Domain-specific reference framework for Pharmacy and Pharmaceutical Sciences (2025)

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1 Introduction Domain-specific reference framework for Pharmacy and Pharmaceutical Sciences

The *"Domain-specific reference framework for Pharmacy and Pharmaceutical Sciences (2025)"* outlines the principles on which university programmes in Pharmacy and Pharmaceutical Sciences in the Netherlands (Table 1) base their curricula. It indicates what can be expected from the content of the programmes, their objectives and developments in society within the pharmaceutical field.

A large number of sources were used in drawing up this reference framework (H7). The "*Domain-specific reference framework for Pharmacy (2016)*" has been explicitly included. However, what is new about the current reference framework is that it not only represents university programmes in Pharmacy, but also includes Pharmaceutical Sciences. The disciplines of Pharmacy and Pharmaceutical Sciences are closely related, and including them together in this reference framework describes the entire field of work. This provides a good picture of the total scope of Pharmacy and Pharmaceutical Sciences. Where possible, an attempt has been made to outline joint developments and, where necessary, to highlight the various unique characteristics. This automatically means that a different, broader view of the field has been taken compared to the *'Domain-specific reference framework for Pharmacy (2016)*'.

The overarching reference framework outlines developments and principles, which will then serve as the basis for a new Pharmacist Competency Framework, in which the final attainment levels and competencies (based, for example, on the CanMEDS model) that future pharmacists must meet will be laid down. Since the Pharmacist Competency Framework actually determines which components are included in the final attainment levels, it was decided not to prioritise or rank the various subjects in this reference framework. Unlike the master's programmes in Pharmacy, there are no legal requirements for the Pharmaceutical Sciences programmes in terms of knowledge and skills, and it is important that programmes are able to respond effectively to rapid developments in the field of pharmaceutical science. A competency framework for Pharmaceutical Sciences can provide clarity regarding the minimum requirements for a possible transfer to a master's programme in Pharmacy, but this should not be at the expense of the aforementioned flexibility. This must be taken into account when drawing up a competency framework for Pharmaceutical Sciences and/or merging it with the competency framework for Pharmacy.

Combined with the great need in society for multidisciplinary pharmaceutical professionals, it is very important that the Pharmacy and Pharmaceutical Sciences programmes offer a curriculum that meets the current needs of society. To serve the Pharmacy and Pharmaceutical Sciences domain, Dutch universities offer five three-year bachelor's programmes, three three-year master's programmes and four two-year research master's programmes (see Table 1). This domain-specific reference framework provides important guidance for the programmes going forward.

The *Domain-Specific Reference Framework for Pharmacy and Pharmaceutical Sciences (2025)* has been established by the universities in the Netherlands that offer programmes in Pharmacy and/or Pharmaceutical Sciences, in consultation with the professional association of Dutch pharmacists, the Royal Dutch Pharmaceutical Society (KNMP). This version replaces the *Domain-Specific Reference Framework for Pharmacy (2016).*

The main task of university programmes (Table 1) is to train pharmaceutical professionals with the right knowledge and skills to enable them to function effectively in the broad field of pharmacy. The term *'pharmaceutical professional'* here refers to someone who has studied Pharmacy. This can be either a pharmacist or a pharmaceutical scientist. Pharmacy programmes are primarily aimed at training academically qualified *pharmacists* who are prepared for professional practice. *Pharmacists*[1234] are legally recognised experts in the field of medicines. The professional practice of *pharmacists* mainly, but not exclusively, encompasses the fields of public pharmacy, hospital pharmacy, industrial pharmacy and healthcare policy in the field of pharmacy. Pharmacists are authorised by law to dispense and prepare medicines. A *pharmaceutical scientist* is a qualified expert in aspects of the science and technology of medical pharmaceutical products. Pharmaceutical Sciences programmes prepare students in particular for a career in scientific (medicinal) research and in pharmaceutical work at policy organisations or companies, although the latter career prospects are also open to *pharmacists.* A more detailed description of the career prospects for *pharmacists* and *pharmaceutical scientists* is provided in Chapter 3 (H3).

Although Pharmacy and Pharmaceutical Sciences are closely related disciplines, an attempt has been made to explain not only the similarities but also the differences between the two. This will be discussed in more detail in the discussion of the specific knowledge domains of the Pharmacy and Pharmaceutical Sciences programmes (see Chapter 2: H2).

1 Wet op de beroepen in de individuele gezondheidszorg (Wet BIG)

2 Geneesmiddelenwet

3 Opiumwet

4 Burgerlijk wetboek, boek 7, Afdeling 5: overeenkomst geneeskundige behandeling

Table 1: Overview of Pharmacy and Pharmaceutical Sciences programmes per university

Programme: **University**	***Bachelor's in Pharmacy***	***Bachelor Pharmaceutical Sciences***	***Master's in Pharmacy***	***Master Pharmaceutical Sciences***
University of Groningen (RUG)	Pharmacy (English*; joint Bachelor's programme in Pharmacy and PS) *Croho 56157*		Pharmacy *Croho 66157*	Medical Pharmaceutical Sciences (English) *Croho 60611*
Utrecht University (UU)	Pharmacy (joint bachelor's programme in Pharmacy and PS) *Croho 56157* College of Pharmaceutical Sciences (combined bachelor's programme in Pharmacy and PS; English) *Croho 56157*		Pharmacy *Croho 66157*	Drug Innovation (English) *Croho 68713*
Leiden University (LEI)	Biopharmaceutical Sciences (BPS; 2 specialisations: BPS or BPS and Pharmacy). *Croho 50207*		Pharmacy *Croho 66157*	Bio-Pharmaceutical Sciences (English) *Croho 60207*
Vrije Universiteit (VU)		Pharmaceutical Sciences *Croho 56989*		Drug Discovery Sciences (English) *Croho 66989*

CROHO; Central Register of Higher Education Programmes. PS: Pharmaceutical Sciences; BPS: Bio-Pharmaceutical Sciences.
*Currently still in English, but from the 2025-2026 academic year, Dutch will be reintroduced as the language of instruction.

In this *Domain-Specific Reference Framework for Pharmacy and Pharmaceutical Sciences,* the following topics will be discussed in succession:

- H1. Introduction to the Domain-Specific Reference Framework for Pharmacy and Pharmaceutical Sciences
- H2. Knowledge domains:
    - H2.1 The knowledge domains for the Bachelor's programmes in Pharmacy and Pharmaceutical Sciences and the joint, overlapping areas
    - H2.2 The knowledge domains specific to the master's programmes in Pharmaceutical Sciences
    - H2.3 The knowledge domains specific to the Master's programmes in Pharmacy
- H3. Current developments in Pharmacy and Pharmaceutical Sciences
- H4. Career prospects for aspiring pharmaceutical scientists and pharmacists
- H5. International benchmarking
- H6. Summary

2 Areas of knowledge

2.1 General introduction

The Pharmacy and Pharmaceutical Sciences programmes cover broad areas of knowledge and are highly multidisciplinary in nature. The bachelor's programmes lay a broad foundation of fundamental scientific knowledge in biology, chemistry, mathematics and physics, with a focus on medicines and their interaction with the body. The Bachelor's programmes are designed to expose students to all aspects of pharmacy and/or pharmaceutical sciences and to provide sufficient insight into professional aspects to enable students to make an informed choice for a follow-up Master's programme. Depending on the Master's programme chosen, students can further develop into *pharmacists* and/or *pharmaceutical scientists*.

The three chapters below discuss the knowledge domains for Dutch university programmes in Pharmacy and Pharmaceutical Sciences in more detail:

- H2.1 Knowledge domain of bachelor's programmes in Pharmacy and Pharmaceutical Sciences
- H2.2 Knowledge domain of master's programmes in Pharmacy
- H2.3 Knowledge domain of master's programmes in Pharmaceutical Sciences

The knowledge domains described are based on the current Pharmacy Competency Framework (2016) for Pharmacy and the current curriculum for Pharmaceutical Sciences programmes. For bachelor's and master's programmes in Pharmacy, the knowledge domains are also based on the European guidelines for these programmes (Delegated Directive (EU) 2024/782).

For this domain-specific reference framework, five main pillars have been defined that recur in all the knowledge domains mentioned above (H2.1 – H2.3). These main pillars indicate that all Pharmacy and Pharmaceutical Sciences programmes contain these components to a greater or lesser extent. The extent to which a pillar is present highlights the similarities and differences between pharmacy and pharmaceutical sciences. The pillars also serve to provide a clear overview of the knowledge domains. The five main pillars are shown in the figure below, with the pillar 'Research and innovation' indicated as a cross-cutting pillar, as the aspect 'Research and innovation' can be applied to all four other pillars:

- **Body**: Knowledge of the human body in relation to disease and health belongs to the pharmaceutical knowledge domain and mainly concerns knowledge of anatomy, physiology and pathophysiology.
- **Medicinal product:** The pharmaceutical knowledge domain encompasses knowledge of medicinal products in the broadest sense of the term, both inside and outside the human body. Knowledge of medicines includes the physical/chemical characteristics of the product, as well as characteristics relating to storage and use, the development, production and quality control of medicines and control relating to biopharmaceutical properties, such as bioavailability and absorption. In addition, the domain also includes knowledge and understanding of the effects of medicinal products in the human body and the resulting application of the medicinal product.
- **Research and innovation:** Pharmaceutical research, ranging from fundamental (preclinical) and clinical research, encompasses a wide range of activities aimed at the discovery, development, evaluation and regulation of new medicines and therapies. The aim is to develop safe and effective medicinal products that can contribute to human health and well-being.

- **Professional development:** The acquisition of knowledge, insight, (academic) skills and professional behaviour at an academic level. These qualities are generally applicable for a successful career in the pharmaceutical field and beyond.
- **Patient and society:** This pillar encompasses communication with the patient and patient characteristics (such as wishes, genetic predisposition and behaviour) that determine the choice of pharmacotherapy, as well as pharmacy policy at the societal level and/or the societal role of drug research.

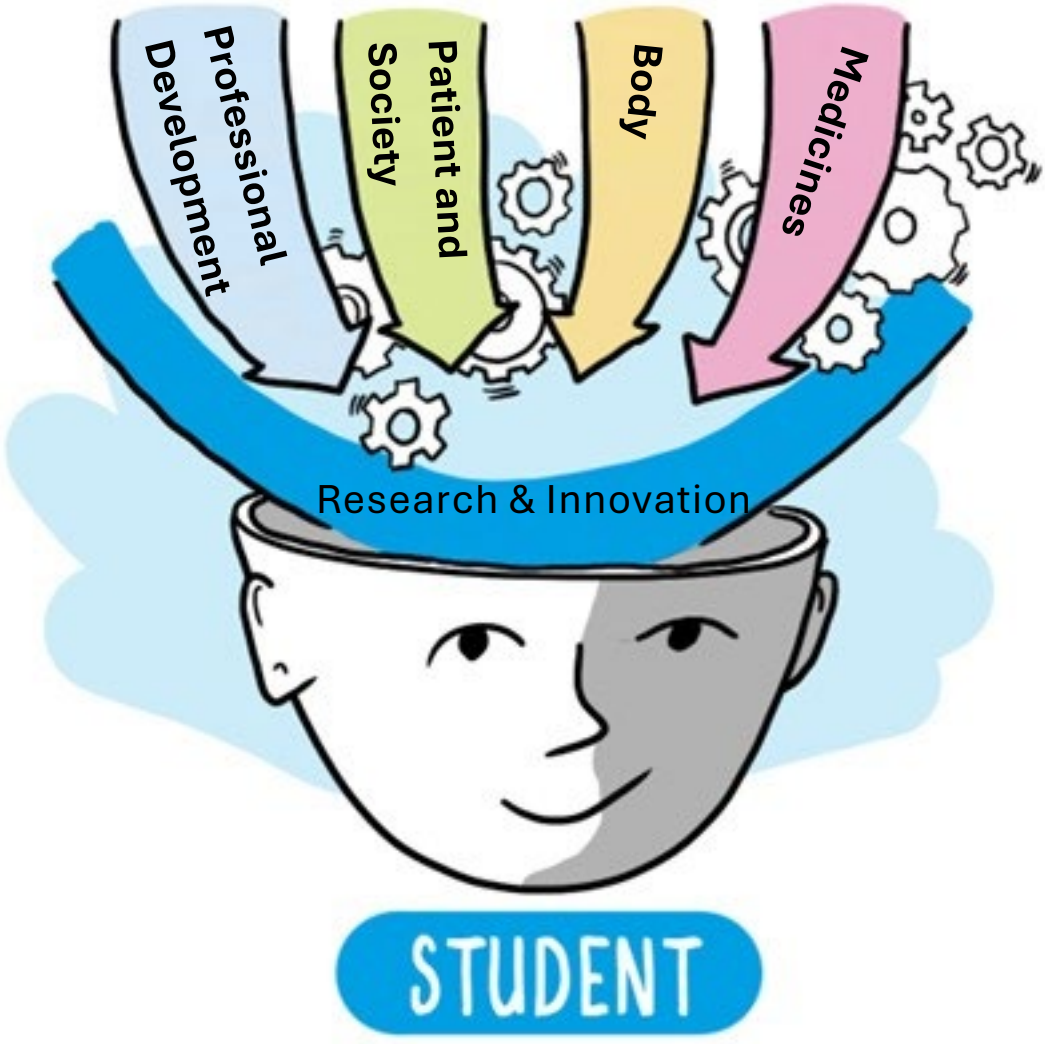


Figure 1*: Illustrative representation of the five main pillars (1) Medicines, (2) Body, (3) Patient and Society, (4) Professional Development, and (5) Research and Innovation. These five main pillars are discussed separately and in more detail in the knowledge domains for Pharmacy and Pharmaceutical Sciences.*

2.2 Knowledge domain of bachelor's programmes in Pharmacy and Pharmaceutical Sciences

This chapter describes the knowledge domain of the Bachelor's programmes in Pharmacy and Pharmaceutical Sciences. These knowledge domains are discussed together because of the significant overlap between the two types of programmes. The current Bachelor's programmes in Pharmacy at the University of Groningen and Utrecht University are actually combined programmes in Pharmacy and Pharmaceutical Sciences, which can give access to both a Master's programme in Pharmacy and a Master's programme in Pharmaceutical Sciences. At Leiden University, students of the Bio-Pharmaceutical Sciences programme with a specialisation in Pharmacy as part of the programme's free elective component, can gain access to the Master's programme in Pharmacy. Table 2 lists the main knowledge areas and associated sub-knowledge areas of the programmes for the Dutch university Bachelor's programmes in Pharmacy and Pharmaceutical Sciences (PS). For each area of knowledge, the main pillar(s) (described in H2 – Knowledge domains – General introduction) to which the area of knowledge belongs is indicated.

Table 2 shows that there are many similarities between the bachelor's programmes, but that there are also (subtle) differences. The bachelor's programmes in Pharmaceutical Sciences at LEI and VU focus primarily on research, including the discovery of new and safer medicines, drug development and modelling the interaction between drugs and receptors and the behaviour and effect of drugs in the body. The bachelor's programmes in Pharmacy at UU focus more on pharmacotherapy, product care and communication with patients. These are also important aspects of the bachelor's programme in Pharmacy at the RUG, in addition to subjects related to pharmaceutical research.

As proof of their competence, students complete a bachelor's research project in the final part of the bachelor's programme. In the bachelor's programmes in Pharmacy at the University of Groningen and Utrecht University, students can choose between experimental research (in the laboratory) or a literature study. At LEI, students can choose from:

1) project research (computational and/or experimental research), which must be concluded with a report in the form of a scientific article, or
2) the design of new research, which is concluded with a research proposal.

In the Bachelor's programme in College of Pharmaceutical Sciences (CPS) at Utrecht University and the Bachelor's programme in Pharmaceutical Sciences at VU Amsterdam, all students conduct experimental and/or computational research.

Table 2: Knowledge areas of bachelor's programmes in Pharmaceutical Sciences at LEI and VU and bachelor's programmes in Pharmacy at RUG and UU

Main pillar	**Areas of knowledge**	**Sub**-area of knowledge	**BSc. Pharmaceutical Sciences VU**	**BSc. Bio-Pharmaceutical Sciences LEI**		**BSc Pharmacy RUG[a)]**	**BSc Pharmacy UU**	**Bachelor College of Pharmaceutical Sciences UU[b)]**
				Specialisation PS	**Specialisation Pharmacy**			
Body	Biology	Physiology	x	x	x	x	x	x
		Cell biology	x	x	x	x	x	x
		Human anatomy		x	x	x	x	x
		Patho(physio)logy	Elective course	x	x	x	x	x
		Immunology	Elective course	x	x	x	x	x
		Microbiology	Elective course			x	x	
Body and Medicine	Interaction between medicine and the body	(Pharma)genetics	x	x	x	x	x	x
		Pharmacology - pharmacokinetics	x	x	x	x	x	x
		Pharmacology - pharmacodynamics	x	x	x	x	x	x
		Toxicology	x	x	x	x	x	x
		Molecular pharmacology	x	x	x	x	x	x
		Pharmacotherapy[c)]			x	x	x	
		Pharmacogenomics[d)]						
		Pharmacognosy				Elective course	Elective course	
Medicine	Chemistry	Analytical chemistry	x	x	x	x	x	x
		Biochemistry	x	x	x	x	x	x
		Organic chemistry	x	x	x	x	x	x
		Physical chemistry	x	x	x	x	x	x
		Theoretical chemistry	x	x	x			
	Product care	Formulation, preparation and			x	x	x	

		quality criteria for medicines						
Medicines and Research and innovation	Medicine research	Development process	x	x	x	x	x	x
		Development of new medicines	x	x	x	x	x	x
		Developing new forms of administration		x	x	x		x
		(Pharmacological) epidemiology		x	x	x	x	
		Analytical quality control				x	x	
	Computational research skills / computer-aided drug design	(Bio-)informatics	x	x	x			
		Programming	x	x	x			
		Computational modelling and design	x	x	x			
Research and innovation	Mathematics	Statistics	x	x	x	x	x	x
		(Applied) mathematics	x	x	x	x		
	Conducting research	Conducting empirical cycle[e)]	x	x	x	x	x	x
		Written and verbal reporting[f)]	x	x	x	x	x	x
		Experimental skills and working safely in the laboratory	x	x	x	x	x	x
Research and innovation, and Professional development	Critically assessing information	Critically assessing scientific literature	x	x	x	x	x	x
		Critically assess pharmaceutical data and issues			x	x	x	
Professional development	Communication	Effective collaboration	x	x	x	x	x	x
		(Peer) feedback	x	x	x	x	x	x
		Debate	x	x	x	x	x	x
		Patient communication			x	x	x	

	Reflection	Personal development	x	x	x	x	x	x
		Reflection on knowledge/actions/behaviour	x	x	x	x	x	x
	(Study) career insight	(Study) career insight	x	x	x	x	x	x
	Establishing connections with adjacent fields of knowledge[g)]		x	x	x	x	x	x
Patient and society	Society, ethics, history, philosophy	Aware of role in society	Aware of the role of PS in society		Familiar with/aware of the role of pharmacists and pharmaceutical scientists in healthcare and society			

a. For direct access to the Master's programme in Pharmacy (RUG), students must have completed the Bachelor's programme in Pharmacy with the minor in Pharmacy (30 ECTS). Students who have completed the Medical Pharmaceutical Sciences major will receive the Bachelor's degree in Pharmacy but will not have direct access to the Master's programme in Pharmacy. If these students wish to enrol in the Master's programme in Pharmacy, they must first successfully complete the courses in the minor in Pharmacy.

b. The Bachelor's programme in College of Pharmaceutical Sciences (CPS) at Utrecht University has the same Croho label and the same learning outcomes as the Bachelor's programme in Pharmacy at Utrecht University. The differences between the two Bachelor's programmes are that CPS focuses on research into new medicines rather than the treatment of medicines, as is the case with the Bachelor's programme in Pharmacy. The teaching method is also different at CPS, where research-based learning is used (as is customary in other Pharmaceutical Sciences programmes), while the Bachelor's programme in Pharmacy mainly uses case-based learning.

c. To be admitted to the Master's programme in Pharmacy at UU, graduates of the BPS with a specialisation in Pharmacy at LEI must take the following additional courses in pharmacotherapy in a pre-Master's programme: Neurology, Psychopharmacology of the Central Nervous System and Chronic Inflammatory Disorders.

d. Pharmacogenomics is a newly added field of knowledge in the recently updated DELEGATED DIRECTIVE (EU) 2024/782. Pharmacogenomics is not yet included in any of the bachelor's programmes.

e. Searching for information, Formulating questions, plan and hypothesis, Data collection and analysis, Well-founded conclusion

f. PS VU and LEI in English, Pharmacy RUG in English, Pharmacy UU in Dutch, CPS UU in English

g. Such as chemistry, physics, and biology.

2.3 Knowledge domain Master's in Pharmacy

In the Master's programme in Pharmacy, pharmacists are trained within the existing legal framework defined for pharmacists[5,6,7,8] . After completing their Master's programme, pharmacists often have a direct or indirect role in healthcare.

The knowledge domain in the Master's programme in Pharmacy comprises a combination of knowledge about medicines, the human body, patients and the (healthcare) society. In addition, the future role of pharmacists requires the development of a professional identity. Scientific research also plays an important role in this master's programme, in which students develop competencies relevant to the interpretation and implementation of research in areas relevant to pharmacy.

The Master's programme in Pharmacy builds on the broad interdisciplinary knowledge, skills and attitude in these areas that have been developed during the Bachelor's programme in Pharmacy or other equivalent Bachelor's programmes (see also table 2). Students are challenged to apply the knowledge and skills they have acquired in the clinical field during internships with an appropriate attitude. The Master's programme includes at least 26 weeks of education in the form of clinical placements in the clinical setting of public or hospital pharmacy.
The knowledge, insight (combined understanding) and skills are listed below within the five main pillars (H2.1) of the knowledge domain on which students work during the Master's programme in Pharmacy. These main pillars are translated in the Pharmacist Competency Framework into the competencies for a pharmacist analogous to the CanMEDS model.

2.3.1 Medicines

- In-depth understanding of the structure, function and action of medicines within and outside the human body, including pharmacokinetics, pharmacodynamics, pharmacogenetics and pharmacogenomics.
- In-depth understanding of the main groups of medicines and the pharmacotherapeutic treatment options for the most common conditions.
- Understanding of the biopharmaceutical (un)certainty that medicines will be effective at the site of action after administration.
- Understanding of product characteristics, including development, production, quality control and the influence of packaging materials on medicines.
- Understanding of dosage forms for delivering pharmacologically active substances to the site of action, including complex formulation issues such as those encountered with high molecular weight drugs.
- Awareness of the social impact of medicines, including their sustainability in healthcare.
- Knowledge of medication stock management and ensuring safe medication management processes.

5 Wet hoge onderwijs en wetenschappelijk onderzoek

6 Besluit opleidingseisen apotheker

7 Richtlijn 2005/36/EG betreffende de erkenning van beroepskwalificaties (apothekers)

8 Richtlijn 2001/83/EG tot vaststelling van een communautair wetboek betreffende geneesmiddelen voor menselijk gebruik

2.3.2 Body

- In-depth understanding of the anatomy and physiology that explain the effects of medicines in the body. In addition, in-depth understanding of the pathophysiology of the most common disorders.
- Understanding of the interaction of the human body with drugs and the influence of disease, health, genes and behaviour on these interactions.
- Understanding of the effects of drugs at the patient and societal levels, including knowledge of treatment and care guidelines and scientific evidence for effectiveness, safety and cost-effectiveness.
- Understanding of and skills in the prevention of disease and drug-related problems, such as side effects.
- Skills in optimising pharmacotherapy in the clinical setting, integrating pharmacological knowledge with medical knowledge and taking patient characteristics into account.

2.3.3 Patient and Society

- Understanding of human behaviour in relation to disease and health, including the social determinants that may influence it.
- Understanding how to apply medicines in a practical and feasible way in the treatment of individual patients and at the population level.
- Knowledge of and skills in making patient-centred decisions, taking into account the patient's wishes and preferences.
- Understanding the role of the pharmacist in society, including the relationship with people, nature and the healthcare system. This also includes relevant pharmaceutical and medical legislation.

2.3.4 Professional Development

- Effective communication skills to provide pharmaceutical care to individual patients and at the population level, primarily communication with the patient themselves and other healthcare providers.
- Effective communication skills for communicating research results.
- Insight and skills in responsible, clinically reasoned decision-making, even in situations of uncertainty.
- Skills to collaborate with other healthcare providers, including leadership qualities.
- Understanding of the core values of the pharmacist, insight into one's own actions as a professional and skills in dealing with moral dilemmas.
- Skills to independently explore relevant topics in greater depth and to acquire the necessary skills.
- Understanding how to shape *lifelong learning* and being able to make conscious choices for one's own professional development in a largely self-directed or autonomous manner.

2.3.5 Research and Innovation

- Understanding of the various methodologies used in (pharmaceutical-related) scientific research.
- Skills in defining and substantiating a research question based on theory and recent literature, and designing a research plan.
- Skills in assessing, interpreting and applying literature, research results and other data based on critical thinking skills.
- Skills in research methodology and (bio)statistics within drug research or pharmaceutical practice research.
- Insight into assessing, applying and integrating innovations in pharmacy into practice.

2.4 Knowledge domain of master's programmes in Pharmaceutical Sciences

The various Master's programmes in Pharmaceutical Sciences in the Netherlands (Table 1; H1) prepare students for a career in scientific research and the discovery and development of new, better and safer medicines. These programmes teach students the competencies required to conduct preclinical and/or clinical pharmaceutical scientific research, enabling them to acquire professional skills that are important for the labour market. The programmes cover all pharmaceutical-related fields: from the design and synthesis of medicines, molecular modelling of drugs and their targets, (molecular) pharmacology, pharmaceutical analysis, the availability and safety of drugs, drug formulation, to personalised treatment strategies, pharmacoepidemiology and pharmacoeconomics.

The Master's programmes in Pharmaceutical Sciences build on the broad interdisciplinary knowledge base, skills and scientific attitude acquired during the Bachelor's programme in Pharmaceutical Sciences or other closely related biomedical and/or pharmaceutical-related Bachelor's programmes. Students with a degree from the latter Bachelor's programmes may be subject to additional admission requirements, such as demonstrating relevant pharmaceutical knowledge and research experience, before being admitted to the Master's programmes in Pharmaceutical Sciences (see H5.1).

Each university offering the Pharmaceutical Sciences programme makes its own choices regarding the distribution of compulsory, semi-optional and elective modules, as well as the number and duration of the research projects and the associated thesis. However, a fixed component is a research project, in which the research cycle is completed and the outcome is of such quality that it is potentially publishable in a scientific journal. For this reason, the research project normally comprises at least one semester (30 EC). Pharmaceutical scientists work on global issues, and therefore a good command of the English language, both spoken and written, is essential. For this reason, reporting on the research project in English is a requirement.

It is important for pharmaceutical scientists to have both a broad mastery of general pharmaceutical knowledge and deep domain expertise in one or more areas of pharmaceutical knowledge. Students can develop into 'T-shaped' professionals with a combination of breadth and one very deep area of expertise, 'Pi-shaped' professionals who combine breadth with multiple deep areas of expertise, or versatile 'Key-shaped' professionals with a very broad knowledge base combined with multiple slightly less deep specialisations. The pharmaceutical field needs a mix of these profiles to meet the diverse challenges of modern pharmaceutical (drug) research. In addition to broadening and deepening their knowledge in the pharmaceutical domain, students of Pharmaceutical Sciences can also choose to obtain a teaching qualification so that they can teach chemistry at secondary and high schools.

The development of the various types of pharmaceutical professionals is ensured during the Master's programmes in Pharmaceutical Sciences by the aforementioned structure of the curriculum, which offers students freedom of choice and various opportunities for differentiation. The courses, taught by university lecturers, professors, leading scientists and other experts in the pharmaceutical field, provide an overview of the latest developments and challenges in drug research and stimulate critical thinking and problem-solving skills among students. Furthermore, students develop in-depth specialist knowledge and practical skills by carrying out current pharmaceutical research projects.

In addition to acquiring professional knowledge and academic skills, such as writing and presenting, reflection and insight by students into their own interests and motivations, combined with knowledge of

the labour market, are important aspects. This enables students to develop a professional attitude and learn to make independent choices, to continue to develop during and after their studies, and to keep abreast of new developments in their field.

Below is a brief summary of the knowledge, insight (combined understanding) and skills in the various areas of the knowledge domain that students work on during one of the master's programmes in Pharmaceutical Sciences. The aspects listed below fall under the five main pillars (H2.1) Body and Medicine, Research and Innovation, Professional Development, Patient and Society, which are described in the domain-specific reference framework for the Pharmacy and Pharmaceutical Sciences programmes (H2 – Knowledge Domains – General Introduction).

2.4.1 Body and Medicine

- In-depth understanding of current core concepts and recent developments in one or more specialist pharmaceutical-related fields (see also first paragraph of H4.3).
- Knowledge of the aetiology and pathophysiology of diseases and ability to integrate this knowledge in order to design and develop more effective and safer medicines.

2.4.2 Research and Innovation

- Has knowledge and insight into the drug research cycle and is familiar with the techniques and methods used.
- Is able to assess, interpret and apply literature, research results and other data on the basis of critical thinking skills.
- Can define and substantiate a research question based on theory and recent literature and design a research plan.
- Practical skills in experimental and/or computational research methods to carry out a research plan within a specialised area of drug research.

2.4.3 Professional Development

- Knowledge of and adherence to the principles of responsible scientific behaviour, scientific standards and the regulations applicable to drug research.
- Skills in critical thinking and problem-solving.
- Insight and skills to reflect on one's own actions.
- Skills to work in a research team, including planning activities, taking responsibility and leadership skills such as motivating colleagues.
- Effective oral and written presentation skills in academic English with regard to project work, results achieved, and participation in discussions with both specialists and a wider audience.
- Skills to independently explore relevant topics in greater depth and to acquire the necessary skills.
- Understanding how to shape *lifelong learning* and being able to make conscious choices for one's own professional development in a largely self-directed or autonomous manner.

2.4.4 Patient and society

- Knowledge and understanding of the social role of drug research in order to reflect on and respond to scientific and social challenges.
- The role of the patient and patient characteristics (such as wishes, genetic predisposition and behaviour) that determine the choice and dosage of medicines.

3 Current developments in Pharmacy and Pharmaceutical Sciences

Because the field of Pharmacy and Pharmaceutical Sciences is dynamic and constantly evolving, it is important to identify recent and future trends and developments in the field. There are also societal developments for which programmes can or must prepare future professionals. This chapter provides an overview of trends in the field and society that are relevant to pharmaceutical professionals. The trends identified are based on numerous vision documents from all relevant stakeholders (see the literature list H7 for an overview). It is not possible to provide a complete picture of all trends, as new developments are constantly emerging. The trends are divided into different areas in which they manifest themselves. These are areas that are relevant to the professional field or within the bachelor's and master's programmes. These areas are (in no particular order): (i) Drug development, production and expertise, (ii) Education, (iii) Pharmaceutical patient care – population, and (iv) Pharmaceutical patient care – individual. A number of trends recur in (almost) all areas; these are referred to as 'general trends'. It should be emphasised that this overview does not indicate any prioritisation of trends and developments.

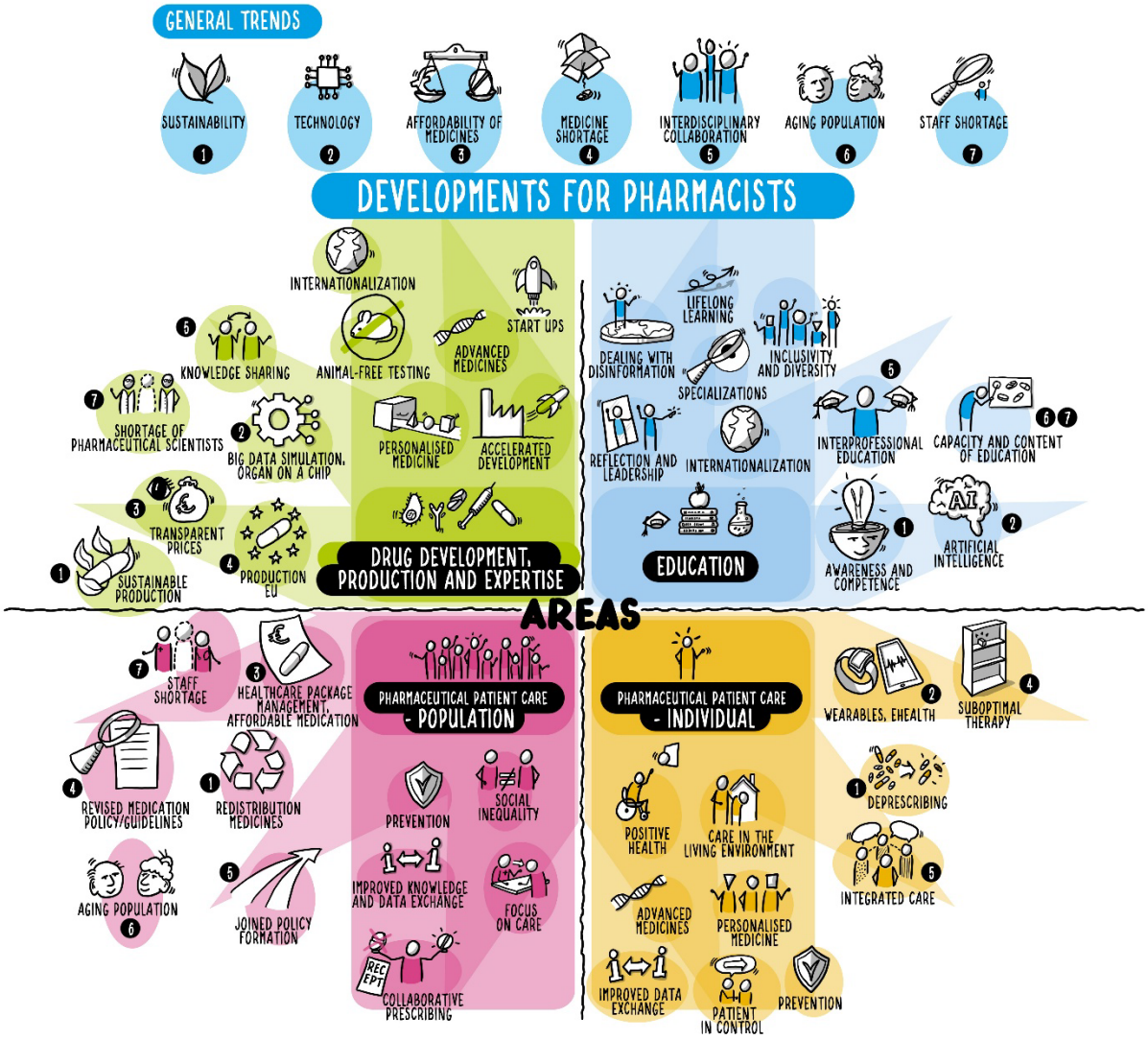


Figure 2: Illustrative overview of recent and future trends and developments within the pharmaceutical domain.

Pharmaceutical Sciences focuses primarily on the areas of Drug Development, Production and Expertise, and Education, while Pharmacy encompasses all four areas. The general developments are reflected in several areas, in a manner specific to each area. These general developments are marked with a number corresponding to the relevant general development. The overview with accompanying text is not exhaustive, but is primarily intended for illustrative purposes.

3.1 Drug development, production and expertise

3.1.1 General developments for Drug development, production and expertise

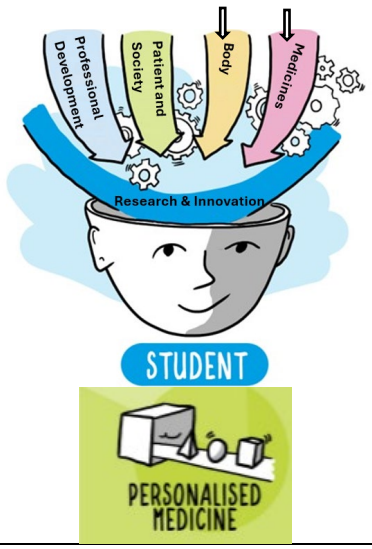
- **Sustainability (1) – Sustainable production**: Sustainable production of medicines covers the entire life cycle of a drug: from design and manufacture to use and final disposal. The further development of 'green chemistry', with chemical products and processes that minimise environmental impact, plays

an important role in this. For example, biodegradable pharmaceuticals are being designed and substances are being produced using synthetic biology.

- **Technology (2) – Big data, simulations, organ-on-a-chip:** Various *'omics' technologies* make it possible to obtain large amounts of molecular data (big data) at patient and population level. This data is generated from clinical studies and epidemiological studies (such as genome-wide association studies). AI can be used to interpret the data. All in all, this accelerates the identification of new targets in the body for pharmaceuticals. Simulations with computer models and the use of 'organ-on-a-chip', miniature models of human organs, make it possible to test large quantities of new medicines efficiently.
- **Affordability** of **medicines (3) – Transparent pricing:** New medicines, or medicines with a new application, often come with a hefty price tag. Society increasingly demands insight into the financing required for the development and production of medicines in order to limit healthcare costs. This also requires a critical look at the profits of the pharmaceutical industry.
- **Medicine shortages (4) – Production in the EU (European Union)**: The availability of existing medicines is regularly under pressure because there is only one or a few (foreign) suppliers. Increasing production in the EU of both raw materials and medicines will reduce dependence on a limited number of suppliers outside the EU.
- **Interdisciplinary cooperation (5) – Knowledge sharing:** The discovery and development of new medicines is a long and complex process. It requires close cooperation between a wide range of specialists, including, for example, fundamental researchers, bioinformaticians, computer programmers, clinicians, epidemiologists and registration specialists. Interdisciplinary cooperation is stimulated by ever-increasing knowledge and data sharing (‘open science’), whereby research methods, data and results are published and made available to everyone.
- **Staff shortages (7) – Shortage of pharmaceutical scientists:** While Pharmacy programmes in the Netherlands train students to become pharmacists who will mainly work in the Netherlands, English-language master's programmes in Pharmaceutical Sciences are more international. It is important to retain pharmaceutical scientists who graduate in the Netherlands, so that there is no shortage of pharmaceutical scientists. Some pharmaceutical companies are already dependent on foreign workers, and the demand for pharmaceutical scientists is expected to grow in the coming years.

3.1.2 Specific developments in drug development, products and expertise

- **Internationalisation:** Expertise in fundamental research is by definition not bound by national borders. Certainly for a relatively small country such as the Netherlands, it is important that Dutch researchers seek cooperation with researchers abroad, for example for access to certain new technologies. It is also essential that the Netherlands maintains a good business climate in order to attract talent from abroad.
- **Advanced medicines:** The number of registered advanced medicines has increased and this development will continue in the coming years. Advanced medicines include *biologicals* (such as monoclonal antibodies), *advanced therapy medicinal products (*such as CRISPR-Cas technology) or cells (such as stem cell therapy) and *nanomedicine* (such as liposomes). It is therefore important to have expertise in the field of (the development of new) advanced medicines.
- **Personalised medicine:** Personalised medicine (of which precision medicine is a part) make pharmacotherapeutic treatments more effective by taking into account specific biological and genetic factors of the patient, including gender differences. In contrast to precision medicine, personalised medicine also takes into account the patient's living environment and lifestyle. Technological developments such as 3D printing of medicines, proteogenomics and machine learning will accelerate the development of personalised medicines.

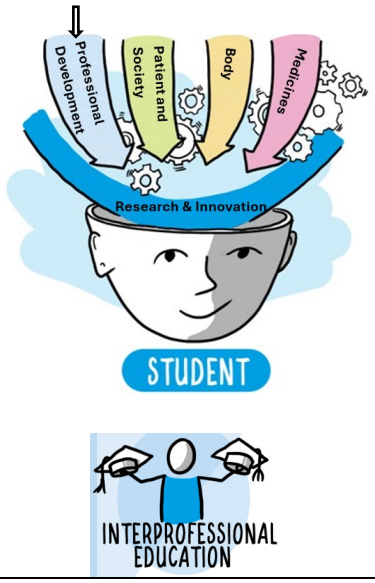
How does this trend relate to the knowledge domains? *An illustrative example* *Bas is studying Pharmaceutical Sciences. During his bachelor's programme, he acquired a solid foundation of knowledge about the human body and the dynamics and kinetics of medicines. In his master's programme, he is now building on this knowledge by delving deeper into personalised medicine. All his knowledge of biological and genetic factors comes in handy here. His ambition is to work for a start-up that 3D prints medicines.*	

- **Reduction in animal testing:** There is a transition underway towards alternatives that reduce animal testing for the development and testing of the effectiveness and safety of medicines. These include patient-specific cell lines, computer simulations and organ-on-a-chip.
- **Start-ups:** In the coming years, the government wants to take steps to further improve the Dutch start-up business climate and the subsequent scale-up. This offers opportunities for knowledge-intensive start-ups that combine fundamental knowledge from, for example, universities with research, development and production. These start-ups develop products or offer services for, among others, the healthcare and pharmaceutical industries.
- **Accelerated development and access to medicines:** Technological developments, including improved preclinical models and computer models, will accelerate the development of new medicines. In addition, development will be accelerated through collaboration between public and private organisations. This collaboration takes place through 'open science' (the sharing of knowledge and data). Accelerated approval and access to new medicines can be achieved by better predicting the safety and effectiveness of new medicines with AI, the involvement of regulatory authorities (FDA, EMA) already during the conduct of clinical trials, and adaptive licensing.

3.2 Education

3.2.1 General developments in education

- **Sustainability (1) – Awareness and competence**: 7% of the Dutch CO_2footprint comes from healthcare, of which chemical products such as medicines account for approximately 40% [FTK]. We need to educate a new generation of students who are aware of the impact of medicines (and research into medicines) on the environment and who also have the knowledge and skills to reduce this footprint. Students will need to learn how to use medicines effectively to prevent waste.
- **Technology (2) – Artificial Intelligence**: Students need education to learn about the possibilities, opportunities and risks of AI. For example, they need to form a picture of where AI can and cannot be used, how to assess the value of advice generated by AI and how AI can make the various stages of drug research more effective. In addition, current education needs to be adapted so that AI is a valuable addition, a tool in the acquisition of competences, and not a replacement for them.
- **Interdisciplinary collaboration (5) – Interprofessional training:** Pharmaceutical research requires different professional expertise and it is important to be able to work together in interdisciplinary research teams. For safe patient care, it is also important that multiple healthcare professionals work together seamlessly. Students need to work together with students from other programmes during their studies in order to get to know each other and also to learn about themselves in relation to others.

How does this trend relate to the knowledge domains? *An illustrative example* *Until the start of her master's programme, Karin was not sure what she wanted to do after her studies, but she knew she wanted to work with patients. During her clinical rotations in the hospital, she noticed that she could apply her knowledge and skills in an interprofessional setting. She was able to explain her questions and points of view to the doctor in training with a professional attitude, which enabled them to jointly determine the best treatment for the patient. The joint education with medicine that she followed prior to her internship has increased her ability to work with other healthcare providers and helps her to take on her professional role in the hospital.*	

- **Ageing population ↔ Staff shortages – Capacity and content of the programme**: Approximately 20% of the population in 2023 was aged 65 or older, and this number is expected to continue to rise [CBS]. The ageing population is leading to an increasing number of patients with complex conditions and polypharmacy. In Pharmacy and Pharmaceutical Sciences programmes, extra attention is therefore needed for the physiology and mechanisms in older patients who are taking multiple medications

simultaneously. In addition, there is an increasing number of older lecturers, which may lead to staff shortages in the long term.

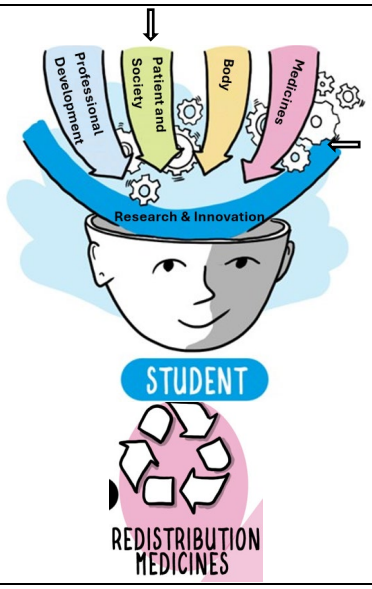
3.2.2 Specific developments within education

- **Inclusivity and diversity**: Multicultural, LGBTIQIA+, neurodiversity: everyone is different. Students need knowledge and skills to communicate effectively with others, to create a socially safe environment and to make the most of everyone's talents. In addition, the diversity of students requires inclusive education that meets individual study needs. In clinical research, too, specific attention is paid to the inclusion of diverse groups of patients.
- **Internationalisation**: The number of foreign university students and students with a migrant background has increased significantly in recent years. This requires increasing attention in education to the proper use of the English and Dutch languages and cultural diversity. Approximately one third of foreign students go on to work in the Netherlands, which is beneficial given the shortage of qualified pharmacists. In addition, lecturers with an international background enrich the education and, thanks to increasing cooperation with international institutions, students can more easily complete part of their education, research project or internship abroad.
- **Lifelong learning**: Graduates continue to develop throughout their lives through, among other things, feedback and reflection on practical experience, further training, peer-to-peer learning and keeping up with professional literature. Refresher courses are offered by universities, but also by a large number of commercial providers. Education is self-regulating. Subject matter experts at universities continue to develop and innovate through mutual knowledge exchange within and between educational institutions and provide evidence-informed education.
- **Dealing with disinformation**: The amount of non-peer-reviewed, unreliable information has increased, partly due to social media platforms. It is therefore necessary for students to acquire the knowledge and skills that enable them to assess the value of the large amount and diversity of information, separate correct information from disinformation and deal professionally with others who express disinformation.
- **Specialisations**: After completing their pharmacy training, most pharmacists specialise as community pharmacists or hospital pharmacists through targeted further training. Further specialisation through additional postgraduate training is becoming increasingly common, for example with a focus on a common chronic disease.
- **Reflection and leadership**: Increasing technological possibilities, accelerating innovation, more advanced medicines and the need for better affordability and sustainability are making drug research and healthcare more complex. To meet these challenges, we need to educate self-aware students who are agile, continue to develop through self-reflection and dare to take the lead. It is therefore important that reflection and leadership skills are an integral part of the programme.

3.3 Pharmaceutical patient care – Population

3.3.1 General developments Pharmaceutical patient care at the population level

- **Sustainability (1) – Reuse of medicines**: Waste is prevented where possible by reissuing expensive medicines. There is also a strong focus on reducing medicine residues in waste water, for example by collecting old medication.

How does this trend relate to the knowledge domains? *An illustrative example* *Quirine is particularly interested in the bigger picture. She excels at maintaining an overview and developing policy. After completing her master's degree, she hopes to work in the field of sustainability. Her master's research focuses on the reuse of medicines, a hot topic. With both her solid background in biochemistry and her knowledge of pharmacoeconomics, she is achieving great results in her research. After this research, she is certain: she first wants to pursue a PhD and later perhaps seek a policy position so that she can realise her ideals.*	

- **Affordability of medicines (3) – Healthcare package management, expensive medicines**: Efforts are being made to improve the management of healthcare packages, particularly for expensive medicines, partly on the basis of proven effectiveness. There is also a call from the policy field to work with more transparent pricing models, as mentioned earlier.
- **Medicine shortages (4) – Review medication policy/guidelines:** The effective use of medicines at population level is being compromised by medicine shortages. These shortages are caused by problems in supply, an increase in demand and economic factors, among other things. As a result, the medication policy in place must be reviewed regularly and guidelines must even be adapted based on the availability of resources.
- **Interdisciplinary cooperation (5) – Joint policy-making**: Extramurally, efforts are being made to develop joint regional policies. These policies are taking shape through the interdisciplinary development of regional profiles and plans that identify care needs and the care available. Intramurally, pharmacists are already part of multidisciplinary teams in consultations as well as in direct patient care. Pharmacists support each other through advanced specialisation, for example by training to become a senior pharmacist.
- **Ageing population (6)** The ageing population will lead to an increase in patients with polypharmacy and an increase in demand for care.
- **Staff shortages (7)**: Staff shortages in pharmacies are a major and growing problem. This is partly caused by the ageing population and partly by an increased outflow of employees. These staff shortages require, among other things, a shift in tasks and the use of smart tools and digitisation.

Furthermore, the self-reliance of patients must be critically examined. The National Healthcare Institute ( ) will also have to change the intake of pharmacists and employees in terms of job profiles, career paths and quantity.

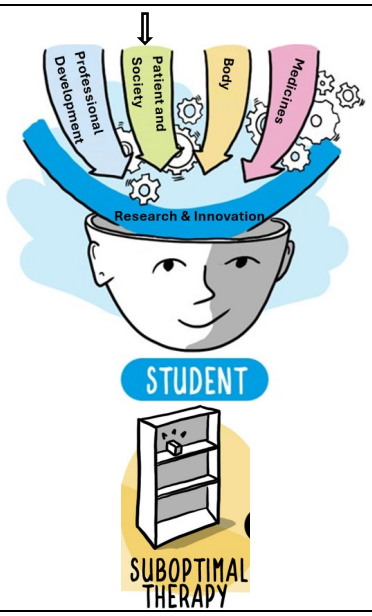
3.3.2 Specific developments in pharmaceutical patient care at the population level

- **Joint prescribing**: The pharmacist will work together or consult with a prescriber to dispense medicines from an open or limited formulary. Pharmacists already do this in practice, for example when converting medicines that are not available. This form of prescribing requires a decision to make use of the BIG Act, Article 36A.
- **Prevention**: The pharmacist's role is not only reactive, but increasingly proactive. Prevention is being promoted in various ways at national and regional level. Insurance companies and local authorities are working together in prevention coalitions to set up prevention activities, such as information campaigns and vaccination programmes. In addition, the use of data-driven technology (big data) helps to monitor lifestyle and enable early diagnosis of conditions.
- **Focus on care**: Pharmacists will take on an increasingly important role in healthcare, for example by providing more and better consultations during pharmacotherapeutic treatment in order to respond to changing care needs in a timely manner. Pharmacists will derive more of their income from proactively providing care than before, which will require a change in the reimbursement system. Care and logistics will be separated more often, for example because pharmacies will open logistics branches.
- **Social inequality**: The ambition is to reduce health inequalities between different socio-economic classes. Efforts are being made to support and strengthen the health skills of the lower socio-economic classes. For example, by making information more accessible and understandable and involving this target group in pilot projects that work on the pillars of positive health in order to motivate behavioural change.
- **Improved knowledge and data exchange**: The trends seen in data exchange are the further roll-out of the medication transfer programme, which also includes the personal health environment (PGO) and the exchange of lab values and the pharmacogenetic profile. In the future, a national register that also records epidemiological data, side effects and value-driven outcomes will be a huge step forward. New technologies, such as big data and blockchain, can make an important contribution to analysing data and identifying trends, and improving the way information is exchanged.

3.4 Pharmaceutical patient care – Individualised

3.4.1 General developments Pharmaceutical patient care at the individual level

- **Sustainability (1) – Deprescribing**: Deprescribing is a trend that has emerged in recent years and is a form of appropriate care in which pharmacists are actively involved in reducing or discontinuing medication when it is no longer necessary or effective. This may lead to more affordable care and a lower impact of healthcare on the environment.
- **Technology (2) – Wearables, eHealth**: Technology such as wearables and eHealth tools offer pharmacists and patients new opportunities to monitor health, track medication use and provide personalised care solutions in the patient's living environment.
- **Medicine shortages (4) – Suboptimal therapy**: Medicine shortages may result in patients receiving suboptimal therapy because existing pharmacotherapy has to be changed to an alternative. Pharmacists have a role to play here in selecting the best possible alternative medication; see also the aforementioned trend 'Delegated prescribing'.

What is the relationship between this trend and the knowledge domains? *An illustrative example* *Yous knows all about it from his part-time job at the pharmacy: drug shortages are the order of the day. During the pharmacy game in his master's programme, he regularly encounters cases where an alternative must be found. With his knowledge of medicines, he can make patient-centred decisions and explain to the simulated patient what is going on and what the possible solutions are. The communication skills he has refined in his master's programme are extremely helpful in finding a solution together with the patient.*	

- **Interdisciplinary collaboration (5) – Integrated care**: Patients with chronic conditions in particular require integrated care from multiple care providers, such as doctors, pharmacists, dieticians, district nurses and physiotherapists. Together with other care providers, the pharmacist forms a network in the region that coordinates the treatment and guidance of the patient, ensuring that they receive appropriate care close to home.

3.4.2 Specific developments in pharmaceutical patient care at the individual level

- **Advanced medicines**: The emergence of advanced medicines, such as cell and gene therapy, is creating new challenges and opportunities for patients and pharmacists, with the need to manage these medicines appropriately at the point of care and to support patients in understanding and using these innovative therapies.
- **The patient as director**: The emergence of the patient as director, as part of appropriate care, emphasises the involvement of patients in their own care, with patients deciding on the best possible treatment together with pharmacists and/or other healthcare providers ('shared decision-making'). Pharmaceutical care is tailored to the patient's needs, for example by using patient-reported treatment outcomes and experiences (PROMs and PREMs).
- **Personalised medicine:** Pharmacists are increasingly able to use patient data, such as genetic information and information from advanced diagnostics, to tailor medicines to individual patients. This increases the effectiveness and safety of treatment.
- **Positive health**: The goal of therapy, including pharmacotherapy, for patients has changed from cure to meaning, quality and participation in society. This so-called 'positive health' is part of appropriate care with the patient as the director.
- **Prevention**: Prevention is becoming a central theme in individual pharmaceutical patient care, with a greater focus on preventing disease by identifying health problems, providing lifestyle advice and preventive medication.
- **Improved knowledge and data exchange**: With improved knowledge and data exchange between healthcare providers, the right information is available at the right time within a reliable health information system. This enables pharmacists to increase the effectiveness, safety and efficiency of the care provided. This exchange also offers more opportunities to promote health.
- **Care in the living environment**: This involves integrating pharmaceutical care into the daily lives and environment of patients as part of appropriate care. Examples include video calls with pharmacists and an information session on fall prevention with pharmacists.

4 Career prospects for aspiring pharmaceutical scientists and pharmacists

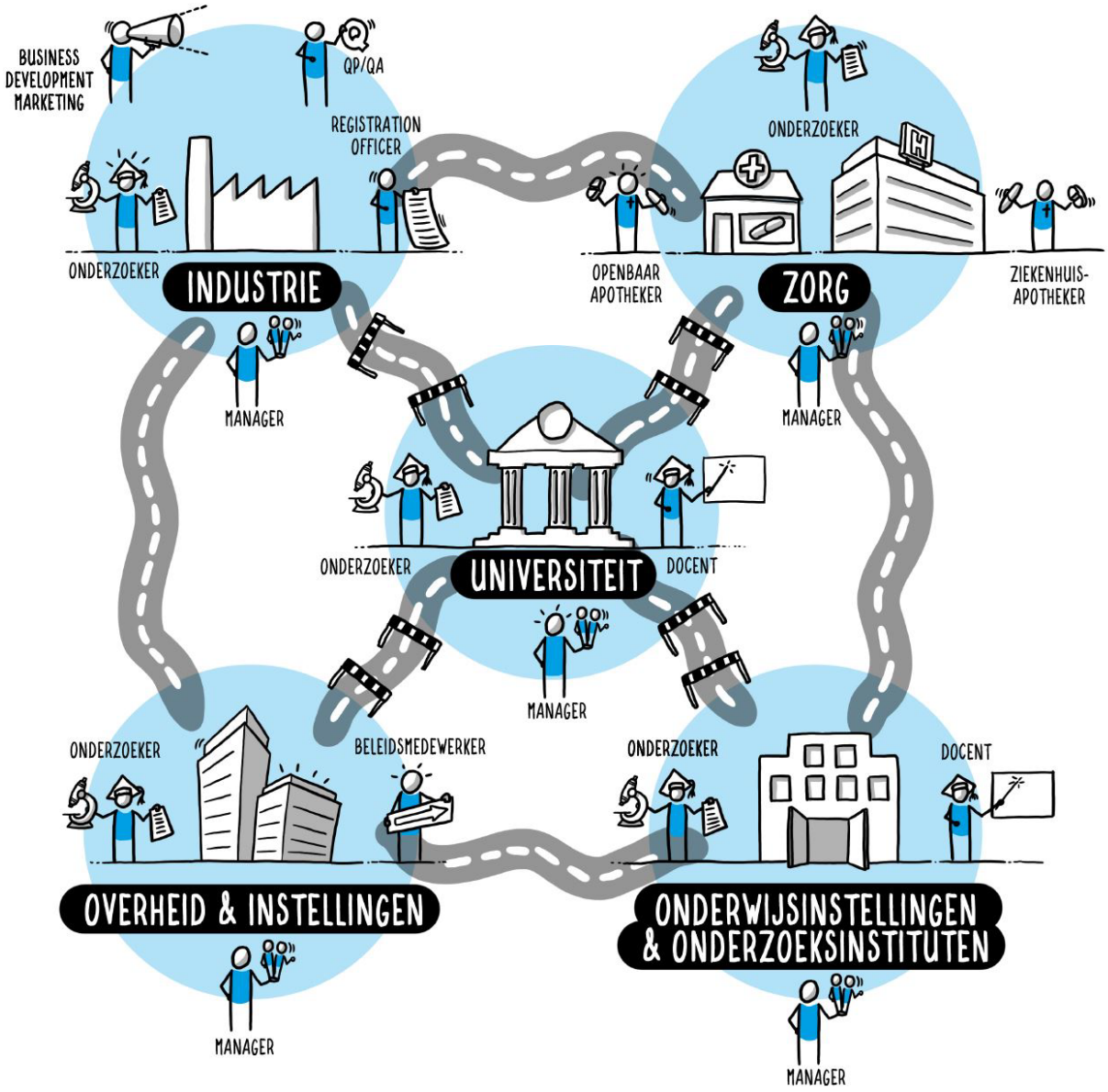


Figure 3: Career prospects for (aspiring) pharmacists and pharmaceutical scientists. A concise visual overview of possible career paths within pharmacy and pharmaceutical sciences. The infographic shows different career paths, with 'hurdles' symbolically indicating the additional training or qualifications required to access specific positions.

The pharmaceutical field offers a wide range of career opportunities in various areas of work. Additional training is often required on the path to these positions. There are still hurdles to overcome, as can be seen in the visualisation above. This text highlights some of the specific roles within the pharmaceutical field and emphasises the opportunities for further development after obtaining a master's degree in Pharmacy or (Bio)Pharmaceutical Sciences.

Once a field of work has been chosen after graduation, there are always opportunities to move into a different field over time. In practice, different fields of work are also combined, for example with a position in both healthcare and academia.

Below you can read which positions are specific to (basic) pharmacists and which positions can be held after completing both the Master's programme in Pharmacy and the Master's programme in (Bio)Pharmaceutical Sciences.

4.1 Industry

With a Master's degree in (Bio)Pharmaceutical Sciences or Pharmacy, there are countless positions available within the industry. A researcher within the industry can conduct applied research in the field of Research & Development. For example, as a medicinal chemist, molecular toxicologist, molecular pharmacologist, biopharmaceutical scientist or bioanalyst. Research can also be conducted outside the laboratory, for example by a computer-aided drug designer. In addition, clinical research is supervised by pharmacists in a role as clinical research associate. Pharmacists can also work in production, where they are responsible for quality control and the release of medicines as a Qualified Person (QP), or in the approval process for new medicines as a registration officer. The term business development and marketing also includes a role in sales. Ultimately, a pharmacist can hold a managerial position within the industry, for example as a medical affairs manager, R&D manager, QA manager or project manager.

4.2 Healthcare

With a master's degree in Pharmacy, there are positions available in healthcare as a pharmacist in primary and secondary care. After completing further training to become a public pharmacist specialist or hospital pharmacist, pharmacists can specialise further in these disciplines. Within the discipline, there is also the possibility of further specialisation, for example as a senior pharmacist or clinical pharmacologist. Pharmacists also conduct practical research within healthcare. Pharmacists in healthcare hold managerial positions in many areas and therefore also have a managerial role. Within healthcare, a master's degree in Pharmaceutical Sciences can lead to a role as a researcher, for example in the field of PK/PD.

4.3 Government and institutions

There are numerous institutions that play a role in the chain from drug development to registration and the final product. Within government institutions, there is a role for pharmaceutical professionals in a wide range of institutions. It is not feasible to provide a complete overview here. Only a few examples are listed below. Within government institutions, pharmaceutical professionals play a role in inspection services such as the IGJ and the NVWA, in knowledge institutes such as the KNMP, Lareb and RIVM, in registration bodies such as the CBG and the EMA, in scientific research funding bodies such as the NWO, and in institutions involved in the reimbursement of medicines such as the NZa, ZN and insurers.

Pharmaceutical professionals play an expert role in all these institutions. For example, as inspectors or healthcare purchasers or as policy officers in the field of medication policy. These institutions conduct research (mainly literature research) and support research in other areas.

4.4 Educational institutions & research institutes

There are roles for pharmaceutical professionals within educational institutions and research institutes. A pharmaceutical professional can take on a role as a teacher in secondary or higher education after obtaining a minor or master's degree in Education. Pharmaceutical professionals work at many different research institutes in the United Kingdom and abroad, for example at the NKI, KNAW institutes such as Hubrecht and the Brain Institute, the Nivel and in centres for drug research.

4.5 University

A pharmacist obtains a master's degree from a university. After that, they can take up a position as a researcher in a PhD programme, a post-doctoral programme or a tenure track programme. Pharmaceutical professionals can develop their career in academia to become a university lecturer or professor. To do so, they must obtain a PhD (and a basic teaching qualification). In addition, it is possible to teach on the pharmacy master's programme as a pharmacist, the practical instructor. Pharmaceutical professionals can also work as managers, mainly in supervisory roles.

5. International benchmarking

The structure of (academic) programmes in the Netherlands must comply with the agreements established within the European Union (EU). All (vocational) programmes in European higher education, including Pharmacy and Pharmaceutical Sciences, are subject to the principle of 'free movement' for graduates. This means that all students with a bachelor's degree obtained in a country that is part of the European Economic Area (EEA: all EU countries plus Liechtenstein, Norway and Iceland) are subject to the same entry requirements with regard to the required knowledge and skills. In an effort to achieve an equivalent level of education in the various countries in Europe, the Dublin descriptors [Ministry of Science, Technology and Innovation Denmark, 2005] and the European Qualifications Framework (EQF) for lifelong learning [European Commission, 2008] have been established. These set out generic requirements that European university programmes must meet. The alignment of the qualification framework used in the Netherlands (NLQF) with the qualification levels of the EQF has been enshrined in Dutch law since April 2024 [Nationaal coördinatiepunt NLQF, 2024]. Specifically for pharmacist training, the European Directives include requirements for subjects that must be included in the study programme for pharmacists. In March 2024, this European legislation was updated with additional training requirements that were not yet included in the 2005 directive and the previous reference framework (see list of required subjects) [European Commission, 2024]. Dutch legislation regarding the training requirements for pharmacists must comply with these European requirements. For the Dutch situation, recommendations will be formulated by the field based on the updated competency frameworks for the programmes. The chapters on the knowledge domains describe in more detail what is covered during the bachelor's and master's programmes.

List of required subjects in the pharmacist training programme according to European legislation [European Commission, 2024]	
• Plant and animal biology • Physics • General and inorganic chemistry • Organic chemistry • Analytical chemistry • Pharmaceutical chemistry, including analysis of medicines • General and applied biochemistry (medical) • Microbiology • Pharmaceutical technology • Biopharmaceutical technology • Toxicology • Pharmacognosy	• Anatomy, physiology, pathology and pathophysiology; medical terminology • Pharmacology and pharmacotherapy • Legislation and, where appropriate, professional ethics • Genetics and pharmacogenomics • Immunology • Clinical pharmacy • Pharmaceutical care • Social pharmacy • Public health, including epidemiology • Pharmaceutical practice • Pharmacoeconomics

5.1 International benchmarking of master's programmes in Pharmacy

In order to assess whether Dutch pharmacy education is in line with international frameworks, reference bodies worldwide were examined. An important international reference body is the European Association of Faculties of Pharmacy (EAFP). In 2018, a report was drawn up sharing the vision on pharmacy education. It defines four pillars for education that the EAFP considers relevant for contemporary and future pharmacy:

- Maintaining a balance between science and practice, translating science into practical applications;
- Teaching methods must offer opportunities for experience-based learning;
- Students must be prepared to take on a role within an interdisciplinary team;
- Students must be prepared for lifelong learning and to embrace innovation.

Another important international reference body for pharmacy education is the International Pharmaceutical Federation (FIP), with its education sub-division called FIP Education initiative (FIPEd). In 2017, the Nanjing Statement was drawn up [International Pharmaceutical Federation, 2017], describing how pharmaceutical education can contribute to the pursuit of a global professional standard. This document lists 67 statements that reflect international expectations of what an effective pharmaceutical education system for Pharmacy and Pharmaceutical Sciences should look like in order to meet local needs. These statements are grouped into the following eight clusters: shared global vision, mix of professional skills, student recruitment, basic education and leadership, experience-based education, resources and academic staff, quality assurance and continuing professional development. In addition, in 2020, the FIPed defined a second version of a global competency profile for newly graduated pharmacists [International Pharmaceutical Federation, 2020]. The competencies are grouped into the following domains: pharmaceutical public health, pharmaceutical care, organisation & management, and professional/personal development. In 2024, the FIP also published a handbook for improving academic capacity in pharmacy and pharmaceutical sciences [International Pharmaceutical Federation, 2024]. This handbook focuses on professional development, partnerships, diversity, quality assurance, digitisation and innovations in educational programmes. It offers practical tools and strategies for educational institutions worldwide.

In the report 'Educational Outcomes' (2022) by the Centre for the Advancement of Pharmacy Education (CAPE), the American Association of Colleges of Pharmacy mentions developments compared to the previous version from 2013. New in this version is that it not only looks at educational outcomes in terms of knowledge, skills and attitude, but also at actions performed under the supervision of a pharmacist, known as EPAs (*Entrustable Professional Activities)*. Developments described in this report that offer opportunities for further growth in the master's programme include the pursuit of equal health skills, cultural sensitivity, technological developments and interprofessional education [American Association of colleges of pharmacy, 2022].

The Australian report 'Pharmacy learning domains for Pharmacy programmes' (2020) by the Australian Pharmacy Council Ltd. describes the learning domains for Pharmacy programmes in Australia [Australian Pharmacy Council, 2023]. These are defined as:

- The healthcare consumer
- Medicines: mechanism of action
- Medicines: the active ingredient
- Medicines: the medicine
- Healthcare, the broader context

In several countries, pharmacists have prescribing powers. Legislation has been implemented in these countries to enable so-called *non-medical prescribing*. In the United Kingdom (UK), for example, there is the *' independent prescribing* pharmacist', a pharmacist who is responsible and accountable for assessing

patients with undiagnosed or diagnosed conditions and for decisions about the required treatment, including prescribing [Royal Pharmaceutical Society, 2021]. In the UK, independent prescribing pharmacists can manage any clinical condition and prescribe any medicine within their clinical competence. To date, pharmacists have had to undergo additional training for this. From September 2026, all newly qualified pharmacists in the UK will be authorised to prescribe independently after registration. In other countries, independent prescribing by pharmacists may be restricted to a specific list of authorised medicines or conditions. Another example of a model for prescribing by pharmacists is *collaborative prescribing,* where prescribing takes place within the framework of a partnership with one or more doctors or by a multidisciplinary team, as in New Zealand [Pharmacy council Te Pou Whakamana Kaimatu O Aotearoa]. In Canada [Canadian Pharmacists Association, 2023] and the United States [Adams, 2023], powers vary from state to state. In some countries, the administration of vaccines also falls within the remit of pharmacists, for which training is provided in their education programmes. The role of the pharmacist as an (independent) prescriber seems to be limited to Anglo-Saxon countries so far, but the debate on these powers is ongoing in several countries, including the Netherlands [Kempen, 2024].

This overview shows that there are clear European guidelines for pharmacist training, which are met by Dutch master's programmes in Pharmacy. The structure of Dutch Pharmacy programmes is well aligned with the international competency framework. One important difference is the duration of the programme: six years in the Netherlands, compared to five years elsewhere in Europe. The longer duration of the Dutch programme is due to the extra attention paid to science in the form of a research internship (see below for information about the quality of the research).

The developments described worldwide to ensure that education meets the needs of contemporary and future pharmacy are also recognised and acknowledged in the Netherlands and have been incorporated into this reference framework.

5.2 International benchmarking of Master's programmes in Pharmaceutical Sciences

The Master's programmes in Pharmaceutical Sciences are research-oriented programmes. There are no formal, statutory international frameworks for training as a pharmaceutical scientist.

Since March 2015, the FIP has used the following definition of a pharmaceutical scientist: "*A pharmaceutical scientist is a qualified expert in aspects of the science and technology of medical products. This includes, but is not limited to, the discovery, development, production, regulation and use of medical products. This includes how medicines work, how safe and effective products are brought to market, their impact on the body and their effect on the prevention and treatment of diseases*." [International Pharmaceutical Federation, 2015] The Nanjing Statement on Pharmacy and Pharmaceutical Sciences Education [International Pharmaceutical Federation, 2017], drawn up in 2017 , focuses primarily on the training of pharmacists, but also provides some guidance for the training of pharmaceutical scientists. The statement emphasises that 'there *is a common scientific basis for both pharmacists and pharmaceutical scientists, but that the context for learning and teaching is different*'. 'Research-based learning' and active

participation in research projects are central to all master's programmes in Pharmaceutical Sciences in the United Kingdom and abroad.

Important aspects for the international benchmarking of research master's programmes in Pharmaceutical Sciences are:

- **Curriculum structure and duration of the programme.** This includes the balance between theoretical education and practical research components, alignment with innovation in research and current trends in the industry, and career preparation.
- **Research opportunities and facilities.** This concerns students' access to state-of-the-art laboratories, research equipment and technologies, opportunities for students to participate in groundbreaking research projects and collaboration with industry, hospitals and other research institutions.
- **International Perspective.** This includes, for example, the possibility of studying (parts of) the programme abroad and the international learning environment.

The duration of Pharmaceutical Sciences programmes varies internationally from one to three years. In the Netherlands, all research master's programmes in Pharmaceutical Sciences have a standard duration of two years. The programmes usually consist of a relatively small fixed course component and a larger research component, in which students participate in an ongoing research project. The programmes are offered at leading research institutes. These are the Leiden Academic Centre for Drug Research (LACDR, Leiden University), Utrecht Institute for Pharmaceutical Sciences (UIPS, Utrecht University), Groningen Research Institute of Pharmacy (GRIP, University of Groningen) and Amsterdam Institute of Molecular and Life Sciences (AIMMS, VU Amsterdam). Researchers from the institutes are closely involved in teaching and supervising students' research projects.

Pharmaceutical research at the institutes offering Master's programmes in Pharmaceutical Sciences in the Netherlands is highly regarded worldwide. The QS World University Ranking for the field of 'Pharmacy & Pharmacology' is a benchmark for, among other things, academic reputation, student/staff ratio, international research network and citations in this field. Leiden University, Utrecht University and the University of Groningen have been ranked in the top 50 worldwide for many years, while VU Amsterdam is ranked between 101 and 150. The research facilities at the four institutes are state-of-the-art.

Master's programmes in Pharmaceutical Sciences, both in the Netherlands and abroad, offer opportunities to carry out research projects at academic institutions and/or in the pharmaceutical industry. A major advantage of Dutch programmes is that they are located on or near (bio)science campuses (Leiden Bio Science Park, Utrecht Science Park, Amsterdam Science Park, Campus Groningen) that are among the best in Europe. This promotes opportunities for internships and research projects and increases networking opportunities and a culture of innovation and entrepreneurship. As a result, students are better prepared for the wide range of opportunities available in a pharmaceutical career. The pharmaceutical innovation climate in the Netherlands is underlined by the fact that the European Medicines Agency (EMA) has been based in the Netherlands since 2019.

Students enrolled in the Master's programmes in Pharmaceutical Sciences are trained for an international career in drug research. International collaboration is essential for this. From a global perspective, research in the Netherlands is very strongly internationally oriented. While on average only 20% of

research worldwide is carried out in collaboration with foreign researchers, the average for the European Union is 43%, with the Netherlands at the top with 63% [Kolman, M., 2024]. An important international consortium in the field of Pharmaceutical Sciences in Europe is the ULLA consortium. Leiden University and VU Amsterdam participate in this consortium. It stimulates international collaboration in education and research between the 10 partner universities[9], ULLA scholarships are available for master's students to conduct a research project at one of the partners or to take courses. The University of Groningen organises a two-year International Master's programme in Sustainable Drug Discovery in collaboration with Ghent University, the Medical University of Gdańsk and the University of Lille.

In short, from an international perspective, the Master's programmes in Pharmaceutical Sciences in the Netherlands offer students excellent preparation for an international career in drug research, thanks to their strong research component, the high quality of the research, the advanced research facilities, and close ties with both (international) academic institutions and the pharmaceutical industry. Through integration into an innovation ecosystem and international collaboration, such as the ULLA consortium, students have the opportunity to gain valuable international experience and develop into expert and innovative researchers in a global context.

[9] Uppsala University (Faculty of Pharmacy, Sweden); University College London (School of Pharmacy, United Kingdom); Leiden University (Leiden Academic Centre for Drug Research, Netherlands); VU Amsterdam (Chemistry and Pharmaceutical Sciences, Netherlands); University of Copenhagen (Drug Research Academy, Denmark); Université Paris-Saclay (Faculty of Pharmacy, France); Università di Parma (Department of Food and Medicines, Italy); KU Leuven (Faculty of Pharmaceutical Sciences, Belgium); University of Helsinki (Faculty of Pharmacy, Finland); Université de Genève (School of Pharmaceutical Sciences, Switzerland).

6 Summary

6.1 Introduction

This *"Domain-specific reference framework for Pharmacy and Pharmaceutical Sciences (2025)"* outlines the principles on which university programmes in Pharmacy and Pharmaceutical Sciences in the Netherlands base their curricula. It indicates what can be expected from the content of the programmes, their objectives and developments in society within the pharmaceutical field.

6.2 Knowledge domains

The Pharmacy and Pharmaceutical Sciences (PS) programmes are structured around five main pillars: the body, medicines, research and innovation, professional development, and patients and society (Figure 1). The bachelor's phase lays a broad foundation in the natural sciences. The bachelor's programme in PS focuses more on drug research and development, while Pharmacy also devotes more attention to pharmacotherapy and patient communication. For the master's programmes, the areas of knowledge are described separately: the master's programme in Pharmacy trains students to become pharmacists within a legal framework, with an emphasis on clinical skills and patient-centred care, while PS master's programmes focus on specialist drug research and scientific skills.

6.3 Current developments in Pharmacy and Pharmaceutical Sciences

This chapter summarises important new developments (trends) in the pharmaceutical field and in education in the infographic in Figure 2. The trends are based on input from vision documents from stakeholders.

6.4 Career prospects for aspiring pharmaceutical scientists and pharmacists

As bachelor's and master's programmes in Pharmacy and PS, it is important to know the purpose of the training. The various fields of work and roles that PS and Pharmacy graduates can fulfil are summarised in the infographic in Figure 3.

6.5 International benchmarking

Dutch university programmes in Pharmacy and Pharmaceutical Sciences comply with European guidelines, including free movement within the European Economic Area (EEA). The Master's programme in Pharmacy meets specific European requirements and is in line with international standards (EAFP, FIP). Although there are no formal European requirements for the Master's programmes in Pharmaceutical Sciences, they are internationally recognised for their strong research component, high-quality facilities and extensive international collaboration.

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