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Executive Summary

In this report we provide an analysis and evaluation of the current training needs for promoting the development, usability, adoption and qualification of Organ-on-Chip systems. The ORCHID consortium conducted stakeholders' consolidations using workshops and an on-line survey tool from the European Commission, EU Survey. This survey aimed at evaluating the key aspects for the future of the Organ-on-Chip field, at identifying who to train and in which skill set, career moment as well as knowledge areas. The overarching aim is, on the one hand, to **prepare scientists and technicians for new types of employment** that will arise and, on the other hand, to **provide industry and academia with professionals able to keep up with innovation** in the field. The survey and the raw data can be found in the appendices. The data showed that there is a need (i) to increase end-users familiarity with the chip development and production; (ii) to focus on technicians and end-users in both industry and academia with special emphasis on quality assurance and qualification of the models; iii) to train early career researchers early and include Organ-on-Chip in applied sciences studies such as Bioengineering and Pharmacology/Toxicology. This will foster education in Europe in this technology, and result in well-qualified and competent researchers and engineers, who will continue exploring organ-on-chip applications.

Introduction and Overview

Organ-on-Chip applications in basic research, pharmaceutical drug development, safety assessment of drugs, cosmetics and chemicals among others are facing an exponential rise in interest. The identification of the training needs is essential to assure the long-term success of **Organ-on-Chip systems as well as their development, usability, adoption and qualification** in a variety of fields. This identification is one of the goals of the ORCHID project and presents several challenges due to the multidisciplinary character of the field and the fast evolution of supporting technologies ranging from material science, microfabrication, stem cell culture, live cell imaging and omics approaches. Microfabrication technologies have advanced rapidly allowing for a fine-tuning of tissue culture platforms in a 3D fashion and under different perfusion settings. The cell culture techniques, molecular biology and imaging tools were democratized in the last few years increasing the readout possibilities at a much smaller scale and in a higher throughput. In the interface of both worlds, the development of sensors and advanced strategies to apply to the micro-world are also enabling in line monitoring of the living system in a non-invasive and long-term fashion. A structured identification of skill sets and training needs covering all stakeholders at diverse career stages is essential to bring those worlds together towards a consolidated easily available, innovative and constantly growing field. Online surveys are useful for determining knowledge translation¹ training needs of different stakeholders associated to their background while evaluating their current views of the development and state of the field. We identified a variety of positions for which a training need could exist:

- Scientists as developers,
- Scientists as end users (Academia),
- Scientists as end users (Industry),

¹ Knowledge Translation involves gathering, evaluating, summarizing and sharing relevant knowledge on a particular topic. It is a complex, two-way process between those who develop the knowledge and those who will use the knowledge (Straus, Tetroe, & Graham, 2009).

- Scientists as decision-makers (Regulators / Grant Evaluators / Peer Reviewers),
- Technicians,
- Clinicians,
- Postgraduate Students (Doctorate studies),
- Postgraduate Students (Master's studies),
- Undergraduate Students (Bachelor's Studies).

In the Organ-on-Chip field it is essential to consider all aspects of knowledge translation in training opportunities, while taking into account different stakeholder interests. Until now, a few companies and universities started to take action on specific training in the Organ-on-Chip field (Table 1). The recently started EUROoC Marie Currie Training Network is a good example of an integrated training strategy at the European level for 15 PhD students. Further initiatives, where funding bodies are playing a role in developing new training opportunities as part of a broad effort to build capacity for the development and use of these new technologies is the Netherlands Organ-on-Chip Initiative ([NOCI](#)). Using the survey strategy, we aim at providing an objective needs assessment based on core competencies acknowledging the complexity of knowledge translation in several disciplines, existing training activities, and the expertise stakeholders already have. Similar assessments of training needs have been performed in several emerging fields such as data analysis (Federer, Lu, & Joubert, 2016), metabolomics (Weber, Winder, Larcombe, Dunn, & Viant, 2015), involvement of healthcare and public health professionals in and use of applied health research (Barratt & Fulop, 2016). The urgent need to invest in Organ-on-Chip specific training has been highlighted in the literature (Zhang & Radisic, 2017) and by ORCHID in the Guideline for the Research Community (D5.3): The recommendations for the Research Community (D5.3) highlighted the need to invest **in training across disciplines but also go beyond scientific training only**. This should include

- a combination of theoretical and hands-on immersive trainings with exposure to work flows and processes;
- utilization of the learning experience in case studies to develop in-take procedures, training programs and additions to curricula;
- Enlargement of such trainings with non-technical components such as bioethics, data privacy, trial management, personal safety.

In this report, we will explore which are the training needs and the key skill sets for preparing the next generation of researchers for the high demand of Organ-on-Chip related projects (Mastrangeli et al., 2019; van den Berg, Mummery, Passier, & van der Meer, 2019).

Science and Technology

The online survey was distributed and open between the 15th of January and the 15th of July of 2019. The distribution was conducted i) via email to the network of contacts already built before and within the ORCHID project, ii) in the framework of the ORCHID Workshop that took place on January 17th 2019 and iii) using online multipliers such as the ORCHID website, the ORCHID newsletter as well as ORCHID and personal accounts on social networks such as Twitter and LinkedIn. The survey consisted of a total of 15 questions and had an average duration of 15 minutes (cf. Appendix 1). A total of 71 respondents completed the survey, and 68 answered all questions. The survey structure consisted of 3 sections: Section 1 – Professional profile; Section 2 – Opinion on the state of Organ-on-Chip field development; Section 3 – Specific training needs.

Table 1. Examples of European training initiatives covering different complexity and amount of training

Current available training Initiatives on Organ-on-chip	Organizers	Focus	Target	Duration	Links (consulted in September 2019)
EurOrgan-on-a-chips Marie Currie Training Network		Create a trans-European network of application-oriented researchers fully trained in development and application of the emerging Organ-on-Chip technology	PhD Program	3 years	https://www.eurOrgan-on-a-chip.eu/
Live-cell microarray & Organ-on-a-chip Technology	TU Wien	Integrated on the studies in Chemistry	Undergraduate and Postgraduate Students (Bachelor's and Master's Studies)	1 Semester Lectures	https://tiss.tuwien.ac.at/course/courseDetails.xhtml?dswid=7159&dsrid=522&courseNr=163179&semester=2019S
Hands on BioMEMs (Biomedical or biological microelectromechanic systems)	Karsruhe Institute of Technology, Institute of Microstructure Technology (IMT)	Sensors and diagnostic applications	Undergraduate and Postgraduate Students (Bachelor's and Master's Studies)	1 Semester Practical course	https://www.imt.kit.edu/lectures_1330.php
BioMEMS IV - Mikrosystemtechnik für Life-Sciences und Medizin				1 Semester Lectures	https://www.imt.kit.edu/lectures_89.php
Entwicklung eines Organ-on-Chips zur Nachbildung der Lymph-Gewebe-Schranke				Seminar	https://www.imt.kit.edu/seminar_biomems2018.php
Current Applications of Organs-on-a-Chip for the Pharmaceutical Industry	Mimetas, CAAT (Center for Alternatives to Animal Testing), CN Bio and TissUse	Cell culture and application	Students and technicians	two-day hands-on training	https://mimetas.com/mimetas-news/two-day-organ-chip-training
Laboratory workshop for researchers for using company specific devices	Mimetas	Cell culture and application	Laboratory workshop for researchers	two-day hands-on training	https://mimetas.com/page/workshops
Using organ-on-a-chip technology to reduce animal testing	Event organizer company FSRM	Cell culture and application	Researchers in academia or industry and Managers in the pharmaceutical, nutraceuticals, cosmetics, tobacco or chemical industry.	two-day theoretical course	https://www.fsrn.ch/doc/c545.php?language=e
C3Bio training workshop on Lab-on-Chip	Centre for Biosensors, Bioelectronics and Biodevices (C3Bio)	Biosensors construction Lab-on-Chip computer design Device prototyping Device measurement and testing	Scientists in Academia, Industry	two-day hands-on training	https://www.bath.ac.uk/events/c3bio-training-workshop-on-lab-on-chip/
NOCI Practical Training in Leiden	NOCI Partners at LUMC	Organ-on-Chip within LUMC, hIPS hotel	NOCI PhD-students and postdocs	two-day hands-on training	https://noci-organ-on-chip.nl/noci-practical-training-in-leiden-members-only/
NOCI Practical training in Enschede	NOCI partners at UTwente	Organ-on-Chip within UTwente, NanoLab	NOCI PhD-students and postdocs		https://noci-organ-on-chip.nl/noci-

					practical-training-in-enschede/
Organ-on-Chip Workshops in International MicroNanoConference in 2017 and 2018	hDMT	2017 - Gut-on-Chip (WUR and TNO) and 3D Vessels-on-Chip (LUMC, UTwente). 2018 - Eye-on-Chip (UTwente); Skin-on-Chip (Amsterdam UMC)	Undergraduate and Postgraduate Students (Bachelor's and Master's Studies) Scientists in Academia, Industry	1 day hands-on workshops (practical and theoretical)	https://www.hdmt.technology/event/6354/international-MicroNanoConference-2017 https://www.hdmt.technology/news/10049/hDMT-at-the-international-Micronanoconference-Amsterdam
College on Organ-on-Chip	TU Delft		Bachelor and master students Biomedical Engineering		
Inserm Workshop "Organ-on-chip: understanding and mimicking living organisms for better treatment", phase I Critical Assessment and phase II Technical Workshop	CEA-BGE-Biomics, Grenoble).	The course covered ongoing efforts and various applications of OoC and also addressed ethical issues	Scientists in Academia, Industry and Postgraduate Students (Bachelor's and Master's Studies)	3 days of theoretical discussions (Phase I) and 4 days of practical training in groups of 8 participants including training in 3 different facilities	https://h2020-orchid.eu/organ-on-chip-inserm-workshop/

Section 1 – Professional profile

The survey on the training needs in the Organ-on-Chip field attracted a diverse profile of stakeholders from public and private institutions as represented in Figure 1. More than half of the respondents work in academia and more than one fifth in Industry. Our survey also reached 9 % of respondents working in the governmental sectors showing the interest of those in the Organ-on-Chip field. The covered field of work is mainly Applied Research that together with Pharmaceutical Industry represents 62% of the respondents while almost one third of the respondents work in basic research. The number of respondents working in the Chemical or Cosmetic industry was very low (3 %). Those industries were identified previously as new markets that may have not yet been addressed extensively by the scientists developing the technology (D3.1). Despite Organ-on-Chip was long identified as a player in safety assessment (Rebello et al., 2016), the low amount of respondents in those fields might relate to an already strong awareness and use of other non-animal studies due to regulatory enforcement prior to the emerging Organ-on-a-Chip technologies (Akbarsha & Mascarenhas, 2019; Gourmelon & Delrue, 2016; Sewell, Doe, Gellatly, Ragan, & Burden, 2017). As initially targeted, the respondents are mainly in senior positions and 14 % hold top management responsibilities. Respondents that hold a senior position are expected to have a broader view of the current and future needs in the field, also when not working directly with Organ-on-Chip technologies.

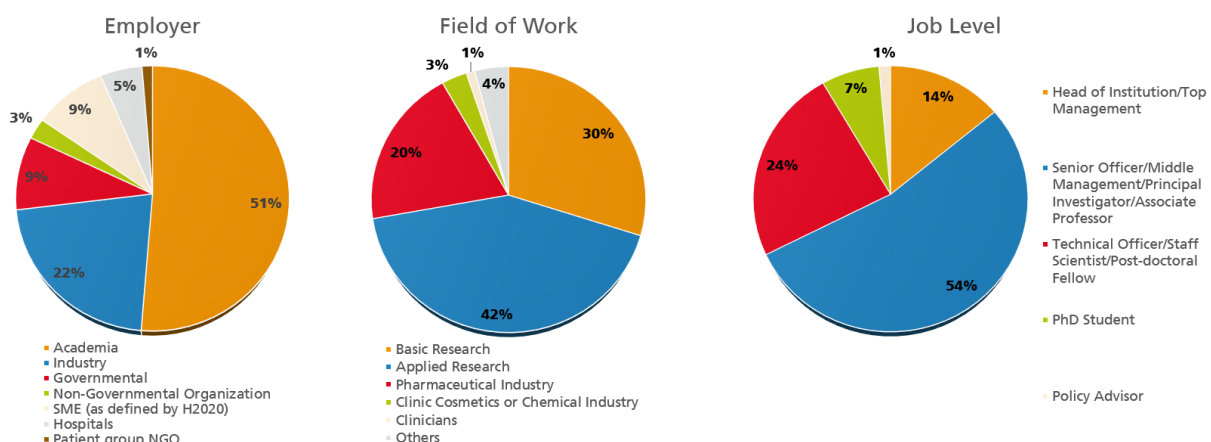


Figure 1. Survey respondents' distribution according to employer, field of work and job level. Respondents were able to select up to two options on the employer and field of work but only one on the job level.

Due to the multi- and interdisciplinary nature of the Organ-on-Chip field we performed a detailed evaluation of the respondent's background and training (Figure 2 and 3) accompanied by what they consider to be their main area(s) of expertise (Table 2). The majority of the respondents had an undergraduate degree in Biology/Biochemistry or in a pure Engineering field, while the majority of the field of Doctoral studies is in translational sciences such as Bioengineering. Almost half of the respondents (44%) changed the field of studies from initial Bachelor Degree to Master and/or Doctorate degree. Only 12% of the respondents do not hold a Doctorate Degree.

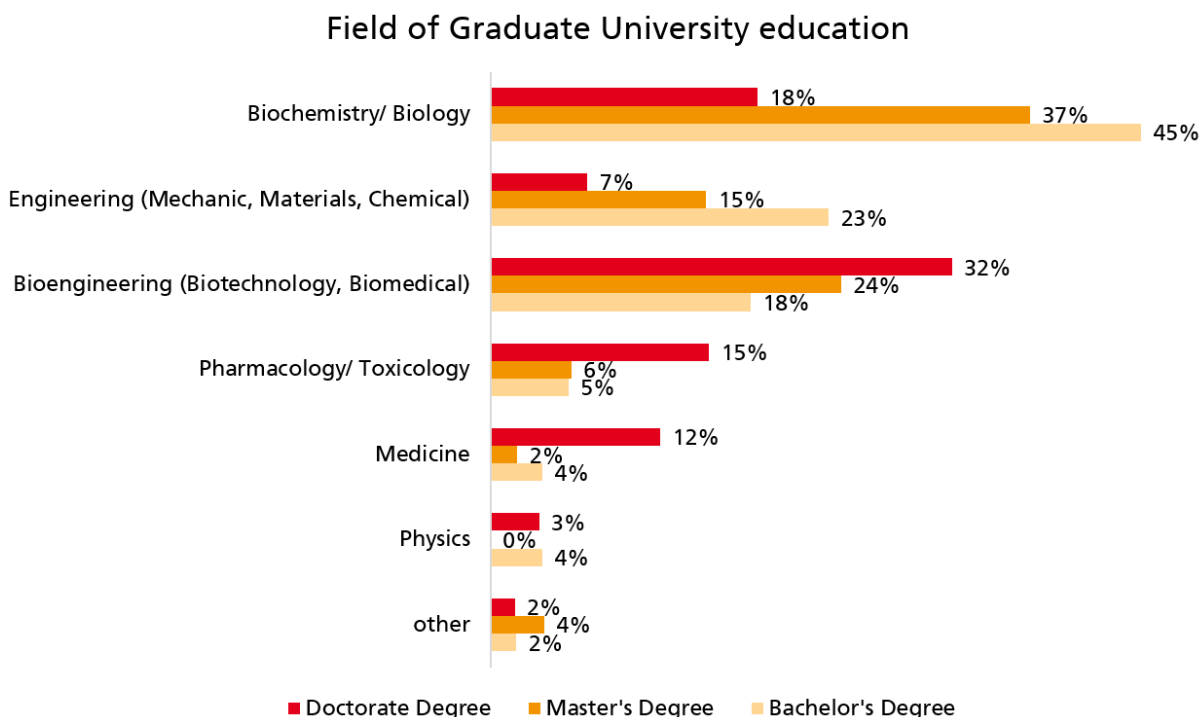


Figure 2. Survey respondents' characterization based on field of University studies

In line with the answers on the previous question about the field of studies, the main area of expertise is Cell and Molecular Biology. Interestingly, the interdisciplinary nature of the respondents is reflected in the fact that 15,5% selected one engineering and one biological option as main areas of expertise (Table 2). Nevertheless, 64,9% selected at least one biological option while 37,9% selected at least one engineering option, showing a tendency of a more biologically biased population of respondents (Table 2).

To better understand our respondents' background and possible biases, we asked about their familiarity with specific microfabrication techniques on the engineering side and specific tissues/organs/systems or biological functions on the application side (Figure 3). The fact that only 1% of the respondents are not familiar with any specific tissue/organ/system biological function reveals that the field is focused on the application of the technology. Conversely, 35,2% are not familiar with any microfabrication techniques, which might reveal a missing connection between end-user and the continuous development of new cell culture platforms.

Table 2. Survey respondents' characterized based on areas of expertise

	Main areas of expertise	Percent of answers (%)	Sum of Percent of answers (%)
Engineering areas of expertise	Materials Science	11,7%	37,9%
	Microfabrication / Microfluidics	23,3%	
	Automation / Process engineering	2,9%	
Biological areas of expertise	Cell Biology / Molecular Biology	41,7%	64,9%
	Clinical Sciences	2,9%	
	Pharmacology / Toxicology	14,6%	
	Genomics / Multi-omics	2,9%	
Total of respondents that selected at least one Biological AND one Engineering area	Microfabrication / Microfluidics + Cell Biology / Molecular Biology	10,7%	15,5%
	Materials Science +Cell Biology / Molecular Biology	4,9%	

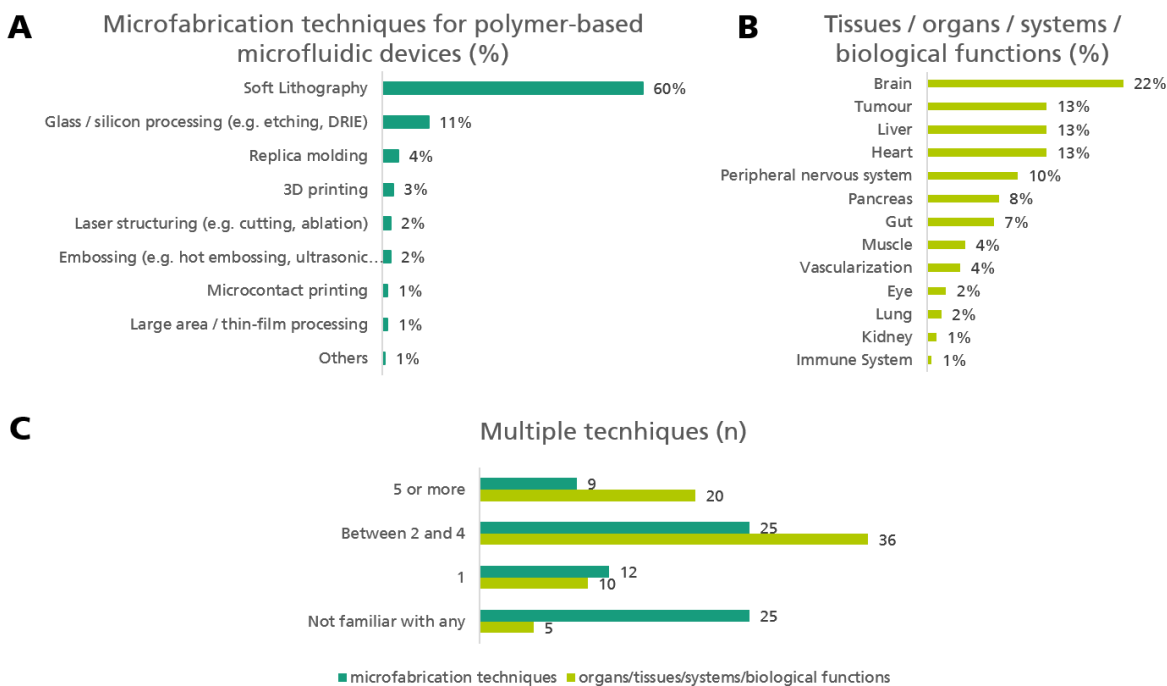


Figure 3. Familiarity with specific microfabrication techniques (A), tissues/organs/systems or biological functions (B) and with multiple of those techniques within each field (C). Respondents were able to select all of the answers that apply. Graphs A and B reflect the % within the total of answers, which was 159 and 190, respectively.

Section 2 – Opinion on the state of Organ-on-Chip field development

The understanding of the training needs in the Organ-on-Chip field is also influenced by the respondent current view on the key aspects for the field development. As such, we were interested in understanding if there is an agreement that training is within the most important needs and who should be trained (Table 3). Indeed, training was considered very important by 46 (65 %) and somewhat important by 18 (25 %) respondents. The majority of respondents has a biological background (Table 1), which might explain an attribution of a higher importance to aspects as Definition of specific cell culture standards – function and origin of cells as well as to microfabrication techniques because of the need of the establishment of reproducible models for assuring the development of the field. This is also reflected by a higher degree of importance attributed to the training of end users and technicians (Table 3). Interestingly, although the qualification of the models is considered *Very Important*, the importance given to the comparison with animal data is only considered *Somewhat Important*. This might reflect a paradigm change on how those cell culture models should be qualified with regards to standards other than animal testing.

Table 3. Importance of key aspects to contribute to the Organ-on-Chip field development

Aspects	Rank of Importance*	Degree of Importance
Definition of specific cell culture standards – function and origin of cells	4,79	Very Important
Usability	4,64	
Qualification of the models	4,51	
<u>Training</u>	<u>4,51</u>	
Sensors integration and real-time monitoring	4,38	
High throughput cultivation and endpoint measurements	4,37	Somewhat Important
Production scale-up of Organ-on-Chip systems	4,28	
<u>Microfabrication techniques</u>	<u>4,25</u>	
Comparison with clinical data	4,06	
Uptake by scientists from other fields	4,00	
Comparison with animal data	3,48	Somewhat Important
PKPD modelling	3,35	

* The answers were ranked considering by points: Very Important = 5; Somewhat Important = 4; Less Important = 3; Not Important = 1; Not Sure = 0

Table 4. Importance of training for key stakeholders to promote the Organ-on-Chip systems qualification, usability, uptake and/or long-term development

Stakeholders	Rank of Importance*	Degree of Importance
Scientists as end users (Industry)	4,77	Very important
Technicians	4,49	
Scientists as end users (Academia)	4,42	
Scientists as developers	4,37	
Scientists as decision-makers (Regulators/Grant Evaluators/Peer Reviewers)	4,29	
Clinicians	3,63	Somewhat Important

* The answers were ranked considering by points: Very Important = 5; somewhat Important = 4; Less Important = 3; Not Important = 1; Not Sure = 0

Section 3 – Specific training needs

The specific questions on accessing the training needs aimed to cover the following aspects:

- (i) at which level should the training take place (Figure 4 and Table 5),
- (ii) the importance of training specific stakeholders according to their role in promoting the Organ-on-Chip systems qualification, usability, uptake and/or long-term development (Table 6),
- (iii) the level of complexity and amount of training for each stakeholder (Tables 7 and 8).

The data in Figure 4 and Table 5 shows that training should be translational during all career levels with focus on Master and Doctorate Programs (64%). Undergraduate and postdoctoral training should be accompanied by posterior or previous training at other career level (4% vs 42 % and 3 % vs 31 %, respectively).

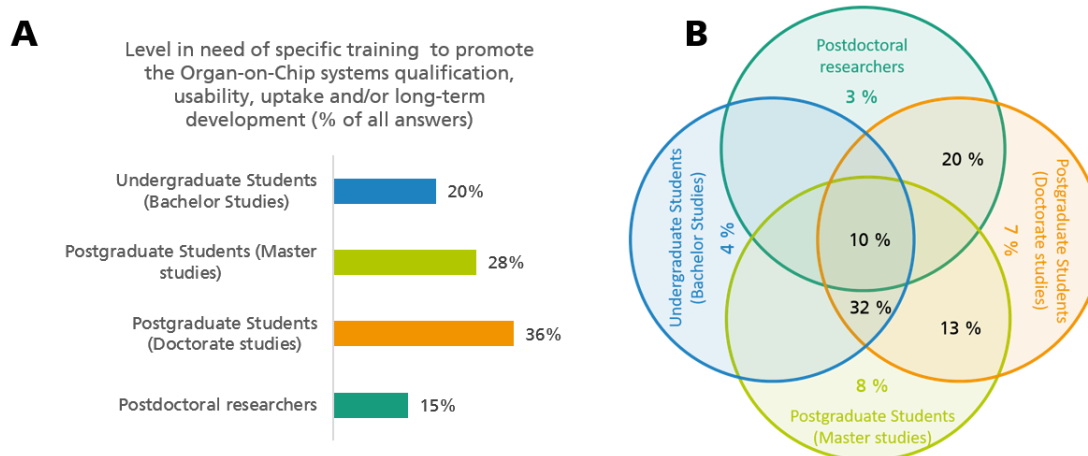


Figure 4. Career level in need of specific training reflecting the total amount of answers (A) and the Venn diagram of the different combinations that reflect the data described in detail in Table 4 (B). In (B), for simplicity (B) only includes conditions with more than 2%.

Table 5. Definition of the need of specific training respective to study level to promote the Organ-on-Chip systems qualification, usability, uptake and/or long-term development

Level or combinations of levels that should be provided with specific training	Levels	Percentage (%)
Postdoctoral researchers + Postgraduate Students (Doctorate studies) + Postgraduate Students (Master studies) + Undergraduate Students (Bachelor Studies)	All	10%
Postgraduate Students (Doctorate studies) + Postgraduate Students (Master studies) + Undergraduate Students (Bachelor Studies)	3	32%
Postdoctoral researchers + Postgraduate Students (Doctorate studies)	2	20%
Postgraduate Students (Doctorate studies) + Postgraduate Students (Master studies)	2	13%
Postdoctoral researchers	1	3%
Postgraduate Students (Doctorate studies)	1	7%
Postgraduate Students (Master studies)	1	8%
Undergraduate Students (Bachelor Studies)	1	4%

For simplicity, only conditions with more than 2% were included in the table.

To identify the most important aspects that need to be included in the training of each stakeholder (also following the recommendations in D5.4), we included several aspects related to good practices, quality, ethics and dissemination. Among all evaluated aspects covering the engineering, biological and translational aspects, the highest importance was attributed to *Cell Culture and Stem Cell Technology* and *Quality Assurance* (Table 6). This is in alignment with the data in Table 3, where the aspect of training with higher importance (4.79) is the *Definition of specific cell culture standards – function and origin of cells*. This might be associated with the reproducibility crisis in biomedical research (Baker, 2016; Bergh, Sharp, Aguinis, & Li, 2017) and with a correspondent increasing demand of high quality in vitro data (Gourmelon & Delrue, 2016; Organisation for Economic Co-operation and Development. & OECD-iLibrary - York University., 2018). Not only reproducibility but also a common understanding of i) what a specific in vitro system is representing, ii) for which applications it is designed, and iii) what its limitations are, is essential to build trust in the Organ-on-Chip technology. Following this trend, ECVAM launched last year a survey on issues influencing end-user confidence in complex in vitro models for use in research and testing (“Survey on issues influencing end-user confidence in complex in vitro models for use in research and testing | EU Science Hub,” n.d.) .), which also covered Organ-on-Chip technologies, the results of which are yet to be published.

The aspects of training were divided into three groups for analysis proposes: *Engineering aspects*; *Biological aspects*; *Translational aspects* (Table 6). Interestingly, scientists in academia and industry as well as technicians were more associated with a higher importance of training in *Biological aspects* while developers in *Engineering aspects*. Clinicians and decision makers were more associated with training in *Translational aspects*. When we sum the overall importance of the training independently of a specific aspect, the respondents considered it the most important to train developers. The group with the lowest importance of those training aspects was technicians. The discrepancies in the respondents’ answers between question 3 (where technicians were identified as in high need of training to promote the Organ-on-Chip systems qualification, usability, uptake and/or long-term development (Table 3)) and question 11 (*How important are the following elements to consider for training, for Technicians, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?*) may reveal a lack of detail on the proposed aspects or a less clear idea of which aspects should be addressed. On the other hand, the identified need to train scientists in industry might reflect the high expectations on the uptake of the technology. For that structured and efficient training programs are expected too. Until now, such training is mostly provided directly by companies that sell Organ-on-Chip systems (see table 1). Although this is a valuable contribution, it is not providing a broad training and is contributing for a distant relationship between users and developers. Such training actions are commonly limited to a 2-day hands-on or training session. More complex training programs are less often offered. Therefore, we wanted to understand our respondent’s views regarding the **complexity of training** (Table 7). Herein, there is an agreement that developers should hold a *deep knowledge* and Scientists as end users a *competence level* distributed between practical and theoretical skills. A deep knowledge level reflects the ability to develop more technology out of their knowledge level, while a competence level reflects the ability to use or supervise the use of the technology, with a high degree of success. Decision makers and technicians should be trained only at a competence level on theoretical and practical skills,

respectively. Surprisingly, the same number of respondents (20%) considered that clinicians and scientists in academia should have the same level of training in practical skills.

Table 6. Elements to consider for training regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development for different stakeholders

		Rank of Importance*					
		Scientists as developers	Scientists as end users (Academia)	Scientists as end users (Industry)	Scientists as decision-makers	Technicians	Clinicians
Engineering aspects	Biomaterials	4,43	3,87	3,76	3,20	3,86	2,90
	Microfabrication techniques and manufacturability	4,32	3,42	3,32	3,11	3,94	2,47
	Microfluidic principles	4,46	3,96	3,72	3,20	3,94	2,90
	Monitoring and analyzing (sensors, imaging)	4,46	4,41	4,44	3,73	4,01	3,89
	Cell culture and stem cell technology	4,66	4,58	4,46	3,70	4,47	3,91
Biological aspects	Bio banking, Data Management and Protection	3,84	4,00	4,21	3,97	3,47	4,34
	Monitoring and analyzing (molecular biology / omics)	4,19	4,42	4,41	3,84	3,99	3,96
	PKPD modelling	3,62	3,75	3,96	3,60	2,79	3,43
	Pharmacology and Toxicology principles	3,99	4,24	4,56	4,06	3,30	4,26
Translational aspects	Quality Assurance	4,41	3,99	4,51	4,47	4,14	4,11
	Science Communication	4,12	4,27	3,85	4,14	2,83	3,86
	Regulatory affairs	3,84	3,73	4,47	4,61	2,70	4,09
	Ethics	3,84	3,97	4,10	4,54	3,07	4,54
	Average of total ranking in all aspects	4,17	4,05	4,14	3,86	3,58	3,74
Data from Table 3 on how important is training		4,37	4,42	4,77	4,29	4,49	3,63

* The answers were ranked considering by points: Very Important = 5; Somewhat Important = 4; Less Important = 3; Not Important = 1; Not Sure = 0

Table 7. Complexity level of specific training for each stakeholder to promote Organ-on-Chip systems qualification, usability, uptake and/or long-term development.

	Scientists as developers	Scientists as end users (Academia)	Scientists as end users (Industry)	Scientists as decision-makers	Technicians	Clinicians
Deep knowledge/Theoretical and practical skills	96%	46%	33%	13%	13%	10%
Competence/Theoretical skills and Practical skills	0%	12%	10%	7%	9%	12%
Competence/Theoretical skills	4%	22%	26%	54%	7%	25%
Competence/Practical skills	0%	20%	30%	7%	65%	19%
Introductory/Awareness	0%	0%	0%	19%	4%	33%
None	0%	0%	0%	0%	1%	1%

* The respondents were required to answer the most adequate, although it was possible to provide more than one answer per complexity level. Several respondents considered Competence/ Theoretical skills and Practical skills a lower level than Deep knowledge. Therefore, a new level was created for data analysis proposes. When more than one level was selected and Deep Knowledge was one of the options, the others were removed due to redundancy. The same applies to double selection of Competence and Introductory, in such cases, only Competence was considered.

Table 8. Most adequate amount of specific training per stakeholder to promote Organ-on-Chip systems qualification, usability, uptake and/or long-term development

	Scientists as developers	Scientists as end users (Academia)	Scientists as end users (Industry)	Scientists as decision-makers (Regulators / Grant Evaluators / Peer Reviewers)	Technicians	Clinicians	Postgraduate Students (Doctorate studies)	Postgraduate Students (Master's studies)	Undergraduate Students (Bachelor's Studies)
Seminars/courses integrated in a broader training program (1 semester)	8%	49%	42%	31%	41%	24%	39%	53%	28%
Specific postgraduate course (1 to 2 years)	85%	33%	27%	12%	12%	9%	52%	19%	13%
Up to approx. 20 h of non-practical training	2%	1%	2%	41%	6%	36%	2%	4%	16%
Up to approx. 20 h of practical training	5%	16%	28%	11%	40%	27%	7%	24%	39%
None	0%	0%	0%	5%	1%	4%	0%	0%	5%

Note: Respondents were able to select more than one type of training per stakeholder

The amount of specific training was also inquired to identify what would be the best training approach for each stakeholder (Table 8). There is a general consensus that for each stakeholder training on some level is needed (Option *None* is lower than 5 % for all stakeholders). There is a strong agreement (85 %), that *Scientists as developers* should be trained under a *Specific postgraduate course* (1 to 2 years), preferably

during their doctorate studies. *Scientists as end-users, Technicians and Clinicians* as well as *Master's and Bachelor's students* would ideally be trained with a program of *Up to approx. 20 h of practical training* accompanied by *Seminars/courses integrated in a broader training program (1 semester)*. Up to one third of the respondents considered that *Scientists as end users* should also be trained under a *Specific postgraduate course (1 to 2 years)*. Surprisingly, shorter training programs (up to 20 h) were not considered as an option for PhD students. The respondents who considered it important to include the topic of Organ-on-Chip technologies as a seminar course in a broader field of education, i.e., *Master's and Bachelor's studies* were additionally asked which fields would be more important (Table 9). Here, we observe a clear priority attributed to areas that are by nature “applied sciences” such as *Bioengineering* and *Pharmacology/Toxicology*. This might reflect the need of increasing awareness for the end users and by promoting their interest, possibly involving them more in the development of the field. Additionally, this would allow to train the future generation in the whole process from chip development, production and use for a specific application. Indeed, the answer to this question is not corresponding to our population of respondents regarding their fields of *Bachelor/Master degree* but to their field of *doctorate studies* (Figure 4).

Table 9. Importance of including the topic of Organ-on-Chip technologies as a seminar course in the following broader field(s) of education¹

	Rank of Importance*	Degree of Importance
Bioengineering (Biotechnology, Biomedical)	4,81	Very important
Pharmacology/ Toxicology	4,73	
Biochemistry/ Biology	4,49	
Medicine	4,10	
Engineering (Mechanic, Materials, Chemical)	4,09	
Chemistry	3,44	Somewhat Important
Physics	3,29	

¹ Only answered by respondents that considered the option of seminar training on the previous question

* The answers were ranked considering by points: Very Important = 5; somewhat Important = 4; Less Important = 3; Not Important = 1; Not Sure = 0

Summary

In summary, the development and utilization of Organ-on-Chip technology requires experts with a broad and interdisciplinary skillset at several levels. The identified training needs are:

- Technicians and end-users in both industry and academia are the main target populations in need of training covering both practical and theoretical training and covering mainly:
 - (i) *Cell culture and stem cell technology*;
 - (ii) *Monitoring and analyzing (sensors, imaging)*; and
 - (iii) *Quality assurance*.
- The key aspects for the development of the field and, hence, with the largest need for specific training are:
 - (i) *The definition of specific cell culture standards – function and origin of cells*;
 - (ii) *Usability*; and
 - (iii) *Qualification of the models*.
- Early career researchers should be trained at all levels of studies with particular focus on

Master's and Doctorate's Studies.

- Organ-on-Chip specific training should be included in the curriculum of programs within applied sciences, i.e., *Bioengineering and Pharmacology/ Toxicology*.

Additional experiences from a Marie-Curie Innovative Training Network on Organ-on-Chip (EUROoC) that started in December 2018 training 15 PhD Students will be used as further input for the future refinement of a training strategy in the Organ-on-Chip field. Further data resulting from a comprehensive analysis of this survey and from interviews with a further group of stakeholders (PhD candidates) will be compiled and submitted as a peer review publication on the training needs.

Conclusion

The Deliverable 3.4 has been achieved in time.

Appendix

Appendix I - Online version of the survey used for this study:

https://ec.europa.eu/eusurvey/runner/Orchid_Questionnaire_Training_needs_Organ-on-a-chip

Appendix II - Raw data of the survey

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Questionnaire for stakeholders: Training needs of the next generation of researchers and technicians in Organ-on-a-Chip field

Fields marked with * are mandatory.

Questionnaire for stakeholders

Organ-on-a-chip

Training needs of the next generation of researchers and technicians

This questionnaire aims at surveying the **training needs** of the Organ-on-Chip community to **promote the Organ-on-Chip systems qualification, usability, uptake and long-term development** in a variety of fields.

Organ-on-Chip applications in Basic Research, Pharmaceutical Drug Development, Safety assessment of Drugs, Cosmetics and Chemicals among others are facing an exponential rise in interest. Therefore, **specific training is required** on the production of such cell culture systems using advanced microfabrication techniques and adequate on-chip characterization of relevant cell functions. This survey is directed to those we considered to be the current and future strategic stakeholders in the advance and use of Organ-on-Chip. On the one hand, we aim at **preparing scientists and technicians for new types of employment** that will arise while, on the other hand, **providing industry and academia with professionals able to keep up with innovation** in the field. The answers to this survey will contribute to designing appropriate training programs to fulfil the needs of this emerging field.

The data resulting from the survey will be publicly available on the [ORCHID website](#) and disseminated on the project [twitter](#) account.

This survey contains 15 questions and will take around **15 minutes** of your time.

The privacy statement, available below, outlines in detail how the data that you provide as part of this survey will be protected.

[Privacy Statement.pdf](#)

☐ * I agree with the privacy statement.

Section 1 – Professional profile

* 1. How would you **define yourself as a professional?**

a) Type of institution

at most 2 choice(s)

- ☐ Academia
- ☐ Industry
- ☐ SME (as defined by [H2020](#))
- ☐ Governamental Organization
- ☐ Non-Governamental Organization
- ☐ Hospitals
- ☐ Other (please specify)

Other:

* **b) Job Level**

- ☐ Head of Institution/Top Management
- ☐ Senior Officer/Middle Management/Principal Investigator/Associate Professor
- ☐ Technical Officer/Staff Scientist/Post-doctoral Fellow
- ☐ Other (please specify) _____

Other:

* **c) Field of work**

at most 2 choice(s)

- ☐ Basic Research
- ☐ Applied Research
- ☐ Pharmaceutical Industry
- ☐ Clinic Cosmetics or Chemical Industry
- ☐ Food Industry
- ☐ Other (please specify) _____

Other:

* **d) Field of Graduate University education** (Bachelor's Degree)

at most 1 choice(s)

- ☐ Engineering (Mechanic, Materials, Chemical)
- ☐ Bioengineering (Biotechnology, Biomedical)
- ☐ Physics
- ☐ Chemistry
- ☐ Biochemistry/ Biology

- ☐ Medicine
- ☐ Pharmacology/ Toxicology
- ☐ None
- ☐ Other (please specify) _____

Other:

*** e) Field of first Postgraduate University education (Master's Degree)**

at most 1 choice(s)

- ☐ Engineering (Mechanic, Materials, Chemical)
- ☐ Bioengineering (Biotechnology, Biomedical)
- ☐ Physics
- ☐ Chemistry
- ☐ Biochemistry/ Biology
- ☐ Medicine
- ☐ Pharmacology/ Toxicology
- ☐ None
- ☐ Other (please specify) _____

Other:

*** f) Field of second Postgraduate University education (Doctorate Degree)**

at most 1 choice(s)

- ☐ Engineering (Mechanic, Materials, Chemical)
- ☐ Bioengineering (Biotechnology, Biomedical)
- ☐ Physics
- ☐ Chemistry
- ☐ Biochemistry/ Biology
- ☐ Medicine
- ☐ Pharmacology/ Toxicology
- ☐ None
- ☐ Other (please specify) _____

Other:

*** g) Main area of expertise**

at most 2 choice(s)

- ☐ Materials Science
- ☐ Microfabrication / Microfluidics
- ☐ Automation / Process engineering

- ☐ Cell Biology / Molecular Biology
- ☐ Genomics / Multi-omics
- ☐ Pharmacology / Toxicology
- ☐ Clinical Sciences
- ☐ Other (please specify)_____

Other:

*2. Select the **tissues/organs/systems/biological functions** with which you are familiar and/or you work with? (Select all that apply)

- | | | | |
|---|--|---|--|
| <input type="checkbox"/> Skin | <input type="checkbox"/> Brain | <input type="checkbox"/> Pancreas | <input type="checkbox"/> Reproductive System |
| <input type="checkbox"/> Eye | <input type="checkbox"/> Peripheral nervous system | <input type="checkbox"/> Thyroid | <input type="checkbox"/> Exocrine glands |
| <input type="checkbox"/> Heart | <input type="checkbox"/> Tumour | <input type="checkbox"/> Muscle | <input type="checkbox"/> Not familiar with any specific tissues/organs/systems /biological functions |
| <input type="checkbox"/> Liver | <input type="checkbox"/> Vascularization | <input type="checkbox"/> Kidney | <input type="checkbox"/> Others |
| <input type="checkbox"/> Gut | <input type="checkbox"/> Immune System | <input type="checkbox"/> Lung | |
| <input type="checkbox"/> Adipose tissue | <input type="checkbox"/> Blood | <input type="checkbox"/> Bone/Cartilage | |

*3. Select the **microfabrication techniques** for polymer-based microfluidic devices with which you are familiar and/or you work with?

- ☐ Soft Lithography
- ☐ Glass / silicon processing (e.g. etching, DRIE)
- ☐ Large area / thin-film processing
- ☐ Embossing (e.g. hot embossing, ultrasonic embossing)
- ☐ Replica molding
- ☐ Microcontact printing
- ☐ 3D printing
- ☐ Micromilling
- ☐ Laser structuring (e.g. cutting, ablation)
- ☐ Injection molding
- ☐ Not familiar with any microfabrication technique
- ☐ Others (please specify)_____

Other:

Section 2 – Opinion on the state of Organ-on-Chip field development

4. **How important** are the following aspects for the Organ-on-Chip field development?

between 12 and 13 answered rows

--	--	--	--	--	--

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Microfabrication techniques	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Production scale-up of Organ-on-Chip systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Definition of specific cell culture standards – function and origin of cells	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sensors integration and real-time monitoring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
High throughput cultivation and endpoint measurements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modeling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Qualification of the models	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Usability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Comparison with clinical data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Comparison with animal data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uptake by scientists from other fields	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

Section 3 – Specific training needs

5. **How important** is it to provide specific training for each of the following stakeholders, to promote the Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 6 and 7 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Scientists as <u>developers</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scientists as <u>end users</u> (Academia)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scientists as <u>end users</u> (Industry)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Scientists as <u>decision-makers</u> (Regulators, Grant evaluators or peer reviewers)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Technicians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Clinicians	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

*6. **At which level** do you consider that specific training is necessary to promote the Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

- ☐ Postdoctoral researchers
- ☐ Postgraduate Students (Doctorate studies)
- ☐ Postgraduate Students (Master's studies)
- ☐ Undergraduate Students (Bachelor's Studies)
- ☐ Other (please specify) _____

Other:

7. **How important** are the following elements to consider for training, for **Scientists as developers**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

8. **How important** are the following elements to consider for training, for **Scientists as end users (Academia)**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

9. **How important** are the following elements to consider for training, for **Scientists as end users (Industry)**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

10. **How important** are the following elements to consider for training, for **Scientists as decision-makers (Regulators, Grant evaluators or peer reviewers)**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

11. **How important** are the following elements to consider for training, for **Technicians**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

12. **How important** are the following elements to consider for training, for **Clinicians**, regarding the improvement of Organ-on-Chip systems qualification, usability, uptake and/or long-term development?

between 13 and 14 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Biomaterials	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfabrication techniques and manufacturability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfluidic principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cell culture and stem cell technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bio banking, Data Management and Protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Monitoring and analysing (molecular biology / omics)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Monitoring and analysing (sensors, imaging)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
PKPD modelling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology and Toxicology principles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Assurance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Science Communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory affairs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ethics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

13. What is the most adequate **complexity level of specific training** for each of the following stakeholders, to promote Organ-on-Chip systems qualification, usability, uptake and/or long-term development? (Select the most adequate)

between 6 and 7 answered rows

	Deep knowledge /Theoretical and practical skills	Competence/ Theoretical skills	Competence /Practical skills	Introductory/ Awareness	None
Scientists as <u>developers</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>end users</u> (Academia)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>end users</u> (Industry)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>decision-makers</u> (Regulators, Grant evaluators or peer reviewers)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technicians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Clinicians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other:

14. What is the most adequate **amount of specific training** for each of the following stakeholders, to promote Organ-on-Chip systems qualification, usability, uptake and/or long-term development? (Select the most adequate)

between 9 and 10 answered rows

	Specific postgraduate course (1 to 2 years)	Seminars/courses integrated in a broader training programme (1 semester)	Up to approx. 20 h of practical training	Up to approx. 20 h of non-practical training	None
Scientists as <u>developers</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>end users</u> (Academia)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>end users</u> (Industry)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scientists as <u>decision-makers</u> (Regulators, Grant evaluators or peer reviewers)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technicians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Clinicians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Postgraduate Students (<u>Doctorate studies</u>)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Postgraduate Students (<u>Master's studies</u>)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Undergraduate Students (<u>Bachelor's</u> Studies)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other:

15. **How important** would it be to include the topic of Organ-on-Chip technologies as a **seminar of course in the following broader field(s) of education:**

between 7 and 8 answered rows

	Very Important	Somewhat Important	Less Important	Not Important	Not Sure
Engineering (Mechanic, Materials, Chemical)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bioengineering (Biotechnology, Biomedical)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Physics	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemistry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Biochemistry/ Biology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Medicine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pharmacology/ Toxicology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
None	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify) _____	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other:

If you consider other relevant topics not covered by this questionnaire, **please leave you comments here**

.
Choose to leave your comments anonymus or add your Name and Contact details.

If you have questions regarding this questionnaire, please contact madalena.cipriano@igb.fraunhofer.de

1. How would you define your organization?	b) Job Level	Other:	c) Field of work	Other:	d) Field of Graduate University	Other:	e) Field of first Postgraduate	Other:	f) Field of second Postgraduate	Other:	g) Main area of expertise	Other:
Governamental Organization	Technical Officer/Staff	Other (please specify) _	Other (please specify) _						Bioengineering (Biotechnology)		Cell Biology / Molecular	
Academia	Technical Officer/Staff		Applied Research						Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Applied Research		Bioengineering (Biotechnology)						Microfabrication / Microfluidics	
Academia	Technical Officer/Staff		Basic Research								Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Basic Research;Applied		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Physics		Materials Science;Cell Biology	
SME (as defined by H2020)	Head of Institution/Top Institute		Applied Research		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Other (please specify) _ Tissue Engineering, Biomaterials	
Academia	Head of Institution/Top Institute		Basic Research								Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Applied Research		Other (please specify) _ Chemistry		Other (please specify) _ Chemistry		Physics		Microfabrication / Microfluidics	
Industry	Senior Officer/Middle Manager		Applied Research;Clinical								Cell Biology / Molecular	
Academia	Head of Institution/Top Institute		Basic Research		Physics		None		Other (please specify) _ Biophysics		Cell Biology / Molecular	
Academia;SME (as defined by H2020)	Senior Officer/Middle Manager		Applied Research								Cell Biology / Molecular	
Governamental Organization	Senior Officer/Middle Manager		Pharmaceutical Industry						Other (please specify) _ Toxicology		Pharmacology / Toxicology	
Academia	Senior Officer/Middle Manager		Basic Research;Applied								Materials Science;Microfluidics	
Industry	Other (please specify) _ Project leader		Pharmaceutical Industry								Cell Biology / Molecular	
Other (please specify) _ Patient group	Other (please specify) _ Policy Advisor		Other (please specify) _ Daily medicine as a patient		Other (please specify) _ Economics		Other (please specify) _ Economy		Other (please specify) _ Evonym		Other (please specify) _ Health care policies	
Academia	Senior Officer/Middle Manager		Basic Research;Applied		Other (please specify) _ Chemist		Other (please specify) _ Chemistry		Other (please specify) _ Chemistry		Materials Science;Other analytical chemistry	
Governamental Organization	Senior Officer/Middle Manager		Clinic Cosmetics or Chemical						Other (please specify) _ Toxicology		Pharmacology / Toxicology	
Industry	Senior Officer/Middle Manager		Applied Research		Other (please specify) _ Applied Chemistry						Risk assessment/exposure	
Academia;Governmental Organization	Other (please specify) _ Innovation marketing		Other (please specify) _								Cell Biology / Molecular	
Academia	Technical Officer/Staff		Basic Research;Applied						Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Applied Research		Bioengineering (Biotechnology)		None				Materials Science;Microfluidics	
Academia	Senior Officer/Middle Manager		Applied Research								Microfabrication / Microfluidics	
Governamental Organization	Senior Officer/Middle Manager		Pharmaceutical Industry						Other (please specify) _ In vitro toxicology		Pharmacology / Toxicology	
Academia	Senior Officer/Middle Manager		Applied Research						Bioengineering (Biotechnology)		Materials Science;Microfluidics	
Industry	Other (please specify) _ Scientist - between postdoc and senior		Pharmaceutical Industry		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Industry	Senior Officer/Middle Manager		Basic Research;Pharmaceutical		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Industry	Senior Officer/Middle Manager		Pharmaceutical Industry		Pharmacology/ Toxicology		None		Pharmacology/ Toxicology		Cell Biology / Molecular	
Industry	Senior Officer/Middle Manager		Pharmaceutical Industry		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
SME (as defined by H2020)	Head of Institution/Top Institute		Basic Research;Applied		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		Materials Science;Microfluidics	
Industry	Other (please specify) _ PhD student		Basic Research		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Basic Research		Pharmacology/ Toxicology		Pharmacology/ Toxicology		Pharmacology/ Toxicology		Cell Biology / Molecular	
SME (as defined by H2020)	Head of Institution/Top Institute		Applied Research;Pharmaceutical		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Applied Research		Other (please specify) _ broad training in physics		Other (please specify) _ interface biology/chemistry		Other (please specify) _ physics and chemistry		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Basic Research;Applied		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Hospitals	Other (please specify) _ Surgeon		Other (please specify) _ General Surgery		Other (please specify) _ General Surgery		Medicine		Other (please specify) _ General surgery		Clinical Sciences	
Academia	Senior Officer/Middle Manager		Applied Research		Biochemistry/ Biology		Biochemistry/ Biology		Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Basic Research;Applied		Biochemistry/ Biology		Biochemistry/ Biology		Medicine		Microfabrication / Microfluidics	
SME (as defined by H2020)	Head of Institution/Top Institute		Pharmaceutical Industry		Engineering (Mechanics, Electronics)		Other (please specify) _ Business Management		None		Other (please specify) _ Market Development in vitro	
Academia	Other (please specify) _ Research Technician		Basic Research;Applied		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		None		Microfabrication / Microfluidics	
Academia;Hospitals	Head of Institution/Top Institute		Basic Research;Applied		Biochemistry/ Biology		Biochemistry/ Biology		Medicine		Genomics / Multi-omics	
Academia	Other (please specify) _ PhD Student		Applied Research		Biochemistry/ Biology		Biochemistry/ Biology		Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Academia;SME (as defined by H2020)	Senior Officer/Middle Manager		Basic Research;Applied		Biochemistry/ Biology		Biochemistry/ Biology		Medicine		Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Applied Research		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Microfabrication / Microfluidics	
Academia	Other (please specify) _ Graduate student		Applied Research		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		None		Materials Science;Microfluidics	
Hospitals	Technical Officer/Staff		Pharmaceutical Industry		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		None		Automation / Process engineering	
Academia	Senior Officer/Middle Manager		Basic Research		Biochemistry/ Biology		Biochemistry/ Biology		Bioengineering (Biotechnology)		Cell Biology / Molecular	
Academia	Technical Officer/Staff		Basic Research;Applied		Bioengineering (Biotechnology)		Pharmacology/ Toxicology		Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Non-Governamental Organization	Senior Officer/Middle Manager		Basic Research;Applied		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Basic Research		Biochemistry/ Biology		None		Medicine		Cell Biology / Molecular	
Industry	Senior Officer/Middle Manager		Basic Research;Pharmaceutical		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Senior Officer/Middle Manager		Basic Research		Engineering (Mechanics, Electronics)		Bioengineering (Biotechnology)		Medicine		Other (please specify) _ Vascular biology, human	
Governamental Organization	Senior Officer/Middle Manager		Basic Research;Applied		Engineering (Mechanics, Electronics)		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Other (please specify) _ Biomedical optics	
Academia	Technical Officer/Staff		Applied Research		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		None		Microfabrication / Microfluidics	
SME (as defined by H2020)	Head of Institution/Top Institute		Applied Research		Biochemistry/ Biology		Biochemistry/ Biology		Other (please specify) _ Physiology		Cell Biology / Molecular	
Academia	Technical Officer/Staff		Applied Research;Pharmaceutical		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Pharmacology/ Toxicology		Microfabrication / Microfluidics	
Academia	Senior Officer/Middle Manager		Basic Research;Applied		Physics		Chemistry		Bioengineering (Biotechnology)		Materials Science;Cell Biology	
Non-Governamental Organization	Other (please specify) _ Scientific Consultant		Other (please specify) _ NGO focused on animal health		Biochemistry/ Biology		Pharmacology/ Toxicology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Other (please specify) _ PhD Student		Basic Research;Pharmaceutical		Biochemistry/ Biology		Biochemistry/ Biology		Pharmacology/ Toxicology		Cell Biology / Molecular	
Academia	Technical Officer/Staff		Applied Research		Biochemistry/ Biology		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Other (please specify) _ Professor emeritus		Basic Research;Applied		Engineering (Mechanics, Electronics)		Engineering (Mechanics, Electronics)		Bioengineering (Biotechnology)		Cell Biology / Molecular	
Academia;Industry	Head of Institution/Top Institute		Applied Research;Pharmaceutical		Biochemistry/ Biology		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Industry	Technical Officer/Staff		Pharmaceutical Industry		Biochemistry/ Biology		Bioengineering (Biotechnology)		Pharmacology/ Toxicology		Pharmacology / Toxicology	
Industry	Senior Officer/Middle Manager		Pharmaceutical Industry		Biochemistry/ Biology		None		Pharmacology/ Toxicology		Pharmacology / Toxicology	
Academia;Industry	Technical Officer/Staff		Basic Research;Applied		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Microfabrication / Microfluidics	
Industry	Senior Officer/Middle Manager		Pharmaceutical Industry		Biochemistry/ Biology		None		None		Cell Biology / Molecular	
Industry	Technical Officer/Staff		Applied Research		Engineering (Mechanics, Electronics)		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Materials Science;Cell Biology	
Industry	Technical Officer/Staff		Applied Research;Pharmaceutical		Engineering (Mechanics, Electronics)		None		Bioengineering (Biotechnology)		Cell Biology / Molecular	
Industry	Senior Officer/Middle Manager		Applied Research;Pharmaceutical		Biochemistry/ Biology		Other (please specify) _ Genetics		None		Cell Biology / Molecular	
Academia	Other (please specify) _ PhD Candidate		Applied Research		Bioengineering (Biotechnology)		Bioengineering (Biotechnology)		Engineering (Mechanics, Electronics)		Materials Science;Cell Biology	
Governamental Organization	Technical Officer/Staff		Other (please specify) _		Biochemistry/ Biology		Biochemistry/ Biology		Bioengineering (Biotechnology)		Cell Biology / Molecular	
Academia;Hospitals	Technical Officer/Staff		Basic Research		Medicine		Biochemistry/ Biology		Biochemistry/ Biology		Cell Biology / Molecular	
Academia	Technical Officer/Staff		Basic Research;Applied		Biochemistry/ Biology		Pharmacology/ Toxicology		Medicine		Cell Biology / Molecular	
Academia;Governmental Organization	Technical Officer/Staff		Basic Research;Applied		Biochemistry/ Biology		Bioengineering (Biotechnology)		None		Cell Biology / Molecular	

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