frames are movable, and the lamps can be adjusted to a desired level. The general view of the equipment of the forced growth room is shown in Fig. 3.

Fig. 2. Lowering of the lead container with gamma radioactive material into the vertical drain in the radioisotipe storage room.

Fig. 3. The general view of equipment of the forced-growth room.

Radiochemical Rooms. There are three radiochemical rooms (Figs. 1, 4, 7, and 8). All preparatory and analytical work with radioactive materials is done in these rooms. They are equipped with special workbenches with hot and cold water, gas, compressed air and vacuum outlets. Each place at the radiochemical workbench has a set of instruments and safety devices needed for work with radioactive materials (a large enameled tray; a safety shield made of lead glass; a set of plexiglass safety boxes for flasks, compounds and radioactive materials; a set of remote control instruments; etc.). The general view of a workbench in the radiochemical rooms is shown in Fig. 4.

The exhaust hoods of special construction are installed in the radiochemical rooms (Fig. 5). The movable front windows of these hoods are equipped with built-in gloves with long sleeves. This allows work to be conducted in hoods with closed windows. Each exhaust hood has hot and cold water, gas, compressed air and vacuum lines. To trap radioactive dust, the hoods are also equipped with filters.

There are also special removable plexiglass boxes in the radiochemical rooms for grinding radioactive materials. Fig. 6 shows the use of such plexiglass safety boxes.

Each plexiglass box is connected through a filter to a vacuum line for protection of personnel and rooms from

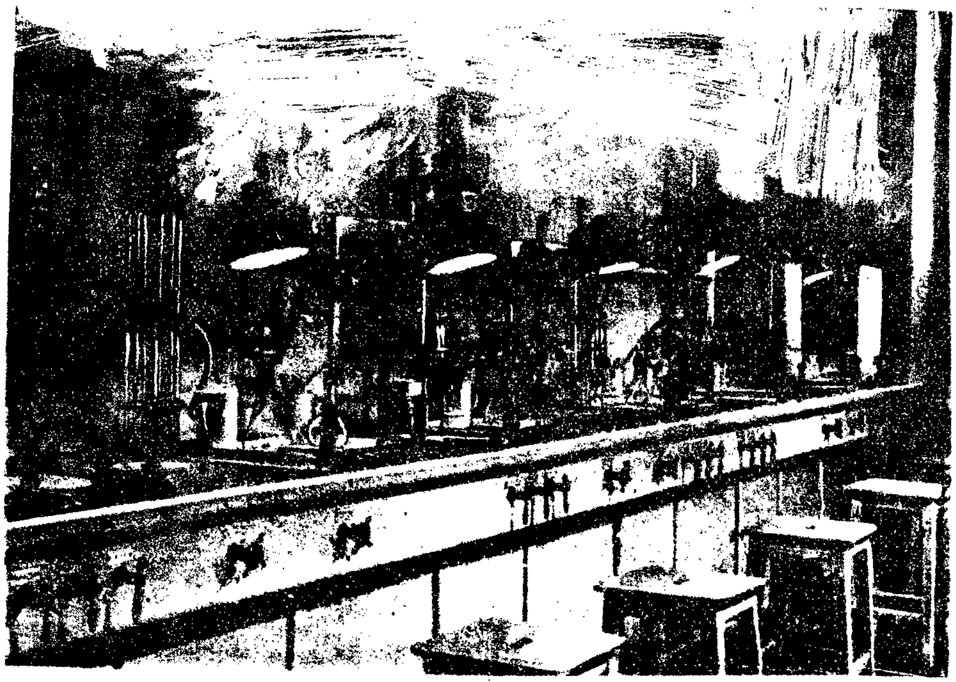

Fig. 4. The general view of the work benches and equipment in radiochemical rooms.

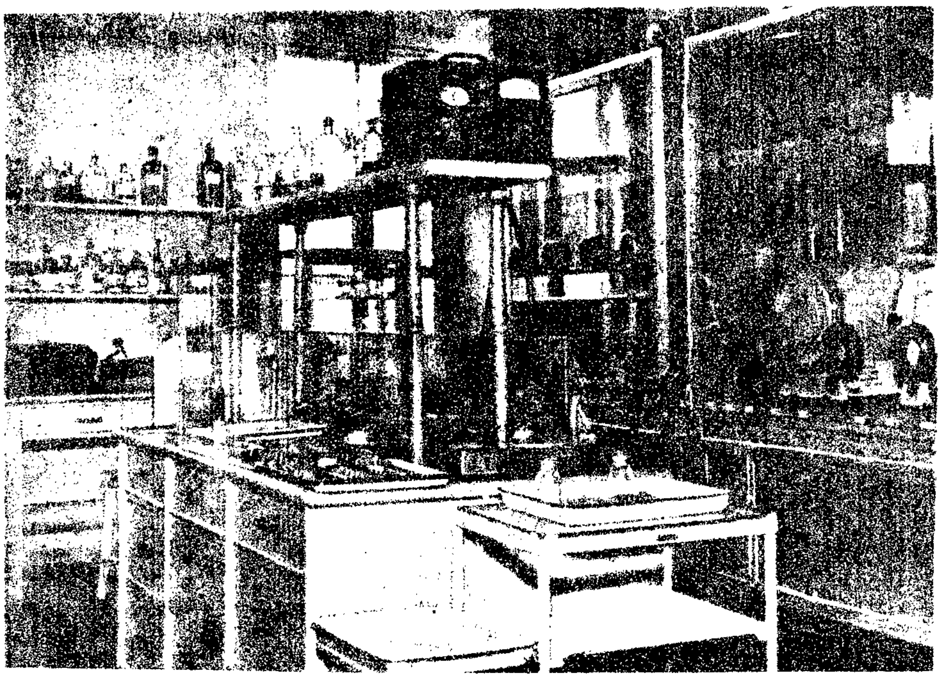

Fig. 5. The general view of the equipment of the radio-chemical room: right - the exhaust hoods; in the middle - a table with various equipment on it (plexiglass boxes, lead shield, remote control equipment, dosimeter and other).

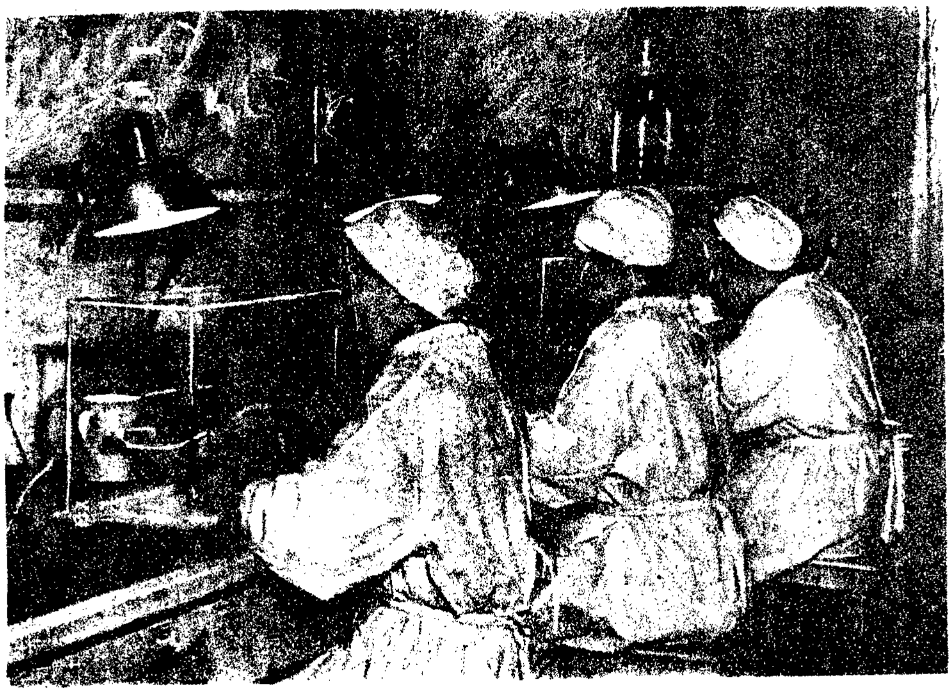

Fig. 6. Experiments with the use of plexiglass safety boxes.

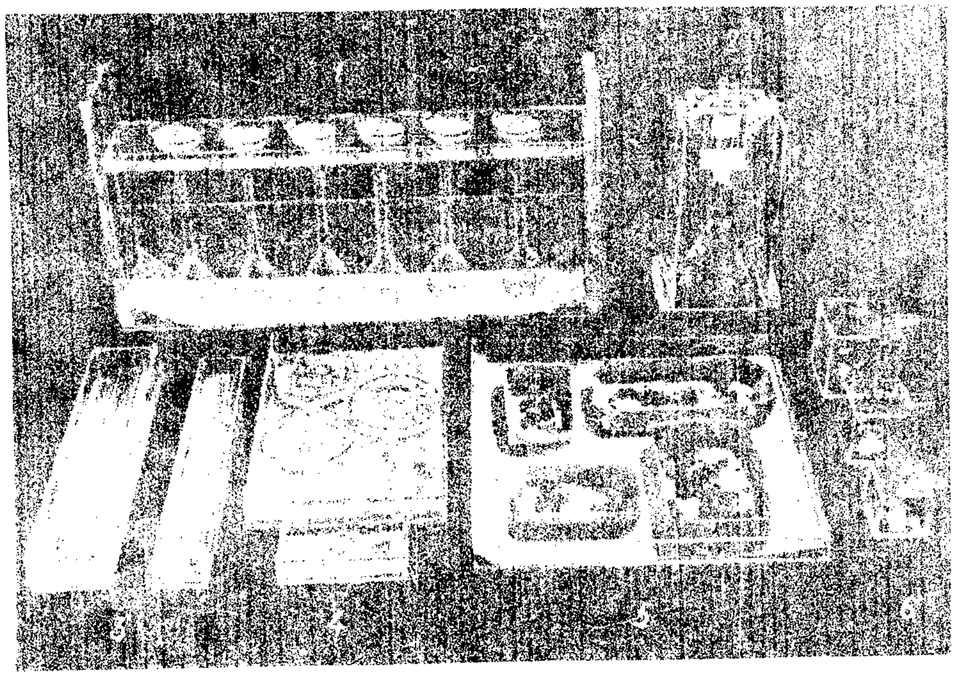

Fig. 7. The plexiglass safety equipment designed by S. P. Tselishchev: 1 - filtering equipment rack; 2 - assembly for preparation of radioactive precipitates; 3 - box for pipettes; 4 - boxes for radioactive materials; 5 - boxes for plant speciments; 6 - boxes for flasks containing radioactive solutions.

radioactive dust. Because of this requirement, the pressure in the boxes is lower than that outside. For work with radioactive materials, different safety devices of plexiglass are used, such as filtering equipment racks, boxes for pipettes, chemicals, plant samples, flasks (Fig.7).

Special airtight plexiglass chambers are used in experiments with plants involving assimilation of carbon dioxide, labeled with C^{14}. One such chamber is shown in Fig.8.

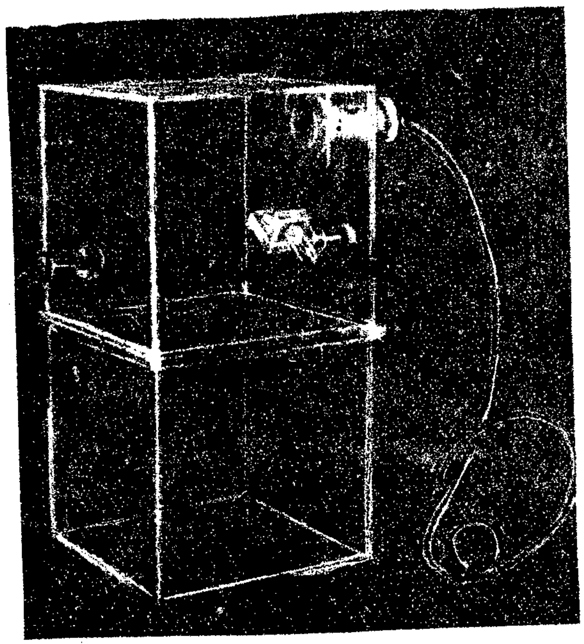

Fig. 8. Airtight plexiglass assimilation chamber designed by V. V. Rachinskiy. Such chambers are used in experiments with plants involving assimilation of carbon dioxide labeled with C^{14}. The assimilation and discharge by plants of the labeled carbon dioxide is checked with end-window counter.

The work with gamma-active materials is conducted with remote control instruments behind the lead shield or the wall made of lead bricks.

The wash basins in the radiochemical rooms are equipped with foot pedals for hot and cold water and with splash protectors.

Radiometric Room (Fig.1,1). The radiometric room is a large room where radiometric measurements are carried out. All radiometric and dosimetric apparatus needed for educational and scientific purposes is located here.

Fig. 9. Experiment with gamma active material.
The work is carried out with the remote-control equipment behind a safety lead shield.

The newest radiometric and dosimetric instruments are being added to the laboratory all the time. The radiometric room is also used for classes and seminars. The general view of this room is shown in Fig. 10.

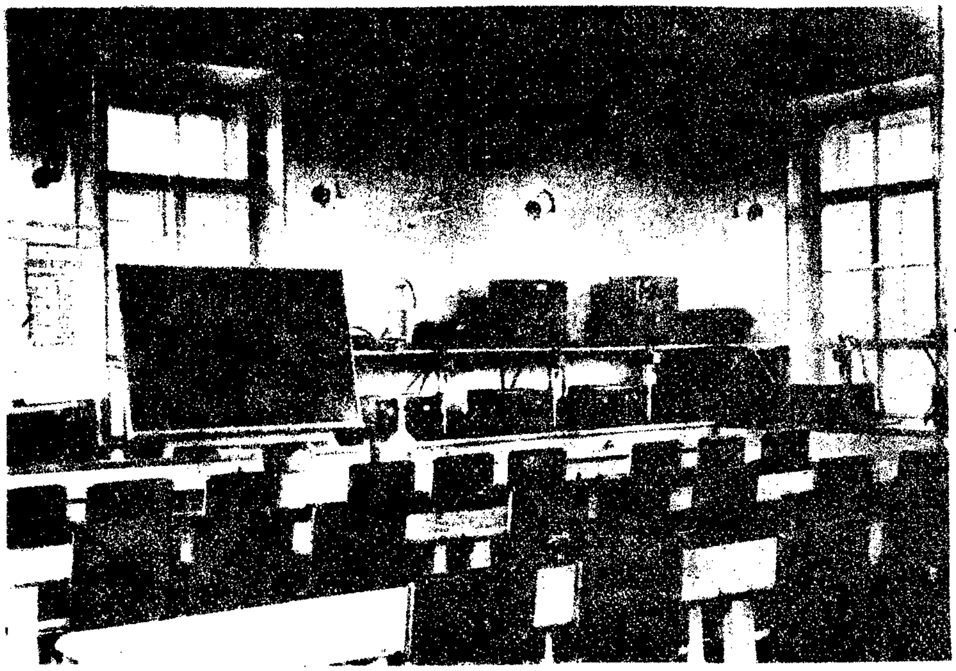

Fig. 10. The general view of the radiometric room.

Each student in the laboratory uses a standard counter unit of type B-2. Such a unit in operation is shown in Fig. 11. As a rule, the laboratory uses the end-window counter BFL-25 (designed by the Biophysics Laboratory of the Academy). These counters are well known in our country for their high efficiency and a good stable performance.

The end-window counters are enclosed in vertical lead boxes, as is shown in Fig. 11. The laboratory also uses gas-flow counters of type SOT-30 BFL (Fig. 12, left) and type SA-4P (Fig. 12, right). These counters are designed by the Biophysics Laboratory of the Academy. The counters of type SOT-30 BFL are highly effective for measurements of radioactivity, up to 10^{-10} curie, they emit soft β and α radiation. The counters of type SA-4P BFL are classed with the so-called 4P counters and are used for measurements of absolute beta activity of the radioactive isotopes in the energy range of beta particles, from 10 Kev and higher. All counters designed by the Biophysics Laboratory are madê by the experimental shops of the Academy.

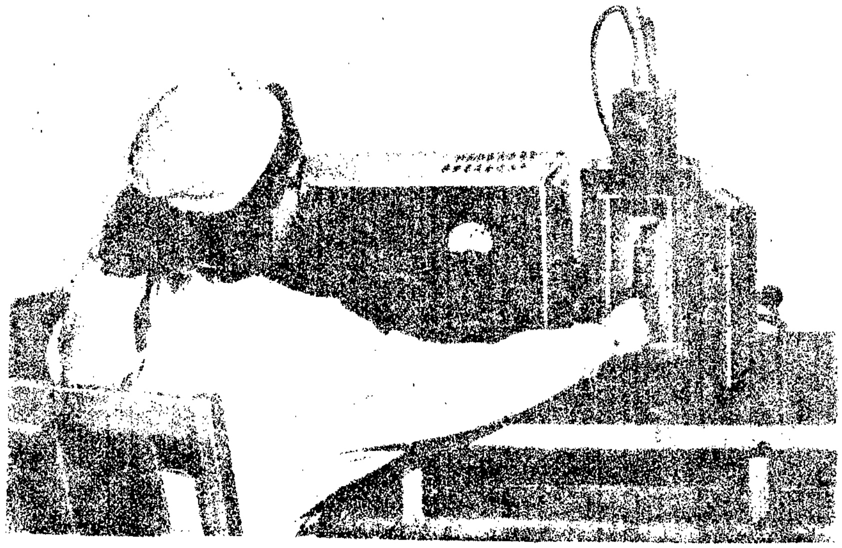

Fig. 11. Work with a B-2 counter with a lead box. The lead box contains the end-window counter BFL-25 (designed by the Biophysics Laboratory of TSKhA).

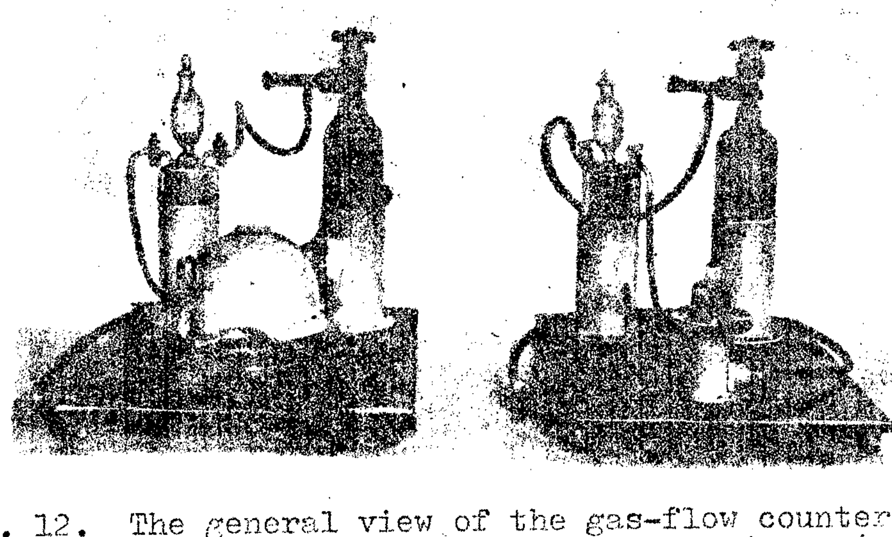

Fig. 12. The general view of the gas-flow counters of type SOT-30 BFL (left) and SA-4P BFL (right).

Decontamination quarters consist of a dressing room (Fig. 1, 14), a shower room, where personnel can be decontaminated in the case of accidents (Fig. 1, 15), and a washroom (Fig. 1, 13). The dressing room is used for putting on and taking off special uniforms. Decontamination of vessels and equipment is done in a washroom, equipped with a deep tub, exhaust hood, drying chamber, device for washing of pipettes (they are washed with hot water inside and outside.

All other laboratory rooms such as the repair shop, photographic, balance and distillation rooms, teacher(s room, are of an auxiliary nature and are not mentioned here.

The Main Aims of The Laboratory

The main aims of the Laboratory are defined by "The Statute of the Radioactive Laboratory of TSKhA". According to this "Statute", the Laboratory is an educational and scientific institution of the Academy in which the training of specialists in the field of atomic technology is carried out and scientific research is conducted with the application of radioactive materials. Teachers, scientists, postgraduate students and students of the Academy are trained in the Laboratory. Scientists and teachers of other agricultural institutions as well as foreign specialists (on a contract basis) are also instructed in the Laboratory.

The Laboratory conducts systematic work: develops the educational plans and curriculum on "Atomic Technique in Agriculture", develops teaching aids for the course of study as well as application of isotopes and radiations. The Laboratory personnel is occupied not only with educational work but also with research, with different theoretical problems, and with application of isotopes and radiation in physics, chemistry, biology and agriculture.

The Laboratory assists other chairs and Laboratories of the Academy in the development of the research work on the use of isotopes.

Organizational Setup of The Laboratory

The Laboratory is managed by a head and a scientific director. Its personnel belongs to different specialized groups (physicotechnical, chemical, bio-agricultural). The peculiar nature of the work on the application of atomic techniques in agriculture requires close collaboration of different specialists: physicists, engineers, chemists, biologists and agronomists. Each of them, being a qualified specialist in his own field, should be acquainted to some extent with other general theoretical and specialized fields. Such erudition is absolutely necessary in dealing with atomic techniques. In order to collaborate successfully with biologists and agronomists and to assist them in mastering atomic techniques and their application, the physicists, engineers and chemists should also master the methods of biological and agronomical investigationa. On the other hand in order to apply deliberately the atomic technique methods and to progress in their particular sciences, the biologists and agronomists should be well acquainted with the physico-chemical and technical basis of the atomic technique methods.

The staff of the Laboratory consists of teachers, laboratory workers, technicians, assistants and laboratory cleaning attendants.

The Laboratory, as the interacademy institution, has a main storage room, in which it handles the receipt, distribution and registration of isotopes. The Laboratory is also responsible for the safety measures of the Academy, namely, the dosimetric control of the workbenches in the radioisotope laboratory as well as in other departments of the Academy where experiments with the radioactive materials are conducted. The safety technique office includes a chief instructor, a chief controller and a person responsible for the storage of radioactive materials.

In order to coordinate the educational and research work of the Academy in the application of atomic techniques a scientific and technical advisory board is established at the Laboratory.

Educational Work of The Laboratory

The Laboratory offers courses for agricultural specialists, postgraduate students, teachers, and scientists of the Academy, as well as lectures for students, consultations and excursions. The main educational work of the Laboratory is a two-months course on the application of atomic techniques in agriculture.

The curriculum of these courses is planned for 384 academic hours, and it is shown in the Table on page 248.

Curriculum of Two-months Course of the Radioisotope Laboratory on the Application of Atomic Techniques in Agriculture (hours)

Subjects	Lectures	Practical training	Total
Atomic physics.	24	--	24
Radiometry.	--	112	112
Radioautography	--	8	8
Radiochemistry and radiochromatography	20	40	60
Radiobiology.	8	--	8
Dosimetry	4	16	20
Safety technique.	4	16	20
Radiation hygiene	4	--	4
Total	64	192	256
Specialized part of the course* . . .	32	96	128
Total	96	288	384

The course of studies consists of a general part, which consumes two thirds of the time, and a specialized part. The general part has the following sections: atomic physics, radiometry, radioautography, radiochemistry and radiochromatography, radiobiology, dosimetry, safety techniques, and radiation hygiene.

In the section on "The Basic Principles of Atomic Physics" the following basic topics are studied: the structure of atoms, the structure and properties of atomic nuclei, natural radioactivity, nuclear reactions, artificial radioactivity, nuclear radiations and their properties, cosmic rays, elemental particles, atomic energy, and stable isotopes.

In the section on "Radiometry" the following topics are studies: characteristics of various methods of detection and measurement of nuclear radiation, gas-discharge counters,

* The curriculum of the specialized part of the course depends on the narrow specialization

measurements of radioactivity, and absolute measurements of the radioactivity.

The section on "The Fundamentals of Radioautography" deals with physical principles of the radioautography, preparation of biological specimens for radioautographic analysis, and application of radioautography in experiments with plants.

The section on "The Fundametnals of Radiochemistry" offers at the beginning a short survey of the history of radiochemistry and the basic theoretical principles of chemical bonds and the structure of chemical compounds. This survey is followed by lectures on physicochemical principles of isotopes, radiochemistry of nuclear reactions, preparation of radioactive isotopes, general principles of the preparation of labeled compounds, labeled-atom methods, and the basic principles of radiation chemistry.

In the section on "The Fundamentals of Chromatography and Radiochromatography," a description of different types of chromatography and of the preparation and analysis of chromatograms is given together with theoretical principles of chromatorgraphy. The application of chromatography and radiochromatography in physiology and biochemistry, agrochemistry and soil science is also surveyed in this section.

In the section on "The Fundamentals of Radiobiology," the physical and chemical processes in living organisms under the effect of ionizing radiation, the theoretical explanation of the effect of ionizing radiation on living organisms, and the fundamentals of radiation genetics are studied.

In the section "The Dosimetry of the Ionizing Radiation," the following subjects are studied: the dosimetry of ionizing radiation, the fundamentals of dosimetry, the physical basis of dosimetry, the characteristics of the permissible doses, and the theory and calculation of protective measures against nuclear radiation.

The section "Radiation Hygiene" is devoted to hygienic and medical problems encountered during the work with the radioactive materials.

The section "Protective Techniques" deals with general safety principles, the organization of work with radioactive materials, layout and equipment of radioactive laboratories.

Lectures on atomic physics, radioautography, radiochemistry and radiochromatography are given during the first three weeks. At the same time, the practical training on radiometry is carried out. The practical training on radiometry includes 15 laboratory hours during which students master the radiometric measurement techniques. The fourth week is devoted to lectures on radiobiology, dosimetry, radiation hygiene and safety techniques. The practical training on dosimetry and safety techniques are carried out concurrently. The practical training is devoted to mastering the use of dosimetric apparatus and of safety methods against nuclear radiation. During the practical training on safety techniques, the students become familiar with the radioisotope laboratory equipment, its use and decontamination in the case it becomes contaminated during the work, This part of the course ends with study of the existing USSR safety regulations in regard to radioactive material, local regulations, and a final examination on the safety techniques. After this part, the students start practical training on radiochemistry, which also includes some training on the use of radiochromatography.

The Radioisotope Laboratory has completed on the whole the organization of the general part of the course and continues to develop the most difficult, specialized part of the course. One of the difficulties in the development of the special part is the diversity of specializations in agriculture. It is impossible to cover all of them in this short course. Therefore, we confine ourselves to the following principle: the special part of the course should include the most general principles concerning the fundamentals and applicability limits of the atomic techniques in biological and agronomical investigations and the most general typical methods used in the most important branches of the agricultural sciences.

The specialized part of the course, like the general, consists of several large sections. It starts with a section called "The Fundamentals of Labeled Atoms Methods in Biology." The fundamentals and applicability of labeled atoms in biology and in biological investigations, the typical methods used in works with radioactive and stable isotopes are studied in this section.

The section "Application of Isotopes and Radiation in Biochemistry and Plant Physiology" follows next, in which the applicability of isotopes and radiation in biochemistry and in plant physiology is surveyed.

In the section on "The Use of Isotopes and Radiation in Agrochemistry," the possibilityies of applying isotopes and radiations in agrochemistry are studied, as well as experimental methods with labeled fertilizers and problems in agrochemistry of the natural radioactive elements and fission products of the heavy nuclei.

The section on "The Use of Isotopes and Radiations in Soil Science, Agriculture and Melioration" includes application of nuclear radiation to determine density, moisture content and porosity of soils; field radiometry methods; use of labeled atoms for the determination of physicochemical properties of soils, methods used for the investigation of the labeled water movement and labeled substances in soils, and other problems.

It is planned to include in this course such sections as "The Use of Isotopes and Radiations in Plant Selection" and "The Use of Isotopes and Radiations in Plant Protection."

Presently, the Laboratory has finished, in general, the development of a practical training program on the use of isotopes in biochemistry and plant physiology. This program includes laboratory experiments with the use of radiochromatorgraphy and radioautography. The Laboratory is in the process of organizing the practical training on the use of isotopes in agrochemistry, soil science, agriculture, melioration, radiation genteics and selection.

As a result of the variety of professions, the students are placed in separate groups in approaching the second half of the course, and then go through highly specialized practical training.

The Laboratory can train simultaneously four groups of six people each. One teacher is responsible for one group. Because of the specific work with radioactive substances and complexity of the equipment, the practical training is semi-individual. The lectures are given to all groups simultaneously.

In 1959 the Radioisotope Laboratory organized a short training course for the third-year students of the chairs of agronomy, fruits and vegetalbes, and agrochemistry. The curriculum of the course consisted of two survey lectures devoted to fundamentals of atomic techniques and their applications in agriculture, and two days of training in the Radioisotope Laboratory. During the first training day in the Laboratory, the students became familiar with the B-2 counter, after which they began to work on an assignment, "The Study of the Intake of Labeled Phosphorus by Plants." The assignment consisted of the preparation of the labeled phosphate solution, determination of the specific activity of the labeled phosphorus, and of practicing place the plant (sunflower or bean) on nutrient solution with labeled phosphorus. The next day was devoted to the study of the distribution of labeled phosphorus in plant leaves _in vivo_, by means of a counter, as well as in samples taken from the leaves. The over-ground part of the plant was cut off, and the dynamics of the labeled phosphorus in xylem was studied. In this study, the students had a chance to observe in the root system a rhythmic phenomenon discovered by I. I. Gunar and Ye. Ye. Krastina. The curves of the labeled phosphorus intake by xylem were of a pulsating nature with periods every 15 to 30 minutes. This phenomenon was observed in all experiments conducted by the students.

The Radioisotope Laboratory is visited by many excursions and visitors. The staff of the Laboratory offers scientific consultations and discusses with visitors the advances of the Soviet science in the field of peaceful use of atomic energy.

In 1959 the Laboratory offered a one-week seminar for excursion guides of the pavilion on "The Atomic Energy for Peaceful Purposes" of the All-Union exposition of the advances of the national economy.

Research Work of The Laboratory

The efforts of the Laboratory staff are dedicated to organization of educational training.

The Laboratory has started publication of practical training booklets which appear under the name: "The Practical Training on the Application of Isotopes and Radiations in Agriculture." These booklets will appear as the following separate issues: issues 1 and 2 will be devoted to "Radiometry"; issue 3, to "Dosimetry; issue 4, to "Safety Technique"; issue 5, to "Radiochemistry and Radiochromatography", and issue 6, to "The Use of Labeled Atoms in Plant Physiology and Biochemistry." The publication of booklets devoted to other sections of the course is also planned.

In the field of research, the Laboratory is occupied basically with the development of those theoretical and practical problems which will promote the perfection of the educational training and raise its scientific level.

The Laboratory has started studies in the field connected with one of the interacademy problems, - "The Isotopes and Nuclear Radiations in Agriculture." The basic direction of these investigations is devoted to the theory and application of isotopes and radiations in agriculture. It means that the laboratory will be occupied mainly with theoretical and methodical problems concerning the use of atomic techniques in agriculture. In order to coordinate these investigations with those of other chairs of the Academy, the Laboratory will also participate in the applications to industrial problems.

In the field of physical investigations, the Laboratory is occupied with the development of theoretical and methodical problems on radiometry and dosimetry applicable to experiments with plants and soils.

In the field of chemical investigations, the Laboratory is guided by further developments of the theory of sorption dynamics and chromatography, radiochromatography, and the use of isotopes in investigations of the physicochemical properties of sorbents and soils. Work has been started on the application of radiochemical investigations to analytical chemistry.

Work has begun in the field of biological investigations on the theory of the labeled atoms methods. Successful investigations are being conducted in the field of radiochromatographic analysis of plants and in the use of C^{14} in experiments with plants.

It is planned to expand the laboratory and to add some equipment to it in the near future. Two separate radiochemical rooms, 12 seats in each, will be assigned for studies. The washroom will be also expanded and equipped. The isotope storage room and dumping ground for radioactive waste will be relocated to a more suitable site. A room for physical investigations and irradiation of plants will be also assigned. It is planned to increase the capacity of the ventilation system. A special box will be equipped for work with C^{14}, as well as separate rooms free from radiation for the laboratory staff.

The realization of all these measures will ensure the maximum utilization of the laboratory in carrying out its future, important assignments. The total number of the work benches in the laboratory will be doubled. It is planned to complete this expansion in 1960.

Submitted 19 May 1959

END