

NWA ORC

Research along routes by consortia

Call for proposals



Contents

1	Introduction	1
	1.1 Background	1
	1.2 Available budget	3
	1.3 Submission deadline(s)	3
2	Aim	4
	2.1 Aim of the programme	4
	2.2 Societal impact	5
3	Conditions for applicants	7
	3.1 Who can apply	7
	3.2 What can be applied for	10
	3.3 Preparing an application	11
	3.4 Conditions for submission	13
	3.5 Conditions on granting	13
4	Assessment procedure	16
	4.1 The San Francisco Declaration (DORA)	16
	4.2 Procedure	16
	4.3 Criteria	21
5	Obligations for grant recipients	22
6	Contact and other information	25
	6.1 Contact	25
	6.2 Other information	25
7	Annex(es):	26
	7.1 Explanation of budget modules	26
	7.2 Industrial and Societal Doctorates	32
	7.3 Public knowledge organisations	33
	7.4 Condition for co-funding	33
	7.5 Description of the themes	35

1 Introduction

In this Call for proposals information is provided about the application procedure for the "Research along routes by consortia 2024" funding round. This Call for proposals falls under the responsibility of the Dutch Research Council (NWO).

In this Call for proposals you will find information about the aim of this programme (Chapter 2), the conditions for the grant application (Chapter 3) and how your proposal will be assessed (Chapter 4). This is the information you need to submit a grant application. Chapter 5 states the obligations for grant recipients in the event you are awarded funding. Chapter 6 contains the contact details and Chapter 7 the annexes.

1.1 Background

What does the Netherlands want to know? This was the idea behind the creation of the Dutch Research Agenda (Dutch acronym NWA). The NWA has been created by an innovative process with input from scientists and citizens: the Dutch general public was invited to submit questions about science online. This call yielded an impressive 11,700 questions about a wide variety of subjects. These were consolidated in 140 big issues, the so-called 'cluster questions'. Around these cluster questions, researchers and societal organisations formed 25 networks that were given the name NWA routes. These networks were given their own route management and, inspired by the cluster questions in the NWA agenda, they develop knowledge agendas and organise meetings and communication activities. The 25 NWA routes and the associated cluster questions can be found via <u>Routes | NWO</u>.

Collaboration between researchers from different disciplines, on the one hand, and knowledge organisations and societal (public and private) organisations, on the other, has added value for the complex issues that are part of the NWA. In these collaborations, new knowledge flows from researcher to user, and new questions from professional practice and from society find a way into new research. In the conviction that people can achieve more together than they can individually, the NWA programme therefore encourages collaboration between different partners.

The key elements of the NWA programme are:

- the Dutch Research Agenda that consists of 25 routes and 140 cluster questions;
- knowledge-chain-wide¹ and interdisciplinary consortia, in which researchers from different disciplinary backgrounds, knowledge and societal (public and private) organisations and, where relevant, citizens collaborate on complex issues;
- societal organisations, society and citizens have a clear role in the research;
- giving back the results to society through dialogue and interaction.

In 2018 the Ministry of Education, Culture and Science (Dutch acronym) OCW entrusted NWO with implementing the Dutch Research Agenda. The NWA comprises four programme lines²:

- a. Research along Routes by Consortia (ORC);
- b. Thematic Programming in consultation with government bodies;
- c. Innovations and Networks;
- d. Science Communication and Outreach.

The Call for proposals 'Research along routes by consortia 2024' is being realised in the context of programme line 1. This call is specifically intended for the funding of research by consortia that focuses on themes put forward by NWA routes, and is based on the cluster questions of the Dutch Research Agenda (for the themes in this call, please see Section 2.1 and Annex 7.5).

¹ The broad knowledge chain comprises a diversity of the public knowledge institutions: universities of applied sciences, universities, NWO and KNAW institutes, university medical centres and TO2 institutes, as well as other public knowledge organisations such as National Knowledge Institutes (see Chapter 6 for a full list of public knowledge organisations).

² More information about the different programme lines is available at <u>Dutch Research Agenda (NWA) | NWO</u>.

1.1.1 Changes since the previous Call for proposals

Changes compared to 2022

Following the evaluation of the NWA programme that took place in 2022³, several changes have been implemented compared to the Call for proposals 'Research along Routes by Consortia 2022'. The changes are described below.

Themes

The Call for proposals invites research aimed at the defined themes, which have been proposed by NWA routes and are based on one or more of the 140 cluster questions. This prioritisation contributes to focus and alignment with the proposals to be awarded funding as part of the Dutch Research Agenda.

Collaborative workshops

For each theme, NWO will organise two collaborative workshops. The workshops are part of the procedure and contribute to the formation of broad, innovative consortia and to the reduction of mutual competition and work pressure (see Section 4.2.2).

Budget per project

In this Call for proposals, the maximum budget that can be applied for is determined per theme. As a result, the different budget ranges (small, medium, large) that were deployed in previous ORC calls no longer apply.

The pre-proposal phase will be omitted: this Call for proposals now consists of two phases: 1) an initiative and workshop phase and 2) an application phase (see Section 3.3).

Co-funding not mandatory

Co-funding is no longer mandatory.

Flexible budget for projects with a duration more than 4 years

Applications with a duration of more than 4 years need to submit a budget for the first 4 years of the project. In addition, a reservation should be outlined for the remaining duration of the project. Prior to the mandatory interim evaluation after 4 years, the consortium will produce a definitive budget for the remaining period. This approach will create room for interim adjustments to the approach and to the parties involved, and for the flexibility that long-term research requires (see Section 5.1.4).

Changes compared to 2023

Impact approach

In this Call for proposals, the Impact Plan approach is mandatory for all 14 themes, as described in Section 2.1 of the Call for proposals. The Impact Outlook approach does not apply in this Call for proposals.

Formal conditions for submitting an application

The main applicant has substantively participated in both meetings of the collaborative workshop of the theme for which the proposal will be submitted (see also Sections 3.3.1 and 4.2.2). If the main applicant cannot attend the meetings, then a deputy should be found. NWO needs to be informed of this prior to the start of the respective workshop via email (<u>nwa-orc2024@nwo.nl</u>).

³ See: NWO to work on recommendations for the NWA evaluation committee <u>NWA programme | NWO</u>

1.2 Available budget

The maximum budget for each theme is € 6,750,000. The grant ceiling for this Call for proposals totals € 94,500,000.

Within this Call for proposals, a maximum of one application per theme will be awarded funding (see Section 4.2). Any remaining funds will not be deployed for a different purpose within this Call for proposals.

1.3 Submission deadline(s)

The deadline for registering an initiative is 9 April 2024, before 14:00:00 CEST.

The deadline for submitting applications is **1 October 2024**, before 14:00:00 CEST.

You will need to fill in additional details online when you register your initiative on the website, and when you submit your proposal in ISAAC. You should therefore start registering your initiative and submitting your proposal at least one day before the deadline stated in this Call for proposals. Initiatives and proposals that are submitted after the deadline will not be taken into consideration.

2 Aim

This chapter describes the aim of the programme and the societal impact.

2.1 Aim of the programme

The aim of the NWA ORC programme is to encourage research in knowledge-chain-wide as well as inter- or transdisciplinary consortia in which researchers collaborate with societal (public and/or private) partners and, where relevant, with citizens too. The research question formulated for the NWA ORC round 2024 is based on one of the themes listed below, which are explained in greater detail in Annexe 7.5. In the application form, the main applicant indicates the theme for which they will submit an application.

	Route	Title of the theme
		(see Annexe 7.5)
1	Materials – Made in Holland	Ab-initio circular materials design
2	The quantum /	Nanomedicine in society: nanotechnology
	nanorevolution	and its societal impact for improved
		diagnosis, prevention, and treatment of
		diseases
3	Smart, liveable cities	New forms of partnership between
		government and residents for transitions
4	Creating value through	Empowerment of Dutch citizens through
	responsible Artificial	Transparent AI
	Intelligence and Big Data	
5	NeuroLabNL: the ultimate	Emotion regulation and the brain: individual
	living lab for brain, cognition	differences and societal relevance
	and behavioural research	
6	Personalised medicine: the	Disease, individual, and environment: the
	individual at the centre	importance of mutual interactions across
		two or more pathologies, and the
		differences per individual.
7	Regenerative medicine: game	The biomedical innovation, product
	changer moving to broad	development and application of 3D models:
	areas of application	building bridges between fundamental
		research and healthcare
8	Sport and exercise – Science	Younger through sports, exercise and
	opens up to society	nutrition
9	Transition to a sustainable	Towards a climate-friendly and biodiversity-
	food system	friendly production of plant-based proteins
10	Child and adolescent	Strengthening social relationships between
	development, upbringing and	pupils at school to promote their mental
	education	health
11	Living history	Sites of value; context-aware negotiations
		about the future of historically fraught
		sites.
12	Towards resilient societies	Resilience and justice in transition:
		building reflective institutions
13	Smart Industry	Smart Industry 5.0
14	Art: research and innovation	Art research for new perspectives on climate
	in the 21st century	justice

Collaborative workshops

For each theme, a collaborative workshop will be organised that consists of 2 meetings. The collaborative workshops are part of the procedure in this Call for proposals (see Sections 3.3.1 and 4.2.2). The aim of the collaborative workshops is to bring interested parties (researchers and public and/or private societal parties) into contact with each other around a specific theme, to combine research ideas (consolidation of strengths) and to form broad, innovative consortia. This will contribute to the reduction of mutual competition and work pressure.

Aimed at breakthroughs

Proposals in the NWA ORC focus on innovative, demand-driven research aimed at realising scientific and societal breakthroughs⁴. Proposals in the NWA ORC round are therefore demonstrably relevant and full of impact for society. The proposed research is also scientifically pioneering, at both the national and international level.

Collaboration in consortia

In all consortia:

- if relevant, citizens (or their representatives) are actively involved in the research. Citizen Science initiatives can be funded from the budget module 'Material' (see Annexe 7.1);
- organisations from the entire knowledge chain⁵ take part;
- all scientific disciplines relevant for answering the research question are represented;
- the relevant societal stakeholders are involved;
- there are productive interactions (see below text box): the relevant parties actively work together in all phases of the research.

The added value of collaboration in consortia lies in:

- the further reinforcing of diversity and complementarity in knowledge, (technical) skills and expertise of the individual consortium partners;
- the stimulating effect of the collaboration on talent development, where experienced researchers in the consortium attract new, talented young⁶ researchers. These researchers can develop themselves and, in turn, attract new talent as well;
- the creation of a (social) network in and around the project. This network exists both during the project and continues to exist after the project has been completed. Societal organisations bring knowledge further and incorporate this in, for example, products, policy, guidelines, education, cultural expressions, methodologies or public debate.

Productive interactions

Productive interactions are realised if all parties in the consortium are actively involved in all phases of the research process: from formulating the research questions, to elaborating the approach to answer these questions and realising the desired scientific and societal breakthroughs.

2.2 Societal impact

New knowledge and insights from scientific research can make an important contribution to developing solutions for the various issues society faces, including, amongst other things, the energy transition, health and care, or climate change. By facilitating greater interaction and alignment between researchers and potential knowledge users, the chance of knowledge utilisation increases, as

⁴ In this call, NWO understands 'breakthroughs' to be a change that takes place in either science or society. This change is broadly understood, appropriate to the breadth of the NWA as an agenda, the cluster questions and the routes linked to these.

⁵ The broad knowledge chain includes a diversity of public knowledge institutions such as universities of applied sciences, universities, NWO and KNAW institutes, university medical centres, TO2 institutions, but also other public knowledge organisations, such as government knowledge institutions (see Section 7.3 for a complete list of public knowledge organisations).

⁶ The term 'young' does not refer to the age of the researcher, but to the phase of their research career (see also Section 3.5.8 'Involvement and development of young researchers'.

well as the likelihood of generating societal impact. Through its policy on impact, NWO promotes the potential contribution that research can make to societal issues by encouraging productive interactions with societal stakeholders, both during the development stage and the subsequent implementation of research. It does so in a manner that is in accordance with the aim of the particular funding instrument.

2.2.1 Tailor-made impact

Depending on the aim of the funding instrument, NWO will select the approach that has the greatest chance of achieving societal impact. The primary aim of the funding instrument determines the method that NWO will deploy to facilitate knowledge utilisation in various phases of the project (proposal, realisation, project completion) as well as the effort required from the applicant(s) and partner(s).

In this programme, the Impact Plan approach for knowledge utilisation will be applied. NWO will thus facilitate the development of an integrated strategy by specifically giving researchers and partners the opportunity to increase the intended societal impact. This approach will be required for all themes.

NWO offers an e-learning module that can help interested parties via <u>NWO Impact - Online workshops</u>. The modules are intended to help with elaborating the Impact Plan approach in the proposal. The development and realisation of the research project in collaboration with partners is a key element of the NWA. We therefore strongly advise you to jointly follow the workshop with (representatives of) the scientific and societal partners.

For more information on our policy on impact, please visit the website: Knowledge utilisation | NWO.

2.2.2 Impact Plan approach in the call NWA ORC 2024

In NWA the programmes focus on complex issues where coordination and cooperation has added value to realise scientific and societal breakthroughs. NWA stimulate the cooperation between different partners, making the whole is greater than the sum of its parts and stimulating that new knowledge for societal issues is developed.

Impact Plan approach

Societal impact is never solely the result of knowledge and insights gained from the research. To increase the chance of the research's societal impact, demonstrable involvement is needed from important stakeholders from the moment the consortium is formed until the completion of the project and beyond. Societal impact is often realised in the years after a research project has been concluded. By ensuring continuous alignment between researchers and possible knowledge users from the start of the research articulation (co-design) and when carrying out the research (co-creation), the chances of productive interactions, and finally impact, will increase.

Consortia draw up an Impact Plan together with stakeholders as part of the full proposal. The Impact Plan describes how the consortium expect to realise societal impact and the role that productive interactions play in this. It shows how achieving the expected impact has been integrated into the research design and what role consortium partners and stakeholders from the fields of policy, practice and industry play in this.

3 Conditions for applicants

This chapter contains the conditions that are applicable to your grant application. Firstly it describes who can apply for funding (Section 3.1) and what you can request funding for (Section 3.2). Subsequently, you will find the conditions for preparing and submitting the application (Sections 3.3 and 3.4) and the specific funding conditions (Section 3.5).

3.1 Who can apply

Applications are submitted by the main applicant on behalf of a consortium. The main applicant has substantively participated in both meetings of the collaborative workshop of the theme for which a proposal is submitted (see also Sections 3.3.1 and 4.2.2). If the main applicant cannot attend the meetings, then a deputy should be found. NWO should be informed about this at least one working day before the start of the workshop concerned via email (<u>nwa-orc2024@nwo.nl</u>).

There are four categories of participants within a consortium:

- 1.Main applicant;
- Co-applicant(s);
- 3. Cooperation partner(s);
- 4. Co-funder(s) (optional).

A consortium should consist of at least a main applicant, a co-applicant and cooperation partner. The conditions for each type of participant are explained in more detail in the following sections.

3.1.1 Main and co-applicants

The main applicant submits the proposal via the NWO web application ISAAC. During the assessment process, NWO will communicate with the main applicant.

After a proposal has been awarded funding, the main applicant will become the project leader and point of contact for NWO. The knowledge institution of the main applicant is the main beneficiary and will become the official secretary.

Main applicants

Full, associate and assistant professors and other researchers with a comparable position* may submit an application if they have a tenured position (and therefore a paid position for an indefinite period) or a tenure track agreement at one of the following organisations:

- universities located in the Kingdom of the Netherlands;
- university medical centres;
- institutes affiliated to the Royal Netherlands Academy of Arts and Sciences (KNAW) or NWO;
- Netherlands Cancer Institute;
- the Max Planck Institute for Psycholinguistics in Nijmegen;
- Naturalis Biodiversity Center;
- Advanced Research Centre for NanoLithography (ARCNL);
- Princess Máxima Center.

*A comparable position refers to a researcher that has a demonstrable and comparable number of years of experience in carrying out scientific research and supervising other researchers as a full, associate or assistant professor.

** Lectors employed at a university of applied sciences and researchers employed at a TO2 institute may also submit as a main applicant provided that they have at least a salaried position for a limited period of time.

Persons with a zero-hour employment agreement or with a contract for a limited period of time (other than a tenure track appointment) may not submit a proposal.

It could be the case that the applicant's tenure track agreement ends before the intended completion date of the project for which funding is applied for, or that before that date, the applicant's tenured contract ends due to the applicant reaching retirement age. In that case, the applicant needs to include a statement from their employer in which the organisation concerned guarantees that the project and all project members for whom funding has been requested will receive adequate supervision for the full duration of the project.

Extra conditions:

- the main applicant may submit only one proposal in the role of main applicant;
- the main applicant may participate a maximum of one time as co-applicant in another consortium.
- A main applicant from the NWA ORC rounds 2018, 2019, 2020/2021, 2022 or 2023, who received funding for a project, is excluded from participating in this round as a main applicant by submitting an application unless the project concerned has already been fully completed by NWO before the deadline of the application by means of a grant settlement decision. However, this person may assume another role within a consortium.

Applicants with a part-time contract should guarantee adequate supervision of the project and all project members for whom funding is requested.

Co-applicants

Co-applicants have an active role in realising the project. The (sub)project leaders and beneficiary/beneficiaries are jointly responsible for realising the entire project.

Extra conditions:

- a co-applicant can participate in up to two consortia in that capacity;
- persons with a zero-hours contract are excluded from submitting as a co-applicant.

Co-applicants can be affiliated to the institutions stated in Section 3.1.1 and the public knowledge organisations stated in Annex 7.3, but also to other organisations.

If the organisation to which a co-applicant is affiliated is not listed in Section 3.1.1 or Annex 7.3, then it must meet the cumulative criteria indicated below:

- be established in the Netherlands;
- have a public service mission;
- carry out research independently;
- have no profit motive other than for the purposes of conducting further research.

Based on the above, capital companies⁷ and partnerships⁸ are in any case excluded from participating in the consortium as co-applicants. Other legal forms will be assessed against the cumulative criteria.

'The conduct of research' from the sub criterion 'is independent in the conduction of research' means that conducting research, as defined in the NWO Grant Rules 2017, chapter 5, is the main task of the research organisation; evidenced by official documentation as the statutes, deed of incorporation or other formal documentation. In addition, the research must be conducted by the organisation's own employees with a salaried employment contract.

Please note: prior to the submission of an application, NWO will assess whether an organisation satisfies these cumulative criteria and may therefore participate as a co-applicant. NWO carries out this assessment amongst other things to check there is no provision of forbidden state support. This assessment should also be carried out if an organisation was previously assessed and permitted as a co-applicant within another NWA programme.

⁷ In Dutch: kapitaalvennootschappen.

⁸ In Dutch: personenvennootschappen.

The organisation of the intended co-applicant should submit at least the following documents by email no less than 10 working days before the submission deadline (before **17 September 2024** at 14:00:00 CEST):

- a recent extract from the Netherlands Chamber of Commerce;
- the deed of incorporation or current articles of association or other formal document evidencing the public service mission and absence of profit motive;
- the latest available annual accounts accompanied by an audit statement⁹.

Other relevant documentation may be added. NWO may request additional information if the above documents are not sufficiently conclusive to determine whether there would be the provision of forbidden state support or whether the organisation may act as a co-applicant.

The aforementioned requirements for co-applicants also apply to employees of foreign knowledge institutions who participate as co-applicants in the context of 'Money follows cooperation' (see Annexe 7.1), with the exception of the condition that the co-applicant must reside in the Kingdom of the Netherlands.

If the applicant's organisation does not submit the necessary documents for this check in time, NWO cannot accept the organisation as a co-applicant.

Extra conditions:

- In this Call for proposals, a co-applicant may participate as a co-applicant in a maximum of two consortia.
- Persons with a zero-hours employment contract are excluded from submitting as a coapplicant.

3.1.2 Cooperation partners

Cooperation partners are mandatory in this Call for proposals, because active involvement (from demand articulation up to carrying out the project) from societal stakeholders, both public and private, is of great importance to share knowledge about challenges and possible solutions. A cooperation partner is a party that is closely involved in the implmentation of the research and/or knowledge utilisation, but is unable to capitalise its contribution in advance. A cooperation partner is therefore not a main or co-applicant or co-funder, but can, for example, be involved by participating in an advisory committee.

Please note: no funding may be requested for salary or research costs as a co-applicant for personnel of organisations that participate as a cooperation partner in the consortium. However, it is possible to remunerate costs by hiring in these organisations as third parties via the modules 'material costs', 'knowledge utilisation' or 'project management (see Section 3.2 and Annex 7.1).

3.1.3 Co-funders

Co-funding is not compulsory within this call. Co-funders are organisations that participate in the consortium and contribute to the project in cash and/or in kind. Co-funders do not receive any funding from NWO. The conditions regarding co-funding are specified in Annex 7.4 to this call.

Organisations whose employees are permitted to act as main applicants in accordance with the description given in Section 3.1.1 may not participate as co-funders in this call for proposals.

Organisations that are not legally obliged to have their annual accounts audited do not need to provide such an auditor's statement. They must however be able to demonstrate that this legal requirement is not applicable to the organisation concerned.

An exception will be made for TO2 institutes. They may participate in a consortium as co-funders, unless they also participate as a main applicant or co-applicant in the same consortium.

3.2 What can be applied for

For an application in this round of this Call for proposals, a maximum of € 6,750,000 can be applied for. The minimum duration of the proposed project is 4 years. The maximum duration of the proposed project is 8 years. In the case of co-funding, NWO never funds less than 50% of the total project budget.

Projects with a duration of 4 years

For these projects, a detailed budget is requested for the entire duration of the project (number of PhDs, postdoc positions, etc.) as is usually the case when applying for NWO grants. NWO will make a budget template available on the funding page of the Call for proposals.

Projects with a duration of more than 4 years

NWO requests projects with a duration of more than 4 years to prepare a flexible budget based on a maximum amount for the entire project period. To realise societal and scientific impact (see also Section 2.2) based on productive interactions, room is needed for interim adjustments to the research approach and the parties involved in the research. In addition, long-term research requires flexibility in the budget.

For the flexible budget:

- For the first period of 4 years, a detailed budget should be drawn up (number of PhDs, postdoc positions, etc.) as is usually the case for NWO grants. NWO will make a budget template available for this on the funding page of the Call for proposals.
- For the second period of at least 2 years and at most 4 years, a general expenditure plan is made, and the amount is included in the budget.

At least 3 months before the end of the first period of 4 years, the consortium will elaborate the general expenditure plan into a detailed budget. This detailed budget, including the adjustment of the project plan in accordance with the NWO Grant Rules for the project in years 6 to 8, will also be submitted to NWO for approval at least 3 months before the end of the first period of 4 years. The funding for the second period will only be released after both the adjusted project plan and the budget have been received by NOW in good order. The specification of the second part of the budget cannot exceed the budget allocated with the awarding of the grant.

The budget modules (including the maximum amount) available for this Call for proposals are listed in the table below. Apply only for funding that is vital to realise the project. A more detailed explanation of the budget modules can be found in the annexe to this Call for proposals (7.1).

Budget module	Maximum amount
PhD student	Unrestricted number of positions, according to UNL or UNF rates ¹⁰
Engineering Doctorate degree (EngD)	Unrestricted number of positions, in combination with PhD student(s) and or postdoc(s), according to UNL or NFU rates ⁶
Postdoc	Unrestricted number of positions, according to UNL or NFU rates ⁶

¹⁰ For personnel outside the Netherlands, the local rates are reimbursed. These rates are capped at a maximum equal to the UNL rates corrected by the NWO Country correction coefficients (CCC) table, see <u>Money Follows Cooperation | NWO</u>.

Budget module	Maximum amount
Non-scientific staff (NSS) at universities	€300,000, according to UNL or NFU rates ^{6,} per requested PhD student and or postdoc-position, up to a maximum of €300,000 per application
Other Scientific personnel (OSS) at universities	€100,000, in combination with PhD student and/or postdoc
Research leave	10% of the total budget requested from NWO according to UNL or NFU rates ⁶
Personnel at universities of applied sciences, educational institutions and other organisations	Unrestricted number of positions, in accordance with the applicable rate at the time of the granting decision as taken from Table 2.2, column 'Hourly rate productive hours, excl. Dutch VAT' from the <i>Handleiding Overheidstarieven</i> [HOT- Manual Dutch Government rates] (<u>Salary Tables NWO</u>).
Material costs	€15,000 per year per FTE scientific position ¹¹
Investments (up to €150,000)	€150,000
Investments (€150,000 to €500,000)	Greater than or equal to €150,000 (for data collections, a minimum of €25,000 applies) and less than or equal to €500,000, with 25% contribution by the applying research institution
Knowledge utilisation	Mandatory to apply for: minimum 5% and maximum 20% of the total budget applied for
Internationalisation	€ 100.000
Money follows Cooperation	Less than 50% of the total budget applied for
Project management	Mandatory to apply for: 5% of the total budget applied for

3.3 Preparing an application

The initiative should be written in Dutch and English. The proposal must be written in English.

An application can only be submitted via the web application ISAAC. Applications that are not submitted via ISAAC will not be taken into consideration.

As the main applicant, you are required to submit the application via your own personal ISAAC account.

It is important to start with your application in ISAAC on time:

- if you do not yet have an ISAAC account, then you should create this on time to prevent any possible registration problems;
- any new organisations must also be added to ISAAC by NOW;
- you also need to submit other details online.

Applications submitted after the deadline will not be taken into consideration by NWO. For technical questions, please contact the ISAAC helpdesk, see contact (Chapter 6).

Does a main and/or co-applicant work at an organisation that is not included in the ISAAC database? You can report this via <u>relatiebeheer@nwo.nl</u> so that the organisation can be added. This will take several days. It is therefore important that you report this at least one week before the deadline.

¹¹ This also includes positions at universities of applied sciences, educational institutions and other applying organisations.

The applicant must inform the organisation where she/he works about the submission of the application, and the organisation must accept the granting conditions of this Call for proposals.

3.3.1 The registration of initiatives and collaborative workshops

The first phase of this call covers the initiative phase, followed by the two successive collaborative workshops per theme.

An initiative must focus on one of the themes as stated in Section 2.1, and consists of:

- a) A concise project idea, including an initial indication of the parties involved in the consortium, the name of the submitter of the initiative and that person's contact details, or;
- b) An individual or organisation that states how, with available expertise, a possible contribution can be made to the theme.

An initiative must be registered by filling in the online initiative form. A link to this form can be found on the programme page of this call 'NWA-ORC 2024'. The concise project ideas will be published by NWO online via <u>Research along Routes by Consortia | NWO</u>. Those who register an initiative will be automatically registered for the collaborative workshops. It is strongly recommended that for every initiative submitted, as many consortium partners as possible participate in these workshops.

The substantive basis of the collaborative workshops will be formed by the registered initiatives (see also Section 4.2.2). Both researchers and societal parties will be invited to register their initiative. Initiatives in the form of project ideas will be published on the NWO website prior to the workshops so that interested parties can be informed about this. In addition, the initiatives will be shared with the workshop participants of that specific theme in the form of individual contributions from individuals or organisations.

You can also register for the workshops without registering an initiative via the web page of the call. Societal organisations are emphatically invited to register an initiative and/or participate in the workshops.

3.3.2 Preparing and submitting a proposal

A proposal is written (and submitted) after the collaborative workshops in which initiatives have been brought together, possible collaboration with other participants in the workshop was explored and where the crucial initial agreements have been made for the joint elaboration of the proposal.

The main applicant must have substantively participated in both collaborative workshops of the theme concerned, or a deputy should have been found. NWO needs to be informed about this at least one working day before the start of the relevant workshop via email (<u>nwa-orc2024@nwo.nl</u>).

The steps involved in writing your application are:

- download the application form from the NWO web application ISAAC or from the NWO web page (on the grant page of the funding instrument concerned);
- complete the application form;
- save the application form in ISAAC as a PDF file and upload it with any compulsory annexes;
- fill in the requested information online in ISAAC.

Compulsory annexes:

- budget;
- generic expenditure plan, if applicable (see Section 3.2);
- declarations of commitment of cooperation partners (see section 3.1.2);
- declaration co-funding from co-funders (mandatory if applicable, see section 3.1.3);
- confirmation of contribution to investment (mandatory if applicable, see paragraph 7.1);

- letter guaranteeing the continuity of the project supervision (compulsory if applicable, see paragraph 3.1).
- form 'Statement and signature'.

In case NWO has made a template available, the annex should be drawn up according to the NWO template. Annexes must be uploaded in ISAAC separately from the application. All of the annexes, except for the budget, must be submitted as PDF files (without encryption). The budget must be submitted in ISAAC as an Excel file.

Upon submission of the application, the attached declaration of co-funding should state the full co-funding pledged according to the conditions described in Section 7.4.

Any annexes other than those above-mentioned are not permitted.

3.4 Conditions for submission

3.4.1 Formal conditions for submission

NWO will assess your application against the conditions listed below. Your application will only be admitted to the assessment procedure if it meets these conditions. After submitting your application, NWO requests you to be available to implement any possible administrative corrections so that you can (still) meet the conditions for submission.

These conditions are:

- the main applicant and co-applicant(s) meets the conditions stated in Section 3.1;
- the application complies with the DORA guidelines as described in Section 4.1;
- the application form is, after a possible request to make additions or changes, complete and filled out according to the instructions;
- the application is submitted via the main applicant's ISAAC account;
- the application is received before the deadline;
- the application is written in English;
- the application budget is drawn up in accordance with the conditions for this Call for proposals;
- the proposed project has a duration of at least 4 and at most 8 years;
- all of the required annexes are, after a possible request to make additions or changes, complete and filled out according to the instructions;
- the main applicant has substantively participated in both meetings of the collaborative workshop of the theme to which the proposal is submitted (see also Sections 3.3.1 and 4.2.2). If the main applicant cannot attend the meetings, then a deputy should have been found. NWO needs to be informed about this at least one working day before the start of the relevant workshop via email (<u>nwa-orc2024@nwo.nl</u>).

3.5 Conditions on granting

The <u>NWO Grant Rules 2017</u> and the Agreement on the Payment of Costs for Scientific Research are applicable to all applications.

3.5.1 Compliance with the National Knowledge Security Guidelines

World-class science can benefit from international cooperation. The National Knowledge Security Guidelines (hereafter: the Guidelines) helps knowledge institutions to ensure that international cooperation can take place securely. Knowledge security concerns the undesirable transfer of sensitive knowledge and technology that compromises national security; the covert influence of state actors on education and research, which jeopardises academic freedom and social safety; and ethical issues that may arise in cooperation with countries that do not respect fundamental rights. Applicants are responsible for ensuring that their project complies and will continue to comply with the Guidelines. By submitting an application, the applicant commits to the recommendations stipulated in these Guidelines. In the event of a suspected breach of the Guidelines in an application submitted to NWO for project funding, or in a project funded by NWO, NWO may ask the applicant to provide a risk assessment demonstrating that the recommendations in the Guidelines have been taken into consideration. If the applicant fails to comply with NWO's request, or if the risk assessment is in apparent breach of the Guidelines, this may affect NWO's grant award or decision-making process. NWO may also include further conditions in the award letter if appropriate.

The National Knowledge Security Guidelines can be found on the central government website at: Home | National Contact Point for Knowledge Security (loketkennisveiligheid.nl).

3.5.2 Data management

The results of scientific research must be replicable, verifiable and falsifiable. In the digital age, this means that, in addition to publications, research data must also be publicly accessible insofar as this is possible. NWO expects that research data resulting from NWO-funded projects will be made publicly available, as much as possible, for reuse by other researchers. "As open as possible, as closed as necessary" is the applicable principle in this respect. Researchers, at very least, are expected to make the data and/or non-numerical results that underlie the conclusions of the published work resulting from the project publicly available at the same time as the work's publication. Any costs incurred for this can be included in the project budget. Researchers should explain how data emerging from the project will be dealt with based on the data management section in the proposal and the data management plan that is drawn up after funding is awarded.

Data management Section

The data management section is part of the proposal. Researchers are asked before the start of the research to consider how the data collected will be ordered and categorised so that this can be made publicly available. Measures will often already need to be taken, both during data genertation and as part of analysing the data, to make its subsequent storage and dissemination possible. If it is not possible to make all data from the project publicly available, for example due to reasons of privacy, ethics or valorisation, then the applicant is obliged to list the reasons for this in the data management section.

The data management section in the proposal is not evaluated and will therefore not be weighed in the decision whether to award funding. However, both the referees and the committee can issue advice with respect to the data management section.

3.5.3 Scientific integrity

In accordance with the NWO Grant Rules 2017, the project that NWO funds must be carried out in accordance with the nationally and internationally accepted standards for scientific conduct as stated in the Netherlands Code of Conduct for Research Integrity (2018). By submitting the proposal, the applicant commits to this code. In the case of a (possible) violation of these standards during a project funded by NWO, the applicant should immediately inform NWO of this and should submit all relevant documents to NWO. More information about the code of conduct and the policy regarding research integrity can be found on the website: <u>Scientific integrity | NWO</u>.

3.5.4 Ethical statement or licence

The applicant is responsible for determining whether an ethical statement or licence is needed for the realisation of the proposed project. The applicant should ensure that this is obtained from the relevant institution or ethics committee on time. The absence or presence of an ethical statement or licence at the time of the application process has no effect on the assessment of the application. If the project is awarded funding, then the grant is issued under the condition that the necessary ethical statement or licence is obtained before the latest start date for the project. The project cannot start until NWO has received a copy of the ethical statement or licence.

3.5.5 Nagoya Protocol

The Nagoya Protocol ensures an honest and reasonable distribution of benefits emerging from the use of genetic resources (Access and Benefit Sharing; ABS). Researchers who make use of genetic sources from the Netherlands or abroad for their research should familiarise themselves with the Nagoya Protocol (<u>ABS Focal Point - ABS Focal Point</u>). NWO assumes that researchers will take all necessary actions with respect to the Nagoya Protocol.

3.5.6 Co-funding

Co-funding is not compulsory within this call. However, co-funders may be included in the project proposal. A distinction is made between in cash co-funding, which serves to cover the budget for the project activities described in the proposal, and in kind co-funding, which can consist of the use of resources from the organisations involved. Conditions for co-funding are specified in Annex 7.4 to this Call for proposals.

Declaration co-funding

In a declaration co-funding, the co-funder expresses both substantive and financial support for the project and confirms the pledged co-funding. In the declaration co-funding, the co-funder also states whether the support pledged originates from private sources. The declarations co-funding from all co-funders are mandatory annexes to the proposal. The declaration co-funding must be signed by an authorised signatory of the co-funder. NWO will provide a mandatory template for the declaration co-funding.

In the case of funding being awarded, the co-funder should state their contribution(s) in the consortium agreement (amongst other things for invoicing in the case of in cash co-funding). In this agreement, further agreements are also made between the co-funder(s) and the applicant(s) (see Section 5.1.3).

3.5.7 Declarations of commitment of cooperation partners

In a declaration of commitment a cooperation partner enounce support for the project en describes their role within the project. Declarations of commitment may only be provided in the proposals phase. NWO make a letter available on the funding page.

In case of awarding funding the cooperation partner must confirm its contribution in the project. Further agreements are also made in this agreement between the cooperation partner(s) and the applicant(s) (see also section 5.1.3).

3.5.8 Involvement and development of young researchers

NWO considers it important that projects in the NWA-ORC programme should serve as a breeding ground for talented researchers. For this reason, applications should focus on how the project will create scope for the development of talented young and mid-career researchers both within and outside academia (i.e. postdocs, tenure trackers, assistant professors). This should be explained in the proposal by means of a brief plan for the development of these researchers. This plan is a mandatory part of the full proposal, and the quality of this plan will be considered in assessing the full proposal.

4 Assessment procedure

This chapter first describes the assessment according to the DORA principles (Section 4.1) and the course of the assessment procedure (Section 4.2). Second, it states the criteria that the assessment committee will use to assess your application (Section 4.3).

The NWO Code for Dealing with Personal Interests applies to all persons and NWO employees involved in the assessment and/or decision-making process (Code for Dealing with Personal Interests | NWO).

NWO strives to achieve an inclusive culture where there is no place for conscious or unconscious barriers due to cultural, ethnic or religious background, gender, sexual orientation, health or age (<u>Diversity and inclusion | NWO</u>). NWO encourages referees and members of an assessment committee to be actively aware of implicit associations and to try to minimise these. NWO will provide them with information about concrete ways of improving the assessment of an application.

4.1 The San Francisco Declaration (DORA)

NWO is a signatory to the San Francisco Declaration on Research Assessment (DORA). DORA is a worldwide initiative that aims to improve the way research and researchers are assessed. DORA contains recommendations for research funders, research institutions, scientific journals and other parties.

DORA aims to reduce the uncritical use of bibliometric indicators and obviate unconscious bias in the assessment of research and researchers. DORA's overarching philosophy is that research should be evaluated on its own merits rather than on the basis of surrogate measures, such as the journal in which the research is published.

When assessing the scientific track record of applicants, NWO makes use of a broad definition of scientific output.

NWO requests committee members and referees not to rely on indicators such as the Journal Impact Factor or the h-index when assessing applications. Applicants are not allowed to mention these in their applications. You are, however, allowed to list other scientific products besides publications, such as datasets, patents, software and code, et cetera.

For more information on how NWO is implementing the principles of DORA, see DORA | NWO.

4.2 Procedure

The application procedure consists of the following steps:

- register an initiative;
- publication of the initiatives on the website;
- participation in collaborative workshops;

The assessment procedure includes the following steps:

- submission of the proposal;
- admissibility of the proposal;
- peer review by referees;
- rebuttal;
- pre advice assessment committee;
- interview selection;
- interview;
- assessment committee meeting;
- decision-making.

Assessment committee

NWO allocates the applications across the different thematic clusters. For each thematic cluster, the NWO Executive Board appoints an external, independent, broadly composed cluster assessment committee. This assessment committee is made up of representatives from science and the entire knowledge chain, including societal stakeholders and representatives from the target group with knowledge of the discipline. You should therefore formulate your proposal clearly and comprehensively for experts from diverse backgrounds.

The assessment of the applications takes place within a relevant thematic cluster. In the following sections, the term 'assessment committee' always refers to the 'cluster assessment committee'.

The assessment committee's tasks are to assess the submitted applications and the documents associated with these against each other and to judge the applications on their own merits based on the assessment criteria stated in this Call for proposals.

4.2.1 Registration or withdrawal of an initiative

With the registration of an initiative, you state that you have a potential contribution to a theme or an idea for a project for one of the themes in this Call for proposals. Project ideas will be published per theme on the NWO website. You can withdraw an initiative at any time. You can do this by sending an email to NWO (<u>nwa-orc2024@nwo.nl</u>). After withdrawing an initiative, it is no longer possible to submit a proposal.

4.2.2 Participation in collaborative workshops

After the registration of the initiatives, NWO will organise two successive collaborative workshops per theme. These workshops will take place at a physical location in May and June 2024 (see Section 4.2.11) on two half days, with an intervening period of about two weeks. The applicants who register an initiative will be automatically registered for the collaborative workshops.

The main applicant of a proposal must have participated in both workshops. If the main applicant cannot attend the meeting, then a deputy should be found. NWO needs to be informed about this at least one working day before the start of the relevant workshop via email (<u>nwa-orc2024@nwo.nl</u>). The collaborative workshops are explicitly also open to parties who have not submitted an initiative. In this way, they also receive the opportunity to join existing consortia or consortia that are in the process of being formed.

The aim of the collaborative workshops is to facilitate the optimal formation of networks around the themes and to encourage collaboration. The registered initiatives form the basis for the discussions during the workshops. The workshops offer the possibility to combine research ideas and to form broad innovative consortia (consolidation of strengths). It is subsequently up to the participants to enter into collaboration in inter- and transdisciplinary innovative consortia that span the entire knowledge chain.

More information about the workshops will also be published on the programme page of the NWO website.

4.2.3 Submission of a proposal

For the submission of the proposal, a standard form is available on the funding page of this Call for proposals on the NWO website. When you write your proposal, you must adhere to the questions stated on this form and the procedure given in the explanatory notes. You must also adhere to the conditions for the maximum number of words and pages.

Your complete application form must have been received before the deadline via ISAAC (see Section 1.3). After this deadline, you can no longer submit a proposal. After submitting the proposal, the main applicant will receive a confirmation of receipt.

4.2.4 Admissibility of the proposal

As soon as possible after you have submitted your proposal, you will hear from NWO whether or not your proposal will be taken into consideration. NWO will determine this based on several administrative-technical criteria (see the formal conditions for submission, Section 3.4). NWO can only take your proposal into consideration if it meets these conditions.

Please bear in mind that within two weeks after the submission deadline, NWO may approach you with any possible administrative corrections that need to be made so that your proposal can (still) meet the conditions for submission. You will be given one opportunity to make the corrections, and you will be given five working days to do this.

4.2.5 Peer review by referees

Prior to the assessment committee considering your proposal, NWO will request input from at least two external referees. These are independent advisers who are experts in the subjects of the proposal. They will assess the proposals based on the assessment criteria outlined in the Call for proposals (Section 4.3).

A maximum of three non-referees can be registered. Applicants can register these non-referees in ISAAC when submitting the proposal. NWO will not approach these non-referees to assess the proposal as external referees.

4.2.6 Rebuttal

The main applicant subsequently receives the anonymised referee reports. You then have the opportunity to formulate a rebuttal. You will be given ten working days to submit your rebuttal via ISAAC. If you decide to withdraw the proposal, then you should do this as quickly as possible by sending an email stating this to the office and withdrawing the proposal in ISAAC. If NWO receives your rebuttal after the deadline, then it will not be included in the rest of the procedure.

4.2.7 Pre-advice assessment committee

After this, your proposal, the referees' reports and your rebuttal will be submitted for comments to several members of the assessment committee (the pre-advisers). The pre-advisers will provide a written substantive and reasoned response to the proposal. They will formulate these comments based on the substantive assessment criteria (see Section 4.3.1) and will give the proposal a numerical score per assessment criterion. For this, the NWO score table will be used (on a scale of 1 to 9, where "1" is excellent and "9" unsatisfactory).

4.2.8 Interview selection

In principle, all consortia that submitted a proposal will be invited for an interview by the assessment committee. If the number of full proposals within a theme is more than three times the expected number of full proposals that can be allocated funding, then the assessment committee can decide to invite just a selection of the consortia for an interview.

The proposals, 'the referees' reports and the rebuttal/the pre-advices and the rebuttal will be submitted to the assessment committee. The assessment committee will then make its own assessment based on these documents. Subsequently, the applicants with the highest ranked proposals for the theme will be invited for an interview. If, after the interview selection, it is clear that two or more proposals based on their weighted total score cannot be distinguished from each other than an ex aequo situation exists (see Section 4.2.11).

4.2.9 Interview

During the interview, the assessment committee will have the opportunity to pose questions, including new questions that the referees did not ask. During the interview, the consortium will be able to respond to these in the discussion with the committee. In this manner, the principle of having a hearing and an opportunity for rebuttal is further applied. The interview is an important part of the assessment procedure and can lead to an adjustment of both the assessment and the score of the proposal.

4.2.10 Meeting of the assessment committee

The assessment committee will make its own assessment based on the available material. Although the referees' reports will 'guide' the final assessment to a large extent, it will not be blindly accepted without question by the committee. The assessment committee will consider and compare the arguments of the referees/pre-advisers (also amongst each other) and examine whether the rebuttal contains a well-formulated response to the critical comments from the referees' reports. Furthermore, the assessment committee, unlike the referees, will assess the quality of all the proposals and rebuttals submitted. Therefore, the committee's assessment may differ from that of the referees.

Following the discussion, the assessment committee draws up a written recommendation addressed to the NWO Executive Board about the quality and ranking of the proposals. This recommendation is based on the assessment criteria. The proposal must receive an overall qualification of at least "very good" to be eligible for funding. In addition, the application must receive at least the qualification 'very good" on the assessment criterion 'Problem Statement and Analysis' and at least the qualification "good" on the other individual assessment criteria to be eligible for allocation.

If, after the discussion of the full proposals, two or more of the full proposals cannot be distinguished from each other based on their weighted total score, then this will result in an ex aequo situation (see paragraph 4.2.11).

For more information about the qualifications, see <u>Applying for funding</u>, how does it work? | NWO.

4.2.11 Ex aequo

NWO understands ex aequo to be a situation in which two or more proposals based on their weighted score cannot be distinguished from each other. An ex aequo situation is relevant with respect to the borders of the available budget or the selection borders. The existence of an ex aeguo situation is determined as follows. The starting point in this process is the ranking drawn up by the assessment committee, with the final scores rounded down to two decimal points. The reference score here is the score of the lowest-ranked proposal within the borders of the available budget or the selection borders. All proposals with a score that is within 0.05 or less of the reference score will be considered. In this way, the proposals that are equal within a score of 0.1 will be selected. If an ex aequo situation occurs at the borders of the available budget or the selection borders, then with a better assessment pertaining to criterion 'Alignment with the objectives of the programme', will end as the highest. This criterion is considered first due to its central role in assessing the relevance and urgency of the proposed research and its connection with the theme. If the ex aequo situation is not resolved with this, then the proposal with the highest score for the criterion 'Quality of the consortium' will end highest. This emphasises the importance of a well-composed and fully collaborating consortium, which is in line with the NWA ORC objectives that promote collaboration and inter-and transdisciplinary research. If the ex aequo situation is not resolved with this, then the proposal with the highest score for the criterion 'Quality of the research' will end highest. Excellent research is a crucial factor for the progress of scientific knowledge and societal impact. If the ex aequo situation is not resolved with this, then the proposal with the highest score for the criterion 'Envisaged impact and route to impact' will end highest. If the proposals subsequently in a tie, the assessment committee, with the help of an (anonymous) majority vote, will determine the ranking (in accordance with Article 2.2.7, third paragraph, sub a, part iv of the NWO Grant Rules 2017). If this vote provides no resolution either, or is not desirable to vote, the ex aequo situation will be send on to the decision-making body.

4.2.12 Decision-making

Finally, the NWO Executive Board will assess the procedure followed as well as the advice from the assessment committee. They will subsequently determine the final qualifications and make a decision over awarding or rejecting the proposals.

4.2.13 Timetable

Below, you will find the timetable for this Call for proposals. During the current procedure, NWO might find it necessary to make further changes to the timetable for this Call for proposals. You will be informed about this in time.

Registering initiatives	
9 April 2024 , before 14:00:00 CEST	Deadline registering initiatives
6 May – 28 June 2024	Collaborative workshops (per theme)
Proposals	
17 September 2024, before 14:00:00 CEST	
1 October 2024, before 14:00:00 CEST	Deadline proposals
October – December 2024	Referees consulted
January 2025	Applicants can submit a rebuttal
April – May 2025	Interview selection interviews Assessment committee meeting
June 2025	Decision by the board

4.3 Criteria

4.3.1 Substantive assessment criteria

The applications submitted within this Call for proposals will be substantially assessed on the basis of the following criteria:

The applications submitted within this Call for proposals will be substantially assessed on the basis of the following criteria:

- 1. Problem definition and analysis (20%)
- 2. Envisaged impact and route to impact (20%)
- 3. Quality of the consortium (30%)
- 4. Quality of the research (30%)

The following specific aspects of the four assessment criteria will be assessed:

- 1. Problem definition and analysis
- Clearly formulated definition of the problem and resulting research questions, logically related and contributing to the objective of the call and the theme formulated within this, to which the proposal relates.
- Societal and scientific urgency and relevance of the defined problem.
- Interdisciplinary and transdisciplinary character of the problem definition and the research questions.
- 2. Envisaged impact and route to impact
- The envisaged scientific and societal impact is clearly defined and follows logically from the identified problem or question.
- The Impact pathway describes a clear route to the societal impact, as well as the role of the partners involved.
- Appropriate strategic activities to achieve the impact, such as stakeholder engagement, communication, monitoring and evaluation, and capacity development.

3. Quality of consortium

- The composition of the consortium is a logical fit with the proposed project: interdisciplinary, involvement of relevant societal stakeholders and/or citizens and the wider knowledge chain.
- Complementarity of the consortium partners in terms of the knowledge, skills and expertise required to execute the project.
- Active involvement of the partners in the development of the project (co-design), from the articulation of the problem definition and the research questions, and in its execution (co-creation). This results in the formation of a (social) network as part of and around the project.
- A clear division of tasks and roles within the consortium with respect to the execution of the research and the governance of the project.
- There is a tangible and feasible plan for the professional development of talented young and midcareer researchers both within and outside of the academic world.

4. Quality of the research

- The scientific research question follows logically from the analysis of the problem and is original and innovative for the disciplines and expertise areas concerned.
- The proposed approach and methodology are suitable for achieving the specified objectives and answering the research question. The consortium employs fundamental, applied and practical research in its approach.
- The integrated character of the inter- and transdisciplinary research.
- The structure of the proposed research plan: clearly defined and logically coherent work packages;
 suitable and well-substantiated budget; risk analysis; and, if necessary, a back-up plan.

5 Obligations for grant recipients

This chapter details the various obligations that - in addition to the conditions stated in Section 3.5 - apply after funds have been awarded.

5.1.1 Limitation submission future calls

Main applicants whose application is awarded funding in the NWA ORC round 2024 may not submit an application as the main applicant in subsequent rounds of the NWA ORC programme throughout the duration of the project awarded funding.

5.1.2 Start meeting

Shortly after the awarding of the project, a start meeting will take place between the NWO employee who supervises the project and at least the project leader. Subjects discussed at this meeting will include information about starting the research, the organisation of a kick-off meeting at the beginning of the project, the supervision and monitoring, and the appointment of the Advisory Committee (see Section 5.1.3).

5.1.3 Content monitoring

NWO will assume responsibility for the substantive monitoring of the proposals awarded funding. Each year, the main applicant will, on behalf of a consortium, report about the progress of the project in a progress report. NWO will make a template available for this. For the duration of this programme, NWO will organise programme meetings. All projects within this call theme will be invited to participate.

Meetings

NWO will organise various meetings within the NWA programme. The project leaders will be invited whenever meetings relevant to the NWA-ORC projects are organised. A representative from the project is expected to participate and actively contribute.

Advisory Committee

Each consortium will appoint an Advisory Committee to strengthen the monitoring. The main task of the Advisory Committee is to advise the project leader in general about the direction of the project based on the progress report with the aim of maximising the chances of scientific and/or societal impact.

The Advisory Committee meets at least once a year and consists of:

- representation from the cooperation partner(s);
- representation from the co-funder(s) (if applicable);
- at least one independent scientific member not involved in this consortium;
- at least one independent societal member not involved in this consortium and relevant for advancing the results.

The consortium is responsible for the secretariat of the Advisory Committee. At least the main applicant and project manager will be present during the annual meetings, as well as the NWO employee responsible for supervising the project.

5.1.4 Accountability and project completion

Annual reporting

Consortia will report annually about the progress of the research, amongst other things, as preparation for the annual meeting of the Advisory Committee (see 5.1.3). The project leader is responsible for these reports about the project in which both the substantive and financial progress must be reported upon. In this reporting, accountability for the co-funding provided must also be given. NWO will provide a template for the progress report.

Interim evaluation

NWA-ORC projects with a duration between 6 and 8 years will undergo an interim evaluation. This will take place at least 3 months before the end of the first 4-year period and consists of a self-evaluation by the consortium, carried out in a joint workshop with collaborative partners and other stakeholders. Prior to the evaluation, at least 3 months before the end of the first period of 4 years, the budget for the project in years 6 to 8 will be compiled (if applicable), and the adjusted project plan will be submitted to NWO for approval in accordance with the NWO Grant Rules. In due time, projects will receive more information about the NWO requirements set for this self-evaluation.

Accountability and project completion

Upon completion of a project, NWO requests final substantive and financial reports. In the substantive report, the consortium presents (if an Impact Plan has been drawn up) the output achieved and, where applicable, the outcomes. After NWO has approved both reports, the final amount of the grant and co-funding is determined.

5.1.5 Data management

After a proposal has been awarded funding, the researcher should elaborate the data management section into a data management plan. For this, applicants can make use of the advice from the referees and committee. The applicant must describe in the plan whether existing data will be used, or whether new data will be collected or generated, and how this data will be made FAIR: Findable, Accessible, Interoperable, Reusable. Before submission, the data management plan should be checked by a data steward or similar officer of the organisation where the project will be realised. The plan should be submitted to NWO via ISAAC within 4 months after the proposal has been awarded funding. NWO will check the plan as quickly as possible. Approval of the data management plan by NWO is a condition for disbursement of the funding. The plan can be adjusted during the research.

More information about the data management protocol of NWO can be found at: <u>Research data</u> <u>management | NWO</u>.

5.1.6 Intellectual property and and consortium agreement

With respect to intellectual property (IP), the NWO IP policy applies. This can be found in Chapter 4 of the NWO Grant Rules 2017.

Applicants must carry out a project funded by NWO during the time that they work for the knowledge institution. If an applicant or a researcher funded by NWO is appointed by more than one employer, then the other employer should relinquish any possible IP rights that emerge from the project of the applicant.

NWO's ambition is that research results can be applied by partners involved in the project. NWO aims that all research results from projects it funds are made publicly accessible while at the same time encouraging parties to further develop the research results by giving them the possibility to exploit these. For the exploitation of results, it can be desirable to transfer intellectual property rights or to license the use of these to (one of) the private parties involved in the project. The basic premise is that all research results can be published with due consideration for agreements made about publication procedures.

After a proposal has been awarded funding, the conclusion of a consortium agreement is one of the conditions for starting the project. In this agreement, arrangements are made about intellectual property and publication, knowledge transfer, confidentiality, co-financing payments, progress reports, and final reports. Uploading in ISAAC is required before the project can start. The responsibility for arranging the consortium agreement lies with the applicant.

The model agreement that NWO makes available must be used and can be found on the funding page of this Call for proposals. This model agreement has been drawn up in accordance with the NWO Grant Rules 2017.

5.1.7 Socially responsible licensing

The knowledge that emerges from the project could be suitable for use in society. When agreements about licensing and/or the transfer of research results developed under this Call for proposals are made, due consideration should be given to the ten principles for socially responsible licensing, as stated in the NFU factsheet "<u>19.4511 Ten principles for Socially Responsible Licensing v19-12-</u><u>2019.pdf (nfu.nl)</u>".

5.1.8 Open Access

As a signatory to the Berlin Declaration (2003) and a member of cOAlition S (2018), NWO is committed to making the results of the research it funds openly accessible via the internet (Open Access). By doing this, NWO gives substance to the ambitions of the Dutch government to make all publicly funded research available in Open Access form. Scientific publications arising from projects awarded on the basis of this Call for proposals must therefore be made available in Open Access form in accordance with the Open Access Policy.

Scientific articles

Scientific articles must be made available in Open Access form immediately at the time of publication (without embargo) via one of the following routes:

- publication in a fully Open Access journal or platform registered in the DOAJ;
- publication in a subscription journal and the immediate deposition of at least the author accepted manuscript of the article in an Open Access repository registered in Open DOAR;
- publication in a journal for which a transformative Open Access agreement exists between UNL and a publisher. For further information, see <u>Open Access |</u>.

Books

Different requirements apply to scholarly books, book chapters and edited collections. See the Open Access Policy Framework at <u>Open Science | NWO</u>.

CC BY licence

To ensure the widest possible dissemination of publications, at least a Creative Commons (CC BY) licence must be applied. Alternatively – in case of substantial interest – the author may request to publish under a CC BY-ND licence. For books, book chapters and collected volumes, all CC BY licence options are allowed.

Costs

Costs for publication in fully Open Access journals can be budgeted in the application using the budget module for "material costs". Costs for publications in hybrid journals are not eligible for reimbursement by NWO. For Open Access books, a separate NWO Open Access Books Fund is available.

For more detailed information about NWO's Open Access policy, see Open Science | NWO.

6 Contact and other information

6.1 Contact

6.1.1 Specific questions

For specific questions about this Call for proposals, please contact: Jean-Pierre Oudsen +31 70 3440 572 nwa-orc2024@nwo.nl

6.1.2 Technical questions about the web application ISAAC

For technical questions about the use of ISAAC, please contact the ISAAC helpdesk. Please read the manual first before consulting the helpdesk. The ISAAC helpdesk can be contacted from Monday to Friday between 10:00 and 17:00 hours on +31 (0)70 34 40 600. However, you can also submit your question by email to <u>isaac.helpdesk@nwo.nl</u>. You will then receive an answer within two working days.

6.2 Other information

The whole text of this Call for proposals has been published in both Dutch and English. The Dutch version is deemed authentic. For legal interpretation the text of the Dutch version will be decisive.

NWO processes data from applicants received in the context of this Call in accordance with the NWO Privacy Statement, <u>Privacy Statement | NWO</u>.

NWO might approach applicants for an evaluation of the procedure and/or research programme.

7 Annex(es):

7.1 Explanation of budget modules

It is possible to apply for the funding of the salary costs of personnel who make a substantial contribution to the research. Funding of these salary costs depends on the type of appointment and the organisation where the personnel are/ will be appointed.

- For university appointments, the salary costs are funded in accordance with the UNL salary tables applicable at the moment the grant is awarded (<u>Salary tables | NWO</u>).
- For university medical centres, the salary costs are funded in accordance with the NFU salary tables applicable at the moment the grant is awarded (<u>Salary tables | NWO</u>).
- For personnel from universities of applied sciences, educational institutions and other organisations, salary costs will be funded based on the collective labour agreement pay scale of the employee concerned in accordance with the applicable rate at the time of awarding the grant as taken from Table 2.2, column 'Hourly rate productive hours, excl. Dutch VAT' from the *Handleiding Overheidstarieven* [HOT- Manual Dutch Government Rates] (Salary tables | NWO).
- For the Caribbean Netherlands, the Dutch government employs civil servants on Bonaire, Sint Eustatius and Saba under different conditions than in the European part of the Netherlands <u>Employment terms and conditions | Working at the Rijksdienst Caribisch Nederland | Rijksdienst</u> <u>Caribisch Nederland (rijksdienstcn.com)</u>.

NWO will apply a mandatory one-off indexing of the salary¹² costs with respect to:

- UNL rates: for proposals submitted before 1 July and that are awarded funding after 1 July;
- NFU rates: for proposals submitted before 1 August that are awarded funding after 1 August;
- HOT rates: for proposals submitted before 1 January that are awarded funding after 1 January.

The mandatory one-off indexing does not affect the level of the grant ceiling or the maximum amount of the grant awarded for each proposal. Both the level of the grant ceiling and the maximum amount of the grant awarded will remain unchanged during the assessment procedure. The mandatory one-off indexing will be applied after the decision-making process about awarding or rejecting proposals is completed.

If co-funding is required or permitted then the one-off mandatory indexing will have no consequences for the co-funding requirement or the IP rights that can emerge from the co-funding.

The rates for all budget modules are incorporated in the budget template that accompanies the application form. For the budget modules "PhD student", "EngD" and "Postdoc", a one-off individual bench fee of €5,000 is added on top of the salary costs to encourage the scientific career of the project employee funded by NWO. Remunerations for PhD scholarship students ('bursalen') at a Dutch university are not eligible for funding from NWO.

The available budget modules are explained below.

PhD student (including MD-PhD student)

A PhD student is appointed for 1.0 FTE for a duration of 48 months. The equivalent of 48 full-time months, for example an appointment of 60 months for 0.8 FTE, is also possible. If a different duration of appointment is considered necessary for the realisation of the proposed research, then the standard time can be deviated from as long as this is properly justified. However, the duration of appointment must always be at least 48 months.

In line with the NWO strategy, Industrial and Societal Doctorates are included in this category under this call. Conditions regarding Industrial and Societal Doctorates are explained in Annex 7.2.

¹² 1 July, 1 August and 1 January are the dates on which the relevant rates are generally adjusted, in the case of indexation the date of actual annual adjustment will be taken into account.

Engeneering Doctorate degree (EngD)

Funding for the appointment of a EngD can only be applied for if funding for a PhD student or postdoc is also applied for.

The appointment for a EngD position is a maximum of 1.0 FTE for 24 months. The EngD trainee is employed by the institution applying for funding and can realise activities that are part of the research at an industrial partner for a specified time. If the research proposal is awarded funding, then an agreement must be concluded with the industrial partner(s) concerned. The underlying "Technological Designer Programme" must be described in the proposal.

Postdoc

The size and duration of the postdoc appointment is at least 6 full months and at most 48 full-time months. The size and duration of the appointment is at the applicant's discretion, but the appointment is always for at least 0.5 FTE or for a duration of at least 12 months. The product of FTE x duration of appointment should always be a minimum of 6 full-time months.

The material budget is available to cover the costs of a more limited appointment of a postdoc.

Non-scientific staff (NSS) at universities

Funding for the appointment of NSS required to realise the research project can only be applied for if funding for a PhD student or postdoc is also applied for. A maximum of €100,000 per PhD student of postdoc can be requested for NSS, up to a maximum of €300,000. This includes personnel such as student assistants, programmers, technical assistants or analysts. Depending on the level of the position, the appropriate salary table for NSS at MBO, HBO or university level applies. The size of the appointment is at least 6 full-time months and at most 48 full-time months. The size

and duration of the appointment is at the applicant's discretion, but the appointment is always for at least 0.5 FTE or for a duration of at least 12 months. The product of FTE x duration of appointment should always be a minimum of 6 full-time months.

The material budget is available to cover the costs of a more limited appointment of NSS.

Other Scientific personnel (OSS) at universities

Budget for OSS such as AIOS (doctor training to be a specialist), ANIOS (doctor not training to be a specialist), scientific programmers or employees with a master's degree can only be applied for if funding for a PhD student or postdoc is also applied for. For this category, a maximum of €100,000 can be applied for.

The size of the appointment is at least 6 full-time months and at most 48 full-time months. The size and duration of the appointment is at the applicant's discretion, but the appointment is always for at least 0.5 FTE or for a duration of at least 12 months. The product of FTE x duration of appointment should always be a minimum of 6 full-time months.

Research leave for applicants

With this budget module, funding can be requested for the costs of the research leave of the main and/or co-applicant(s). The employer of the applicant(s) can use this to cover the costs of relinquishing him or her from educational, supervisory, administrative or management tasks (not research tasks). The time that is released through the research leave grant can only be used by the applicant(s) for activities in the context of the project. The proposal must describe which activities in the context of the project the applicant(s) will carry out in the time relinquished.

The total funding requested for research leave in the NWA-call may not exceed 10% of the total budget requested from NWO. NWO funds the research leave in accordance with the salary tables for a senior scientific employee (scale 11) at the time the grant is awarded (Salary tables | NWO).

Personnel universities of applied sciences, educational institutions and other organisations

With the exception of personnel that fall under UNL or NFU rates, costs for the funding of personnel employed at a university of applied sciences, educational institution or at other organisations will be remunerated in accordance with Table 2.2, column 'Hourly rate productive hours, excl. Dutch VAT' from the *Handleiding Overheidstarieven* [HOT- Manual Dutch Government Rates] (Salary tables | NWO).

For the calculation you should use the number of productive hours stated in the valid volume of the *Handleiding Overheidstarieven*.

Explanation of budget module Material

For each FTE scientific position (PhD student, postdoc, EngD) applied for, a maximum of €15,000 material budget can be applied for per year of the appointment. Material budget for smaller appointments can be applied for on a proportionate basis and will be made available by NWO accordingly. Per 0.2 FTE scientific employee applied for at a university of applied sciences, educational institution or other organisation (with a minimum appointment of 0.2 FTE for 12 months) a maximum of €15,000 in material budget can be applied for per year.

The applicant is responsible for distributing the total amount of material budget across the NWOfunded personnel positions. The material budget that can be applied for is specified according to the three categories below:

Project-related goods/services

- consumables (e.g. glassware, chemicals, cryogenic fluids, etc.);
- measurement and calculation time (e.g. access to supercomputer, etc.);
- costs for acquiring or using data collections (e.g. from Statistics Netherlands [CBS]), for which the total amount may not be more than €25,000 per proposal;
- access to large national and international facilities (e.g. cleanroom, synchrotron, etc.);
- work by third parties (e.g. laboratory analyses, data collection, citizen science, etc.);
- personnel costs for the appointment of a postdoc and/or non-scientific personnel for a smaller appointment size than those offered in the personnel budget modules.

Travel and accommodation costs for the personnel positions applied for

- travel and accommodation costs;
- conference attendance (maximum of two per year per scientific position applied for);
- fieldwork;
- work visit.

Implementation costs

- national symposium/conference/workshop organised by the project researchers;
- costs for Open Access publishing (solely in full gold Open Access journals, registered in the "Directory of Open Access Journals" <u>https://doaj.org/</u>);
- costs data management;
- costs involved in applying for licences (e.g. for animal experiments);
- audit costs (only for institutions that are not subject to the education accountants protocol of the Ministry of Education, Culture and Science), maximum €5,000 per proposal; for projects with a duration of three years or less, a maximum of €2,500 per proposal applies.

Costs that cannot be applied for are:

- basic facilities within the institution (e.g. laptops, office furniture, etc.);
- maintenance and insurance costs.

If the maximum amount is not sufficient for realising the research, then this amount may be deviated from, if a clear justification is provided in the proposal.

Citizen science

Involving citizens (citizen science) can contribute to the quality of the research. With the help of citizens, data and insights can be acquired that would not otherwise be available for research. NWO also funds citizen science. Applicants can use the budget module "material, project-related goods/services, work by third parties" to request a remuneration for the involvement of citizens in projects. The budget module offers a possibility and is not a requirement. Applicants are free to decide whether it is worthwhile involving citizens in the project and what exactly they use this budget for (for example, reimbursement of expenses of citizens, skills training for citizens or technical devices for the participating citizen).

Researchers must ensure the responsible use of citizens¹³ and guarantee the quality of the work/data. This means that public involvement in the research entails obligations and requires constant time and attention. With regard to managing citizen science, NWO recommends that researchers:

- organise sufficient interaction, ideally by combining virtual and physical events;
- ensure regular feedback to participating citizens, for example from the project manager.

The effective implementation of citizen science also requires:

- that researchers are transparent towards the citizens/participants about the goals, working methods and phases of those parts of the research project in which the citizens are involved.
- That researchers explicitly state and monitor the quality standards. The same principles and standards apply to citizen science as to the assessment of scientific practice in general. The Netherlands Code of Conduct for Research Integrity also applies to citizen science. This means that participating citizens must also comply with privacy legislation.
- That researchers should fully recognise the participation of citizens involved in research, for example through acknowledgements in scientific publications.

Explanation of budget module Investments (up to €150,000)

In this budget module, funding can be requested up to a maximum of €150,000 for investments in equipment, datasets and/or software (e.g. lasers, specialised computers or computer programs).

Explanation of budget module Investments (€150,000 to €500,000)

In this budget module, funding can be requested for investments in scientifically innovative equipment and/or data collections of national and international importance. The minimum amount that can be applied for is €150,000.

NWO funds a maximum of 75% of the total investment costs, up to a maximum of \leq 500,000. The applying institution must contribute at least 25% of the total costs of the investment. This contribution to the investment must be confirmed in writing by the applying institution when the proposal is submitted.

The costs for investments should be adequately specified and motivated in the proposal. Funding can be requested for:

- costs for investments in scientific equipment;
- costs for investments in datasets;
- personnel costs for the setting up of databases and the initial digitisation of the bibliographical equipment, if these cannot be purchased;
- personnel costs for employees with essential technical expertise that is necessary in order to build or develop an investment.

¹³ By "responsible use", NWO means that the use of citizens must have a clear added value for the research, that occupational health and safety and privacy legislation must be complied with, and that clear agreements must be made concerning hours to be contributed, supervision and further training. One way in which this can be implemented is by a volunteer agreement (for a model agreement in Dutch, see <u>Model vrijwilligersovereenkomst | Movisie</u>).

If funding for personnel costs is applied for, then the need for these personnel costs must be justified. If the applicant does not have this expertise available, then it must be stated that this expertise needs to be procured with these costs. The internal procurement procedures and/or guidelines of the applicant are applicable.

Funding cannot be requested for:

- costs of infrastructure facilities that can be regarded as part of the usual infrastructure;
- data collections and any associated software and bibliographies that are already available in other ways;
- other personnel costs, including personnel costs required to operate and conduct research with the facility;
- costs for maintenance and use of the equipment on a project. The costs for researchers using equipment for a project can be applied for via the material budget.

Explanation of budget module Knowledge utilisation

The aim of this budget module is to facilitate the use of the knowledge that emerges from the research.¹⁴ At least 5% but no more than 20% of the total budget applied for should be spent on knowledge utilisation activities via this budget module.

As knowledge utilisation takes many different forms in different scientific fields, the applicant needs to specify the required costs, e.g. costs of producing a teaching package, conducting a feasibility study into potential applications, or filing a patent application. The budget applied for should be adequately specified in the proposal.

It is up to the consortium to specify in the proposal which costs are required.

In the context of the Impact Plan, consortia are expected to earmark budget for the following activities:

- Specific activities to promote knowledge utilisation towards intermediary or other parties not funded in the projects, e.g. knowledge platforms. These activities include joint learning, training and communication activities.
- Stakeholder engagement: activities organised by the consortium aimed at involving stakeholders, such as consultation workshops, expert meetings, round table meetings, etc. Communication: activities organised by the consortium such as national and international learning events, development of videos, blogs, newsletters and other media communications. This may include the hiring in of communication expertise.
- Skills development: Activities aimed at developing skills beyond the levels of individual students,
 PhD students or postdocs, such as developing courses for stakeholders or Master's students.
- Monitoring and evaluation moments in which knowledge utilisation is discussed, such as interim evaluations and supervisory committee meetings (see Section 5.1.1 and 5.1.3).

Travel expenses for co-funding partners are explicitly not eligible for funding in this module. However, travel expenses for cooperation partners and external parties in the social practice of the project are eligible. The budget applied for should be adequately specified in the proposal.

Explanation of budget module Internationalisation

The budget for internationalisation is intended to encourage international collaboration. The budget applied for may not exceed €100,000. The amount requested must be specified. If the maximum amount is not sufficient for realising the research, then it may be deviated from if an adequate justification is provided in the proposal.

Funding can be requested for:

¹⁴ In this budget module, the definition for "knowledge transfer" as used by the European Commission in the Framework for State aid for research and development and innovation (PbEU, 2014, C198) applies.

- travel and accommodation costs in so far as these concern direct research costs emerging from the international collaboration and additional costs for internationalisation that cannot be covered in another manner, for example from the bench fee;
- travel and accommodation costs for foreign guest researchers;
- costs for organising international workshops/symposia/scientific meetings.

Explanation of the budget module Money follows Cooperation (MfC)

The module Money follows Cooperation provides the possibility of realising a part of the project at a publicly funded knowledge institution outside of the Netherlands.

The applicant must convincingly argue how the researcher from the foreign knowledge institution will contribute specific expertise to the research project that is not available in the Netherlands at the level necessary for the project.

This condition does not apply if NWO has concluded a bilateral agreement concerning Money follows Cooperation with the national research council of the country where the foreign knowledge institution is located. At <u>Money Follows Cooperation | NWO</u> you will find an overview of research councils that signed a bilateral MfC agreement with NWO.

The budget applied for within this module must be less than 50% of the total budget applied for.

The co-applicant from the participating foreign knowledge institution must meet the conditions set for co-applicants in Section 3.1 of this Call for proposals, with the exception of the condition that the co-applicant must be employed in the Kingdom of the Netherlands.

The rates for the personnel costs of researchers at the foreign knowledge institution are calculated on the basis of the NWO Country Correction Coefficients (CCC). The table can be found at <u>Money Follows</u> <u>Cooperation | NWO</u>.

The main applicant receives the grant and is responsible for transferring the amount to the foreign knowledge institution and for providing accountability for the MfC part of the grant. The MfC part will be part of the overall financial accountability of the project.

The exchange rate risk lies with the applicants. Therefore, gains or losses due to the exchange rate are not eligible for funding.

The applicant is responsible for:

- the financial accountability for all costs in both euros and the local currency, for which the exchange rate used must be visible;
- a reasonable determination of the size of the exchange rate. If requested by NWO, the applicant must always be able to provide a description of this reasonable determination.

If more than €125,000 is requested within this module, then the final financial statement must be accompanied by an audit report.

NWO will not award any funding to co-applicants that fall under national or international sanction legislation and rules. The EU Sanctions Map (<u>EU Sanctions Map</u>) is guiding in this respect.

Explanation of the budget module Project management

The Project Management module offers the opportunity to request a project management post up to a maximum of 5% of the total budget requested from NWO. The main applicant must adequately justify this post.

Project management includes the following: optimising the organisational structure of the consortium, supporting the consortium and the main applicant, safeguarding the coherence, progress and unity of the project, and coordinating between the sub-projects within the project. These tasks may also be carried out by external parties if they are not available within the main applicant's knowledge institution. Knowledge institutions should take account of public procurement rules in the tender procedure for selecting a third party and, where appropriate, follow a European procurement procedure. The activities of main applicants and co-applicants themselves in relation to the project or project management may not be funded under this budget module.

The budget to be requested for project management can consist of material or implementation costs and personnel costs. For personnel costs, a maximum rate of \notin 121 per hour can be claimed. The hourly rate of personnel to be appointed must be based on a cost-covering rate and is calculated on the basis of the standard productive number of hours used by the organisation. The cost-covering rate includes:

- (average) gross salary corresponding to the position of the employee who will contribute to the project (based on the collective labour agreement grade of the employee concerned);
- holiday allowance and 13th month (if applicable in the relevant collective labour agreement) in proportion to the FTE deployed;
- social security charges;
- pension costs;
- overheads.

Project management tasks may be carried out by external parties, but the part of (commercial) hourly rates that exceeds the rates stated is not eligible for funding and therefore cannot be included in the budget.

7.2 Industrial and Societal Doctorates

Industrial and Societal doctorates are understood to be PhD students who will do their research at both the knowledge institution and an organisation that is not a (co-)applicant. If an organisation and the knowledge institution closely collaborate, then this increases the chance that the knowledge will actually find its way into everyday practice. The research should be an integral part of the project. In the case that an Industrial or Societal Doctorate is appointed, the private or public organisation which is involved in the doctorate should assume responsibility for at least 25% of the salary costs. This contribution may be part of the minimum required co-funding and in that case should always be in cash.

The intended PhD student may be employed by the knowledge institution or the organisation. The activities realised by the PhD student must always fall under fundamental or industrial research. The salary costs of the PhD student are always remunerated in accordance with the valid UNL rate. NWO will fund a maximum of 75% of this amount and at least 25% of the amount must be contributed by the organisation that is not a (co-)applicant. Any additional salary costs – due to an actual salary that is above the UNL rate – should be covered by the employer and may be contributed to the project in the form of in-kind funding. For the calculation of a surplus, the employer costs minus the UNL rates for an appointment of the same size is assumed. The support/grant may not be transferred to the organisation that is not a (co-)applicant.

If an industrial doctorate or societal doctorate PhD position is applied for, then the parties should make agreements about possible IP rights that are generated by the PhD student concerned. With this, allowance should be made for possible access to the research results by other project participants, under FRAND (fair, reasonable and non-discriminatory) conditions or otherwise. The NWO grant is only awarded to the knowledge institution for the purpose of the PhD research project. In this context, it is relevant to state that in accordance with the application of the NWO Grant Rules 2017, all research results should be published as soon as possible in Open Access form and accordingly serve the public interest. Furthermore, all other provisions from Section 3.5, such as Consortium agreement and Intellectual Property & Publications, apply.

7.3 Public knowledge organisations

The public knowledge organisations listed below may act as co-applicants in a consortium. The check mentioned in Section 3.1.1 is not required for these organisations.

National knowledge institutes (from: Knowledge and data center | KNMI) - Dutch only):

- 1. CBS Centraal Bureau voor de Statistiek (Statistics Netherlands)
- 2. CPB Centraal Planbureau (Netherlands Bureau for Economic Policy Analysis)
- 3. KiM Kennisinstituut voor Mobiliteitsbeleid (Netherlands Institute for Transport Policy Analysis)
- 4. KNMI Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute)
- 5. NFI Nederlands Forensisch Instituut (Netherlands Forensic Institute)
- 6. PBL Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency)
- 7. RCE Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency of the Netherlands)
- 8. RIVM Rijksinstituut voor Volksgezondheid en Milieu (National Institute for Public Health and the Environment)
- 9. RKD Nederlands Instituut voor Kunstgeschiedenis (Netherlands Institute for Art History)
- 10. RWS Rijkswaterstaat (Directorate-General for Public Works and Water Management)
- 11. SCP Sociaal en Cultureel Planbureau (Netherlands Institute for Social Research)
- 12. WODC Wetenschappelijk Onderzoek- en Documentatiecentrum (Research and Documentation Centre)

Other public knowledge institutions (from: <u>Public Knowledge Organisations Netherlands | Rathenau</u> <u>Institute</u>):

- 13. Boekman Foundation Institute for arts, culture and related policy
- 14. Clingendael Netherlands Institute of International Relations
- 15. Geonovum Knowledge organisation for geographic information
- 16. Movisie Centre for social issues
- 17. Mulier Institute Centre for sports research
- 18. (N) IFV (Netherlands) Institute for Safety
- 19. NIVEL Netherlands Institute for Health Services Research
- 20. NJi Nederlands Jeugdinstituut (Netherlands Youth Institute)
- 21. Police Academy Training, knowledge and research for the Dutch National Police
- SWOON-NLDA Stichting Wetenschappelijk Onderwijs en Onderzoek Nederlandse Defensieacademie (foundation for scientific education and research of the Netherlands defence academy)
- 23. SWOV Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (Institute for Road Safety Research)
- 24. Trimbos Institute Institute for mental health, drug abuse and addiction
- 25. VeiligheidNL Organisation to promote safe behaviour
- 26. Vilans Research into long-term care

7.4 Condition for co-funding

Invoicing in cash co-funding

After the proposal has been awarded funding, NWO will invoice the private or public party that has pledged an in cash contribution. After these funds have been received, NWO will allocate the funding to the project.

The following are permitted as in kind co-funding:

The use of personnel and material contributions is permitted on the condition that these are capitalised and are fully part of the project. Services and know how may not already exist or be available to the applicant. In kind contributions are only accepted under the condition that the part contributed by the co-funder is an integral part of the work plan and can be made visible as an identifiable effort.

Determining the value of in kind co-funding

- The use of personnel is valued on the basis of hours x rate, whereby the hourly rate is based on the actual salary costs (incl. a premium for social benefits and employer costs). Furthermore, 1400 hours is taken as the standard number of productive hours per year for the calculation of the hourly rate. This hourly rate may be no more than 119 euros per hour;
- The value for material in-kind contributions is determined on the basis of the cost price of consumables. The value of investments/equipment is determined based on standard depreciation costs bearing in mind the intensity of use and any existing depreciations according to applicable reporting principles;
- For in-kind contributions in the form of services or know-how (knowledge, software, access to databases or cell lines) the economic value must be established and only the actual costs that can be directly attributed to the project may be counted as co-funding. This is always without a profit margin. Furthermore, the service or know-how must not already be present at or available to the applicant.

Co-funders should justify the structure and size of the in-kind contributions provided (including hourly rates) in the letter of support. NWO can request substantiation and documented evidence of the rates used and can also request their adjustment.

The following may not be contributed as co-funding (both in cash and in kind):

- funding awarded by NWO;¹⁵
- PPP allowance;
- co-funding may not come from parties that on the basis of this call for proposals can submit a funding proposal to NWO
- discounts on commercial rates, e.g. on materials, equipment and services;
- costs related to overheads, supervision, consultancy and/or participation in the supervisory committee (see Section 5.1.5);
- costs of services that are conditional. The co-funding provided may not be subject to any conditions. The provision of the co-funding does not depend on whether a certain stage in the research plan is achieved (e.g. go/no-go moment);
- costs that are not reimbursed according to the call for proposals;
- costs of equipment if one of the (main) objectives of the proposal is the improvement or creation of added value for this equipment.

Accounting for in kind co-funding

The main applicant reports to NWO about the in kind co-funding that he or she has received from a cofunder. The main applicant provides accountability in accordance with the NWO Grant Rules 2017 on an annual basis. If a co-funder fails to partly or entirely fulfil its obligations to the main applicant and/or NWO, then this can have consequences for the grant settlement (see Article 3.4.5 of the NWO Grant Rules 2017).

¹⁵ Funding awarded by NWO is understood to be funding obtained through a proposal submitted to NWO that is granted funding. In this regard it does not matter from which programme this funding was obtained or who the recipient of the funding is.
7.5 Description of the themes

7.5.1 Ab-initio circular materials design

Aim

As part of the sustainability agenda driven by climate change, the scarcity of rare elements and the responsible use of natural resources, <u>circularity</u> is a generally accepted solution for the current waste streams that go to landfills or are incinerated. Avoiding scarcity in raw materials through reuse is also an important part of strategic autonomy (NL/EU).

Various research programmes focus on investigating the technological options for the increased circular use of materials and the devices or construction elements produced from these, especially if these use scarce resources, such as rare elements and energy-intensive materials. These existing materials and devices have often evolved over successive generations of design and redesign based on criteria such as affordability, performances, lightweight, energy saving, miniaturisation, convenience, and sustainability that are all related to the (single-use) lifespan. Only in recent years have renewability criteria been added to this evolution, such as reusability, recyclability, avoiding residual waste, energy efficiency and carbon intensity at the end of the lifespan. Recently, ever-increasing attention for the origin of scarce materials has also been added to this list. Geopolitical considerations play a role in that, but there are also concerns about, for example, the social conditions under which raw materials are extracted and the environmental effects of this extraction.

If further progress is to be made in circularity, it is essential to first of all make a more in-depth analysis of the options for <u>"ab initio" design</u> in which the criteria for renewability are completely in balance with the previous criteria, but now without evolutionary design prejudice. Examples of design prejudice are visible in devices or construction elements in which several materials are combined, such as composites, multilayers and "stacks", such as in batteries and solar cells: attention could be devoted to possible technologies to separate these different materials from each other in the current design, but it would better to ask the question whether it is possible to satisfy the same functional requirements in a redesign in which just one material is used ("mono-material composites") or in which the different materials are intrinsically easier and simpler to separate from each other and simpler to reuse. The focus in this call is achieved by specifically addressing multi-material applications, in which, in the current design, the separate recovery of these primary materials is hindered by the simultaneous use of multiple (primary) materials. Examples of multi-materials include multilayer films, composites, alloys, formulated compositions, bonded systems, etc. The objective within this focus is to facilitate the reuse of individual material components (including, for example, scarce materials), or even to base a new and smarter selection and design on just one material.

For this process of selection and redesign, the entire chain must be examined from fabrication, processing, application and use with the necessary socially acceptable processes to collect the materials and devices, reprocess these and reuse them. Here "closed loop" reuse is preferred but sometimes chains can be intertwined: the residual waste stream of one chain can be the raw material for another as long as no non-reusable residual waste streams arise. This requires not only technological innovations but also innovation supply chains and business models and creating a market for materials that are currently still incinerated as waste. In creating a fully circular supply chain, it is crucial, for instance, that companies collaborate and share data, even as they maintain a strategic interest in not doing so.

Knowledge gaps

The knowledge gap covers both technological and social aspects. On the one hand, there is a lack of indepth fundamental insight into the optimal selection and redesign of materials independent of the currently accepted designs, in such a way that the required functionality and performances are obtained in the most effective, raw materials-efficient and energy-efficient manner. This knowledge gap is, for instance, but not solely, present for materials that contain scarce elements and energyintensive materials. For example, in the current designs of solar panels and batteries, it is possible to recover the most valuable elements, such as silver and copper, but in doing so, the other materials (carbon and silicon) become unusable. On the other hand, insight into the conditions for a broad, socially accepted solution for circular use and reuse is lacking.

The technological knowledge gap has various levels: is a fully functional redesign possible without the scarce materials, or with less, or in such a way that *all* separate material components (so, in addition to scarce materials) can be reused? In that sense, the gap concerns both the materials science itself in different classes of materials and the application and integration of materials in a device or construction element in an application. For this, efficient use of energy is also an important aspect of the life cycle assessment (LCA), in all phases (manufacture, processing, separation, reuse) and integral inclusion of the LCA methodology of repeated reuse in redesign must also be viewed as a knowledge gap.

The social and societal knowledge gap also includes several levels: which redesign best meets use requirements, both at the individual level (consumption, disposal, handing in, participation, acceptation, new values and norms) and the societal level (facilitating collection and processing, and legislation)? How do these factors influence each other and how can new economic business models come into being that connect to these, and provide an accepted balance between the quality of the environment, health, convenience and earning models? Who are the stakeholders for new designs, and how can they be optimally involved in both the design and use/reuse phases?

Intended societal and scientific impact

The physical shortage of raw materials already described back in the 1970s is now becoming visible, and it has become clear that our linear model of manufacture to waste (landfills, incineration) is no longer sustainable and must be replaced by more of a transition to circular materials. In close connection with this, the necessary energy transition requires no further discussion, and it is clear that material manufacturing accounts for a large part of our current energy use. In addition, geopolitical tensions have also reduced the availability of raw materials and energy carriers and created a heightened awareness of the fact that the Netherlands and Europe as a whole must become strategically less dependent. The redesign of functional materials from scratch, including identification and selection of new materials and even classes of materials, in which the availability of materials and the efficient use of energy are included from the outset, will help to ensure that the materials transition as well as the energy transition can be realised faster and will not be needlessly hindered or delayed by (subconscious) design prejudices, such as those that crept into the evolution process of linear use of materials.

To ensure that besides materials sciences breakthroughs due to ab-inito material science redesign, societal breakthroughs can also be realised, interdisciplinary activities and research will be deployed at different levels, for which the entire knowledge chain from science to citizen will be involved. The involvement of society as a whole is vital to realise a breakthrough at the system level. After all, the values of stakeholders (national and local) jointly determine the (new) design criteria. This value-based design will result in different design choices in the current processes that are mainly aimed at efficiency and maximising profits. The system level consists of the entire life chain: from the extraction of raw materials, production, distribution, use and collection through to reprocessing. The designer needs to know where all materials come from and what will happen with these after the use of a product or packaging. For each of the different processes, the challenge is to minimise the harmful effects of the flow and to search for circular opportunities. Choosing societally accepted recovery processes and energy-efficient recovery technologies and, therefore, a circular business model greatly influences the possible directions of technological developments. Only when society connects with trajectories for circular materials development can both technological and societal breakthroughs be successful in a circular economy, and this calls for an integrated and interdisciplinary research approach along the entire knowledge and value chain, as foreseen here.

Background

A crucial sustainability aspect of materials is the claiming of finite or even scarce resources to be relieved through circular use (avoiding "waste"): reconsider, reduce and reuse. Reducing dependence on those scarce resources contributes to strategic autonomy, avoids waste problems and increases energy efficiency. At present, existing materials and devices have evolved through successive generations of design and redesign against different criteria over time (affordability, performance, lightweight, energy saving, miniaturisation, convenience, sustainability), all related to the lifespan (in single use). Although it is unavoidable that efforts to take into account criteria for the lifespan after use (usability, recyclability, avoiding residual waste, energy efficiency and carbon intensity at the end of the lifespan) also assume the currently standard designs, a more in-depth analysis of options for "ab initio" redesign must also be considered in which the criteria for the lifespan of the service and the life cycle *after* the service are completely balanced without evolutionary design prejudices.

Just like the energy transition (from fossil to CO2-neutral), the material transition (from linear to circular) is, in effect, a system transition, in which several parties in the value and knowledge chains must, concomitantly and in a coordinated manner, take the gradual steps for transitioning to other technologies. In the materials transition, raw material extractors, manufacturers, processors and users must, via design by knowledge workers, become aligned with reprocessors, separators and users. Although this is a formidable challenge in itself, it mainly becomes complex when multi-materials are used for which the separate components must be reprocessed in different ways, and therefore first need to be separated from each other. Therefore it is very tempting to immediately seek solutions for reuse based on the existing designs. Due to the many evolutionary advantages that have crept into these designs, from a linear mindset focussed on single use, the obvious solutions will ultimately not achieve the high efficiency that is required, as a result of which many non-usable or non-reusable residual streams will remain and reprocessing will require unnecessarily high levels of consumption of energy.

The "ab initio" redesign circularity requires a <u>multidisciplinary</u>, <u>interdisciplinary</u> and <u>transdisciplinary</u> approach: the technological aspects of deep circularity require multidisciplinary contributions to process technology, organic and inorganic chemistry, physics, analysis and characterisation, architecture, environment, system integration, and much more. The design aspects also call for an interdisciplinary approach: digital tools and calculation models, socioeconomic relevance of rare components and feasible recovery routes. Furthermore, the societal acceptance of technology, starting with a redesign from the end user and consumer by definition requires transdisciplinary insights from the social and behavioural sciences, and the analysis of policy and legislation. An often overlooked aspect is that providing information and education is also a condition for societal acceptance since this helps consumers make choices with respect to circularity – and this will also have to be included in the design.

The subject of circularity therefore also requires a <u>combination of a fundamental, applied and practice-oriented approach</u> with integration of perspectives and insights. Circularity can only contribute to sustainability if it works in both theory and practice. This requires a combination of fundamental innovations in redesign and practical solutions that interact with each other and enjoy broad support in society. In-depth redesign, first of all, requires a thorough analysis of the required functionality and the boundary conditions for acceptable usage. Obtaining these insights requires practice-oriented researchers (vocational and higher vocational level), who can also map which concepts would make recovery after use acceptable. Next, these insights have to be translated to the required characteristics of the (multi-)materials, or the devices produced from these, as well as the development of new concepts that can form the basis for an "ab initio redesign" with a fundamental approach. During the elaboration of these concepts and ideas, it must be both fundamentally and practically assessed whether the processes to reprocess them after their lifespan provide a practical and applied perspective on use criteria and acceptance by citizens. Finally, (social) LCAs will have to demonstrate that the circular redesign does indeed make a reduced ecological and social footprint possible.

Relevant cluster questions and knowledge agenda

To sum up, this theme focuses on the ultimate avoidance of scarcity in raw materials through reuse, as equally avoiding dependence on primary raw materials by selecting other materials that are available based on better available raw materials. Thus, the theme directly relates to the NWA cluster questions:

- Q052: How can we create a truly circular economy so that industrial goods manufacturing depends less on primary raw materials?
- Q053: What are the features of a circular economy and how can we achieve it?
- Q106: What transformation will we see in the manufacturing, service, and maintenance industries, and which technological innovations will make this possible?
- Q120: Can we design smart materials and structures that have new and advanced properties?

In addition, energy inefficiency and reduction of waste play a crucial role in that intended reuse because more sustainable, efficient and cleaner chemical processes arise:

 Q017: How can we make chemical and biochemical production processes more sustainable, more efficient, and cleaner?

Furthermore, this proposal is situated at the centre of both the NWA route Materials (link), in which sustainable materials cycles are defined as a key theme ("game changer"), and at the centre of the National Agenda Materials – Accelerating materials technologies, which was based on these cluster questions and published in 2020 (link) by the Dutch materials platform (MaterialenNL Platform). This constitutes an up-to-date version of a previous materials agenda, and of the original description of the NWA Route Materials from 2016. The National Agenda Materials was written after consultation with a broad ecosystem of materials researchers.

The National Agenda Materials covers five classes of materials with a description per class of the problems, objectives and intended solutions: 1) Energy materials, 2) Electronic materials, 3) Construction materials, 4) Soft/biomaterials, 5) Coating/film materials. Furthermore, cross-cutting themes have been defined as well, that is: 1) Metamaterials, 2) Infomaterials, 3) Producing and characterising materials, and 4) <u>Circular economy and the use of materials</u>. This proposal concerns the last <u>cross-cutting theme</u> and therefore connects with the entire materials agenda and, accordingly, with <u>the entire Dutch materials ecosystem</u>.

7.5.2 Nanomedicine in society: nanotechnology and its societal impact for improved diagnosis, prevention, and treatment of diseases

Aim

The NWA expresses the need to better anticipate the impact of new technology on society, in particular for health care, where affordable improvements are urgently needed. The theme addresses this need in the context of nanomedicine, both by developing this emergent technology and by establishing a comprehensive public dialogue towards acceptable implementation. Consortia should address one or more of the following three focus areas, combining nanotechnological research with a proactive involvement of society through the approach of *upstream public engagement*.¹⁶

Focus areas:

- Nano-enabled diagnostics and sensing: nanotechnology for new sensing concepts in diagnostics, and imaging tools that can detect diseases at an earlier stage with higher specificity and sensitivity, or provide mechanistic insight in disease development at the nanoscale. What are the implications of early disease detection and prediction for the patient and society (e.g. health insurance)?
- Nano-therapeutics and targeted delivery: the use of nanoparticles to deliver therapeutic agents to specific cells or tissues within the body. These nanoparticles can be engineered with specific

¹⁶ See: Upstream Public Engagement in Nanotechnology: Constraints and Opportunities. Science Communication, **37**, 452-484 (2015). <u>https://doi.org/10.1177/1075547015588601</u>

properties, to target specific cells with high selectivity and efficiency and increase drug efficacy while reducing toxicity to healthy cells. *How do we achieve standardised regulatory procedures and criteria, to assess the safety, efficacy, and quality of nanomedicines?*

- Nanotechnology for regenerative medicine: nanomaterials can be engineered to mimic the extracellular matrix, providing structural support and promoting cell adhesion, growth, and differentiation. Nano-electronic interfaces can be used to develop neural prosthetic devices that can restore lost function to individuals with neurological disorders. These procedures pose significant ethical challenges in view of their 'bodily invasive' nature, how does society perceive the risk/benefit balance?

By engaging science and society in early-stage dialogues the nanomedicine innovations developed by the programme will be well-aligned with societal values and expectations, enhancing their potential for real-world application and acceptance.

Knowledge gaps

The programme addresses questions from the National Science Agenda that, on the one hand, express a need for 'minimally invasive', 'personalised', and 'cost-effective' medical innovations, while on the other hand asking how we can better anticipate the impact of new technology on people and society. To address both questions this research programme will need to resolve several knowledge deficits, which couple scientific/technologies uncertainties to issues in the environmental, health and safety (EHS) domain, and to issues with an ethical, legal, or societal (ELSA) aspect.

- The EHS aspects include knowledge deficits regarding toxicity and biocompatibility: Because nanoparticles are significantly smaller and have much higher specific surface areas than traditionally formulated drugs, they interact with cells and tissues in ways that are not yet sufficiently understood, potentially even causing genetic damage. Nanoparticles have been advertised as "cancer targeted magic bullets", but they will not deliver on this promise without a reliable and transparent EHS assessment. Such an assessment will need to involve societal stakeholders at an early stage, to ensure that the public has confidence in the risk governance.
- The ELSA aspects include knowledge deficits centered on the risk-benefit analysis: There is evidence that the general public perceives nanomedicine as having greater risks and fewer benefits than cell-based medical technologies (such as immunotherapy). There appears to be a close link between risk-benefit judgements associated with perceived "bodily invasiveness". Further research is needed to determine how the public makes trade-offs between risk and benefit of nanomedicine applications and how public dialogue can facilitate this decision-making.
- A major ethical concern of nanomedicine is the "terra incognita" of human enhancement: the improvement of human characteristics and capacities. This concern is of specific relevance for the nano-electronic interfacing with neural tissue: where do we draw the line between restoration and enhancement of functionality? For instance, it might be possible to go from correcting eyesight to enhancing vision. Nanotechnology may even operate at the genetic level, altering human DNA to "improve" our species. We lack a framework for acceptable and non-acceptable medical applications of nanotechnology.

The programme will address these scientific and societal issues in an integrated way by the approach of *upstream public engagement*, involving the public in decision-making processes at an early stage, before policies, technologies, or solutions are fully developed or decided upon. This proactive approach stimulates scientists, technology developers, citizens, civil society organisations, patient organisations, and other stakeholders to engage in early-stage dialogues to jointly inquire into the (tacit) assumptions, meanings, values, and consequences of new science and technology. The objective is to proactively seek out public values, concerns, and insights to better inform and guide decisions, rather than reacting to public opinion after the fact.

Intended societal and scientific impact

Nanomedicine is an emerging field that uses nanotechnology to diagnose, treat and prevent disease at the molecular and cellular level. It has the potential to revolutionise healthcare by providing new ways to detect and treat diseases, such as cancer and neurological disorders, with greater precision and fewer side effects.

The development of the technology ties into several research questions posed in the context of the National Science Agenda, as listed in what follows:

- Q94: How do we improve the quality of healthcare and keep it affordable?

Nanomedicine will unlock innovative therapeutic opportunities for a wide range of diseases, including infectious diseases (as evidenced by the role of mRNA vaccines in COVID), cancer, gene therapy and neuropathological diseases. In addition, more effective and efficient treatments are expected to help reduce long-term healthcare costs by reducing the need for hospitalization, surgery and other costly interventions. Many of these technologies and applications are still under development, but in the longer-term nanomedicine will undoubtedly create new industries and economic opportunities.

 Q104: "How do we develop minimally invasive techniques and interventions for the diagnosis, prognosis and treatment of patients?"

Nanomedicine can provide new diagnostic tools to detect diseases at an earlier stage and with greater accuracy than current methods, enabling earlier intervention and better treatment outcomes. A major obstacle that nanomedicine can help solve towards this goal is the limited effectiveness and harmful side effects of current medical interventions. Traditional therapies such as chemotherapy and radiation can damage healthy cells in addition to cancer cells, leading to a range of side effects and complications. Nanotechnology makes it possible to target treatment only at the diseased cells, minimizing damage to healthy cells. This could potentially lead to more effective and less toxic treatments.

 Q107: How can we better anticipate the impact of new technology on people and society, and better understand and assess the impact of existing technology?

The development of nanomedicine faces significant ethical hurdles. Moreover, lack of understanding or appreciation of new, often invisible and complex technologies hinders the development and implementation and application of nanomedicine. Addressing these societal concerns will require significant effort, collaboration, and mutual understanding among scientists, policy makers, ethicists, and society at large. This connection should be made in the earliest possible stage. It is essential to combine the technical and scientific efforts with input from society, both on the technological as well as on the value-based aspects of nanomedicine.

This programme will establish an interdisciplinary collaboration between nanotechnology experts, ethicists, social scientists, and patient organisations, on a topic that is at the heart of the health care questions in the National Science Agenda. The 'upstream' engagement of society will promote interaction with citizens and creative and educational sectors, creating "feedback loops" for a more inclusive approach to the technological development.

Background

Our healthcare system can be significantly changed and improved by the use of nanomedicine, for example:

- Nanotechnology permits disease detection at an early stage by identifying molecular changes even before the symptoms manifest, allowing for early interventions with improved outcomes.
- With the targeted delivery capabilities of nanomedicine, the dosage of drugs can be reduced, leading to fewer side effects and reduced toxicity.
- Nanomaterials can be used as scaffolds to aid tissue regeneration, stimulating the body's own repair mechanisms.
- Neural prosthetic devices can restore lost function to individuals with neurological disorders.
- Because this will involve radically new technologies, a thorough risk analysis and technology
 assessment is essential, in which input from society plays an important role: input from ethicists

and social scientists, informed by patient organisations and by focus groups with citizens. The societal dialogue is even more so important, as the research may invoke completely new ethical and philosophical questions (e.g. in early diagnosis).

A successful programme will require the input from multiple disciplines: bio-physicists and other researchers from the natural sciences and engineering need to connect with the medical and pharmaceutical sciences to improve the impact of nanotechnology on our understanding of diseases and their diagnosis and control. The scientific/technological disciplines need to connect with the societal disciplines in an 'upstream' public engagement approach. This proactive approach will involve the engagement of the public, stakeholders, and relevant communities in early discussions, before any widely accepted empirical evidence of potential health risks can be inferred. This approach not only fosters trust and transparency but also allows the scientific and technological research to be guided by, and responsive to, the broader community's perspectives and needs.

Internationally, the theme is attracting much attention, with the hope that nanotechnology can meet many of the challenges facing healthcare systems. In the USA, the National Institute of Health supports a network of 8 Nanomedicine Development Centers. At European level, the European Union supports the European Technology Platform on Nanomedicine, including the ERA-net "EuroNanoMed" and the forthcoming ERA4Health initiative. The Netherlands participates in European initiatives through NanoNextNL (now Nano4Society), but without an extensive national research program. This programme would be the first of its kind at a national level.

This NWA programme is an opportunity to strongly contribute to the development of this important theme at a national level. The programme fits in the mission of the National Science Agenda because 1) it ties into several of the NWA questions; 2) it calls for an interdisciplinary and knowledge chainwide approach; 3) it needs the proactive engagement of science with society.

Relevant cluster questions and knowledge agenda

The theme ties into the following three NWA questions:

- Q94: How do we improve the quality of healthcare and keep it affordable?
- Q104 How do we develop minimally invasive techniques and interventions for the diagnosis, prognosis and treatment of patients?
- Q107: How can we better anticipate the impact of new technology on people and society, and better understand and assess the impact of existing technology?

And secondarily into three more questions:

- Q98 How can we better translate breakthroughs in fundamental biomedical research into the development of new medicines?
- Q100 How can we use (stem) cells and biomaterials to promote the formation and repair of tissues and organs?
- Q108: Which social changes as a result of technological changes are imminent and influence our prosperity?

Nanomedicine is one of the three "game changers" of the quantum/nano route.

7.5.3 Transitions require new types of partnerships between government and residents

Aim

Without people, there would be no cities. The residents of the smart, liveable city are the starting point of this call and form its focus as the active co-designer of the city and the hinterland of the future. This is necessary because the Netherlands faces several major, mutually dependent crises, such as the housing, healthcare, and climate crises. The current approach to tackling these crises has stranded. These crises have a strong international context due to mutual dependencies between countries and because of cross-border challenges. The aim is to develop new types of partnerships between civil society initiatives, knowledge institutions, and government to give shape to societal transitions and strengthen the resilience of society. In particular, the call should contribute to the development of new methods, models and instruments for partnership. The intended impact is to reduce the power imbalance between these parties and to afford residents more grip on transitions.

In the research, the local civil society initiatives should be the focus. Civil society initiatives are a combination of active citizenship, collectivity and social entrepreneurship. Examples of this are locally organised food collectives, energy cooperations and so-called bread funds. Cooperation between these collectives and the government often proves to be difficult because there are few structures for public-civil society partnerships, whereas these do exist in public-private partnerships. The intention is to provide insight into the current obstacles in the cooperation between government and civil society initiatives and develop new knowledge and working instruments to overcome these obstacles. Two aspects should be addressed:

- 1. The role of digital resources and technologies that increase the ownership of civil society initiatives.
- 2. The call intends to contribute to broad welfare and a fair allocation of burdens in transitions. Inclusivity is central to this: the involvement of different groups in society, especially lower SES groups. One aspect of this is dealing with the friction that arises due to opposing interests.

An interdisciplinary and transdisciplinary approach with players from the entire knowledge chain is needed for the research so that both academic and practical knowledge can be used. For the research, cooperation with society will be sought by means of, for example, a design approach because this increases the action perspective of citizens. The key enabling methodologies (KEMs) can form a framework for this and Living Labs can be a particularly valuable approach. With the research, models, methods, and instruments for cooperation with citizens that can be broadly deployed in different national and international transitions will be set up.

Knowledge gaps

The aim of this call is to address, in cooperation with the government and academia, different knowledge gaps to thus provide insight into the position of the civil society initiatives that aim to shape the major societal transitions of our time. The research should help fill all identified knowledge gaps as described below:

- Which models and methods for cooperation facilitate that civil society initiatives, government and academia can cooperate on an equal footing? Co-creation methods, funding models and legal frameworks should be an aspect of this.
- What is needed for civil society initiatives to organise themselves and to be able to locally achieve the major transitions of our time?
- Which digital tools support residents' initiatives in increasing their action perspectives?
- How can we design resilient digital technologies that support the transitions?
- How do we ensure that everybody is included in the major transitions and that these contribute to the reduction of inequality?
- Which co-creation methods exist or should be developed for the joint design of a digital, social and physical city by residents, government and knowledge institutions? And how do these work in practice?
- How can we deal with friction and conflicting interests in complex societal challenges?

 Which ways of organising civil society initiatives and government bodies are the most suitable for new types of partnership?

Intended societal and scientific impact

By organising a broad cooperation with parties from both practice and the academic world, the aim is to create knowledge and insights that will lead to both societal and scientific impact. The consortium should consist of a transdisciplinary team of civil society initiatives, government and knowledge-chainwide parties from different domains, and should conduct research into new types of partnerships that can help implement the major transitions of this time. These types of partnerships are a basis for organising worldwide transitions together with society. The research intends to build a broad knowledge base for cooperation between civil society initiatives, the government and academia, and to be applicable in various domains (such as energy, housing, mobility and care) at both the national and international levels.

Societal impact

The aim of the call is to achieve the following societal impact:

- Increased ownership and self-sufficiency of civil society initiatives.
- Reduction of the imbalance of power between civil society initiatives, government and academia in favour of cooperation on an equal footing between these parties.
- Civil society initiatives gain control (action perspective, influence, transparency about decisionmaking, publicly available information) over (the consequences of) major transitions and have a structural influence on shaping these via policy, initiatives and interventions.
- Residents get a better grip on digitalisation. They can influence the types of digital technologies and can discuss them. They make use of open technology and open data and, with this, can exert influence on the local environment. They have an influence on policy and decision-making that (partly) arises through digital resources.
- The consequences of major transitions and crises are equally divided among population groups according to the principle: the strongest shoulders bear the greatest burden. That will result in more balance and resilience in society as a whole.
- The strengthening of trust between citizens, government bodies and academia.
- Civil society initiatives are made a fundamental part of the research, and can also continue to develop further in a sustainable manner after the completion of the research.

Scientific Impact

The aim of this call is to achieve the following scientific impact:

- Development of co-creative methods, governance models and digital resources that contribute to honest and inclusive transitions.
- Development of interdisciplinary and transdisciplinary cooperation models that strengthen transparency and equality between residents, government bodies and academia.
- Shaping of digital technologies that meet the needs of civil society initiatives and are responsibly used by government, academia and civil society initiatives to positively contribute to shaping major societal transitions.
- More insight into the complexity of societal challenges and methods to deal with friction and the weighing of conflicting interests.

Background

Worldwide, major, mutually dependent transitions such as the energy transition, raw material transition, and climate change (drought, heat stress, sinking water level, floods) are putting pressure on the liveability of cities. In the Netherlands, this is aggravated by the scarcity of available space, resulting in nature reserves, agricultural land, housing, mobility (roads) and industry competing for priority. At the same time, the Netherlands is experiencing a housing crisis, energy crisis, nitrogen crisis, healthcare crisis, and biodiversity crisis with far-reaching consequences for society, which are starting to manifest increasingly clearly. The negative consequences of this are unevenly distributed across the population, as is the possibility of dealing with these. It is important to obtain insight into how these action perspectives can be improved and developed.

In addition, the current transitions are further catalysed through digitalisation. Due to new technologies (such as AI), society is changing increasingly fast. We cannot yet clearly see the long-term consequences of this and, therefore, more knowledge is required in this area. Amongst other things, the contestability of technology in society is an issue as well as how this could be shaped. In the context of the smart city, residents are often typified as passive consumers instead of creative citizens, and this is how they are excluded from shaping and co-designing the urban environment (Nguyen, Marques & Benneworth, 2022). Furthermore, the smart city throws up obstacles for groups that experience an information gap, increasing the digital divide (Jang & Gim, 2021). The question is how digital infrastructure can reduce inequality and support residents' initiatives.

Partly due to the above-described portrayal, residents experience that they exert only a limited influence on the major transitions of this time and the role of digitalisation in this. They have hardly any say in the decisions made or experience processes as complex and not transparent. In response to this, a growing number of different forms of civil society initiatives have arisen in which, at a local level, solutions are sought for societal challenges (Quist et al., 2021). That yields transformative social innovations: solutions outside of existing structures and systems (Drift, 2019), such as food collectives, energy cooperations or Community Land Trusts (CLTs). However, these initiatives often encounter difficult cooperation with government bodies and academia because, in contrast to the numerous cooperation models and instruments for public-private cooperations. A breach of trust has arisen between the government, academia and society partly due to a lack of constructive partnerships.

Therefore, new forms of collaborations are needed to develop the transitions further. Collaborations in which residents can exert influence on the quality of their living environment (Verheul & Nelissen, 2022), and government bodies can assume a responsive role vis-à-vis participation (Nederhand, Migchelbrink and Edelenbos, 2022). Civil society initiatives must be part of shaping the (smart) city so that societal issues are addressed (Kortlander et al., 2022; Simonofski et al., 2021). The mutual breach of trust between government, academia and civil society initiatives can only be resolved if open and honest cooperation exists between them in which transparency and reciprocity take centre stage.

Relevant cluster questions and knowledge agenda

The route Smart Liveable Cities is domain-overarching and focuses on the urban context in which subjects such as energy, mobility, healthcare, climate, housing and tourism come together. The theme focuses on the intersection between three game changers: citizen empowerment (social city), data commons (digital city), and resilient design (physical city), and is closely aligned with the cluster questions below.

Aligned cluster questions:

- Q033: How robust is democracy, how much confidence does society have in it, and how can we
 make improvements in both cases?
- Q048: How can we encourage self-reliance and social participation?
- Q107: How can we anticipate the impact of new technologies on humans and society, and understand and evaluate the influence of existing technologies?
- Q109: How are new technologies and Big Data impacting the effectiveness of public administration and the constitutional state?
- Q123: How can we manage the unpredictability of complex networks and chaotic systems?

7.5.4 Empowerment of Dutch citizens through Transparent AI

Aim

Recent developments in Artificial Intelligence (AI) and Big Data have radically changed our society in a short space of time. The development of AI technology – intelligent systems that can recognise patterns in (frequently) large volumes of information from different information streams, that can learn on the basis of data and make automatic decisions – has accelerated in recent years. AI systems are now used in many different application areas and therefore affect nearly all facets of Dutch society.

The speed and scale at which these developments are taking place mean many citizens feel they have little influence on the role AI plays in their lives. Furthermore, AI is a complex technology that many people associate with something beyond their imagination, a view partly fed by extreme reports about AI in the media. Also, the development and practical use of AI technology are largely driven by international 'big tech' companies. As a result of all of this, citizens are increasingly concerned about the unequal power relations vis-à-vis AI technology; they often feel that AI is something that just happens to them and, as a consequence, they have little control and often do not entirely trust AI either (see Waag report, August 2023)

This means that there is a considerable need for knowledge and methods with which Dutch citizens can be empowered to get a better grip on the AI society: *How can we provide citizens with more insight into the functioning of AI-based systems, as a result of which they are better capable of exerting an influence on the design and use of the systems and can decide for themselves how they deal with these?*

Achieving this requires interdisciplinary research into the transparency of AI systems. This research combines technical (scientific) disciplines with disciplines that investigate the ethical, legal and social aspects (ELSA). From a technical perspective, expertise will be required to realise the transparency of AI systems and (by extension) the comprehensibility of AI. From the ELSA perspective, expertise will be needed to determine how that transparency impacts people, society and the degree to which people experience control over the technology. One of the desired results is that citizens will become increasingly 'AI literate'; in other words, they will become empowered to deal with AI systems.

The subject 'transparency' is inherently interdisciplinary in nature: it is both a characteristic of AI systems (which must be open and comprehensible) and a quality of society (which understands how AI systems work and can exert an influence on the impact of these systems). The aim is to elaborate the meaning of 'transparency' in an interdisciplinary manner and also to shape it practically in the form of technology and socially acceptable human-technology interactions. This demand for 'acceptable' interaction means that purely 'technical' solutions (of which several have been proposed by the discipline of explainable AI in recent years) will not suffice; many of the solutions are driven from an algorithmic perspective, and focus primarily on making AI systems more understandable for the developer. However, the way in which the transparency is shaped must also connect with the experiences of and intended application by the target group, in other words, the people who use and/or are affected by the AI system.

The current call therefore focuses on interdisciplinary and knowledge-chain-wide consortia that contribute both technical and ELSA expertise. Another condition is that consortia also involve civil societal organisations that represent the perspective of citizens within a certain application domain. The specification of the citizen group should be aligned with the AI systems that are investigated within the consortia.

Knowledge gaps

With the chosen theme, the Route Management intends to increase scientific knowledge in the area of 'transparency of AI systems' and thus aims to empower Dutch citizens.

Within AI research, increasing knowledge about transparency and explainable AI is one of the grand challenges of the discipline (see, for example, the AIREA-NL research agenda of NWO¹⁷ in the Dutch AI Manifesto of IPN's SIG AI¹⁸ and the SRIDA agenda of the AI, Data & Robotics association¹⁹). Although many results are already available in this area, there is still not sufficient insight into the different levels of transparency. Besides the transparency of the actual AI system (in which the system is able to, in comprehensible language, explain to users how the underlying algorithms reach their decisions) it is also important that the design process and the embedding in organisations is transparent as well. A considerable challenge for research into the explain ability of AI (which is related to transparency) is taking into account the user's role, expectations and knowledge level.

Therefore, a need exists for research into more user-oriented transparent AI. This implies the development of methods and techniques that can make the internal functioning of AI systems more transparent and connect with the experiential world of all interested parties. Amongst other things, this requires more research into techniques and models for generating satisfactory explanations for outcomes that AI provides and also into clear user interfaces. An important challenge associated with this is that the same outcome needs to be explained differently to different interested parties. There is also a need for ways to develop AI systems that citizens can actually exert an influence upon themselves. For instance, this could be done by giving users options to influence the algorithm or data collection in a meaningful manner.

On the user side, there is a demand for research that can be used to establish the extent to which citizens are indeed empowered, in other words, whether they actually have more insight into and control over the functioning of AI systems. This connects with the aim of 'demystifying AI' as described in the report 'Mission AI. The New System Technology' of the Netherlands Scientific Council for Government Policy. The term demystification refers to increasing the understanding of AI and nuancing the perception of AI in society, including overheated expectations on the one hand and overblown fears on the other.

Intended societal and scientific impact

Research into the theme 'Empowerment of Dutch citizens through Transparent AI' is expected to have a societal impact in redressing the unequal power relations vis-à-vis AI by ensuring that citizens are in a better position to exert influence on the design and use of AI systems.

It is expected that the scientific impact of the intended type of research will be contributions to several important challenges in the field. These include, for example, the following themes stated in the AIREA-NL research agenda: 'AI Systems and Society' (see p.19 of the agenda, Section 3.4) and 'Explainability and Transparency' (see p.21 of the agenda: Cross-cutting consideration II). These are also important themes in the international AI community, as is clear from the growing international community around explainable AI (XAI) and the attention that the High-level expert group on artificial intelligence of the European Union devote to these themes in its Ethics guidelines for trustworthy AI.

Another impact is more intensive interdisciplinary collaboration between technological research and ELSA research. If technology is to implement the most effective type of transparency, then the knowledge level and expectations of the users and society need to be known – and these will differ per case, which means that personalisation will be necessary. It must also be known which sort of influence users can and will exert (meaningful human control, as formulated by the High-level expert group on artificial intelligence) so that the systems can also actually be influenced. Furthermore, an AI system is never used in isolation: it is part of a (operational) process and if that is not transparent, society will still experience a lack of insight and influence.

 $^{^{17}\,}https://www.nwo.nl/en/news/first-national-research-agenda-artificial-intelligence$

¹⁸ http://ii.tudelft.nl/bnvki/wp-content/uploads/2018/09/Dutch-Al-Manifesto.pdf

¹⁹ https://adr-association.eu/wp-content/uploads/2020/09/AI-Data-Robotics-Partnership-SRIDA-V3.0-1.pdf

Consequently, consortia are expected to include both technical and ELSA expertise. Another condition for human-oriented transparent AI is that citizens are also involved in its development. So, in addition to scientific partners, societal parties that represent the citizens' perspective are expected to be involved as stakeholders in the different phases of the research at both the 'front end' of the trajectory (for example, in co-creation sessions) and at the 'back end' (for example in the design and realisation of experiments).

Background

As described above, recent events in AI and Big Data have radically changed our society in a short space of time, and these changes affect virtually all citizens. A well-known example is the launch of ChatGPT by the company OpenAI at the end of 2022: all of a sudden, this technology became available everywhere and was immediately used by a wide range of parties in many different domains without much up-to-date knowledge about the functioning, effects and limitations of the technology.

Recent research by Waag Futurelab into the societal discussion about AI and Big Data reveals that many people are concerned about developments in the area of AI and that a lack of a counterpoise plays a big role in this. An explanation for those concerns may be found in the increasing inequality between people with a lot of knowledge and expertise concerning AI (the knowledge haves), who have the opportunity to develop AI, and people who lack this knowledge and expertise (the knowledge have-nots). The have-nots cannot assess whether what AI offers is good, reliable or true, and are dependent on the haves for information, explanations and justifications. In brief, there is a growing imbalance between people, which can easily lead to an abuse of power.

Therefore, in this NWA route, it is important to give attention to the growing imbalance of power vis-àvis AI, which could get worse in the future. Just like there are many different ways to reduce the detrimental effects of an imbalance of power in other types of relationships, such as work relations, marriage relations, doctor-patient relations or researcher-participant relations, it is equally important to conduct research into ways of counteracting inequalities of power in our relations with AI.

With the chosen focus on 'Empowerment of Dutch citizens through Transparent AI', it is hoped that projects within the NWA route AI and Big Data can contribute to counteracting this power inequallity. Research into transparent AI is expected to help citizens become more empowered to function in the AI society, where they are more capable of exerting an influence on the design and use of AI systems.

Relevant cluster questions and knowledge agenda

Thee chosen theme touches upon the following cluster questions of the Dutch Research Agenda:

- Q107: How can we anticipate the impact of new technologies on humans and society, and understand and evaluate the influence of existing technologies?
- Q108: What social changes are imminent owing to advancing technology and how will they affect prosperity?
- Q112: Can we use Big Data and Big Data collection to define values, generate insights, and get answers?

The chosen theme is also aligned with the following knowledge agendas:

- AIREA-NL Research Agenda for the Netherlands <u>https://www.nwo.nl/nieuws/eerste-nationale-onderzoeksagenda-voor-artificiele-intelligentie</u>
- Dutch Artificial Intelligence Manifesto <u>https://ii.tudelft.nl/bnvki/wp-</u> content/uploads/2019/09/Dutch-AI-Manifesto-2019.pdf
- Mission AI. The New System Technology <u>https://www.wrr.nl/publicaties/rapporten/2021/11/11/opgave-ai-de-nieuwe-systeemtechnologie</u>

It should also be noted that the chosen theme has, to a certain extent, already been addressed in the VWData kickstarter project of the route, especially with respect to the aspects transparency and explainability. That being the case, the current theme further elaborates upon this project.

7.5.5 Emotion regulation and the brain: individual differences and societal relevance

Aim

Emotion regulation is the ability to be able to exert control over one's own emotional state. Optimal emotion regulation plays an important role in mental and physical health, behaviour associated with controlling impulses, such as controlling aggression, and being able to acquire new information. The brain and the associated "biobehavioural" processes play a crucial role in emotion regulation, but exactly how that happens is not yet fully known. Individual differences in the area of emotion regulation can also contribute to the inequality of opportunities in society.

Research consortia are invited to submit proposals that provide a basis for research into neurological processes that underlie individual differences in emotion regulation among people. The elaboration can focus on one specific domain of brain functioning or at the level of general system-biological processes that are relevant for emotion regulation. These individual differences in emotion regulation should be relevant to (a) mental and/or physical health, (b) behavioural factors related to a safe society, and/or (c) optimising cognitive functioning (for example, for application in education, safety or becoming older healthily). Consortia can combine these three domains or focus on one domain. It is important to indicate how this knowledge can be used for, e.g., improving individualised diagnostics and treatments or approaches, such as making individuals more resilient and/or the prevention of undesirable impulsive behaviour in the areas of health, safety or education. Therefore, in addition to fundamental neurobiological research, research consortia are invited to submit proposals for applied research into new application in the fields of health, education, and/or safety. It is crucial that the theme of emotion regulation takes centre stage.

Furthermore, it is expected that the project also has a clear fundamental research component with theoretical implications (fundamental research is understood to include, among others, basic neurobiological as well as neural network research). Rigorous steps are needed in the development of new methods (for example, AI and machine learning) and theories about how brain cells collaborate to enable mental processes involved in emotion regulation (for example, observation and memory). In the proposal, attention for the fundamental scientific aspect should be reflected in both the research protocol and the budget. The fundamental aspect of the proposal does not need to have an immediate application for emotion

regulation alone, but can also focus on relevant theoretical aspects which will only in the very long term (>10 years) become applicable to the theme Individual differences in emotion regulation.

Knowledge gaps

Fundamental and applied research need to be carried out in conjunction with each other to elucidate the connection between basic neurobiological processes and individual differences in emotional regulation among people. Such research can lead to innovations in, for instance, better individualised diagnostics and approaches for both mental and physical health, as well as problems related to uninhibited behaviour in various social situations (for example, at schools, sports events, et cetera). In addition, this research can result in knowledge about better cognitive functioning in all phases of life; from early youth with implications for knowledge transfer in education, to regulation during adolescence with consequences for safety, through to older persons in our society who often experience mild cognitive deterioration. A good understanding of emotion regulation requires the development of neurological models for how the brain carries out complex processes, on which basis these take place efficiently, and how this can subsequently manifest in emotions and behaviour. Models that make use of AI and machine-learning techniques will play an important role in this in the future. Furthermore, there is currently a lack of experimental and longitudinal research in various cohort studies to get a clearer picture of this. In this regard, it is important that knowledge within the project is linked to research into the application of this knowledge in the areas of health, safety or education. The research in this theme can therefore provide innovative insights into the possible relationships between neurobiological processes, emotion regulation and, with that, the adaptive capacity of people. The latter is an important factor in the development of inequalities of opportunity within education and safety, but also with respect to health. The applied research aspect

helps to connect the fundamental knowledge development with improvements in human adaptability, for example, by means of improved individualised diagnostics and treatments/approaches, but also by making today's and future professionals of the police, defence forces and education more resilient so that they can optimally perform under pressure.

Intended societal and scientific impact

An important question is: why can certain people adapt less well to changes in the environment than others? Which mechanisms determine individual differences in vulnerability for brain disorders or for stress? Emotion regulation plays an important role in these fundamental societal questions that are posed as part of the NeuroLabNL research agenda.

At the level of fundamental research, more knowledge is needed about the uses of brain models to improve the biological basis of emotion regulation in relation to individual differences. For example, which patterns of activity in the prefrontal cortex, and the network connected to it, are of causal importance for behavioural control and what goes wrong when there is no such control? Emotion-related behavioural control plays a vital role in all areas (safety, education and health) and this theme results in focussed research in this NWA route.

In the safety domain, emotion regulation is an important factor in the development and maintenance of antisocial behaviour, and is related to resilience and self-regulation. More insight into this can provide answers to questions such as: Which brain processes in relation to behaviour are important in interactive situations such as conflict, social exclusion and cohesion amongst, for example, population groups with different cultural backgrounds? How can we use this knowledge to facilitate social cohesion? Which brain, cognition and behavioural factors contribute to (the development of) serious antisocial behaviour among children, young people and adults? How can we use new techniques to improve and achieve innovations and instruments for prevention, diagnostics, intervention, risk taxation and supervision?

In the education domain, more knowledge about emotion regulation can bring about better descriptions of individual differences in the planning and monitoring of one's own behaviour, individual performance and social collaboration. This knowledge can help to answer questions about how education can be tailored to children and adults with different cognitive and social capacities. Emotion dysregulation among pupils may not only hinder their own learning process and wellbeing but can also lead to antisocial disruptive behaviour that has a negative effect on their peers and teachers.

In the health domain, research into emotion regulation can provide more insight into the role of automatic processes in the brain, for example, into whether or not an individual is able to achieve behavioural change in the long term, and in response to neurological and other physical disorders. This helps to provide insight into what the resilience and risk factors are when the environment demands adaptation. It can also provide insight into 'sensitive' periods in a person's development in which resilience and risk factors play a greater role than in other life phases. Greater clarity can be obtained about the underlying mechanisms with the help of longitudinal and experimental research among healthy people and people with mental or physical disorders, but also with animal studies. Furthermore, the impact of this theme lies in the diagnostic and therapeutic relevance of disruptions in emotion regulation in various clinical settings. With neurobiological research, a better distinction can be made between adaptive and maladaptive forms of emotion regulation.

In brief, for the different domains within the route NeuroLabNL, the theme concerning the neurological basis of individual differences in emotion regulation processes has both scientific and societal impact.

Background

Research into the neurological basis of emotion regulation has implications for a better understanding of behaviour associated with societally relevant problems, including insufficient impulse control and aggressive behaviour (reduced safety), maladaptive behaviour in various educational contexts (from primary to secondary education), and (health-related) behaviour that increases the risk of mental and physical disorders. This can contribute to inequality of opportunities within society. The inequalities concern sociocultural factors (for example, differences in health), sociopsychological factors (for example, social exclusion, violence, discrimination and gender roles), self-regulated learning (for example, differences in opportunities to benefit from the standard education system), but also in domains such as where people live, financial possibilities and age differences. Individual differences in emotion regulation can further increase the inequalities of opportunity in society that arise due to differences in the availability of socioeconomic resources. The 'digitalisation' of society, with social media and other drastic changes in interpersonal interactions, also requires an increasing flexibility in emotion regulation. Individuals who lack this flexibility in emotion regulation may develop a range of problems and derive less benefit from our society or even exert a negative influence on society. In the safety domain, this mainly concerns the development of delinquent behaviour, but also the ability to adequately cope with conflict situations by professionals like police and defence personnel. In the education domain, emotion regulation influences the ability to absorb new information and to be able to develop further into an independent adult. In the health domain, it is related to various mental complaints (depression, anxiety), but also physical disorders such as obesity. In addition, old age also impacts emotion regulation.

Relevant cluster questions and knowledge agenda

The proposed theme aligns with the cluster questions in several ways. At the basic level, emotion regulation is related to the functioning of the nervous system:

 Q082: How does the central nervous system develop and how can we counteract degeneration processes in that system?

This theme also provides knowledge to answer questions:

- Q058: What are the patterns and causes of crime and how can we influence them?
- Q083: How do neurological, psychiatric, and mental disorders arise, and how can we prevent, mitigate, or cure them?
- Q084: What is the best way for us to analyse and prevent the problem of overweight and obesity?

It is also expected that emotion regulation is influenced by social media and this inspires:

 Q107: How can we anticipate the impact of new technologies on humans and society, and understand and evaluate the influence of existing technologies?

Finally, this theme also provides knowledge to answer question

 Q112: Can we use Big Data and Big Data collection to define values, generate insights, and get answers?

In these questions, it is important to gain a better understanding of the influence of brain functioning on behaviour, with emotion regulation being a key factor.

7.5.6 Disease, the individual and their environment: the importance of mutual interactions across two or more pathologies and the differences per individual

Aim

The aim is to contribute to advancing the health of, and participation in society by, people with severe chronic diseases. For this, it is important that consortia conduct interdisciplinary and transdisciplinary research across two or more pathologies into how diseases, the individual, their (living) environment, lifestyle and the social context influence each other in the development of these diseases, why these interactions at the level of the individual differ, and how you can measure these interactions as non-invasively as possible and how you can measure at the individual level, preferably in the individual's home situation. Therefore, building on this, the aim is to develop personalised interventions that intervene in these interactions and preferably implement these in the context of the project together with the stakeholders involved.

At least one of the pathologies to be investigated must concern the aetiology and/or development of diabetes, cardiovascular disease, cancer, COPD or dementia. This is a deliberate choice because the pathophysiology of these diseases is more or less influenced by the environmental factors in which individuals live, and these diseases have the greatest impact in terms of, among other things, mortality, loss of quality of life, loss of participation in society and increased healthcare consumption.

The individual is understood to refer to the physical whole of a person in the broadest sense of the word. The research can therefore focus on one or more aspects of the human body, such as anatomy, physiology, biochemical processes and metabolism. Invasive measurement is not excluded but non-invasive measurement is preferred, and for this, measurement in the home situation is a definite advantage. The theme is explicitly not just directed at the effect of drugs or medical research. Just as important are the living environment, health differences, participation in society and an individual's lifestyle, and the use of suitable measurement instruments as well. A boundary condition is an interdisciplinary, transdisciplinary and knowledge-chain-wide research approach in which experts from the (bio)medical sciences collaborate with other disciplines within the research consortium (such as sociology, socioeconomic sciences, environmental sciences) and civil society organisations (for example, patient organisations) participate as well. Only through interdisciplinary, transdisciplinary and knowledge-chain-wide to understand the complex networks of interactions between the individual and their environment from different perspectives and across disciplines be able to jointly acquire new insights and develop personalised interventions with societal impact.

The ultimate aim of the research is to develop interventions, measurement methods and analyses that seamlessly fit the crucial aspects of individual patients' health and open up the way for personalised approaches and more effective treatments. All of this is in the context of the patient and their (social) environment that contributes to improving their participation in society and quality of life.

The emphasis is on joint results that should be achieved through research conducted by various disciplines (for example, in the form of co-creation) instead of each discipline individually working towards its own outcomes. Furthermore, instead of a design in which the patient can only provide input, the research plan should also explicitly elaborate on how active collaboration with the patient will be realised. Non-medical interventions should also be included, such as quitting smoking, supporting family or neighbours so that people can live at home longer, or continue to work longer, provided that the research proposal can include more care at home and strengthening (palliative) home care.

Knowledge gaps

Considerable knowledge gaps in current clinical research concern identifying environmental and lifestyle factors at the individual level, using suitable measurement instruments and genuine

collaboration with the patient. Chronic diseases and health differences often arise due to a mix of lifestyle, environmental influences and genetics. Lifestyle changes, such as increased consumption of processed food and less exercise, contribute to obesity and, with that, diabetes, cancer, cardiovascular diseases and pulmonary diseases. Tobacco, alcohol and drugs increase the risk further. Environmental factors such as air pollution and exposure to chemicals, biological particles and pesticides also contribute to the development of diseases. Genetic predisposition partly determines the impact of lifestyle and environment on the individual.

Health is not only determined by one single factor and health differences can be socioeconomic and not just medical in nature. We do not have enough knowledge to be able to genuinely understand the interaction between disease, individual, living environment and lifestyle and societal context. By gaining a better understanding of the interactions, and approaching them from multiple disciplines and bringing them together, health professionals and researchers, together with civil society organisations, can address a broader range of factors that influence the health and well-being of an individual, prevent the development of diseases and, where that is not possible, identify new targets for therapeutic interventions to treat complex diseases and improve the quality of life.

All of this requires interdisciplinary, transdisciplinary and knowledge-chain-wide collaboration, and the deployment and development of advanced analytic methods, advanced techniques for the measurement of the exposome, other innovative techniques and various forms of research (medical, socioeconomic, et cetera). Possible examples are genetic sequencing, omics technologies (such as genomics, transcriptomics, proteomics), the measurement of (ultra)fine particles, fungi and metabolome, the validation of systems via the application of model systems, such as organs-on-chips, pharmacometrics, epidemiological research, demographic research, the application of machine learning (AI) and advanced data modelling, and algorithms that, for example, convert PREM and PROM interventions into a Social Return on Investment (SROI) through which a quantified 'quality of life' outcome can be established.

Intended societal and scientific impact

Much research has already been done but this often focuses on a single disease or a single discipline, frequently medical research. By doing interdisciplinary, transdisciplinary and knowledge-chain-wide research across <u>several pathologies into the interactions</u> between the pathophysiology, living environment and the lifestyle of an individual, we expect to obtain new insights into the reasons why these interactions differ at the individual level, influence each other and cause disease. By examining the entire system and several diseases in an inter- and transdisciplinary manner, more effective personal treatments and drugs can be developed faster, and we will learn to understand the occurrence and development of diseases better so that we can predict and prevent these. By detecting risks in good time, interventions can be used to prevent the development of diseases and to limit the disease burden and health care costs.

Impact will only be achieved if interventions are feasible, measurable and scalable. Societal and scientific breakthroughs that research into this theme can yield are:

- Improved quality of life and health.
- Improved social participation.
- Reduced healthcare costs.
- Increased productivity.
- Development of new treatment strategies and medical technologies.
- Health predictions and management.
- Prevention and early detection of diseases.

These breakthroughs result not only in improved treatments and preventative interventions but also in new knowledge and insights that contribute to our understanding of human health and disease. From an (inter)national perspective, the research contributes to the aforementioned societal and scientific breakthroughs in different ways:

1. Specific needs of society: The NWA routes are based on questions from society. Interdisciplinary, transdisciplinary and knowledge-chain-wide research on the theme will ensure that healthcare

better meets the needs of society and leads to the improved health of the entire Dutch community. What makes the research innovative is that, instead of each discipline working towards its own research results, multiple disciplines will work together with the patient to achieve results.

- 2. Policy-making and regulation: Research into the theme will provide information that can be used to formulate health policy, planning, the development of health policy guidelines and standards, and the effective implementation of personalised care at the (inter)national level.
- 3. Economic impact: The research provides insight into the cost-effectiveness of personalised approaches and technologies as well as into the potential savings in the long term.
- 4. Health infrastructure and innovation: The research stimulates the development of healthcare infrastructure and advances innovation.
- 5. Health awareness and participation: The theme contributes to increasing the population's awareness and participation in personalised care. It offers educational opportunities and disseminates information about personalised care.
- 6. Comparative analyses and knowledge exchange: The research facilitates the comparison of healthcare systems and care models from different research areas and countries, and in this way, we can learn from each other's successes and challenges at an international level.
- 7. Multicultural perspectives: By taking the diversity of cultures, ethnicity and genetic backgrounds of the individual into account in the research, it is possible to establish how personalised care can be tailored to different population groups.

Scaling up of research: The research can be scaled up internationally as a result of which the size and diversity of research populations will be increased.

Background

One of the most important societal problems that the theme should try to contribute to is limiting the gradual increase in chronic diseases such as diabetes, cardiovascular disease, cancer, COPD and dementia. These are responsible for a large proportion of the instances of disease and <u>mortality</u> in the Netherlands, cause the greatest loss of <u>life years</u>, contribute most to the <u>disease burden</u> and the high <u>healthcare costs</u>. Lifestyle, environmental factors, the genetic profile of the individual and ageing influence the aetiology of these diseases and influence each other. Furthermore, the treatment of these diseases is very expensive and places a considerable burden on the healthcare system. The research will contribute to a description of the risk factors in the entire system, the prevention of chronic diseases, the personalised treatment of chronic diseases and improving preventative care.

With personalised care, physicians and researchers can ensure that people with certain diseases are fully informed about the possible risks and benefits of different treatments. Being able to measure non-invasively and in the home situation, facilitates the acquisition of sufficient data with which these personalised treatments can be developed, and reduces the need for patients to travel. In short, physicians and researchers can develop more targeted treatments and increase access to care.

Knowledge plays an important role in understanding the causes of chronic diseases and in developing preventative and curative interventions. Interdisciplinary, transdisciplinary and knowledge-chain-wide research is therefore vitally important to understand the complex factors that contribute to chronic diseases. In this manner, the research can, <u>for example</u>, help with:

- Identifying the mechanisms that lead to obesity and other diseases and the development of
 effective interventions to improve people's health, such as programmes for health education and
 health improvement (lifestyle).
- Identifying the different toxins that are harmful to health and their effects on the body, but also the development of policy measures to reduce exposure to these substances (environment).
- Identifying the specific genetic factors that contribute to the development of chronic diseases (genetics).

Stakeholders who are involved in the aforementioned problems include the food industry, tobacco industry, alcohol industry, chemical industry, government (as regulator, policy developer and funder of research), environmental organisations, patient organisations, civil society organisations (for example, around the domain living environment and/or labour participation), and scientists and researchers from several disciplines (medical, social economic, epidemiology, etc.). Therefore, carrying out research within the theme requires collaboration among universities, research centres, hospitals, industries and, in particular, civil society organisations, such as patient organisations. Certainly, in the area of lifestyle and mental aspects, patient organisations possess a wealth of knowledge and experience that can be used within the research. Consequently, patient organisations should explicitly be actively involved in writing the research proposal from the conception of the initiative onwards and realising the research, including the funding of it. Involving other societal organisations, beyond the sharing of knowledge and results, is a significant advantage. The objective is to genuinely integrate societal organisations into the research and the forming consortium. This can be accomplished in various ways, such as:

- 1. Collaborating in all stages of the research process, from formulating research questions to interpreting results (co-creation).
- 2. Organizing meetings or focus groups to gather input and hear opinions from various stakeholders (stakeholder dialogue).
- 3. Engaging society in the role of co-researchers, where their experiences and expertise are integrated into the research process (participatory research).

Establishing sustainable partnerships with societal groups, organisations, and institutions ensures continuous input and involvement of these entities, thereby enhancing the relevance and societal impact of scientific research.

Relevant cluster questions and knowledge agenda

The theme is aligned with all cluster questions, and more specifically with:

- Q072: How do a healthy lifestyle and wholesome habits promote good health and prevent illness?
- Q073: What effect is the rising 24-hour economy having on human health and performance and how can our knowledge of biorhythms enhance the relationship between the individual and society?
- Q075: How can we use sport, exercise, and nutrition to promote good health and what effects will this have?
- Q080: Can we gain a better understanding of the factors that play a role in the occurrence and persistence of long-term, medically unexplained physical symptoms, leading to better treatments for them?
- Q081: How will our knowledge of genetics play a role in analysing, screening for, and treating diseases?
- Q084: What is the best way for us to analyse and prevent the problem of overweight and obesity?
- Q085: Every tumour is different, so how can we come to understand cancer well enough to develop a treatment for each and every type?
- Q086: Intestinal disorders, and specifically the relationship between gut flora and health: what can we do to benefit our gut flora?
- Q087: What causes type 1 and type 2 diabetes, how can we detect them sooner, and how can we treat them on an individual basis?
- Q088: How can we predict, prevent, and treat cardiovascular diseases (atherosclerosis, heart failure, heart arrhythmia, and thrombosis) in individuals at an early stage?
- Q089: How can we improve our understanding and treatment of pulmonary diseases?
- Q090: How can we improve our understanding and treatment of pulmonary diseases?
- Q094: How do we improve the quality of health care as much as possible while keeping it affordable?
- Q095: How can we personalise health care, for example by using biomarkers?
- Q096: How can we improve diagnostics, treatment, and vaccines for immunodeficiencies and infectious diseases?
- Q098: How can we use breakthroughs in basic biomedical research to develop new medicines?
- Q101: Can we model the human body and use smart technologies for health, nutritional, and toxicity research, drastically reducing the use of laboratory animals at the same time?

- Q104: How do we develop minimally invasive techniques and interventions for diagnosis, prognosis, and treatment?
- Q105: How can Big Data and technological innovation (e-health) contribute to health care?
- Q120: Can we design smart materials and structures that have new and advanced properties?

The theme is also aligned with the following game-changers:

- 1. Personalised Medicine & Health Research infrastructure.
- 2. New methodologies and applications.
- 3. Enhanced collaboration between fundamental, translational and clinical researchers and between knowledge institutions and companies.

Finally, the theme is fully aligned with the Knowledge Agenda Personalised Medicine as well, which specifies that themes should overarch diseases, results should be broadly applicable, and market and civil society parties should be closely involved.

7.5.7 The biomedical innovation, product development and application of 3D models: building bridges between fundamental research and healthcare

Aim

Within the NWA route Regenerative medicine: game changer moving to broad areas of application, we are trying, amongst other things, to produce models of tissues and organs for laboratory research. By studying these models, we learn more about how organs develop and what goes wrong in various diseases. We can also use these models to develop and test drugs.

This theme focuses on the innovation and application of human three-dimensional (3D) tissue models. With this theme, we want to ensure that progress is achieved in both biomedical innovation and the future implementation of these models to help advance the research field and healthcare. Direct clinical applications fall outside of this theme.

As the models are based on human cells, this allows us to gain insight into what occurs in the human body in a new way, and we can also better predict how drugs will work. Although laboratory animals provide valuable information, they are never exactly the same as people. By developing improved human models, we can carry out research that has more meaning for patients and, at the same time, reduce the number of laboratory animals.

At present, many human models are still flat, in other words, 2-dimensional (2D). However, organs are, of course, not flat but 3D. Therefore, many researchers are trying to work towards relevant and good human 3D tissue models. In terms of structure and function, they resemble real organs more, and research with these will therefore yield more useful information for patients. By 3D models, we mean both 3D models made from human (stem) cells and human tissues that are cultured outside the human body with the aim of investigating and/or improving the (re)generative capacities of the tissues.

The development of good 3D models that simulate the structure and function of real organs still faces many challenges. Furthermore, there are several points of attention with respect to the development and deployability of such models as a useful product. These points are listed in the section 'Knowledge gaps'.

We encourage knowledge-chain-wide, inter- and transdisciplinary consortia to tackle the two different types of knowledge gaps in a single project and to yield knowledge that can actually be used on the models for different organs. Examples of relevant disciplines are stem cell biology, biomaterials, cell and tissue engineering, essential technologies for scaling up and (bio) manufacturing, preclinical medicine, biomedical product development, legislation, and ethics. With a view to societal relevance and deployability, we expect that patients, legislators, end users, civil society parties and other stakeholders are involved in the project as well.

Knowledge gaps

Quality of 3D models

- 1. Scalability and production rate: Improving the functionality of human 3D models requires the development of key enabling technologies so that it is possible to produce larger models. It currently costs too much time to make these models, which limits their practical usability by, for example, companies.
- 2. Developing/implementing effective scaffolding materials: Cells in the body grow within an environment, the extracellular matrix (ECM). In the laboratory, cells grow on or in synthetic or natural scaffold materials. We still know too little about what the best approach is and how this influences cell growth, differentiation and the formation of functional, larger structures.
- 3. Support for metabolism: For larger models, it is a challenge to provide all the cells with sufficient nutrients and remove waste products (metabolism). Without metabolism, cells cannot develop and tissues cannot function and survive. Therefore, methods must be investigated to support metabolism, for example, through perfusion or by introducing blood vessels and nerves.
- 4. Development of cells and tissues: Cells and tissues often do not fully grow in the laboratory, as a result of which, they are more similar to structures in the foetus or embryo than in an adult human. The addition of specific cells, such as nerve cells, could possibly lead to a more adult tissue development. A deeper understanding of the molecular organisation and development of 3D models can address this problem.

3D models as a product

- Stakeholder analysis: It is important to identify stakeholders and their needs so that the models can be deployed as products. The stakeholders include patients, those treating them and the (pharmaceutical) industry. For example, we need to consult patients in an early stage of the research to ensure that the models can also investigate aspects of disease and development that are important to patients. A similar co-creation process will need to be followed for other stakeholders and end users.
- 2. Legislation: At present, it is not clear how we can ensure that 3D models with human cells can be used in preclinical research as soon as these models become available. And whether these models can be used to replace animal experiments. Exactly which legislation is applicable here? Should we draw up general guidelines or do we need to conduct case studies first? Societal, sustainability and economic interests: It is necessary to map the impact of these models. For example, do certain organisations, civil society groups or policymakers set conditions for the use of these models? And if we use these models for the development and testing of drugs, then how will that influence the development costs of drugs?

Intended societal and scientific impact

This theme places emphasis on developing innovative technological improvements to (re)generate clinically relevant human 3D tissue models with which the scientific results and knowledge acquired can be used in medicine. To achieve the intended impact, it is necessary for organisations across the entire knowledge chain to collaborate, and for societal organisations to actively be part of the project. The academic research into this theme will provide in-depth insights into crucial biological, biophysical and biochemical aspects that are vital for improving the regeneration of human tissues.

Understanding interactions in the human body is crucial because cells and tissues never exist in isolation. 3D tissue models are only relevant if these complex interactions are included. Research into the regeneration and deployment of clinical, and for patients relevant, 3D tissue models can increase knowledge about interactions between different cell types, surrounding tissues and other environmental factors in both healthy and damaged tissues. It will also make it possible to compare research results between different tissue types. This could result in a better understanding of the processes that occur in damaged tissues, which could ultimately result in new treatment methods.

The premise is that the scientific results and acquired knowledge will be applicable within the field of medicine. If 3D models are to be effectively implemented in practice, then they must be treated as products from the outset. Identifying interested parties and establishing their roles and needs must therefore be an integral aspect of both the consortium formation and the project research. The

development of 3D tissue models needs be done in a co-creation trajectory with interested parties. Several possible interested parties are named below.

The input of patients is vital to create the right impact. For clinically relevant research, the models must have characteristics that are linked to the outcome measures relevant to patients. This can only be achieved through collaboration with patient organisations and care providers from the conception of the project idea through to the implementation.

In addition, legislative bodies such as the Medicines Evaluation Board (CBG) and the European Medicines Agency (EMA) are vitally important. Research into legislation can help in using human 3D tissue models in the future as an alternative to animal experiments, which could lead to a more rapid assessment of drugs that are suitable for people and the earlier termination of the development of drugs that are not.

Furthermore, the influence on the costs of drug development must be examined, as this could influence the implementation possibilities. Healthcare insurers, the National Health Care Institute, policymakers and companies could contribute in this area, for example.

Development and implementation of human 3D digital models might also have major consequences for how drugs are developed in the future and how society views this. Transparency and discussion about this research are therefore vital, especially if ethical questions are involved. We therefore invite consortia to devote explicit attention to this in their proposals, in collaboration with civil society parties such as health foundations, the Dutch Society for the Replacement of Animal Testing and organisations that focus on (science) communication.

The above overview is not complete and serves as a start for consortia to include relevant parties and their proposals. This can certainly also include companies that could contribute to the innovations in various ways.

The theme does not directly focus on clinical impact but tries to realise projects with broad results for different models to increase the future clinical impact.

Background

This theme focuses on the development and implementation of innovative technological improvements for the generation and use of clinically relevant human 3D tissue models in which the scientific results and knowledge required are relevant to the field of medicine. Damage to our tissues and organs during our life can be caused by wounds, undesirable tissue formation (fibrosis), chronic diseases or genetic abnormalities. Examples of this are diseases such as osteogenesis imperfecta, Duchenne and fibrous dysplasia, but also highly prevalent causes such as heart attacks, burns, arthrosis, renal diseases and diabetes. When it becomes possible to restore the function of these damaged parts, then we can take steps towards curing chronically ill patients instead of merely treating their symptoms. Researchers are working on different approaches, including cell and gene therapy, new drugs, and physical stimuli to restore these damages. Within regenerative medicine, technology to simulate human tissues in the laboratory and organs-on-chip technologies provide unique possibilities for both research into diseases as equally the development of new treatments. The current theme focuses not on the challenges within specific tissues, but instead strives for innovations that are relevant for several tissue systems to advance the field as a whole.

The theme focuses specifically on the transition from 2D to 3D models with the aim of being able to contribute to the development of treatments in the future. At present, laboratory animals cannot, and may not, be replaced by models made from human cells in preclinical trajectories in the Netherlands. However, the majority of drugs that work in laboratory animals do not work, or do not work in the same way, in humans. By endeavouring to develop human 3D digital models that are representative of real tissues in terms of size and functionality, the gap can be bridged between fundamental and clinically relevant research.

In general, there are numerous interdisciplinary issues in the field of regenerative medicine concerning legislation, cost efficiency, ethics and societal acceptance. Only if these challenges are tackled parallel to the technological innovations can we respond to problems and concerns from different parties and possibly anticipate them. This is unavoidable within this theme. Approaching human 3D digital models as a product ensures that the project results will closely align with societal needs and contexts, and it

reduces the risk of scientifically valuable but impractical models. Although some models are still in an early developmental stage and could experience limitations during their further development, the knowledge gained about the development of a single human 3D tissue model as a product can also be applied to other models.

In this way, we can work together with society to ensure that these innovations are ultimately implemented in a safe and effective manner. As part of the route, we have already made a start on this within the Small Projects, but we would like to emphasise that it is also an important point in this theme. Therefore, the previously stated points in the development of human 3D digital models as a product, for which researchers need to work together with interested parties, are important aspects of this theme.

Research into and with 3D tissue models is also of interest to various health foundations and is also supported by them in research projects^{20,21,22,23}

Relevant cluster questions and knowledge agenda

This theme touches upon various aspects of the following cluster questions:

- Q094: How do we improve the quality of health care as much as possible while keeping it affordable?
- Q098: How can we use breakthroughs in basic biomedical research to develop new medicines?
- Q100: How can we use cells, stem cells, and biomaterials to engineer and regenerate tissues and organs?
- Q101: Can we model the human body and use smart technologies for health, nutritional, and toxicity research, drastically reducing the use of laboratory animals at the same time?

There also exist a number of disease-specific and organ-specific questions that the project proposals submitted within this same theme may be aligned with.

7.5.8 Younger through sport, exercise and nutrition

Aim

More than half of all Dutch people exercise too little and eat insufficient fruit, vegetables and fish^{24,25}. This causes health risks and contributes considerably to the disease burden of non-transmissible disorders. For many people, the long-term consequences of an unhealthy lifestyle are too far away in time to make them change their behaviour. Consequently, lifestyle interventions aimed at facilitating health through sport, exercise and nutrition have a low impact and little long-term compliance. The need to tackle this problem is huge: the population is ageing and the healthcare costs for older people with avoidable chronic diseases are unmanageable²⁶. It is therefore vitally important that (more) Dutch people adopt an active, healthy lifestyle. But how can this be achieved?

This theme focuses on the development of lifestyle interventions for middle-aged people (30 to 65 years) based on a personalised, optimal synergy of physical activity and nutrition combined with

- ²⁰ https://nierstichting.nl/professionals/projecten/modelling-nephron-endowment-in-multi-hybrid-humankidney-organoids-1084021/
- ²¹ https://www.kwf.nl/onderzoek/nieuwe-doorbraken/organoiden
- ²² https://www.gezondheidsfondsen.nl/wordpress/wp
 - content/uploads/2020/10/HM1_publiekssamenvattingen_22102020_fi.pdf
- ²³ https://www.mlds.nl/kanker/wetenschappelijk-onderzoek/mini-organen-en-mini-tumoren-kweken-omkanker-van-de-galwegen-vast-te-stellen-en-behandeling-te-onderzoeken/
- ²⁴ National Institute for Public Health and the Environment. Opvolging van alle richtlijnen [Compliance with all Guidelines in Dutch]. https://wwwateetnederlandnl/resultaten/richtlijnen/alle_richtlijnen 2022.
- ²⁵ National Institute for Public Health and the Environment. Gezondheidsenquête/Leefstijlmonitor, [Health survey / Lifestyle monitor – in Dutch]; persoonskenmerken [personal characteristics].

https://statlinerivmnl/#/RIVM/nl/dataset/50080NED/table?ts=1697140974336 2022

²⁶ Council of Public Health & Society. Op onze gezondheid - de noodzaak van een sterkere publieke gezondheidszorg [To our health – the need for a stronger public health – in Dutch] 2023; ISBN: 978-90-5732-176-4.

innovative lifestyle monitoring and feedback about biological age as motivating instruments for healthy ageing. This approach is based on the assumption that the target group has the ability to guide their own behaviour more, and that this can be strengthened through the rapid and regular collection of relevant health data combined with motivational interviewing. At present, people only have limited insight into the favourable effects of sport, exercise and nutrition on their health. The rapid developments in the area of physiological measurements, sensor technology and data analysis make it possible to provide insight into these effects in the relatively short term (weeks). By providing individual feedback on these data in relation to people's own biological age, the effects of the initiated behavioural changes become clear. As a result of this, people will more rapidly gain an understanding of their own ageing process and the degree to which sport, exercise and nutrition can favourably influence the difference between their biological age and calendar age. Quality of the data, supervision and education play a crucial role in this. This field is currently experiencing a rather uncontrolled growth. With this call, research is initiated that will provide insight into:

- 1. the individual motives of Dutch people to adopt an active, healthy lifestyle and the physical, mental and socioeconomic barriers to doing so,
- 2. the assumption that the feedback of the effects from sport, exercise and nutrition on biological ageing in lifestyle interventions can promote long-term behavioural change,
- 3. biomarkers of ageing (or combinations thereof) that can be used for identifying and evaluating interventions aimed at ageing healthily, and
- 4. the cost-effectiveness and large-scale applicability of such an advanced approach.

Knowledge gaps

The limited effectiveness of lifestyle interventions is due to a wide range of ((epi)genetic, physical, psychological, socioeconomic) factors, with just as many ways of increasing these. Besides insight into the effectiveness of socioeconomic and spatial measures, more knowledge is needed about the effectiveness of lifestyle interventions that focus on sport, exercise and nutrition, and the health effects resulting from these. Insight is needed into people's motivations to permanently change their lifestyle and how to strengthen such reasons. In this context, the possibility of obtaining real-time insight into personal health constitutes a previously uncharted theme: does the regular feedback of directly interpretable information about one's own ageing process (influenced by sport, exercise and nutrition) result in the long-term espousal of a healthy lifestyle? For which kind of people is this effective, or not or less effective? What are the causes of that? Finally, there are still many unanswered questions about the optimal individual dosing and nature of physical activity and nutrition in relation to ageing.

The concept of biological age provides a possibly useful instrument to motivate people and to support them in trying to adopt lifestyle adjustments aimed at 'becoming younger'. The development of valid and practical indicators for individual ageing is also important for the evaluation of the effectiveness of lifestyle interventions (which, at present, are frequently based on the Body Mass Index (BMI) and psychosocial factors such as self-image and quality of life²⁷). The bathroom scales and the measuring tape around the waist only give an indication of the state of a person's health; multidimensional positive effects of sport, exercise and nutrition on health are not included in this. Recently, a rapidly growing trend has arisen in geroscience (the science of biological ageing, chronic disease and health), which aims to identify and evaluate biomarkers. These biomarkers can be translated into biological age clocks based on (estimates) of the biological age²⁸ and, with that, the age gap; the difference between biological age and calendar age. These biomarkers are partly based on blood values that shed light on the state of the organ system (based on epigenetic parameters). Furthermore, immunological and

²⁷ National Institute for Public Health and the Environment. Goede zorg en gezonde leefstijl - Monitor Gecombineerde Leefstijlinterventie 2023 [Good health and healthy lifestyle – Monitor Combined Lifestyle Intervention – in Dutch]]. <u>https://wwwrivmnl/documenten/monitor-gecombineerde-leefstijlinterventie-2023</u> 2023.

²⁸ Moqri M, Herzog C, Poganik JR, et al. Biomarkers of aging for the identification and evaluation of longevity interventions. *Cell* 2023; 186: 3758-75.

metabolic markers as well as anthropometric or physical values exist, which provide additional insight into the physical and mental state of a person's health. Retrospective studies have revealed that the currently available biomarkers for ageing are predictive for ageing-related outcomes^{28,29,30,31,32} and can be influenced by lifestyle changes^{28,33,34}. However, it is not yet known whether knowledge about one's own biological age, aided by supervision or not, can encourage people to make sustainable lifestyle changes.

Intended societal and scientific impact

The scientific impact of the theme lies in the insights that will be provided into the ageing process as a proxy for health (see 5, Background), the effects of sport, exercise and nutrition on this, and individual optimisation of that in lifestyle interventions. Research is aimed at the following breakthroughs:

- 1. In-depth insight into the biological, psychological, psychosocial and socioeconomic factors that influence the realisation of sustainable behavioural change.
- 2. Expansion and validation of biomarkers that can be applied in practice.
- 3. Identification and validation of a composite, practically applicable measure for the biological age by combining biomarkers of ageing.
- 4. Development of individually optimised exercise and nutrition interventions based on biological phenotype.
- 5. Implementing the acquired knowledge in primary care, sports, and the fitness and vitality sector, and assessing the effectiveness and broad applicability of this.

For this, intervention studies that combine biomarkers, exercise, and nutritional data are needed, where possible, in current cohort studies supplemented with (epi)genetic and microbiome biomarkers²⁸. In this manner, biological clocks can be linked to exercise and nutrition data, age, gender, psychological factors, socioeconomic status, disease and mortality. Data science can provide further knowledge about the measures that can best predict biological age based on genotype and phenotype. Finally, existing cell- and organ-specific biological clocks can be validated to differentiate lifestyle adaptations according to individual factors.

The intervention studies will be deployed to determine the effects of sport, exercise and nutrition on their biological clocks. For this, middle-aged people will be included, who, for various reasons, want to know more about the processes which occur in their bodies and the effect of exercise and nutrition on these (prevention of further deterioration in the case of illness, health improvement, performance improvement). Efforts will be made to include a spread of participants across the entire "human performance continuum": from individuals who scarcely exercise (far under the exercise standard), individuals who approximate the exercise standard, to individuals who far exceeded or exceed this level (former athletes who no longer pursue sports). For nutrition, a similar differentiation will be applied. This is because the biological clock can both be ahead of or fall behind the calendar age. And because it is conceivable that both (poorly dosed) physical exertion and (unfavourable) nutrition can also have a negative effect on the biological clock.

The societal impact of the theme includes an increase in the effectiveness of lifestyle intervention programmes, which could be of great significance for society. Sustainable lifestyle change with an optimal combination of exercise and nutrition will result in a reduction in chronic illnesses and, consequently, a lower absence from work among older people, a curtailment of healthcare costs and a

²⁹ Lu AT, Binder AM, Zhang J, et al. DNA methylation GrimAge version 2. *Aging* 2022; 14: 9484-549.

³⁰ Tanaka T, Basisty N, Fantoni G, et al. Plasma proteomic biomarker signature of age predicts health and life span. *eLife* 2020; 9.

³¹ Moqri M, Cipriano A, Nachun D, et al. PRC2 clock: a universal epigenetic biomarker of aging and rejuvenation. *bioRxiv* 2022: 2022.06.03.494609.

³² Balasubramanian R, Paynter NP, Giulianini F, et al. Metabolomic profiles associated with all-cause mortality in the Women's Health Initiative. *Int J Epidemiol* 2020; 49: 289-300.

³³ Rigamonti AE, Bollati V, Favero C, et al. Effect of a 3-Week Multidisciplinary Body Weight Reduction Program on the Epigenetic Age Acceleration in Obese Adults. *Journal of clinical medicine* 2022; 11.

³⁴ Sellami M, Bragazzi N, Prince MS, Denham J, Elrayess M. Regular, Intense Exercise Training as a Healthy Aging Lifestyle Strategy: Preventing DNA Damage, Telomere Shortening and Adverse DNA Methylation Changes Over a Lifetime. Frontiers in genetics 2021; 12: 652497.

higher deployability of older people. In that case, it will be possible to issue and monitor individually optimised lifestyle recommendations in primary healthcare. Furthermore, new application possibilities will arise for the diagnostics sector and vitality management within or for companies. Should the programme reveal that feedback about the biological age does not contribute to sustainable lifestyle change, then this information will nevertheless provide valuable insights, for example, into the psychological, psychosocial and socioeconomic reasons for this. Knowledge about that can contribute to improving lifestyle intervention programmes.

Background

The population of the Netherlands is ageing, as a result of which the physical and mental capacities of a large group of people are deteriorating, in a context in which less than half of the population satisfies the exercise guidelines and eats unhealthily as well³⁵. Consequently, the prevalence of diseases and comorbidities is growing rapidly, which creates an unmanageable care burden. The situation requires a radical deployment of lifestyle changes at a timely stage, during which it is (still) effective to bring about long-term lifestyle changes. Older people often no longer have the physical and mental possibilities to change their lifestyle, and neither are they motivated to do so.

Lifestyle intervention studies have revealed that only a small number of participants succeed in permanently changing their behaviour^{36,37}. There are many different reasons for this, such as lack of time, social and societal pressure, health limitations, socioeconomic conditions, negative thoughts and feelings, lack of knowledge and awareness, little or no pleasure in exercising and little motivation. There is currently a clear trend towards increasing the effectiveness of lifestyle interventions by integrally addressing these causes with sport, exercise and nutrition as starting point (so, not in isolation, but in their mutual interaction). Such an integral approach is expected to provide better outcomes but, by definition, requires considerable efforts and investments in a very wide range of areas. The approach should, therefore, be linked with knowledge-chain-wide, interdisciplinary, and transitioning research to determine how such interventions can best be shaped and what the effective ingredients within these interventions would be. In this context, it is useful to make a distinction between environment-specific and individual-specific ingredients.

The starting point of the proposed project is the ageing process, which unavoidably leads to physical and mental deterioration (with illness and comorbidity as a consequence). These risks keep pace with the increase in calendar age. Cells, tissues and organs age due to the accumulation of damage as a result of cell division, physical and metabolic load and environmental factors. The rate of this process differs between people and organ systems³⁸. Biological age is therefore a better measure for the risk of disease and mortality than calendar age. Various cellular, molecular, physiological, cognitive and functional biomarkers are currently available with which the biological age of organ systems can be estimated^{28,39,40}. However, a composite measure for biological age still needs to be established. The difference between biological age and calendar age, the age gap, is partly a function of lifestyle^{28, 33, 34}.

If biological age is to be used as a health index (and a possible vehicle for lifestyle change) intervention studies are needed in which biomarkers of age are part of a composite measure that provides

³⁵ National Institute for Public Health and the Environment. Leefstijlmonitor [Lifestyle monitor - in Dutch]. <u>https://wwwrivmnl/leefstijlmonitor</u> 2023.

³⁶ Rössner S, Hammarstrand M, Hemmingsson E, Neovius M, Johansson K. Long-term weight loss and weight-loss maintenance strategies. *Obesity reviews : an official journal of the International Association for the Study of Obesity* 2008; 9: 624-30.

³⁷ van Sluijs EM, van Poppel MN, van Mechelen W. Stage-based lifestyle interventions in primary care: are they effective? Am J Prev Med 2004; 26: 330-43.

³⁸ Tian YE, Cropley V, Maier AB, Lautenschlager NT, Breakspear M, Zalesky A. Heterogeneous aging across multiple organ systems and prediction of chronic disease and mortality. *Nat Med* 2023; 29: 1221-31.

³⁹ Palmer RD. Aging clocks & mortality timers, methylation, glycomic, telomeric and more. A window to measuring biological age. Aging medicine (Milton (NSW)) 2022; 5: 120-5.

⁴⁰ Jansen R, Han LK, Verhoeven JE, et al. An integrative study of five biological clocks in somatic and mental health. *eLife* 2021; 10.

information about the ageing process. Such a measure and, with that, the associated age gap could potentially contribute to people's motivation to make long-term adjustments to their lifestyle - because it is associated with an intrinsic positive value - namely, becoming a younger version of yourself⁴¹. Although the bathroom scales and the measurement tape around the waist provide a rough indication of the state of health, they only provide limited insight into the positive effects of exercise and nutrition on health and life expectancy. The question that needs to be answered is to what extent the assumption that biological age is an effective vehicle for achieving the desired behavioural change is correct.

Relevant cluster questions and knowledge agenda

The theme is directly related to cluster question: The theme is directly related to cluster question:

 Q075: How can we use sport, exercise, and nutrition to promote good health and what effects will this have?

The theme will make both a fundamental and practical contribution to this question. In addition, the theme is relevant to various other cluster questions, including:

- Q072: How do a healthy lifestyle and wholesome habits promote good health and prevent illness?
- Q077: What do non-genetic factors contribute to personal traits and disease processes?
- Q084: What is the best way for us to analyse and prevent the problem of overweight and obesity?
- Q087: What causes type 1 and type 2 diabetes, how can we detect them sooner, and how can we treat them on an individual basis?
- Q094: How do we improve the quality of health care as much as possible while keeping it affordable?
- Q105: How can Big Data and technological innovation (e-health) contribute to health care?
- Q112: Can we use Big Data and Big Data collection to define values, generate insights, and get answers?

The theme contributes to this by integrating two themes of the knowledge and innovation agenda of the route Sport and Exercise, namely "Exercise is Medicine" and "Moving Smarter and Better", and the associated game changers, namely the full deployment (i.e. as part of, and outside of, healthcare) of sport, exercise and nutrition to promote health and vitality and to prevent diseases or the further complications of these, and the utilisation of data and technology to exercise smarter and better, tailored to the individual. Thanks to recent developments in sensor technology, wearables, machine learning and AI, it has become possible to collect exercise and nutritional data on a large scale, analyse these in relation to other data and provide feedback on the results in a compacted and comprehensible form for the promotion of health.

7.5.9 Towards a climate-friendly and biodiversity-friendly production of plantbased proteins

Aim

The aim of the theme is to form consortia that mobilise, utilise, and catalyse the adaptability of local initiatives regarding plant-based proteins, with the ultimate goal of having approximately 70% of proteins consumed in the Netherlands of plant origin by 2050, produced in a climate-resilient and biodiversity-friendly manner. This theme supports collaborative efforts between societal entities and knowledge institutions, engaging in interdisciplinary and transdisciplinary research over the next decade on factors, interventions, and innovations facilitating such a transition. To achieve this protein transition, it is essential for agricultural systems to cultivate a diverse range of protein-rich crops, available for processing and distribution in the consumer market. Initially, the theme focuses on initiatives promoting the biodiversity of grains, nuts, and legumes.

⁴¹ Teixeira PJ, Carraça EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: a systematic review. *The international journal of behavioral nutrition and physical activity* 2012; 9: 78.

The theme integrates the shift to plant-based proteins with enhancing the resilience of food systems. Climate change has profound implications for food supply, and biodiversity is under significant pressure. The production and consumption of animal proteins (currently constituting 60% of Dutch protein consumption) play a negative role due to the relatively high emission of greenhouse gases, other harmful substances, and a narrow choice of crops. A transition to a predominantly plant-based protein food system can be a crucial part of the solution.

The theme specifically addresses the impacts of climate change on water management, such as increased occurrences of water excess or drought. The goal is to enhance water stress resilience of protein crops and achieve higher production by leveraging biodiversity, including both the genetic diversity of the crops used and the diversity of the surrounding natural environment.

A transdisciplinary consortium contributes to a fruitful interaction between practice, chain design, local policy, and science. The guiding principle is context-specific knowledge anchored in local initiatives related to the cultivation of protein crops, involving farmers, Heerenboeren (local community farms), farmers' cooperatives, initiators of food forests, citizen initiatives, allotment associations, and the catering sector. Together with these stakeholders, the theme establishes connections with other entities in the supply chain, such as processors, wholesalers, distributors, retail, and representative organisations like Royal MKB-Nederland, to address conditions in the chain that allow for scaling up and systemic approaches. The issue of water stress resilience links food supply to spatial planning concerns, necessitating the integration of knowledge among municipalities, water boards, and provinces.

Knowledge gaps

There is still a lack of important knowledge concerning the short-, medium -and long-term effects of the interaction between cultivation, biodiversity, climate, chain relationships and regional collaboration for the availability of healthy and affordable plant-based protein. Therefore, specific research is needed to answer the question: which factors promote or hinder the cultivation of biodiversity-friendly, climate-related water stress-resistant protein crops? Interdisciplinary research provides insight into the factors determining why various cultivations of protein crops persist or disappear, as well as why innovations or interventions in the food system often fail to achieve the intended effect.

This overarching question can be broken down into the following sub-questions:

- What is the relationship between water stress-resistant food production and biodiversity? The connection between water stress-resistant food production and the protection and utilization of biodiversity requires research on a realistic spatial and temporal scale. Interdisciplinary and comparative research analyse the interweaving of biological, meteorological, technical, and social dimensions, unravelling how these contribute collectively to climate-resilient food production.
- 2. Which chain relationships promote or hinder a profound and large-scale transition to a healthy and affordable diet based on plant-based proteins? To achieve a large-scale shift towards the consumption of climate-resilient and biodiversity-friendly produced plant-based protein, it is crucial to examine how effective local initiatives for protein crops can be integrated into the practices and logic of related organisations in the broader food system. Research provides insights into feedback mechanisms visible in the behaviour of producers, processors, retailers, consumers, and citizens, as well as in their interactions with the living environment. Systemic research into complex feedback mechanisms, unintended effects, synergies, and trade-offs supports stakeholders in dealing with unpredictability and uncertainty. The theme supports policy-forming and innovation strategies that consider system dynamics. Learning from similar transitions in other systems is central to comparative research with locally embedded initiatives in various geographical locations in the Netherlands and beyond. This shapes a productive and
 - creative interaction between context-specific solutions and science.
- 3. How can locally embedded initiatives become an integral part of innovation, policy, and technical design? The theme values diversity in practices, solution approaches, preferences, and interests, with a particular interest in affordable and straightforward techniques and measures. The communication science question is which vocabulary and heuristics contribute to the integration of local initiatives into a diversified and area-specific range of policy options and innovations.

Intended societal and scientific impact

The intended societal impact is that in 2050, 70% of the proteins consumed in the Netherlands will be plant-based and climate resilient, and produced in a biodiversity-friendly manner. This requires adjustments to the crops in the area of biotic and abiotic stress tolerance as a consequence of existing and new problems due to climate change. It is likely that in the future, the Netherlands will further experience the consequences of flooding or a warmer climate. Problems in the primary production are yields that are too low and increasingly greater insecure crop yields. In addition, there need to be good distribution channels to process and sell the products further up the chain, after which they can be sold to consumers. This food will not only originate from the Netherlands, but also from other parts of the world. Partners from outside of the Netherlands can make a substantial contributions and lessons can also be learned from them.

The theme shares, combines, and generates knowledge about the redesign of our food system aimed at sustainability, affordability, climate and, in particular, resilience during water stress. The intended increase in the proportion of plant-based food in our diet means a transition to protein crops in agriculture that can be cultivated in a sustainable and profitable manner. This will also contribute to a more diverse and for consumers acceptable use of raw materials. That offers opportunities for the integration of the values and wishes of citizens and consumers. Therefore, in the theme, cooperation will be sought with representatives from local initiatives for the creation of new connections in the chain and with local governments.

The intended scientific impact concerns the scientific underpinning of the parameters that contribute to the redesign of a sustainable and climate-resilient food system, for which the aim is to realise a proportion of 70% of plant-based food in our diet. The emphasis within interdisciplinary research needs to be on the systemic and socio-ecological approach that describes the different feedback mechanisms that determine the intended and unintended effects on food systems. This makes it important to discover which agri-ecological, commercial and organisational processes, market dynamics and chain arrangements are compatible with connecting climate resilience and protein crops.

The scientific insights will provide the basis for breakthroughs in technical and organisational innovations for climate-resilient food production. The research will provide room for productive and creative interaction between context-specific possible solutions and science. In-depth research with a system dynamics lens emphasises processes of self-selection and self-organisation, and exposes unintended or unforeseen system effects. In addition, a system dynamics lens makes visible the path dependencies, lock-ins and feedback mechanisms that can explain why it is difficult to use the existing diversity of solution pathways in innovation and policy. New methods and comparative research connect system dynamics to inclusive design processes for a transition to plant-based proteins embedded in local practices that integrate biodiversity and climate resilience. The theme aims to contribute to inclusive public dialogue, the utilisation of design strength and tailored solutions.

Background

This theme is part of the route of sustainable production of safe and healthy food. The sustainability of the current food supply attracts a lot of attention and is part of the public debate. One of the aspects is the intensity of many agricultural systems. In the Netherlands, the spotlight is on large-scale intensive livestock farming and the use of pesticides and artificial fertilisers. Intensive livestock farming contributes to Dutch greenhouse gas emissions and climate change. Intensive agriculture also contributes to the loss of biodiversity. The combination of climate change and loss of biodiversity makes food production vulnerable and unstable. This makes it difficult to use biodiversity in achieving climate-resilient food production (adaptation) and creating new ways of supplying proteins (mitigation).

Proteins are an essential part of a healthy and affordable diet. How and which proteins should be produced is a strategic issue. Switching to plant-based proteins is central to mitigation strategies for climate problems and the excessive use of scarce non-circular resources. Climate adaptation is less visible in the public and scientific debate, although recently, there has been more attention for this in

the area of water management. Up to a point, this is because solutions often focus on parts of the food system and people wish to achieve unequivocal and sometimes uniform solutions. The theme brings together mitigation and adaptation, with a lot of attention for local DIY approaches, such as experimental gardens or food forests. They show that there really are different ways to supply food but that these often remain small scale.

The diversity of crops and solutions seems to be an important boundary condition for rendering successful changes in the provision of proteins in combination with climate resilience. The premise is that climate-resilient food production benefits from the variation of possible solutions matched to specific agri-ecological and socioeconomic contexts. Take, for example, the rich palette of agricultural practices in the Netherlands and worldwide in which plant-based proteins are produced (such as the variation in beans in Mexico or the range of different grains in arid areas in India or Kenya). Despite all the attention for climate problems, transitions to climate-resilient food systems are scant. Biodiversity and water-stress-resilient food production are inseparable and are linked with each other at various integration levels. The theme emphasises interactions between local dynamics and processes at the regional and global scale (both natural processes in weather systems as well as international processes concerning policy and legislation). These interactions can be synergistic but there are also trade-offs. For example, an increase in biodiversity - both the genetic diversity of the used crops as well as the natural flora and fauna in and around the agricultural system – increases crop production due to water stress resilience. At the same time, there are also trade-offs. For example, in the case of water scarcity, competition can occur between agriculture and nature conservation. These interactions and dynamics condition the redesign of agricultural systems and the food supply, and are vital for creating a climate-resilient food production.

Endeavours to create a climate-resilient food production benefit from a greater capacity to provide tailored outcomes and to work towards context-specific solutions. This requires room to utilise biodiversity and to combine it in setting out a range of solution pathways. The research offers opportunities for various social groups to experiment, learn by doing and create synergies from existing or new connections.

Relevant cluster questions and knowledge agenda

Cluster questions

- Q002: What do humans and nature mean to each other and what is the ideal relationship between the two?
- Q003: Why is biodiversity important and how do we protect it?;
- Q009: How can we make better use of the carbon, nitrogen, and phosphorous cycles?;
- Q015: How can we make agricultural production systems more sustainable as the worldwide demand for healthy, safe food continues to grow?
- Q016: How can we develop healthy new food crops that have higher yields while requiring fewer harmful chemicals?;
- Q041: What is the 'inequality problem'?;
- Q042: How can we limit poverty and increase wellbeing worldwide?;
- Q044: Can globalisation and development be reinvented in a way that, in time, will mitigate differences in prosperity between world regions?;
- Q052: How can we create a truly circular economy so that industrial goods manufacturing depends less on primary raw materials?
- Q053: What are the features of a circular economy and how can we achieve it?
- Q070: Why do we do what we do, are we who we think we are, and what factors influence our behaviour? In other words, how can we understand our behaviour?
- Q108: What social changes are imminent owing to advancing technology and how will they affect prosperity?

Gamechangers route:

- Biodiverse blue
- Biodiverse green
- Circular systems

- Efficient with protein
- High Tech and IT
- Decision-making capacity of consumers
- Global food security
- Turbo-synthesis

7.5.10 Strengthening social relationships between pupils at school to promote their mental health

Aim

The aim of this theme is to strengthen **the mental health of youth** by improving their **social relationships** with each other. This makes it possible to make optimal use of the strength of social relationships for the mental health of youth. This requires three steps:

- 1. Studying social relationships between pupils, including mechanisms that can explain the positive (and negative) effects of social relationships on the mental health of children and young people.
- 2. Developing approaches based on these mechanisms, and the assessment of their actual impact on mental health.
- 3. Investigating which characteristics of pupils, teachers and other professionals, as well as environmental influences, positively and/or negatively impact the aforementioned approaches.

Proposed knowledge-chain-wide, interdisciplinary and transdisciplinary projects should study these three steps in relation to each other and focus on the following urgent societal themes: a) integration of online and offline social relationships,

b) roles of interactions with contemporaries in the case of (performance) anxiety, social exclusion and depressive feelings (for instance, through support, informal help or co-rumination).

Furthermore, these projects should satisfy the following four conditions to maximise their scientific and societal relevance:

- 1. Active participation of children or young people in the proposal, design, realisation and interpretation of the research is conditional for funding. In doing so, it should be clearly indicated how children or young people will participate in all stages of the project.
- 2. Proposed projects (also) must also focus on pupils in vocationally oriented forms of education (practical education, basic and advanced pathways within pre-vocational secondary education, further professional education) and (secondary) specialised education. It is particularly important to do research among these pupils because there are strong indications that they have a higher risk of reduced mental health, and because education professionals in these forms of education regularly indicate that they do not know what to do. At the same time, this group is strongly underrepresented in scientific research, and the public debate about this group is frequently based on assumptions that have not been investigated.
- 3. Direct **influence**, **reinforcement**, or **enhancement** of social relationships with/among young people. This can be broadly chosen in consultation with young people and not only consist of an intervention or methodology but also involve a change in approach (for example, more systematic input and co-creation by students), (sub)practices (such as strengthening student activities), and the system (for instance, collaboration between education and care or social work forms). A solid theoretical foundation explaining why an approach is expected to have an impact is essential.
- Research on the impact of this influence, reinforcement, or improvement of mental health through social relationships requires appropriate interdisciplinary collaboration in mixed-method longitudinal (experimental) research designs.

The research thus integrates the sub-themes:

- 1. Integration of online and offline social relationships,
- 2. Mechanisms of the influence of social relationships on well-being, (failure) anxiety, depressive feelings (for example, through co-rumination), loneliness, social exclusion, and bullying,
- 3. Impact of direct influence on social relationships on the mechanisms and outcomes mentioned in (2).

Knowledge gaps

In recent years, the mental health of Dutch youth has been under pressure. Traditionally, approaches to improving mental health have focussed on supporting individual children and families by adults such as teachers, parents, and (specialised) care providers. However, this might well have missed an important strength of children and young people <u>themselves</u>: the strength of their mutual social relationships.

After all, good social relationships assist in healthy mental development. Social skills, feelings of autonomy, involvement and a sense of belonging and being valued for who you are, are particularly important for children and young people and are largely derived from contemporaries at and around school. Although this perspective has only received much scientific attention for just under a decade, the initial findings point to a large potential impact of the systematic use of the strength of mutual social relationships in strengthening the mental health of youth.

Furthermore, several developments in society can be seen as a potential threat to the social relationships of youth and, accordingly, to their mental health. This applies in particular to the increasingly overlapping online and offline worlds of young people, worlds in which a large part of entering into and dealing with social relationships takes place: the excessive talking with friends about concerns and mental problems (so-called co-ruminating) and dealing with feelings of loneliness, social exclusion or bullying. The scientific knowledge about these themes is limited.

This theme addresses four knowledge gaps:

- 1. The positive and negative effects of mutual social relationships between youth on their mental health, centred on:
 - 1. social relationships in the integration of online and offline worlds,
 - 2. co-rumination processes between young people in the case of (performance) anxiety, social exclusion and depressive feelings;
- 2. The coherency between the aforementioned aspects of social relationships and mental health, and for whom in particular this is the case (for example, age, sexual identity, education, family income, background);
- 3. Influenceability of these social relationships and the effect/impact of that on the strengthening of mental health;
- 4. The extent to which education and care professionals within the care chain and organisations in the school context can influence the dynamics of social relationships between pupils.

These four knowledge gaps are clearly of great scientific and societal importance, and are vital parts of the knowledge agenda, the NWA knowledge questions, the UN Sustainable Development Goals, the Working Agenda Route to Inclusive Education 2035, and international scientific developments (for example, research priorities APA, SRCD).

A long-term study is desirable because prospective longitudinal studies need to take place, and the longitudinal impact of an intervention in the field of social relationships among students must be examined. This involves tracking the development of these students over an extended period, while also studying the interaction with the context in which the intervention occurs.

We expect that this programme will show that the mental health of children and young people at school can be increased by the further strengthening of social relationships.

Intended societal and scientific impact

The mental health of youth in the Netherlands is under considerable pressure: compared to twenty years ago, the percentage of pupils in secondary education who report mental health problems has almost doubled. Young people experience increasing problems related to (a) integration of social online and offline worlds, (b) (performance) anxieties and depressive feelings, feelings of loneliness, social exclusion and bullying and co-rumination (worrying together and reinforcing each others' worries).

This is problematic not only for young people and their immediate environment but also for society as a whole. That is because mental health problems in this phase of life can have considerable negative consequences for the rest of someone's life, including employment participation and healthcare costs. It is therefore vital to prevent mental health problems among youth as much as possible and to promote their mental health.

Current interventions in this area are mainly aimed at the child itself, their family and their teachers. As a result of this, it is overlooked that social relationships between children and young people in the school context can have a positive protective role in the mental health of youth.

Seeking ways of strengthening the social relationships together with young people could potentially lead to a societal breakthrough. It is expected that the strengthening of social relationships will strongly contribute to promoting the mental health of youth, because young people intensively interact with each other on a daily basis at school, and this creates many opportunities and possibilities for interventions.

Making important steps in this regard requires knowledge and insights about:

- 1. the aforementioned (threats of) social relationships and what is necessary to change this,
- 2. how this contributes to the improvement of the mental health of youth and
- 3. which characteristics of youth, the professionals and the (school) context strengthen these social relationships and their relation with mental health.

This knowledge can subsequently be used for realising preventative (school) wide approaches, the design of school programmes, the training of teachers, the further professional development of current teachers in the context of lifelong learning, the training of healthcare professionals such as ortho-pedagogues and educational psychologists, the design of supervisory structures in the broad school context, collaborations with parents and the collaboration between education and care. Also, this knowledge could possibly even be used in teaching subjects at school.

This call is expected to have a great impact as well because its focus (also) lies on the most vulnerable school contexts in which the dropout rate among pupils is high.

Given the importance of social relationships with contemporaries for the mental health of youth, it is both a societal and scientific priority to gain a better understanding of the dynamics and effects of mutual social relationships between children and young people. For this purpose, groundbreaking scientific theories about the development of social relationships are available (such as resource control, deviancy training, selection and influence, bullying roles, popularity, co-rumination), which urgently require assessment and application in the context of Dutch (secondary) (special) education.

Background

People are social animals with a strong need to feel connected with others, to be able to behave autonomously in such relationships, to feel socially competent and therefore to feel at home or experience a sense of belonging. For this reason, social relationships with contemporaries are vitally important for the development of children and young people. For a long time, research mainly paid attention to the importance of relationships between adults and young people (for example, through attachment and upbringing).

However, recent research shows the stand-alone importance of good and healthy relationships with contemporaries. Good social relationships with contemporaries facilitate the development of wellbeing, (school) performance, a healthy climate in classrooms and schools, and participation in society. Good social relationships can protect against risk factors among children themselves (for instance, a mild learning disability) and their environment (for example, conflict in family relationships). On the other hand, poor social experiences with contemporaries, such as being excluded, have severe and permanent negative effects on the development of children and young people.

The school environment is an important context for the social development of children and young people. If children and young people are harmed in feeling socially connected at school because, for example, they are bullied or excluded (by fellow pupils or teachers), then this has long-term negative effects on their well-being, (mental and physical) health, and participation in society.

Recent research has shown for which reasons specific characteristics of social relationships can both favourably and unfavourably influence the development of young people. Favourable influences are, for instance, strengthening of trust and resilience, social skills, well-being and (school) performance. Unfavourable influences occur, for example, when young people reinforce each other's problematic behaviour, worries or unhealthy actions (e.g. deviancy training, co-rumination or reinforcement of eating problems). In addition, social relationships can protect against known risk factors in the lives of children and young people. For instance, a trusted best friend can provide protection against conflicting family relationships, good relationships in the class can protect against the negative effects of ADHD on school performances, and joint social action such as coming to someone's defence in the case of bullying can buffer against exclusion and the unfavourable long-term effects of that on mental health.

The quality of social relationships at school can be influenced by the behaviour of teachers, school teams and the school management. However, professionals in education and care in the school context find it a challenge to strengthen social relationships. They often feel that they do not know what to do, which leads to high work pressure and burnout. This requires continuous professional development of these professionals (and of future professionals), based on knowledge of what they need and how they can work together on this problem. This also applies to the collaboration between education and care in the school. Often, one-sided interventions that are appropriate for specific target groups are deployed, but without a school-wide structured approach that influences the social relationships and mental health in the school.

The social development of young people is a dynamic process in which characteristics of individual young people, social interactions, group structure, social context and societal processes influence each other. Understanding these themes therefore requires interdisciplinary collaboration for the integration of pedagogical, psychological, sociogeographical, sociological, administrative and system-theoretical perspectives.

Relevant cluster questions and knowledge agenda

The proposed theme is related to the three game-changers within the knowledge agenda:

- 1. Learning and developing in different contexts: research into the complex interaction between the different social contexts in which young people grow up. The proposed theme fits within the research theme 'stress'.
- 2. Diversity and (in)equality: research into how young people with considerably diverse backgrounds (e.g. cultural, religious, gender, age, socioeconomic status or disabilities) can participate fully in society and optimally develop themselves. The proposed theme fits in the research themes 'health differences' and 'social exclusion'.
- 3. The normativity of upbringing and education: research into norms and values that form the foundation of education programmes, care protocols and the provision of help with the aim of safeguarding an inclusive approach in education, support and care. The proposed theme fits in the research themes '21st-century skills', 'norms and values in pedagogic relationships' and 'social identity'.

The proposed theme is related to the following cluster questions:

- Q047: How can we promote social cohesion in a society that is culturally and religiously diverse?
- Q049: How can we ensure that our labour force and labour-market organisations remain robust and resilient as they face the challenges of the 21st century?
- Q059: How can we help children and adolescents grow up safe and healthy?

7.5.11 Places of values; context-aware negotiations about the future of historically fraught sites

Aim

Everywhere in the Netherlands (and abroad, of course) people claim spaces; sometimes, they have strong opinions about their desired use, maintenance or redevelopment. That certainly applies to 'historically fraught sites'. There is a need to systematically describe the values that are contested or that, conversely, actually help in deliberations about these sites. That will give rise to a framework for assessments or values. That framework will support the parties involved with a wide range of historically fraught sites to realise fair and better-justified choices.

By recounting historical narratives, people appropriate the past. If, in doing so, they also lay claim to the past, then tensions, conflicts and violence can arise. How do people deal with sites where a diverse range of historical narratives appropriate the same space, and how can environmental policy take this into account? Tensions are particularly evident in the (former) personal living environment. What is possible if different groups want to remember their ancestors at the same historically fraught site, or when old cultural landscape must make room for new nature reserves?

How public and private spaces are shaped, and what kind of room exists for different historical narratives, depends on the interactions or negotiations between all interested parties. These are dynamic and complex processes in which power imbalances may determine the outcome. A values framework can act as a compass in those negotiations. Since values are more deeply embedded than interests or opinions, they can help to find common ground where opinions clash. Furthermore, a values framework can expose inequalities and responsibilities and thus question the power relations. For example, the values of inclusivity and equality receive a lot of public attention now in the context of long-silenced histories. That applies to human and non-human actors, such as animals, plants, rivers, seas and their representatives. We consider them to be potential stakeholders in the projects under this theme and, in this way, align this theme with the public and scientific debates about diversity and global climate change.

The development of a new values framework requires applied research that identifies and substantiates values. For this, researchers together with various stakeholders, will select fraught sites and work together on concrete visions for the future of those sites. This requires the participation of citizens in the research to create space and recognition for non-academic knowledge in the conversation about heritage. The research focuses on concrete sites, such as nodes for historical narratives and public values, but translocal research is also needed. After all, the negotiations about these sites are connected with national, European and global developments and issues. The digital and virtual worlds bring these contexts closer together.

Knowledge gaps

KNOWLEDGE AND METHODS NEEDED TO OPERATIONALISE VALUES

The research focuses on stating relevant values and developing a framework that can serve as a reference in dealing with historically fraught sites. The aim is to operationalise and weigh those values in such a way that this will result in knowledge for drawing up concrete action perspectives for those values. For example, how can operationalised values contribute to fair negotiations? Answering that question requires more knowledge about how negotiations in various contexts proceeded and proceed, and this also demands a method to integrate previous valuation instruments in the values framework.

Addressing knowledge gaps about contexts

For values to be operationalised, knowledge that is still lacking or has not been systematically collected is needed. This concerns knowledge about historical, sociological, geological and ecological contexts. For example, we lack a proper understanding of how negotiations about historically fraught sites were conducted in the past and which values played a role in this at the time. For example, in the years following the Second World War, how did Jewish survivors of the Holocaust relate to the sites where the persecution of the Jews took place and to the way in which these sites changed or were preserved?
In addition, we still know too little about how the contexts and the position of people and groups in society affected and still affect negotiations about historically fraught sites. For example, to what extent did the descendants of enslaved people have a say in such negotiations in both the past and the present? And how, in contrast, did dominant groups strengthen their negotiating position? Something similar applies to geographical and ecological contexts: how did they play, and how do they continue to play, a role in negotiations about, for example, intangible heritage practices such as Easter bonfires or the Formula One Grand Prix? How do opinions about what constitutes heritage and ecological values relate to each other?

Finally, and that is related to what has already been said, we know too little about the ways in which academic and non-academic knowledge are related to each other in the telling and valuation of historical narratives. Non-academic knowledge involves experiential knowledge, for example, and knowledge from previously subordinated groups, non-human actors and ecological systems.

Developing methods for coherency

In the design of the values framework, it is necessary to identify existing valuation instruments, systematically analyse these, and further develop them in relation to each other. Those instruments focus, for example, on the valuing of objects and processes and, with that, already address sub-aspects of the diversity of perspectives and the layeredness of historically fraught sites. This concerns, for instance, the Value Case Approach, the *Landschapsbiografie* ['the Landscape Biography'], Significance 2.0, *De Museale Weegschaal* ['The Museum Scales'] and *Emotienetwerken* ['Emotion Networks'].

Intended societal and scientific impact

This theme focuses on historically fraught sites and the role of public values, including underlying power relations, in the negotiation about the future of such sites.

Participants in the research develop a values framework and realise new methods for dealing with the different needs and roles of residents, policymakers, heritage institutions, companies and other relevant stakeholders involved with historically fraught sites.

In this context, this theme wants to create **societal impact** through research that contributes to:

- The ability of people to understand and recognise the different perspectives concerning fraught sites;
- well-being of different communities by making them feel involved and seen in dealing with (traces
 of) the past;
- more transparent and fair negotiations about the future of historically fraught sites for all parties involved;
- increasing public resilience in dealing with fraught sites;
- growth of historical insight into the multiplicity of ways in which people experience and embody the history of fraught sites (layers, periods, narratives, voices);
- new instruments and strategies for heritage institutions and heritage policy to deal with historically fraught sites in an informed manner;
- development of innovative uses of heritage data by the cultural and creative sectors.

The research intends to realise **scientific impact** by the way in which researchers from different disciplines and perspectives will develop the values framework for societal issues. This approach concerns the further interdisciplinary development and integration of existing valuation instruments and methods and the direct involvement of citizens from the whole of society. This concerns achieving the following results:

CONTEXT: The research will contribute to knowledge about historically fraught sites and the formation of heritage collections brought together at those sites. The research will also provide new insights into the context-related character of historical narratives and values. This will be done by investigating how different types of historical narratives and values are related to historical, geographical and social contexts.

EPISTEMOLOGY: Additionally, the research will provide more insight into the ways in which academic and other forms of knowledge are related to each other, and how the different types of knowledge are to be valued. The project will also document which characterisations, rituals, language and claims people and organisations use to strengthen or weaken historical narratives. METHOD: The research will contribute to designing and developing methods to systematically investigate the relationship between historical narratives, spatial context, values and power relations, such as methods where communities are the focus, such as action research and citizen science. OPERATIONALISING VALUES: The research will provide insight into the ways in which public values, such as inclusiveness, thoughtfulness and justice, can be operationalised.

These results will have an impact on (1) the local level (at the sites investigated), (2) the translocal level (connections and comparisons between the geographically spread sites that are investigated), and (3) internationally (comparisons beyond the Netherlands). Insights that emerge from this research are also applicable in other contexts with conflicts of interest where public dialogues break down or do not work well.

Background

Diverse and clashing thoughts about the past give rise to tensions in negotiations about the future of concrete, historically fraught sites. The past is alive to people: they question the past, feel pride or shame, want to commemorate and draw lessons, seek purpose and sometimes justifications. The tensions not only arise because people view the past differently but also because they have different perspectives on the so-called triple transitions (social, digital and sustainable), which mean that society is already drastically changing in any case. The vision on the past and also on what the major changes require from society determine the space that people have or experience in the negotiations about the future of historically fraught sites.

One such example is the **terrain of the Westerbork Memorial Centre**, which is a historically fraught site. Different historical narratives come together here (Second World War and Holocaust, the Moluccan camp and the choice to place space telescopes there). The Westerbork Memorial Centre seeks new ways of dealing with the narratives in a responsible manner. Values such as inclusivity and justice play an important role in that quest. Tensions remain, nevertheless. The memorial has to deal with diverse interests from, for example, descendants of interned people, the Cultural Heritage Agency as the responsible party for a number of registered physical heritage objects on the terrain, the Dutch forestry organisation *Staatsbosbeheer* as owner of the ground, and the institute ASTRON, owner of the fourteen radio telescopes on the terrain. The question then arises as to which narratives and values the stakeholders relate to, and how the relationships further translate into the negotiations about the use of the terrain.

Historically fraught sites have not always been preserved or already recognised as heritage. They can also be smaller in scale and touch more upon the everyday lives of people. In negotiations about the future of historically fraught sites, different societal actors play a key role:

- Societal groups call for more attention for forgotten and/or suppressed voices. Their efforts contribute to the increase of diversity and inclusion, just like increased sustainability, representation and the further decolonisation of collections. With this, they also question 'dominant' interpretations of sites and contribute to the importance of new historical narratives.
- In the use of the space, the government determines the rules and residents and other private parties give shape to these within a democratic system.
- Heritage institutions collect and recount narratives and enable people to relate to each other and to the past. Furthermore, in accordance with their public mission, these institutions have the task of finding ways to help people deal with societal challenges regarding inclusiveness and sustainability. The Ministry of Education, Culture and Science affirms this role in <u>De Kracht van</u> <u>Creativiteit</u> [The Power of Creativity] (re. Heritage for the future);
- The creative and cultural sectors encourage people to use their imagination in everyday life.
 Design, fabrication and/or artistic approaches help to deal with transition challenges and/or the acceleration of these.
- In the public discourse, education and the media play an important role in the selection and shaping of historical narratives.

73 Chapter 7: Annex(es): / NWA ORC 2024

Relevant cluster questions and knowledge agenda

Cluster questions:

- Q047: How can we promote social cohesion in a society that is culturally and religiously diverse? Diversity is partly expressed in how people cherish different historical narratives and perspectives. Research into this theme brings people with diverse backgrounds together. For this theme, the local dimension is important for promoting social cohesion beyond cultural and religious differences.
- Q063: How objective are cultural canons?
 The practice of history concerns identifying key moments and turning points; cultural cannons emphasise a solidified image of (national) values. Are historically fraught sites also involved in that? Are canons instruments to perpetuate or question relations of power?
- Q111: Will digitisation save our cultural heritage?
 Digital platforms and AI can uncover interactive historical layers and competing claims. Local historical research into layered sites can identify bias and gaps in collections as well.

Route Living History Game Changers:

- 1. <u>Contested Heritage</u>: focus on historically fraught sites
- 2. Sustainability and temporality: attention for ecological perspectives
- 3. <u>Citizen as expert</u>: innovation in dialogue methods

The theme is also well aligned with the realisation of the Faro Convention, the Knowledge Agenda Climate Adaptation, the Knowledge Agenda Immaterial Heritage(2021-2024), the National Strategy Digital Heritage, and the UNESCO Dossier Contested Heritage.

7.5.12 Resilience and justice in transition: building reflective institutions

Aim

In a world in which transitions as well as creeping and acute crises can exert a destabilising effect on markets, logistic chains, vital infrastructures and certainly also on social cohesion, and political-administrative institutions are being put severely to the test. Even during systemic disruptions and transitions, however, institutions must continue to fulfil their normative, organising, conflict-resolving and meaning-giving functions and remain responsive to all citizens. Otherwise, a vicious circle will be created: negative experiences and effects for citizens lead to decreasing trust in institutions and government, which can lead to a loss of support for social transitions and problems will not be solved.

Breaking this negative spiral requires identifying and designing effective and reflexive intervention strategies and developing actionable perspectives in response to societal transitions and crises. These can act as a counterbalance to crisis responses in which political-strategic considerations or reflexive solutions predominate. An important aspect of this identification and design challenge is the dialogue between citizens and government on pressing, current, and controversial topics.

Within the theme of adaptive institutions for just, resilient societies, the following subjects are considered essential: systematic research on institutional resilience, institutional learning, and institutional adaptation, citizen participation and institutional trust.

The objectives are:

a) to describe, interpret, and assess these complex societal challenges; b) to empirically investigate which combinations of factors, circumstances, and strategies contribute to adaptive institutional responses and derived perspectives for action; and c) to contribute to the design of interventions and innovations to increase the adaptive capacity of institutions.

Guiding questions are:

Conceptual and theoretical:

 How can we describe, explain and assess the adaptive capacity of political-governmental institutions at various levels by, for example, examining the democratic rule of law, representative democracy and the bureaucratic apparatus, or consultative economy, or education at all levels, the labour market and the social security system? Empirical and explanatory:

- What can we learn from historical, comparative and/or prospective research into responses to the consequences of deep and multiple transitions and crises? What combinations of factors and circumstances determine the flexibility experienced by social and political-administrative actors in crisis and transition to develop initiatives and innovations and build coalitions for adaptive institutional responses and perspectives for action?
 Focused on design and intervention:
- How can we increase the adaptive capacity of the stated institutions in co-creation with civil society organisations and citizens? Which design questions for investigative, reflective and reflexlike crisis responses are relevant in this context? And what normative, respectively strategic, deliberations need to be considered in this regard?

Knowledge gaps

The current knowledge gap concerns, amongst other things, the following matters:

- 1. Knowledge about combinations of historical, international, national and local factors and circumstances that contribute to adaptive institutional responses and action perspective;
- 2. Especially in a societal context that is experienced as a 'polycrisis', and in which different societal transitions take place at the same time and are often related to each other; how in the momentum of parallel changes and a high degree of uncertainty, can legitimacy, support and trust be retained and even strengthened?
- 3. Concrete insight into how the adaptation of institutions (like the concept of resilience) can be set forth in processes of rebound, reform, innovation and anticipation. Adaptation should not only be shaped reactively. In other words, adaptation should also be future-oriented.
- 4. Answering the question as to whether and how more organisations and public groups can be involved in the institutional and policy domains for the purpose of integrating action perspectives and performances, and for achieving impact. In doing so, dealing optimally with the increasing diversity and ageing in society. How can various groups and generations with different convictions be involved in a better way?
- 5. Knowledge about strengthening, from the perspective of the institutes, more personal relationships with citizens and civil society organisations instead of highly transactional relationships, which often seem to be based on a high degree of institutional mistrust; Insights into the impact of establishing stronger connections with the citizen's living environment ('human-centered,' social networks) by institutions and the use of digital tools and strategies, including the deployment of 'responsible Al' (as opposed to trust-based and statistically discriminatory 'algorithmic governance').
- 6. Knowledge about designing innovative interventions and action perspectives to strengthen the adaptive capability of our institutions by making optimum use of a dialectical and constructive dialogue between government institutions and citizens within the research consortium; how can that constructive dialogue be tangibly organised, what are good examples from abroad?

Facilitating 'new commons' in the (network) society with which established institutions in society can connect, and can therefore develop more capacity and impact in their approach to societal problems.

Intended societal and scientific impact

The most important societal and scientific breakthroughs concern identifying and designing effective levers for investigative, reflective intervention strategies and action perspectives in response to the societal transition and creeping and acute crises as a counterbalance to political-strategic and reflexive crisis responses.

Consortia can act as agents of change by contributing knowledge and good and next practices to help prepare new institutional approaches in several areas. These areas can range from the democratic rule of law/political participation to labour market/social security, economy, care/health, housing/residential construction/living environment, education/development, climate/greening/energy, digitalisation, et cetera. Moreover, the theme can extend from the local/regional institutional level, to the national level. Institutional changes and innovations partly depend on the trajectory, but the underlying problems seem to be quite universal in nature when seen in terms of societal conditions, and the solutions can be found in a better dialogue and relationship with the (experiential world of) citizens and of the different groups and generations in society. The breakthrough would therefore require that the route in co-creation with societal and institutional partners as well as citizens (citizen science), and based on thorough research, develops and tests knowledge that contributes to strengthening the adaptive capability and responsiveness of politicaladministrative institutions. Responsiveness in terms of strategies that decrease mistrust, increase participation and, in this way, strengthen the connection among citizens and societal groups in all their diversity. This impact can subsequently lead to a more relevant and better functioning of the institutions, as a result of which it is possible to strengthen the capacity and ability of the institutions to take action regarding the major societal challenges and missions. Improved institutional performances are expected to result in more support, trust and certainty among citizens and groups, also in difficult and unprecedented circumstances. Conversely, weak institutions will lead to weak performances, which will fan the uncertainties, feelings of anxiety, anger and frustrations of citizens.

For a long time, the Netherlands has been known for its strong institutions (such as the polder model) and as a 'high trust country'. The ambition of the programme is to once again strengthen and increase the power of institutions and the trust in them, and counteract polarization, especially in times during which the broad welfare and social cohesion in society is under threat.

Background

The underlying problem of the theme concerns societal disruption as a consequence of growing (perceptions of) polarisation and a waning trust in politics – including geopolitics - and other societal institutions. This disruption affects some groups of citizens more than others. This poses a threat to the broad welfare of the Netherlands because it will become difficult to design the necessary transitions in time and with sufficient support. That will give rise to a vicious circle of less welfare, well-being and wellness, which will lead to more dissatisfaction, frustration and to less trust, as a result of which it will be difficult to re-establish or strengthen the broad level of welfare. These causes are knowledge related, as is the described vicious circle.

First, it concerns the question as to why problems and issues are defined in terms of a crisis, and how exactly the different problems and issues are related to each other (the polycrisis idea, as applied by the World Economic Forum). Secondly, we also do not exactly know why in difficult times, institutions seem to emanate a transactional approach and even seem to be based on distrust towards a citizen, and on the system world instead of the experiential world of the citizen, and the experiential world of groups, in particular groups in vulnerable positions. Is that, for example, due to the response to major fraud cases (in the case of the benefits affair)? In the third place, and this is not particularly surprising, it would seem, as stated above, that the negative effects cumulate among already vulnerable groups (energy poverty, poor housing, uncertain work). In recent years, the institutions seem to have shown little awareness of this, and the question is why. Fourthly, and more fundamentally, we also do not yet know enough about the role that different 'truths', 'facts', 'perceptions' and 'convictions' play among public groups, a development which became particularly clear during the COVID-19 crisis. In the 1980s, the slogan in the squatters' world was "Your legal system is not ours". Now, put in a somewhat exaggerated manner, the general feeling may be summarised as: "Your institutions are not ours/mine".

No less important is the knowledge question of how the tide can be turned and the vicious circle broken regarding institutional mistrust, underperformance, and growing distrust, frustration, anger, and distancing among citizens. Knowledge exists about gradual institutional change, but far less is known about the (pro)active strengthening of the adaptive capability and responsiveness of institutions in specific areas and at particular levels of governance and administration. We presume that the involvement of citizens and public groups in this is a sine qua non, but we do not know how we should achieve this in practice and neither do we know whether digitalisation would be a blessing in disguise for this or, on the contrary, an undesirable devil in disguise. However, what we do know is that this issue is very urgent and that our broad welfare is currently under threat, also in terms of social cohesion (see, for example, various Netherlands Institute for Social Research (SCP) reports).

Relevant cluster questions and knowledge agenda

The theme connects with cluster question 050 of the NWA with respect to the secret of resilient societies. Here, the following formulations can be found: "Considerable resilience is demanded from Dutch society, with its open economy and international orientation. The social cohesiveness and inclusiveness of society are under pressure due to technological changes, globalisation of the economy and migration flows, for example. As a result of robotisation and the international division of labour, some sectors and professional groups are shrinking, whereas others are growing. Large flows of migrants are permanently changing the face of society. Partly as a result of new media and internet, events in one part of the world directly impact developments in other parts of the world. It would appear that traditions and rituals are being lost and that the divisions between population groups are deepening.

The question is how, and to what extent, the aforementioned observations are correct. And if they are correct, whether and how the tide can be turned for certain processes, how the cohesion within society can be facilitated and how the divisions between population groups can be reduced. This elicits a range of questions with historical, cultural, economic and social research dimensions, such as: what can we learn about resilient societies from historical and international comparisons? In which way do institutions play a role in the cohesion and cooperation between individuals?

7.5.13 Smart industry 5.0

Aim

Collectively create the fundaments needed to deal with 1) a shrinking workforce while 2) increasing economic competitiveness and 3) reducing emissions and material usage in a 4) rapidly changing market where innovation is accelerating and 5) products are made in Europe adhering to EU values. Managing all these demands at the same time is challenging and requires **a re-think of industrial production and way of working for the whole organisation: "Industry 5.0".** This translates to research in: systems engineering and design thinking, capturing experience & knowledge digitally, empowering the workforce with digital means, increasing the flexibility of all aspects of industrial production, making systems, and systems of systems more intelligent and autonomous, and understanding the relation between company practices and the broader societal environment. This theme focuses on:

- 1. **Human-centred digitalisation & knowledge capture.** By connecting social and technical sciences, technologies like AI and digital Twins can be applied in a way that support work and appropriately meet the needs of workers and citizens in an increasingly complex environment. Similarly jobs, organisations and processes are also going to change due to digital technologies. How should technology change to accommodate people and enable people to keep learning on the job instead of the other way round?
- 2. New design paradigms covering the full lifecycle of products and services enabling sustainability. The new way of engineering requires attention to all aspects of the lifecycle, including not just manufacturability or qualitative aspects but also sustainability, new materials, serviceability, operations, supply chain and end-of-life solutions like re-manufacturing. This will enable products and services that are produced with fewer emissions, last longer and are able to be re-used at their end-of-life.
- 3. Autonomous production. Given the decreasing workforce, industrial facilities need to become more and more autonomous. This means decisions will slowly but gradually transition towards

digital systems. Important research questions are: Which types of decisions are we willing to hand over to systems? How will this affect human responsibility and way of working? Which new jobs will this create and what will the future of the workforce look like? At the same time, the machinery and digital systems require similar flexibility and possibly ethic rules as humans currently employ when making decisions.

- 4. **Collaborative way of working**. Supply chains and departments within an organisation will need to work in cooperation. The depth of knowledge required for Industry 5.0 aligned production is too large for any single company. Similarly supply chains need to share information and together produce high-end products. Efforts to decrease emissions, digitalise or redesign affect the whole supply chain. How can people interact with all different aspects of the industry?
- 5. Flexible & resilient processes. The current volatile and uncertain economic context (Covid-19, geopolitics, cybersecurity, personnel shortages, etc.) has shown that all aspects of industry (equipment, people, processes, etc.) need to become more flexible and resilient. This requires changes in all layers of organisational and individual behaviour (human and organisational resilience), and changes in the functionality of technology addressing new goals (system resilience).

Knowledge gaps

Industry 4.0 (in the Netherlands: Smart Industry) primarily revolves around cutting-edge technologies like AI, interconnected systems, and robotics, revolutionising industrial processes. However, this technology-driven paradigm faces implementation challenges and often sidelines human involvement and environmental aspects, limiting its alignment with broader societal sustainability goals. Notably, only a handful of major companies successfully implement these advanced technologies, leaving SMEs struggling to bridge the digital gap without a clear explanation for this disparity. As industries digitalise and automate, the convergence of digitalisation, intelligent systems, and emerging technologies reshapes manufacturing processes, business models, professions, and consumer behaviours. However, this transition represents only the beginning and is not comprehensive enough for a holistic societal shift within manufacturing. Some important gaps can be identified in understanding how people can take the lead in transforming technology across different industries. These gaps include not just the technologies themselves but also the methods and tools needed to make this transformation happen. 'Industry 4.0,' known as Smart Industry, is a major research programme that forms the foundation for combining different ideas about smart products, production, technologies, skills, and how we respond to challenges. The significance of Smart Industry technologies lies in enhancing Dutch industries' productivity while addressing issues such as high carbon emissions, underutilisation of human potential and skills, and fragile supply chains. Embracing Industry 5.0 becomes pivotal for the Netherlands to achieve its sustainability objectives. Scientifically, this research aims to bring together these diverse interests, fostering new technologies, methods and tools and, therewith, behaviours and innovative production, service, and business models within companies. Ultimately, the goal is to enable carbon-neutral (or even carbon-negative) manufacturing in Europe while securing a workforce with enhanced skills.

Intended societal and scientific impact

Economic impact

The industry is a key economic sector for the Netherlands and Europe as a whole. As the second largest sector behind services, the industry has a significant contribution of around 18% [Statista 2021]⁴² to the national GDP, and around 14% of the workforce [Statista 2022] is employed in the industry. This includes around 70.000 manufacturing companies [CBS 2022]⁴³, whereas most of those are small and medium-sized enterprises (SME). Industry plays a crucial role in economic prosperity (e.g., economic growth, supply with products). Results from this route will directly contribute to the economic competitiveness of our Industry.

Societal impact

⁴² https://www.statista.com/statistics/276713/distribution-of-gross-domestic-product-gdp-across-economic-sectors-in-thenetherlands/

⁴³ https://longreads.cbs.nl/the-netherlands-in-numbers-2020/how-many-enterprises-in-the-netherlands/

Similarly industry has a significant social responsibility (e.g., ensuring employment and proper working conditions). Given the changing demographics, a significant effort is required to get the next generation of people on board for new types of jobs while at the same time capturing the knowledge of the people currently leaving the industry. This route will directly contribute to employability in industry and ensure geopolitical production capabilities in Europe.

Environmental impact

Even more, the (manufacturing) industry plays a key role in the context of environmental impacts; it is the sector with the largest contributions (around a third) to global greenhouse gas emissions (GHG) [IPCC 2014]. Any reduction will have a large potential impact on reducing emissions and used materials.

Scientific impact

The innovations and topics to be addressed (human-centered digitalisation, new design principles, autonomous systems, collaborative working, flexible & resilient processes) are highly relevant scientific challenges. The research brings the possibility for interdisciplinary research, connecting social sciences to industrial and environmental research. Only the integration of such disciplines allows to create the scientific progress needed for the identified economic, societal and environmental impacts.

Background

As mentioned under 4 (Economic Impact) Industry is a key economic sector for the Netherlands and Europe. It plays a crucial role in economic prosperity (e.g., economic growth, supply with products) and has a significant social responsibility (e.g., ensuring employment and proper working conditions). As clearly visible in the last years (e.g. COVID pandemic, blocked logistic routes due to ship accidents, visible consequences of climate change, limited access to materials and energy due to political crisis and/or rising demand), the manufacturing industry faces manifold challenges that go beyond conventional economic objectives of companies. Nowadays, also environmental (e.g., climate change, scarce resources) and social issues (e.g., access to a skilled workforce, ageing society, ensuring employment, occupational health and safety), as well as resilience (e.g. disturbances in supply chain), are major concerns that can actually be life-threatening for companies and therewith for society as a whole. This is also reflected in current definitions and models around the established sustainable development goals (SDG, 'wedding cake' model by Stockholm Resilience Centre), which emphasises that economies and societies are inherently embedded into the (environmental) biosphere, see Figure 1 below.



Figure 1. Major challenges for industry and their link between environment, society and economic aspects

Those changing demands are asking for a necessary paradigm shift towards "Industry 5.0". Industry 5.0 acknowledges the importance of environmental impacts, resilient manufacturing, and the central role of humans in manufacturing. Smart industry technologies are a core enabler of this paradigm shift and show promising potential, e.g., when it comes to increasing energy/resource efficiency, improving circularity or adaption to renewable resources, as well as occupational health and safety. However, those technologies currently only focus on one aspect without taking the others into consideration. Significant advancement is necessary towards more relevant sustainability-related application fields as well as more integrated solutions streamlined towards broad applicability.

Relevant cluster questions and knowledge agenda

The route aims at bridging the gap between a Smart Industry and the contribution to sustainability with all its dimensions (economic, environmental, social). This is even more important given the very strong relevance of manufacturing in this context. Therewith, there are also at least indirect links to other routes like "Circular economy and resource efficiency: sustainable circular impact", "Sustainable production of safe and healthy food", "Energy transition", "Sustainable development goals for inclusive global development". Given this setting, several NWA cluster questions are directly addressed, e.g.,

- Q017: How can we make chemical and biochemical production processes more sustainable, more efficient, and cleaner?
- Q051: Smart industry How do we make our factories smarter?
- Q052: How can we create a truly circular economy so that the manufacturing of industrial goods depends less on primary raw materials?
- Q053: What are the characteristics of a circular economy and how can we achieve it?
- Q054: How do we ensure that the Dutch economy remains competitive?
- Q106: What transformation will we see in the manufacturing, service, and maintenance industries, and which technological innovations will make this possible?
- Q107: How can we anticipate the impact of new technologies on humans and society, and understand and evaluate the influence of existing technologies?

7.5.14 Art research for new perspectives on climate justice

Aim

The public discourse around climate justice provides the context for the theme 'Art research for new perspectives on climate justice'. Although climate justice is an international issue, with a tendency for discussions to gravitate towards developing countries, the scope of this theme is the Kingdom of the Netherlands. This country faces its own set of challenges in this particular field. For instance, in relative terms the least affluent households in the Netherlands bear a heavier burden for climate policies, the impact of climate change is greater on women than on men in the Netherlands, and the climate crisis is more likely to affect the Caribbean part of the Kingdom than the European Netherlands.

Climate justice has several dimensions, including how burdens, benefits and goods are shared; who has a voice in the process; and whose worldviews, insights and needs are recognised. This has led to growing calls from various quarters for fresh perspectives on climate justice by broadening the debate, considering "the climate issue in the broad context of other societal challenges", and greater co-creation and cooperation.

Art research is a dynamic process where artists and designers conduct research, both within and outside the academic context and in cooperation with other researchers, stakeholders and interested parties, aimed at exploring fundamental questions and developing innovative approaches. It includes the creation of artistic works as well as the critical examination of concepts, methodologies and social issues. By using various artistic disciplines, techniques and materials, art research contributes to new insights and strengthens the dialogue between science and society. It is an interdisciplinary field that explores the boundaries of both art and academic research, with the objective of increasing understanding, imagination and social impact.

As such, art research is uniquely equipped to meet calls for a broader debate around climate justice and increased cooperation and connections with other social issues. It can create social awareness around the various dimensions of climate justice, provide frameworks for action for stakeholders, as well as have a direct impact on societal transformation. The theme therefore provides an opportunity for the establishment of an consortium, that will submit a research proposal centred on the question: how can art research be optimally utilised to generate new, more inclusive, perspectives on climate justice?

This research is designed to achieve three concrete objectives:

- 1. New perspectives on climate justice developed by artists and/or designers in collaboration with various stakeholders, the cultural sector, their audiences and other scientific disciplines.
- 2. Based on this, to offer stakeholders new frameworks for action and promote wider social awareness around the issue of climate justice.

Use the insights gained from this to develop art research further with new methods and practices.

Knowledge gaps

Submitted proposals should be aimed at generating knowledge which is currently lacking with regard to three knowledge gaps related to the research objectives.

The first knowledge gap concerns the observation that the multiple and diverse dimensions of climate justice require the participation of various stakeholders in research. The focus in climate justice research tends to be exclusively on local aspects, such as the location of wind turbines and the impact on the residents of that area. However, broader perspectives, such as the impact on people and areas where the extraction and commercialisation of natural resources are reduced by such interventions, are often neglected. An additional shortcoming in this knowledge gap around stakeholder participation in research can be found in the normative nature of the issue itself. There is uncertainty about when something is considered 'sufficiently fair and justifiable' and how this relates to various interests, needs or worldviews. Within this theme, art researchers generate new insights into climate justice by collaborating with more diverse communities in research and connecting them to science.

The second knowledge gap concerns the lack of awareness within society of the social and cultural dimensions of climate justice. This limited understanding of the complex interactions between climate change, societal structures and cultural diversity hampers the development of effective strategies for equitable and inclusive solutions. Art research regarding social and cultural dimensions of climate justice is necessary to generate new insights into climate justice and also connects science with the cultural sector and cultural audiences.

The third knowledge gap concerns the impact and effectiveness of art research in addressing societal challenges. Insufficient awareness persists regarding the broad applicability of methodologies and approaches to art research in the context of social transitions. Moreover, an in-depth understanding of the impact of art research is lacking. Art research within this theme can create scope for discussion, knowledge exchange and exploration of new approaches to enhance the impact of art research in addressing societal challenges.

Intended societal and scientific impact

The theme aims to contribute to three societal and scientific breakthroughs:

1. Stimulate imagination across society around the issue of climate justice:

Art research in relation to this theme deepens understanding of climate justice in cooperation with affected communities and the broader community. It provides a platform for analysing power dynamics and understanding the social and cultural causes of climate injustice. The theme invites involvement by communities in the Kingdom of the Netherlands who are disproportionately affected by climate change and stimulates imagination for awareness and frameworks for action. This imagination contributes to a deeper understanding of climate justice within environmental organisations, climate science, public authorities and society at large.

2. From knowledge to transformation:

The theme performs a vital role in connecting knowledge development across the various dimensions of climate justice with people's everyday experiences of those dimensions. For communities disproportionately affected by the impacts of climate change, it not only provides a platform to make their voices heard and actively participate in the debate on climate justice but also promotes frameworks for action for stakeholders to address the challenges they face.

At the same time, the theme focuses on the audiences of cultural institutions, in which context it is primarily aimed at raising social awareness. By taking part in cultural activities, people are invited to challenge their personal relationship to climate justice in concrete contexts, contributing to societal transformation. Active involvement of audiences for the arts strengthens social awareness in relation to climate justice, thereby advancing the transformation toward a more just society.

3. Innovative research methods

An essential aspect in promoting climate justice is the development of methods for interdisciplinary and transdisciplinary cooperation. Integrating art research with other disciplines provides a fertile basis for developing new perspectives and innovative solutions, while also broadening the scope of established research methods by emphasising the integration of artistic imagination, creativity and experience into scientific research. This approach contributes to the diversification of research techniques and forms of knowledge, allowing different disciplines and sectors to collaborate in and on the innovative forms of interdisciplinary research that are crucial for societal transitions.

Background

The societal issue addressed by this theme is the need for new, more inclusive, perspectives on climate justice. This issue links climate change with socio-economic inequality and has several dimensions, including those encompassing recognition fairness and just procedural practices. Central to this is the expression of voice (here and elsewhere); who are considered relevant players in terms of decision-making; what may be included in the decision-making process; and the degree of influence that can be exercised by various parties. An additional dimension of climate justice is expressed in the notion of distributional justice, which examines who benefits from decisions and their consequences. For example, the discussion about subsidies for solar panels raises questions about who receives the benefits, arguing that these subsidies go to people who already have capital. Distributional justice also entails an assessment of who shoulders the burden, such as the cost of grid expansion that is needed for wind farms that mainly benefit businesses. Solving these complex issues requires not only technological innovation and policy solutions but also a broad effort within society to identify and address inequalities in causes and consequences. Reconsideration of the principles of justice underlying decision-making and the distribution of benefits and burdens within society is possible only in this way.

Several parties are calling for a greater emphasis on fairness in Dutch climate policy and an increased focus on vulnerable communities in climate research. For instance, the Netherlands Scientific Council for Government Policy (WRR) stresses the need to treat climate policy as a distribution issue, and makes three recommendations: (1) broaden the debate, (2) embed justice in the policy process and (3) ensure institutional safeguards and assessment of a fair distribution of climate costs. The recently established Dutch Climate Research Initiative (Klimaatonderzoek Initiatief Nederland, KIN) also draws attention to climate justice, among other things through its work programme 'Climate transition in urban areas through the lens of climate justice'. The Scientific Climate Council (Wetenschappelijke Klimaatraad) is also "examining the climate issue in the broad context of other societal challenges, such as biodiversity, circularity, general wellbeing and justice."

Public authorities, businesses, local communities and international organisations all play a role in the pursuit of climate justice and sorely need the knowledge that research on this theme can generate. Public authorities should take the lead in setting and implementing climate policies, companies should take responsibility for more sustainable production processes and chains and local communities, especially the vulnerable ones, as well as social justice organisations and civic initiatives should be involved in research aimed at gaining insights and exploring solutions.

This involvement mobilises communities, ensuring that research results are directly secured and can have a broad impact at the policy level as well as within society as a whole.

Knowledge-related causes of the lack of more inclusive perspectives, broad-based frameworks for action and limited societal awareness include 1.) a lack of knowledge among public authorities and companies, among others, about participatory approaches and lack of understanding of the social and cultural dimensions of climate justice, 2.) a lack of societal awareness and (direct) engagement, and 3.) insufficient integration of various scientific and societal perspectives.

For all the above aspects, research within this theme can show what art is capable of and, on that basis, interpret concepts such as 'impact' and 'innovation' in relation to art research. The urgency of this is growing as artists and designers increasingly also conduct research within the academic context of research universities and universities of applied science.

Relevant cluster questions and knowledge agenda

The proposed theme aligns closely with several cluster questions within the Art Route, in particular the questions:

- Q067: What does art mean to people?
- Q071: What do we mean by quality of life?
- Q068: How can we promote and utilise creativity and innovation?

All these questions are extremely relevant to the theme and require both fundamental and practicebased research into how art enables people to shape their own identity, define their relationship with others, society and the planet, and thus give meaning to how they relate to the world. The theme also provides an opportunity to establish a connection from art research to cluster questions posed to other Routes, such as:

- Q031: What does globalisation mean for our cultural identity and for the position of the Netherlands on the world stage?
- Q035: How can we best design the socioeconomic institutions of the future?

The theme is also in line with the Route's three game changers:

- Arts as a motor for innovation and reflection in a high-tech society
- Arts as an alternative form of knowledge production
- Arts as a source of inspiration for education and lifelong learning
- The theme also aligns with the Art Route manifesto, see above.

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