NITO

THE NORWEGIAN INSTITUTE OF BIOMEDICAL SCIENCE

FUTURE TRENDS IN BIOMEDICAL LABORATORY SCIENCE

A NORWEGIAN PERSPECTIVE

Competencies
Education
Research
Management
Point of care testing
Profession
Technological development
Laboratory medicine
Blood samples
Demographic changes
Diagnostic partner
Patients of the future
Consultant
Advisor

NITO - The Norwegian Society of Engineers and Technologists, is the largest union for engineers and technologists in Norway, with approximately 75 000 members.

The Norwegian Institute of Biomedical Science (BFI) is a professional body within NITO. BFI's principal aims are to promote and develop biomedical laboratory science and to support the professional interest of biomedical laboratory scientists, nationally and globally. BFI represents 6,400 biomedical laboratory scientists employed predominantly within the field of biomedical laboratory science, as well as students and retired professionals.

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SUMMARY

This document describes the current state of biomedical laboratory science and looks at key trends and developments that will affect the future direction of the education and the professional field of biomedical laboratory scientists, as seen from a Norwegian perspective.

The educational programme for biomedical laboratory scientists consists of a three-year university / university college programme, leading to a bachelor's degree. Biomedical laboratory scientists are authorised health personnel, and have autonomy in practising their profession. They perform most of the daily work at medical laboratories in Norway and hold supervisory positions. They are by far the largest group of professionals in hospital medical laboratories.

Developments in technology create a continuously growing need for biomedical laboratory scientists with specialist training. The biomedical laboratory scientists of the future will need competences on new and highly specialised methods of analysis and automation. Greater use of point-of-care testing and patient self-monitoring will further increase the need for biomedical laboratory scientists with competence on guidance and training of other health professionals and patients. There will also be a greater need for biomedical laboratory scientists to manage biobanks and to work in the field of bioinformatics.

By linking technological and analytical understanding with medical knowledge, biomedical laboratory scientists may, as diagnostic partners, provide guidance and help ensure that results of analyses are delivered to hospitals and primary health care at the right time.

The educational programmes for biomedical laboratory scientists will need to meet future demands for expertise through a close interaction with the field of practice and by keeping up to date with technological development. It is furthermore important that the first degree qualifies students for further specialisation and in-depth studies. There will be a need for biomedical laboratory scientists who supplement their bachelor's degree with additional education, a master's degree or a PhD in a variety of subjects. Satisfactory and committed cooperation between the educational programmes for biomedical laboratory scientists and the field of practice is necessary.

CONTENTS

FUTURE'S BIOMEDICAL LABORATORY SCIENTIST

TECHNOLOGICAL DEVELOPMENT

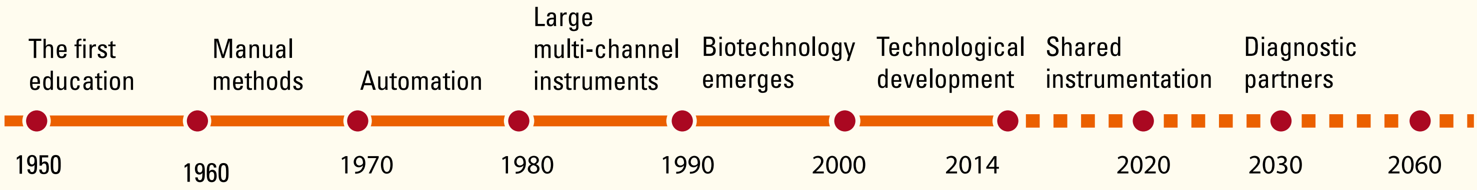
Biomedical laboratory science and laboratory medicine have grown and seen major developments during the past 50–60 years. This process has been facilitated by the expansive development of health services in general and medical laboratories in particular.

FACTS

Biomedical laboratory scientists in Norway

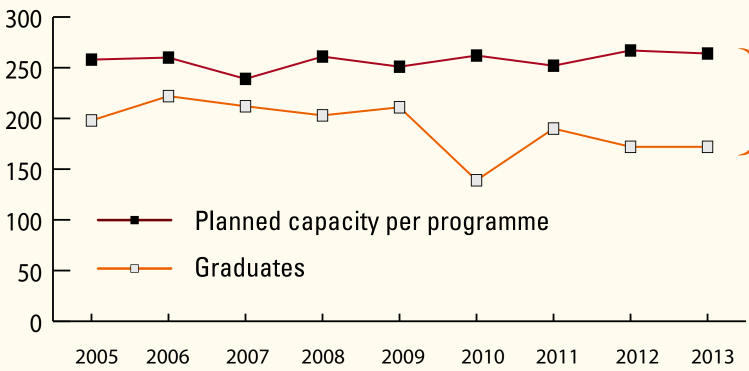
90 % are women

Average age **44,9**

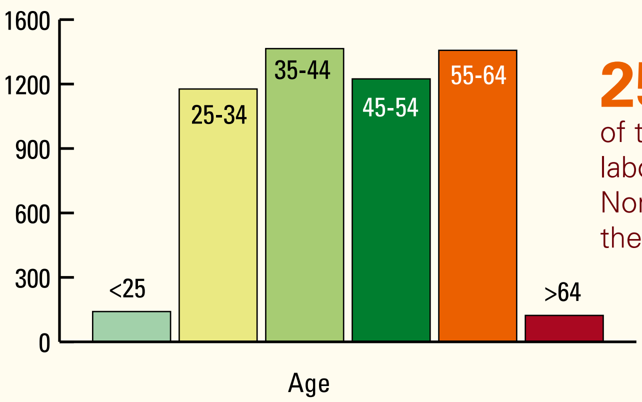


INCREASED COOPERATION

A close interaction between the educational programmes and the field of practice will secure that the educations adapt to the future's needs.



In Norway, **250** new biomedical laboratory scientists should graduate per year.



25 % of the biomedical laboratory scientists in Norway will retire during the next ten years.

TRENDS

LABORATORY MEDICINE
Increased automation and use of new and more specialised analytical methods.

TECHNOLOGICAL DEVELOPMENT
Technological developments make it increasingly important that biomedical laboratory scientists possess specialised knowledge in method development and validation.

DIAGNOSTIC PARTNERS
Biomedical laboratory scientists as diagnostic partners can provide guidance and secure quality.

CONSULTANTS
Greater need for biomedical laboratory scientists providing guidance and training in point of care testing and patients' self testing.

MANAGEMENT
More biomedical laboratory scientists are heading clinics.

FLEXIBILITY
Shared instrumentation and changed professional boundaries entails a need for greater flexibility in the tasks of biomedical laboratory scientists.

POINT OF CARE TESTING
Point of care testing and patient's self testing will increase as a supplement but not replace the need for centralised laboratory services.

Infographic: OPAL design/Margrete Tennfjord NITO, The Norwegian Institute of Biomedical Science, 2014

1

INTRODUCTION

New demands are constantly being made on medical laboratories due to developments in medicine, technology and society. Biomedical laboratory scientists have the knowledge required to introduce and use advanced analyses and instruments. They also contribute in assessing and choosing instruments for use in medical laboratories, point-of-care testing and patients' self-testing. Biomedical laboratory scientists offer guidance and training to other health professionals on the use of point-of-care testing equipment, and in guiding patients who perform self-testing.

The patients of today and tomorrow will play a much larger role in decision-making regarding their treatment than previously. They have more knowledge about their own diseases and make greater demands on the health service. With an increasing number of laboratory analyses available, it is natural for patients to ask for more analyses, quick feedback, as well as access to their own results.

The Norwegian Institute of Biomedical Science expects that the repertoire and the volume of analyses in medical laboratories will continue to grow. We furthermore expect point-of-care testing and self-testing to increase, as a supplement to centralised laboratory analyses. In a 2012 needs assessment, the Norwegian Directorate of Health identified various trends that will affect the future of biomedical laboratory science towards 2030. It was reported that more home treatment, point-of-care testing and self-testing may reduce the need for centralised laboratory analyses, and result in a greater need for guidance on the use of this type of technology; while increasing use of gene technology, specialised laboratory analyses and new technologies in the health service will require greater expertise in biomedical laboratory science (1).

Rapid developments in laboratory medicine and technology have led to constant changes within the biomedical laboratory scientist profession. The ability of biomedical laboratory scientists to acquire new knowledge and positively contribute to further development is the greatest guarantee that medical laboratories will be able to adapt to the needs of patients and the health services also in the future. This requires the education of sufficient numbers of biomedical laboratory scientists and for educational programmes to be adapted to the future need for expertise in biomedical laboratory science.

Photo: Grete Hansen

2

BIOMEDICAL LABORATORY SCIENTISTS TODAY

2.1 WHAT IS A BIOMEDICAL LABORATORY SCIENTIST?

The education of biomedical laboratory scientists is a three-year programme that leads to a bachelor's degree. Biomedical laboratory scientists are authorised health personnel, and have an autonomous responsibility for sound exercise of the profession (2).

Biomedical laboratory scientists perform most of the daily operational work at medical laboratories in Norway and hold supervisory positions. They are by far the largest group of professionals in hospitals' medical laboratories. The combination of laboratory expertise, understanding of technology and systems as well as a health care identity and knowledge makes biomedical laboratory scientists unique; both in the technology and health care professions.

Medical laboratories include laboratories for medical biochemistry, medical microbiology, blood banks and transfusion medicine, immunology, histopathology, cytology, pharmacology and medical genetics.

Biomedical laboratory scientists with further education are also highly-qualified for other positions in the health service. Biomedical laboratory scientists in Norway work as clinic heads, quality managers, quality advisers in interprofessional settings, and as IT advisers.

Biomedical laboratory scientists possess expertise on biomedical laboratory processes that qualify them for work in all kinds of medical laboratories (3). The work performed by biomedical laboratory scientists is an important part of prevention, screening, diagnosis, treatment and follow-up of illness. The technological and methodological competence of biomedical laboratory scientists also qualifies them for work in other types of laboratory and industrial enterprise (4).

The responsibilities of biomedical laboratory scientists in Norway are phlebotomy and pre-analytical work, as well as conducting analyses of biological material using advanced technology. Biomedical laboratory scientists are responsible for all laboratory procedures, from requisitioning of a laboratory analysis until validated results are available. In order to perform this work, knowledge concerning method validation, statistics, assessment of quality controls, and constant quality development and accreditation work is necessary.

The educational programmes place great emphasis on biomedical laboratory scientists being accurate and quality-conscious. The rapid development in laboratory medicine calls for a great willingness to change, which means that biomedical laboratory scientists are gaining even more areas of responsibility. Examples include procurement of advanced analytical instruments, methodological development, method validation, examination of blood smears and electrophoresis results, cytological screening and gross examination and dissection of tissue samples.

Biomedical laboratory scientists have expertise that makes it natural to take responsibility for new technology, as well as tasks like process monitoring and work flow, evaluation of results of analyses and traceability.

Almås and Ødegård charted the core competence of biomedical laboratory scientists in 2012. When discussing a possible change of role in the field of biomedical laboratory science in the future, the authors implied that biomedical laboratory scientists may "go from primarily having a specialised role in the health service to becoming a diagnostic partner in a patient care setting in close collaboration with other health care professionals. Such a role would consist of both highly-specialised expertise, and general communication competence” (5).

2.2 THE NUMBER OF BIOMEDICAL LABORATORY SCIENTISTS IN NORWAY

At present, 5,000 biomedical laboratory scientists are employed by the health and social services in Norway (6). In April 2012, Statistics Norway presented the report “The Labour Market for Health Care and Social Personnel towards 2035: Documentation of Projections with HELSEMOD 2012”. Statistics Norway wrote that the need for biomedical laboratory scientists would increase, partly due to increased use of new and advanced technologies and partly to higher retirement levels (7).

Developments in laboratory technology have shown that some of the routine tasks, previously performed by biomedical laboratory scientists in medical laboratories, have become fully automated, while biomedical laboratory scientists extend their practice into new fields. This is a trend which is found in all laboratory specialities and which, combined with technological developments, to some extent will reduce the need for more biomedical laboratory scientists as test volumes increase.

There are large geographical differences in terms of access to biomedical laboratory scientists. Some regional health authorities have a shortage of them, while the situation elsewhere in Norway is the reverse – a lack of positions. In 2012–2013, several medical biochemistry laboratories (including the Finnmark Hospital Trust, Nordland Hospital Trust, Innlandet Hospital Trust, Førde Hospital Trust and Stavanger University Hospital Trust) reported that it was difficult to recruit biomedical laboratory scientists.

In 2013 there was a capacity for 264 students in biomedical laboratory science in Norway. During the past decade, some 200 biomedical laboratory scientists have graduated annually. The educational capacity is not fully exploited, due to students dropping out, and some study programmes not utilising their full capacity due to lack of student recruitment. About 250 new biomedical laboratory scientists should graduate per year for the national market for biomedical laboratory scientists to be kept in balance. To meet the future need for biomedical laboratory scientists, the capacity should be increased at institutions with a high number of applications, as well as making efforts to ensure that more students complete the programme.

Biomedical laboratory scientists with a foreign education which is equivalent to the Norwegian education may apply for authorisation as biomedical laboratory scientists in Norway. In recent years, about 20 biomedical laboratory scientists with foreign education have been authorised annually.

See also the appendix for details on age distribution, the number of recent graduates and authorisation of biomedical laboratory scientists in Norway.

FACTS

Biomedical laboratory scientists in Norway

90 %
are women

Average age
44,9

2.3 CURRENT EDUCATION OF BIOMEDICAL LABORATORY SCIENTISTS

The education of biomedical laboratory scientists is a three-year higher education programme that leads to a bachelor's degree. The content of the education in biomedical laboratory science is regulated by a national curriculum for biomedical laboratory scientist education. The study programme consists of 180 ECTS credits, consisting of social science and humanities subjects, natural science subjects, and medical laboratory subjects; with the latter being the most comprehensive field of study. Training in educational laboratories and clinical placements in medical laboratories are an integrated part of the study programme. Upon graduation, the candidates qualify for authorisation as a biomedical laboratory scientist. The title biomedical laboratory scientist is protected.

Collection, processing and analysis of human biological samples are core tasks in biomedical laboratory science. Practice of the profession integrates medical, technological and methodological knowledge and skills. The analytical work performed by biomedical laboratory scientists depends on an understanding of medicine.

The education of biomedical laboratory scientists provides knowledge, skills and attitudes related to:

- Collection of blood samples from patients.
- Securing preanalytical conditions and processing biological samples.
- Drawing blood from blood donors and manufacturing blood products.
- Applying techniques and using analytical instruments in medical laboratories.
- Assessing the potential, limitations and sources of error of laboratory methods.
- Assessing the reliability of the analytical results and their statistical and medical probability.
- Performing quality assurance of laboratory services.
- Understanding the role of laboratory medicine in the health service.
- Complying with professional ethical guidelines.
- Continuous updating and developing professional knowledge (4).

2.4 FURTHER EDUCATION AND SPECIALIST CERTIFICATION FOR BIOMEDICAL LABORATORY SCIENTISTS TODAY

Biomedical laboratory scientists with a bachelor's degree are qualified to work in medical laboratories, but certain tasks in medical laboratories require further education and/or specialisation. In addition to their first degree, biomedical laboratory scientists may choose from a wide range of master's degrees and PhDs, as well as a number of further education programmes of shorter duration.

Biomedical laboratory scientists with a master's degree or a PhD work in medical laboratories, in education, and in research. They make major contributions to medical and technological development.

Specialist certification of biomedical laboratory scientists was introduced by the Norwegian Institute of Biomedical Science (NITO BFI), which also manages the scheme. Specialist certification is based on national guidelines drawn up by NITO BFI. The certification documents that the biomedical laboratory scientist has in-depth expertise within his/her field. Specialists must apply for recertification every five years (8).

The future need for further education of biomedical laboratory scientists is outlined in chapter 6.2.

3

KEY TRENDS

3.1 TECHNOLOGICAL DEVELOPMENTS IN LABORATORY MEDICINE

Biomedical laboratory science and laboratory medicine have grown and seen major developments during the past 50–60 years. This process has been facilitated by the expansive development of health services in general and medical laboratories in particular.

The business of biomedical laboratory science, both within and outside hospitals, is part of a continuous technological and medical development, resulting in several new laboratory analyses and new analytical parameters. In the past, most laboratory tasks were performed manually. Today, virtually all biochemical analyses are performed using automated instruments. The demand for efficient patient treatment calls for an increasing repertoire of available analyses and faster results.

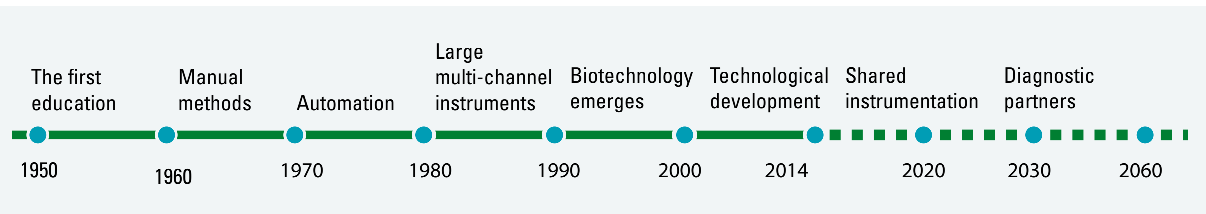
Technological developments make it increasingly important that biomedical laboratory scientists possess specialised knowledge of data processing and statistics.

Technological developments entail increasing automation in all laboratory specialties. This has allowed biomedical laboratories to meet increasing demands for efficiency, as well as improving the level of service to patients and physicians. At present, automation has had the greatest impact in medical biochemistry and immunology. More processes and analyses are becoming automated also in microbiology, histopathology and cytology. The latter field also sees increased digitisation. In microbiology, identification of bacteria, that previously required several days for cultivation, now only needs a few minutes. Automation and auto-validation (automatic approval of normal results of analysis) means an increase in the capacity for analyses. The tasks of biomedical laboratory scientists may thus change, but this does not necessarily mean that more personnel will be needed.

Increasing automation entails a need for biomedical laboratory scientists to validate methods and assure the quality of analyses through constant work with quality assurance and comprehensive control systems.

The increased automation in all laboratory specialties has led to more use of shared instrumentation and cooperation between laboratory specialties.

Several analyses, traditionally performed by different medical laboratories, can now be analysed with the same instrumentation. This has led to greater cooperation between the professional fields within laboratory medicine. For example, biochemical analyses, immunological analyses and infection immunology are analysed from the same sample, using fully-automated analytical instruments. Shared instrumentation also in areas like molecular biology and flow cytometry offers benefits related to gathering and strengthening professional communities.



During their first degree, biomedical laboratory scientists study all of the medical laboratory specialties, making them well-equipped to work with shared instrumentation.

Together with automation, there is an increase in the use of other, more specialised methods of analysis. Knowledge of the entire human genome provides opportunities for customised treatment. Mutation analyses are necessary in order to provide targeted treatment. New applications for separation methods such as chromatography and mass spectrometry to analyse steroids, vitamins, hormones, pharmacological substances and microbiological agents, flow cytometry, gene technology, molecular biology, full genome sequencing, proteomics, nanotechnology and other specialised analyses all produce vast volumes of test results.

There will be a greater demand for biomedical laboratory scientists with a specialised background in gene technology and bioinformatics.

Bioinformatics consists of technologies generating analytical results by organising and analysing large amounts of biological data. The present technology for analyses on the genetic and protein level yields an enormous amount of data. Applied bioinformatics is necessary in order to interpret gene expression, gene sequencing and proteomics analyses etc. These types of analysis may facilitate better diagnostics and personalised treatment.

There will be a greater demand biomedical laboratory scientists with relevant further education who can work within the field of bioinformatics.

Technological developments also lead to more and better analytical instruments for use outside medical laboratories, at the point of care. Selected biomedical laboratory analyses, involving point-of-care testing, offer results that can be obtained quickly and can thus contribute to effective treatment for the patient.

Greater use of point-of-care testing and patient self-monitoring will increase the need for biomedical laboratory scientists with competence on guidance and training of other health personnel and users.

Medical laboratories have stored specimens for analysis in order to check the results of analyses, perform follow-up analyses or new analyses, and quality control. The material has also been used for teaching and research purposes. Storage sites containing biological material are now defined as biobanks, and are subject to legislative regulation. A biobank can be anything from a collection of blood for diagnostic purposes (treatment biobanks) to large depositories containing blood and tissue for research purposes (research biobanks) and forensic biobanks (9, 10).

Biomedical laboratory scientists play an important role in the administration of biobanks at both hospitals and private institutions, in biobanks from population studies and within forensic medicine.

Photo: Svein Arild Sletteng

3.2 DEMOGRAPHIC DEVELOPMENTS AND DEVELOPMENT OF ILLNESS

The number of elderly people in Norway is increasing. An older population, combined with an increase in lifestyle-related diseases means that there will be more patients with diabetes, COPD and other chronic diseases, as well as patients with many and complex illnesses.

The incidence of infectious disease and infections with resistant bacteria is on the rise. This may be due to extensive travel among growing numbers of Norwegians, and increased use of antibiotics internationally in health care and in food production. Another reason may be illnesses or contagious diseases such as tuberculosis, brought to Norway by immigrants.

The number of new cases of cancer in Norway has risen steadily during the past 20–30 years, and a corresponding rise is expected until at least 2020. A minimum increase of 30 per cent in resource allocation for cancer care is expected from 2010 to 2020 (11).

The growth of the population, and the demand for health services, means that a greater repertoire of analyses will be required, as well as greater capacity in medical laboratories to handle large volumes of analysis. New methods and faster results will be demanded. Point-of-care testing and self-testing will become an increasingly important supplement to centralised laboratory analyses.

3.3 THE PATIENT OF THE FUTURE

Patients have access to increasing volumes of information about health issues via the Internet and other sources. They obtain knowledge about different treatments, and are better placed to make demands on health services than in the past. They therefore play a much larger role in decisions regarding their own treatment and make greater demands on the health service than previously.

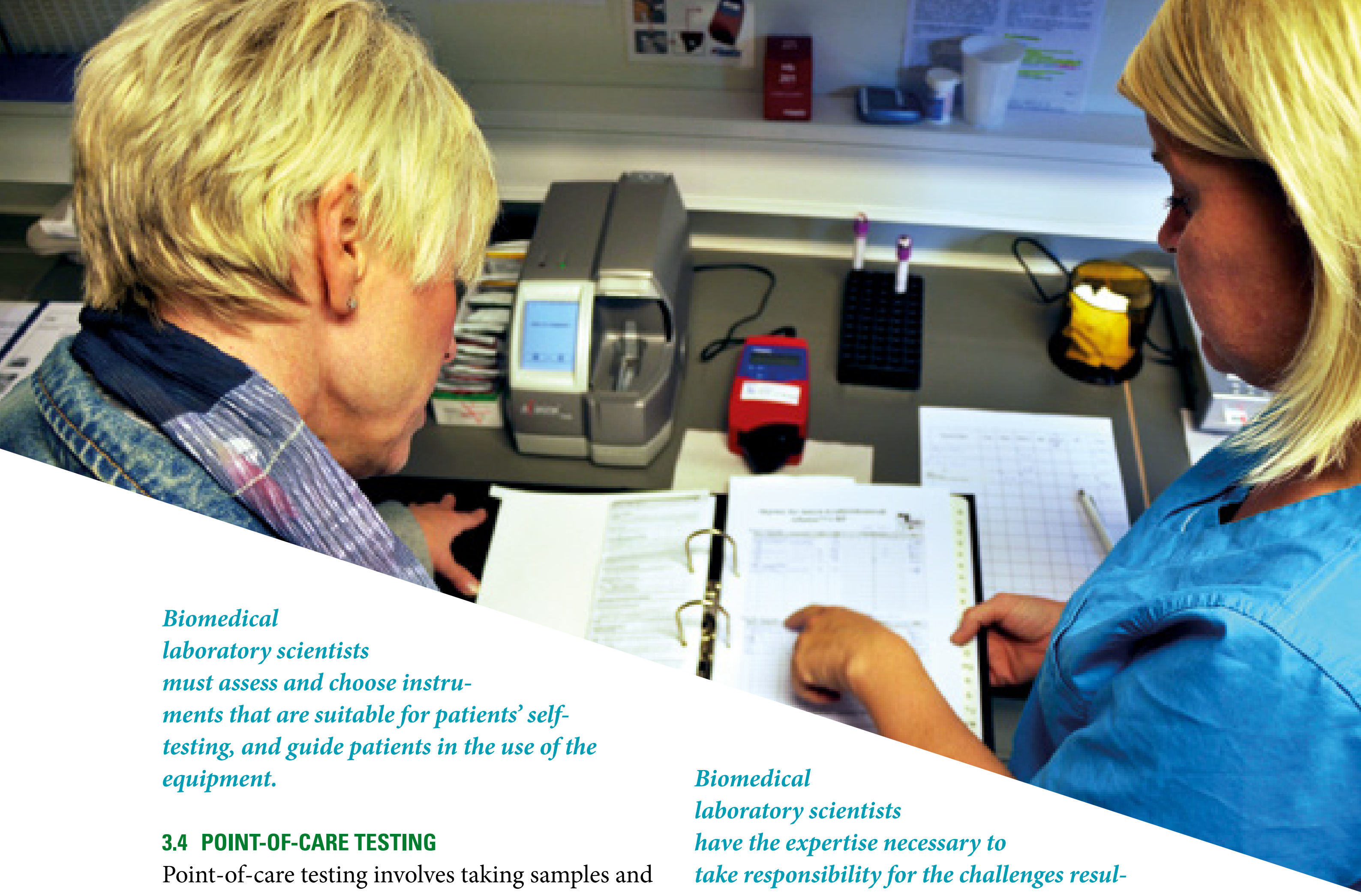
Patients' rights organisations are important agents in society, and make an active contribution to the planning and the development of health services (12).

As growing numbers of laboratory analyses become available, it is only natural to expect patients to demand more analyses. They will also want to receive their test results quickly. The legislation on patients' and users' rights gives patients sovereignty over their own health information.

Biomedical laboratory scientists who are in contact with patients must be expected to be able to provide information about the choice of analyses and give results directly to patients.

Increasing numbers of self-tests are available, and used by patients. Self-testing is laboratory analyses carried out in the homes of patients with chronic conditions (e.g. diabetes), or by individuals in order to screen their own state of health. Such equipment can be purchased at a pharmacy or over the Internet. The quality of self-testing depends on the precision of the test, adequate user training, an understanding of the analytical procedure involved, and knowledge of how to interpret the result of the analysis (13).

Self-testing is socio-economically profitable if the quality of the tests is high enough, if it is used by a suitable target group and if the patients receive adequate follow-up. Blood glucose monitoring has long been available for self-testing, and self-monitoring of prothrombin time (PT-INR) during anti-coagulation therapy is now becoming available to a growing number of patients. Even though for various reasons only 10–15 per cent of patients who need regular PT-INR monitoring are able do this themselves, a considerable group of patients will have a great need for supervision and follow-up.



Biomedical laboratory scientists must assess and choose instruments that are suitable for patients' self-testing, and guide patients in the use of the equipment.

3.4 POINT-OF-CARE TESTING

Point-of-care testing involves taking samples and performing biomedical laboratory analysis close to the patient and outside medical laboratories. This is in keeping with the general development in the Norwegian health service, which is characterised by new technology and the need for quick laboratory results. Regardless of whether the analysis is carried out in the laboratory or close to the patient, it is the responsibility of health personnel to ensure that the results contribute to correct and safe treatment.

At present, only a limited amount of analyses are available and suitable for point-of-care testing. This is because the analyses need to meet a number of criteria in order to be both precise and cost-effective. Factors that influence the introduction of point-of-care testing include access, price and financing. It is also important to receive test results quickly, that the quality of the analysis is sufficient, and that the instruments are easy to operate and maintain. The number of point-of-care tests is expected to increase in the future. It is important to manage this development to ensure that results of analyses offered at the point of care are appropriate and that the instruments are suitable for the purpose.

Biomedical laboratory scientists have the expertise necessary to take responsibility for the challenges resulting from the growing number of tests which can be performed both within and outside medical laboratories. This means that biomedical laboratory scientists can take responsibility for selection and standardisation of methods and equipment, interdisciplinary cooperation, training, user guidance and quality assurance.

The Norwegian Institute of Biomedical Science has defined principles for use of point-of-care testing inside and outside hospitals (13). In hospitals, these principles state that medical laboratories have an overall responsibility for point-of-care testing carried out. All hospitals should have biomedical laboratory scientists with professional responsibility for point-of-care testing – POCT coordinators. This includes responsibility for selection and standardisation of methods and equipment, multidisciplinary cooperation, training, user guidance and quality assurance. The need for, and the costs associated with, point-of-care testing must be assessed in light of optimal patient treatment and the overall allocation of resources in the health service. The quality of point-of-care testing must be assured by monitoring and validating the methods and equipment used. The results obtained from point-of-care testing must be quality assured with routines for test result reporting and for traceability.

The Norwegian Institute of Biomedical Science's principles for point-of-care testing outside hospitals entails a demand for quality assurance of all analytical work. The person who performs the analysis must ensure that the result of the analysis provides a representative parameter of the status of the illness or treatment tested by the analysis. All practitioners of laboratory activity outside hospitals should participate in Noklus (Norwegian Centre for Quality Assurance of Laboratory Activities outside Hospitals) or a corresponding quality assurance scheme. As far as possible, the methods and analytical equipment used outside hospitals should be standardised.

Providers of instruments for point-of-care testing must communicate knowledge of analytical variation and offer necessary quality assurance of methods and equipment. Patients who analyse their own samples and evaluate the results for their own particular condition must have adequate training and follow-up, as well as access to quality control of analytical methods and the equipment used.

Biomedical laboratory scientists provide guidance on analytical activities outside hospitals through the work conducted by biomedical laboratory scientists working as laboratory consultants in Noklus – the Norwegian Centre for Quality Assurance of Laboratory Activities outside Hospitals. Biomedical laboratory scientists in hospitals have responsibility for general guidance vis-à-vis the primary health service.

The Norwegian Institute of Biomedical Science believes that point-of-care testing and self-testing will increase, not as a replacement for but as a supplement to centralised laboratory analyses.

3.5 BLOOD SAMPLE COLLECTION IN HOSPITALS

Correct blood sample collection is crucial in order to ensure that the quality of the specimens is satisfactory upon arrival at the medical laboratory. Phlebotomy has traditionally been centralised to medical laboratories in Norwegian hospitals, and has been carried out by biomedical laboratory scientists – to a large extent those from biomedical chemistry laboratories or their equivalent.

Medical laboratories are constantly adapting to and influencing changes in the health service.

In recent years, some hospitals have decentralised parts of the blood collection work to clinical departments. Experiences from other countries indicate that decentralising phlebotomy leads to poorer quality and increased costs. In addition, research findings from Sweden and the USA reveal that centralised organisation of sample collection is most efficient in terms of both quality and cost (14, 15).

The Norwegian Institute of Biomedical Science has assessed the different models for organisation of blood sample collection in Norway, and believes that keeping the organisation centralised offers better quality and lower costs than decentralised organisation.

All blood collection must be quality assured and conducted in accordance with approved procedures in order to reduce the possibility of preanalytical errors. If phlebotomy is delegated to other professional groups, the biomedical laboratory scientists at medical laboratories must be responsible for staff training and for quality assurance of the procedure. (16).

Correct blood sample collection is so essential for the quality of laboratory analyses that it must be performed by personnel who have learnt this as part of their basic training and have phlebotomy as a core activity.

International experience clearly shows that it will be appropriate for biomedical laboratory scientists to be responsible for and perform most of the blood sample collection in Norwegian hospitals also in the future.

3.6 NEW PROFESSIONAL BOUNDARIES AND DISTRIBUTION OF TASKS

The health service is developing, and medical laboratories are constantly changing. A natural consequence is that tasks may be transferred between professional groups. Quality, finances and correct use of personnel must be taken into consideration when looking at distribution of tasks.

The Norwegian Health Personnel Act allows the allocation of tasks across professional boundaries, as long as professionalism, quality and patient safety are protected. Health personnel are under an obligation to ensure that the best approach is taken to tasks, with a focus on saving resources. The health authorities are constantly looking at measures for better utilisation of the total human resources in the health sector (17).

A higher level of automation, a need for standardisation and a lack of medical specialists has led to several of the tasks, previously performed by laboratory physicians, now being performed by biomedical laboratory scientists. A report from Sweden has shown that the quality of the results reported for serum and urine electrophoresis are either unchanged or improved when the analyses are performed by biomedical laboratory scientists (18).

Biomedical laboratory scientists with specialist certification, a master's degree or a PhD may be able to undertake even more tasks in medical laboratories.

3.7 MANAGEMENT AND MEDICAL EXPERTISE IN MEDICAL LABORATORIES

During the past decade, we have seen a trend where biomedical laboratory scientists have been given supervisory roles on every level in medical laboratories and elsewhere in hospitals. More biomedical laboratory scientists are heading clinics and leading many professional groups. We also see a trend where physicians with specialisation in laboratory medicine are concentrated in university hospitals, and are advisers for their own hospital and for medical laboratories within trusts or regions that do not have their own laboratory specialist on staff.

There is a need for growing cooperation between laboratories and physicians in clinical departments, to provide guidance on the selection of analyses in a constantly growing repertoire, and for the interpretation of analytical results.

3.8 ACCESS TO MEDICAL LABORATORY SERVICES

The demand for faster results is growing. This speaks in favour of having medical laboratories in every hospital, with an adequate repertoire of analyses in order to meet the need for fast test results. At the same time, large centralised laboratories should perform more rare and complex analyses when fast test results are not crucial. Centralisation of rare analysis will save costs and secure good analytical quality in these cases.

Increased activity in operating theatres and outpatient clinics in the afternoons and evenings will lead to a greater need for laboratory services outside ordinary working hours. More flexibility and longer opening hours will be necessary in outpatient clinics.

Photo: Camilla Crone Leinebø

Clinical microbiology, histopathology and cytology laboratories have traditionally had little or no activity in the afternoons or in the weekends. Increased activity in operating theatres and outpatient clinics in the afternoons and evenings will also create a need for access to the results of microbiological analyses and certain histopathological and cytological analyses outside current opening hours. Shared instrumentation and increased automation may make it possible to offer a larger repertoire of analyses around the clock, which will increase the efficiency of patient treatment at hospitals.

3.9 ANALYSIS ACROSS NATIONAL BORDERS

It is in the nation's interest that large volumes of biological material are not lost or are at risk of misuse. Storage of biological material is regulated by the Norwegian Treatment Biobank Act, which also provides rules regarding supervision (10).

It is very seldom necessary to send samples from Norwegian patients for laboratory analyses abroad. This is mainly required for extremely rare conditions. The Norwegian Institute of Biomedical Science does not envisage a development where it will be necessary to send samples abroad in order to cut analysis costs. This is based on the demand for faster results and the need for a safe and stable laboratory service, as well as it being important to have good, close communication between medical laboratories and clinics.

4

THE ROLE OF THE BIOMEDICAL LABORATORY SCIENTIST IN TOMORROW'S HEALTH SERVICE

4.1 THE ADVISORY AND CONSULTATIVE ROLE OF THE BIOMEDICAL LABORATORY SCIENTIST

The Norwegian Coordination Reform (19), which is gradually being introduced from 2012, will lead to a larger number of patients with more complex illnesses being treated outside hospital. Treating these patients outside hospital may lead to increased requisitioning of laboratory services from the primary health service and a greater demand for access to laboratory diagnostics outside hospitals.

Correct diagnosis and treatment depends on high-quality laboratory analyses. To ensure that the necessary laboratory diagnostics are available when required, biomedical laboratory scientists must be involved in the process of planning and supervising patient care and treatment. This also applies to the municipal health services.

The Coordination Reform means that increased access to laboratory services may become necessary outside hospitals and physicians' surgeries. In small units, there will only be a need for a limited number of tests of each analysis. Such units will need analytical point-of-care methods that are easy to perform by personnel without formal education in laboratory analysis, and that comes with reagent packages in small volumes and with a long shelf-life.

In order to assess the quality of analytical instruments and provide advice on which analyses small units would benefit from, biomedical laboratory science expertise should be involved already during the planning phase. This will guarantee quality and an appropriate repertoire of analyses.

Treatment of patients with more complex illnesses outside hospitals has already resulted in an increase in blood transfusions outside hospitals. This increase is expected to continue. Biomedical laboratory scientists must provide help with transfusion issues, including organising courses for health personnel employed outside hospitals, and being available to answer questions around the clock (20).

To allow treatment of patients with more complex illnesses outside hospitals, biomedical laboratory scientists in blood banks must provide guidance on blood transfusions to health personnel outside hospitals.

Biomedical laboratory scientists have high competence in systematic quality assurance of complex processes, including use of internal and external auditing to monitor and improve procedures and work processes. This knowledge may also be useful outside laboratory medicine, by using the competence of biomedical laboratory scientists to secure good patient flow and assure the quality of efficient work processes.

Biomedical laboratory scientists' analytical skills can be utilised better in the processes of creating flow in patient care and monitoring the quality of the interaction between health services. The competence of biomedical laboratory scientists can be utilised in the work with internal and external audits both inside and outside hospitals.

4.1.1 Noklus

The Norwegian Centre for Quality Assurance of Laboratory Activities outside Hospitals (Noklus) is a national non-profit organisation run by a management committee consisting of representatives from the Norwegian Medical Association, the Norwegian Association of Local and Regional Authorities (KS) and the Norwegian government. The organisation was established in 1992.

The goal of Noklus is that all laboratory analyses outside hospitals are requisitioned, carried out and interpreted in accordance with the patient's needs. To achieve this goal, participants are offered: procedures for laboratory activity, knowledge of preanalytical variables, training in taking samples, information and guidance in quality assurance and evaluation of analytical equipment and methods, a quality programme for documentation of the laboratory's own system for quality control, and external quality assurance.

Noklus offers services to enterprises performing laboratory analyses outside hospitals. Participation is voluntary and 99 per cent of Norwegian physicians' surgeries are participating. The participation of physicians' surgeries in Noklus has contributed to a higher quality of analysis within all of the relevant analytical methods in use in primary health care. Other participants are nursing homes, district and local medical centres, prisons, rehabilitation centres, health centres, occupational health services and armed forces infirmaries. Most nursing homes now participate in Noklus, and there has been a documented improvement in the quality of the laboratory work in these nursing homes (21). In 2012 Noklus had 2,900 participants. Noklus has also reported a need for laboratory consultants to provide guidance on methods and analyses that traditionally have not been a part of the biomedical laboratory scientists' core competence in Norway, such as spirometry, ECG and blood pressure monitors.

The laboratory consultants who work at Noklus are all biomedical laboratory scientists, and they meet the individual participant's need for guidance and advice on activities and quality assurance in their own laboratory (22).

The Norwegian Institute of Biomedical Science expects an increased need for services from Noklus, and thus a greater need for biomedical laboratory scientists with knowledge of preanalysis, point-of-care testing, statistics, guidance and training.

4.2 BIOMEDICAL LABORATORY SCIENTISTS AS DIAGNOSTIC PARTNERS

Medical laboratory analyses are an important part of the patient care setting in a modern health service. The clinical services need more knowledge on how to obtain the test results they require, and at the right time. To ensure that necessary laboratory diagnostics are available when required, biomedical laboratory scientists must be involved in patient care procedures both in hospitals and in the primary health service. There is already a need for biomedical laboratory scientists from all laboratory specialties to be involved in developing good patient care procedures.

> Biomedical laboratory scientists as diagnostic partners can provide guidance and secure quality.

The biomedical laboratory scientist as a diagnostic partner is a term that was introduced by the Danish Association for Biomedical Laboratory Scientists (dbio). They define the term as follows: *"Being a diagnostic partner means that biomedical laboratory scientists play a strategic role and enter into a professional dialogue with pati-*

ents, the professional groups they work with, and the administration of diagnostic work. The biomedical laboratory scientist as a diagnostic partner actively shares responsibility for patient treatment, and is proactive and resourceful when new tasks arise in the overall patient care process."

Danish biomedical laboratory scientists work as diagnostic partners in the clinical departments of several hospitals. They participate in the professional community, and offer advice and feedback on how to use medical laboratory services more efficiently in patient care (23).

Increased analytical repertoires and volumes of analysis, greater use of laboratory analyses in the primary health service, and increased use of point-of-care testing and self-testing indicate a need for biomedical laboratory scientists to expand their role as diagnostic partners regarding choice of methods and analyses, and interpretation of test results.

Biomedical laboratory scientists as diagnostic partners can provide guidance and secure that the necessary test results are delivered at the right time.

4.3 THE CONTRIBUTION OF BIOMEDICAL LABORATORY SCIENTISTS TO RESEARCH AND DEVELOPMENT

Biomedical laboratory scientists with a PhD deal with both education and research, and make important contributions to medical and technological development.

Many biomedical laboratory scientists participate in different research projects, and as core facilities are built around research institutions, they play an important role here. Biomedical laboratory scientists contribute in the preanalytical processes, securing quality in storage of specimens for analysis, selection of methods, traceability, securing adequate quality in methods and analyses, and in quality assurance of all steps in the analytical process.

Biomedical laboratory scientists in medical laboratories conduct many large and small development projects, such as method validation and sample stability studies. Due to the lack of formal research expertise in many locations, this important research and development activity is to a lesser extent published.

Research and development in medical laboratories will become an even more important task in the future, and can be performed by biomedical laboratory scientists with a master's or higher degree in collaboration with other groups of personnel.

Biomedical laboratory scientists provide quality assurance in medical research through their expertise on preanalytical conditions, choice of methods, traceability and variation of methods and analyses.

There is a need for more research on the profession and the professional field. This should take place in a close interaction between medical laboratories and educational institutions.

5

FUTURE SKILLS NEEDED

5.1 FUTURE REQUIREMENTS FOR THE COMPETENCE OF BIOMEDICAL LABORATORY SCIENTISTS

New and specialised analytical methods, guidance and dissemination of competence, automation, and flexibility of services are key trends that will have an impact on the competence required of the biomedical laboratory scientists of the future.

There will still be a need for biomedical laboratory scientists with general professional competence to staff routine medical laboratories. The basic degree must cover every medical laboratory specialty, as a larger degree of shared instrumentation and changed professional boundaries entails a need for greater flexibility in the tasks of biomedical laboratory scientists. It will also be appropriate for biomedical laboratory scientists to be responsible for and to carry out most of the blood sample collection in Norwegian hospitals.

Development of complex technology for specialised laboratory analysis will lead to a constantly growing need for biomedical laboratory scientists with specialisation beyond a bachelor's degree, both to implement the technology and to interpret the results. Greater use of point-of-care testing and patient self-monitoring will increase the need for biomedical laboratory scientists with competence in guidance and training of users. There will also be a greater need for biomedical laboratory scientists to manage biobanks and to work in the field of bioinformatics.

Biomedical laboratory scientists must also use their competence to identify new needs in the health service. As diagnostic partners, biomedical laboratory scientists can contribute to a higher quality of patient care through guidance and counselling, and thus ensure that necessary results of analyses are delivered at the right time and with a high level of quality, both inside and outside hospitals.

Photo: Margrete Tennfjord

6

EDUCATION OF BIOMEDICAL LABORATORY SCIENTISTS IN THE FUTURE

6.1 FUTURE BACHELOR'S DEGREE

The educational programme for biomedical laboratory scientists consists of a three-year university college programme leading to a bachelor's degree. The content of the education is regulated by the national curriculum for biomedical laboratory science, and biomedical laboratory scientists are authorised health personnel.

6.1.1 Competence requirements of the education

There are clear guidelines at existing educational institutions regarding the competence required of the academic staff. Theoretical and practical *professional competence* must be a requirement. The staff must also have completed an academic programme and have *research competence*. It is important that the staff have research competence in order to conduct research in their own fields, and thus contribute to the development of biomedical laboratory science. Research-based teaching must also be provided. Arrangements must be made for students to be involved in research projects.

The Norwegian Institute of Biomedical Science believes that most teaching staff at the biomedical laboratory science programmes should be biomedical laboratory scientists with the requisite professional knowledge. Internships at relevant hospitals and institutions should be made available to teaching staff to update their knowledge. Positions combining work within the professional field of practice and teaching may give the biomedical laboratory science programmes the contact they need with working life. This will result in good cooperation and mutual exchange of knowledge.

The third important competence requirement is *educational competence*. Education is changing. New forms of learning methods with increased focus on what students learn will place high demands on professional, technical and educational competence among teaching staff.

Internationalisation in the form of both teacher and student exchange has been a prioritised task during the past few years. This work has helped increase the general competence of both groups, and will continue to be important in the future. Extended cooperation and exchange of teachers between the seven institutions that provide the biomedical laboratory science programmes in Norway is also important. As is the case with internationalisation, such cooperation will improve the quality of the educational programmes and provide opportunities for cooperation beyond a bachelor's degree. Work must be done to release funds for this type of exchange, along the same lines as funds allocated for internationalisation in higher education.

6.1.2 The contents of a degree in biomedical laboratory science

The bachelor's degree is intended to provide a general education. The need for specialised competence must be met through further education in the form of a master's degree or PhD.

The three-year education for biomedical laboratory scientists, leading to authorisation,

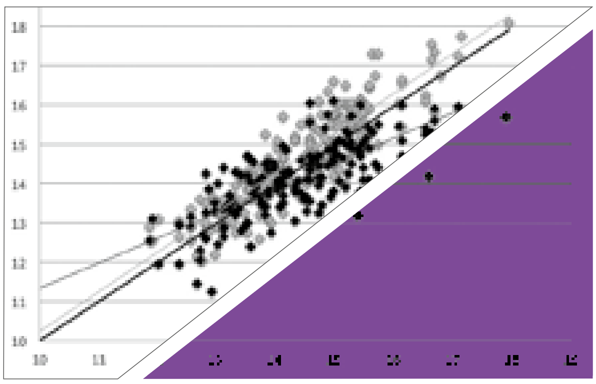


Illustration: Bioingeniøren 8 2013, page 28.

qualifies them for tasks in the different medical laboratories. The education gives biomedical laboratory scientists basic competence, but it also requires employers to be aware of their responsibilities towards new employees for training and certification for particular tasks. This will give biomedical laboratory scientists the necessary supplementary competence to target the desired specialised tasks within the professional field.

The content of the education must be in a dynamic balance between the current and future needs of the field of practice, and the opportunities and visions of the educational programmes. An informal study of the field of practice disclosed the desire for the educational programmes to place greater emphasis on topics like:

- Analytical validation, quality assurance, continuous improvement work and quality control.
- Databases, bioinformatics, statistics and ICT.
- The structure and finances of the health service.
- Communication and guidance of other health personnel and patients.
- Knowledge about the work of biomedical laboratory scientists in the primary health service, point-of-care testing and self-testing.
- New technologies in laboratory medicine.
- Customised patient treatment and new work methods.

All points are relevant topics for the educational programmes, and are part of today's programmes to varying degrees. Further emphasis will require a close review of the curriculum of each educational programme, with an academic and professional assessment of what should be removed in order to make room for new or expanded topics. These assessments are part of the work with the curricula of the educational programmes, and the study programmes must be allocated enough resources for this work to be done in a satisfactory manner. One example is that the growing level of automation and shared instrumentation across laboratories have brought about changes to the basic education. This has resulted in a reduced need for the traditional laboratory-based division of subjects, and must create room for other relevant subjects. At present, the educational programmes are obliged to follow the Norwegian national curriculum for the education of biomedical laboratory scientists, which was last revised in 2005, but they have considerable autonomy in determining how to structure the study programmes as long as they comply with the requirements of the national curriculum.

It is also important that there are programmes for further education and master's degrees in areas where specialisation is needed to supplement a bachelor's degree. The basic degree must qualify students for further specialisation and in-depth studies. In this context, it is important that the subjects taught at the bachelor's level have designations that are transparent and easy to understand for people without in-depth knowledge of the education.

6.1.3 Interaction with the field of practice

The Norwegian White Paper "Education for Welfare: Interaction as Key" from 2012 presents a national knowledge policy for the health and social work educational programmes of the future. The White Paper points out the need for competence in working life, with a focus on health, welfare and care. The government's goal for the educational programmes is to qualify workers in the welfare services to practice their profession based on the general knowledge that comes from research and practical experience. The content of the report provides guidelines for the health care education of the future, and calls for a closer interaction between the educational programmes and the field of practice (24).

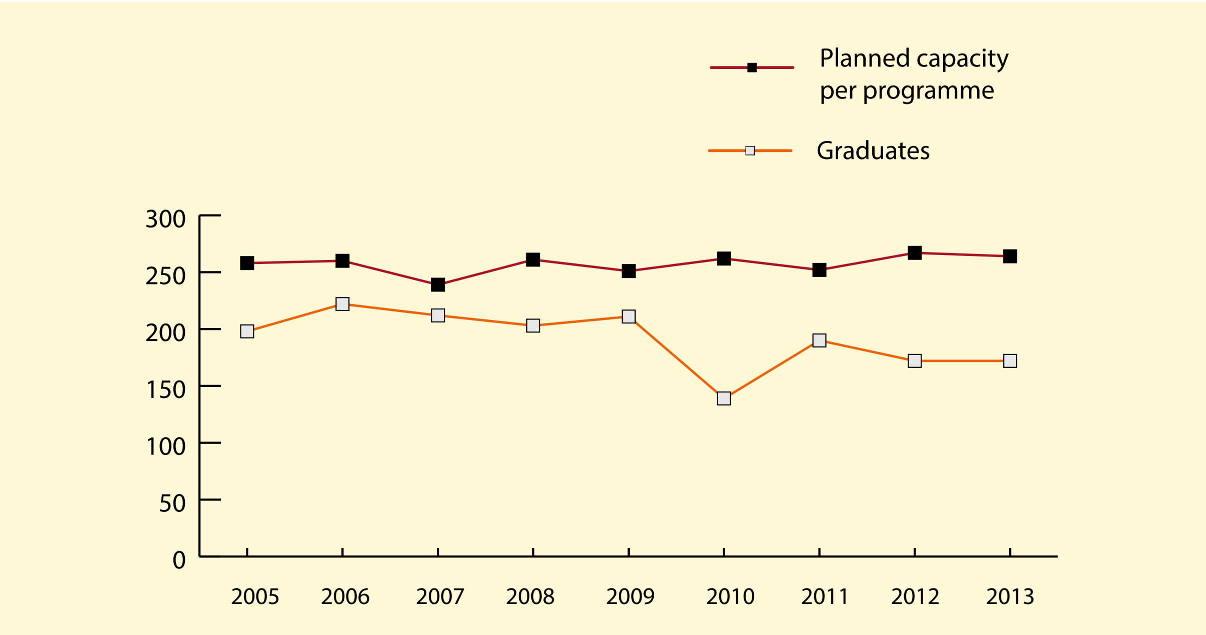
The future education of biomedical laboratory scientists must comply with these guidelines. A closer dialogue must be sought between the field of practice and education. The importance of work experience in vocational programmes must be developed in interaction with theoretical developments, creating a dynamic programme. The White Paper also states that the field of practice must take greater responsibility for the education of health personnel. To achieve this, workplaces must be given greater responsibility for good work experience placements and influencing educational institutions to develop their educational programmes for supervisors.

6.1.4 Bachelor's theses

The topics for bachelor's theses in biomedical laboratory science should be relevant or transferrable to further work at medical laboratories. One example could be comparison of different instruments, such as point-of-care testing instruments vs. automated analytical instruments. Other examples may be projects outside hospitals, such as training schedules for quality control of point-of-care testing at nursing homes, or development of methods in veterinary medicine or fish health that can be transferred to human medicine. Good bachelor's theses require sound knowledge of the field as well as communication competence in biomedical laboratory scientists who provide supervision in the field of practice, while the required research competence is primarily the responsibility of the educational institutions.

6.1.5 Education and capacity needs

In 2013 there was a capacity for 264 students in biomedical laboratory science in Norway. During the past decade, some 200 biomedical laboratory scientists have graduated annually. The educational capacity is not fully exploited, due to students dropping out, and some study programmes not utilising their full capacity due to lack of student recruitment. About 250 new biomedical laboratory scientists should graduate per year for the national market for biomedical laboratory scientists to be kept in balance. To meet the future need for



biomedical laboratory scientists, the capacity of students must be kept at the present level, while measures are taken to increase the number of students who complete the programme. Low application figures to certain biomedical laboratory science programmes may indicate the need to consider a reduction in the present number of educational institutions and increase the number of places for biomedical laboratory science students at the existing programmes with high application figures. However, many recent graduates want to live near their place of study or the region they come from, so geographical issues must be taken into consideration when reviewing the number of biomedical laboratory science programmes.

In Norway, 250 new biomedical laboratory scientists should graduate per year.

6.2 SPECIALISATION AND FURTHER EDUCATION

Developments in laboratory medicine, new technology and changes in society's need for competence make demands on further education and specialisation in the field of biomedical laboratory science. It is important that workplaces take responsibility for influencing educational institutions to offer the further education and specialisation that they see is needed, and for employees receiving opportunities to take advantage of these programmes.

6.2.1 Specialist certification for biomedical laboratory scientists

Specialist certification gives biomedical laboratory scientists documented professional development, letting them meet the challenges of the future laboratory service, and thus work towards better health services. Specialist certification is targeted at biomedical laboratory scientists who work at medical laboratories. Flexibility when choosing one's specialisation makes each candidate particularly suited to meeting the workplace's need for expertise. A biomedical laboratory scientist with specialist certification will thus help ensure high professional standards at their workplace. Biomedical laboratory scientists with specialist certification can also supervise students during their work experience placement and be suitable lecturers and supervisors on the educational programmes for biomedical laboratory science in their fields of specialisation. Specialist certification is based on national guidelines drawn up and managed by the Norwegian Institute of Biomedical Science (8).

In the long-term, the Institute wants the scheme to be transferred to and managed by the national authorities, as has been the case with other health certification schemes. The Norwegian national authorities currently have no such plans (25).

6.2.2 Further education, master's degree and PhD

Higher education in Norway is changing, and applicants to higher education today want the chance to be able to supplement their bachelor's degree with a master's degree or a PhD.

There will be a need for biomedical laboratory scientists with a master's degree in both hospitals and in the municipalities. Medical laboratories need the expertise of master's graduates in terms of contributing to new thinking and innovation processes. Changes in the health service, with subsequent changes of professional boundaries and transfer of tasks will increase the need for biomedical laboratory scientists with specialised competence on a master's level. However, workplaces must appreciate and request such expertise. Higher-level documented formal competence in biomedical laboratory science is a prerequisite for development within the field and for biomedical laboratory scientists to participate in the development of laboratories. Experiences from several medical laboratories show that biomedical laboratory scientists with a master's degree have acquired valuable competence, such as the ability to immerse oneself in a subject, critical thinking skills, and professional development that benefits the field.

There is a proven need for short further education programmes for biomedical laboratory scientists that are not necessarily part of a master's programme. This type of further education is nevertheless placed at the master's level, so that the course being offered may be incorporated into a master's degree.

Institutions offering biomedical laboratory science programmes in Norway should work together to ensure that there is a good, relevant and viable range of further education programmes and master's degrees. It is not sensible that the same further education courses or programmes are offered at several Norwegian educational institutions at the same time. The programmes and courses should be organised online and/or session-based, and thus be suitable for more biomedical laboratory scientists, regardless of their geographical location. Steps must be taken to allow relevant further education from different educational institutions to be incorporated into a master's degree.

As a result of the changes to the health service, master's degrees will be needed in more areas than the traditional laboratory specialties. Examples include:

- Analytical validation, statistics and ICT.
- Medical genetics and genetic counselling.
- Communication and guidance of other health personnel and patients.
- Point-of-care testing and self-testing.
- New technologies in laboratory medicine.
- Biobanking.
- Bioinformatics.

There is also a need for new interdisciplinary master's degrees for biomedical laboratory scientists and other groups of health personnel. Key areas are welfare technology, clinical physiology and nuclear medicine (for biomedical laboratory scientists and radiographers), and interdisciplinary clinical health and social work master's degrees. There is also a need for management training programmes for biomedical laboratory scientists who are, or aspire to be, mangers at different levels. This can be met through existing management training programmes, and is not a specific task for the biomedical laboratory science programmes.

The professional communities in Norway are small. There is a market for developing European and Nordic master's degrees for biomedical laboratory scientists in fields that are not large enough to receive enough applicants for a dedicated master's programme in one country alone. Norwegian biomedical laboratory science programmes can provide modules and courses that can be adapted to international master's degrees, and Norwegian biomedical laboratory scientists must be encouraged to explore further education abroad.

More biomedical laboratory scientists should take the opportunity to undertake internships in medical laboratories that have introduced new methods, equipment or have other areas of specialised expertise. Organised visits abroad and in Norway can be part of or a supplement to traditional further education.

7 CONCLUSION

7.1 THE ROLE OF THE BIOMEDICAL LABORATORY SCIENTIST IN THE FUTURE HEALTH SERVICE

New and specialised methods of analysis, guidance and dissemination of competence, automation, and flexibility of services are key trends that will have an impact on the competence required of the biomedical laboratory scientists of the future.

Technological development will also lead to a growing need for biomedical laboratory scientists with specialisation that is relevant to work in medical laboratories. Greater use of analytical point-of-care testing instruments and patient self-monitoring will increase the need for biomedical laboratory scientists with competence on guidance and training of other health personnel and users. There will also be a greater need for biomedical laboratory scientists to manage biobanks and to work in the field of bioinformatics.

Biomedical laboratory scientists as diagnostic partners can provide guidance and help ensure correct delivery of results to hospitals and primary health care units at the right time by combining technological and analytical understanding with medical knowledge.

TRENDS

LABORATORY MEDICINE
Increased automation and use of new and more specialised analytical methods.

TECHNOLOGICAL DEVELOPMENT
Technological developments make it increasingly important that biomedical laboratory scientists possess specialised knowledge in method development and validation.

DIAGNOSTIC PARTNERS
Biomedical laboratory scientists as diagnostic partners can provide guidance and secure quality.

CONSULTANTS
Greater need for biomedical laboratory scientists providing guidance and training in point of care testing and patients' self testing.

MANAGEMENT
More biomedical laboratory scientists are heading clinics.

FLEXIBILITY
Shared instrumentation and changed professional boundaries entails a need for greater flexibility in the tasks of biomedical laboratory scientists.

POINT OF CARE TESTING
Point of care testing and patient's self testing will increase as a supplement but not replace the need for centralised laboratory services.

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APPENDICES

A: Statistics

1 Age distribution of biomedical laboratory scientists in Norway

Table 1: Age distribution of biomedical laboratory scientists in NITO's membership database as at 14.10.2013, by decade.

Age	<25	25-34	35-44	45-54	55-64	>64
Number	141	1 177	1365	1224	1357	123

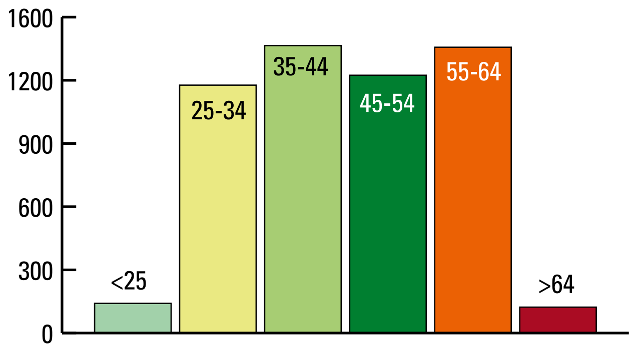

Figure 1: Age distribution of biomedical laboratory scientists in NITO's membership database as at 14.10.2013, by decade

Table 2: Age distribution of biomedical laboratory scientists in NITO's membership database as at 14.10.2013, in detail.

Age	Number	Age	Number	Age	Number	Age	Number	Age	Number
21	2	31	135	41	144	51	133	61	161
22	23	32	150	42	131	52	130	62	136
23	46	33	115	43	135	53	143	63	103
24	70	34	138	44	140	54	141	64	97
25	97	35	137	45	107	55	131	65	56
26	76	36	123	46	129	56	148	66	34
27	104	37	148	47	105	57	137	67	16
28	110	38	144	48	110	58	138	68	10
29	127	39	142	49	121	59	146	69	6
30	125	40	121	50	105	60	160	70	1

NITO the Norwegian Institute of Biomedical Science has 5,387 professionally-active members as of 14.10.2013. The average age is 44.9. Of these members, 90.7 per cent are women.

4,854 biomedical laboratory scientists were employed in the health and social services in Q4 2012. Approximately 90 per cent of them are members of NITO The Norwegian Institute of Biomedical Science.

2 Education statistics

Table 3: Number of recent graduates in biomedical laboratory science from Norwegian educational programmes, 2005–2013, seen in relation to planned capacity per programme.

Year	Planned capacity per programme	Number of graduates	Per cent graduates (based on planned capacity per programme)
2013	264	172	65.2
2012	267	172	64.4
2011	252	190	75.4
2010	262	139	53.1
2009	251	211	84.1
2008	261	203	77.8
2007	239	212	88.7
2006	260	222	85.4
2005	258	198	76.7
Average 2005 – 2013		**191**	**74.5**

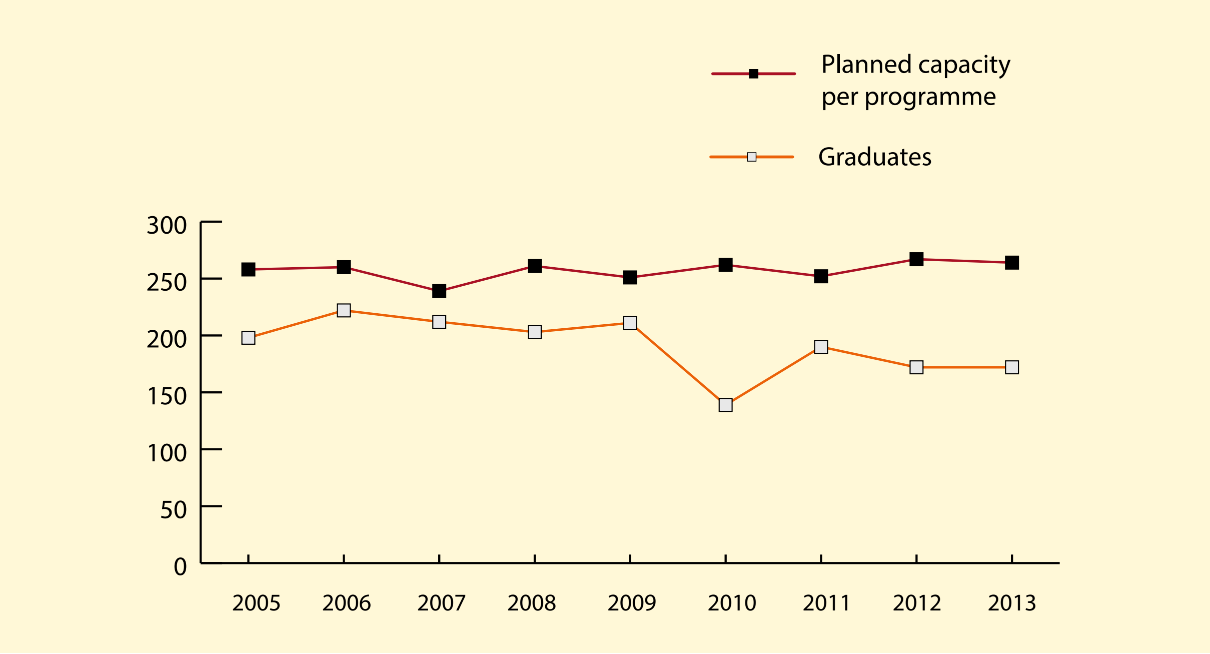

Figure 2: Number of recent graduates in biomedical laboratory science from Norwegian educational programmes, 2005–2013, seen in relation to planned capacity per programme.

3 Authorisation of biomedical laboratory scientists with Norwegian and foreign education

Table 4: Authorisation of biomedical laboratory scientists by country of education. Figures from the annual reports of the Norwegian Registration Authority for Health Personnel. Authorisation numbers from 2007–2009 come directly from the Authority, as annual reports for those years have not been published.

Authorisation year	Norway	Nordic region	EEA	Other countries	Country not given	TOTAL
2012	183	14	3	9	0	209
2011	184	8	4	3	0	219
2010	149	10	9	21	0	189
2009					248	248
2008					220	220
2007					233	233
2006	238	10	2	5	0	255
2005	203	4	0	3	0	210
2004	178	7	5	7	0	197
2003	186	17	2	8	0	213
2002	195	28	1	2	0	226
Total	**1516**	**98**	**26**	**58**	**701**	**2419**
Average	190	12	3	7	234	220
	2002–2006 and 2010–2012				2007–2009	2002–2012

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