



Strategic initiative:

Digital Life — Convergence for Innovation

Stort program

Biotechnology for Innovation — BIOTEK2021

A strategic initiative of the BIOTEK2021 programme:

Digital Life – Convergence for Innovation

Forord

Forskningsrådets BIOTEK2021-program har det siste året vært gjennom en prosess for å definere en ambisiøs strategisk satsing. Satsingen vil bygge videre på forgjengeren FUGE, men ha betydelig mer fokus på innovasjon og verdiskaping FUGE satte varige spor i norsk bioteknologi og bidro til å etablere nasjonalt samarbeid om infrastruktur og kompetanse. På samme måte er det en tydelig ambisjon for programmet BIOTEK2021 å styrke nasjonal innovasjonsevne når det med dette lanserer sin strategiske spydspiss "Digitalt liv – konvergens for innovasjon".

Satsingen gjenspeiler vår høye ambisjon og vår villighet til å ta en kalkulert risiko. Digitalt liv-satsingen vil være programmets største og mest helhetlige satsing. Vårt mål er å fremme ansvarlig innovasjon og verdiskaping gjennom å legge til rette for at bioteknologiske forskningsmiljøer samarbeider mer og tettere med forskere fra andre fag og teknologiområder. Videre tror vi at satsingen vil kunne åpne helt nye muligheter for fremtidig næringsliv i Norge.

Betegnelsen "Digitalt liv" oppfattes ulikt og skaper reaksjoner. Det er nettopp derfor denne betegnelsen er valgt. Vi ønsker at satsingen skal skape oppmerksomhet og engasjement, samt bidra til samarbeid på tvers av fagområder og interessefelt. Dialog og deltagelse fra et bredt lag av aktører underveis i satsingen står også sentralt i det vi kaller "ansvarlig teknologiutvikling", som er en av bærebjelkene i satsingen.

Bioteknologien utvikler seg i en rivende fart og samarbeid med andre fag og disipliner blir stadig viktigere. Mange land har allerede dedikerte satsinger på tverrfaglige områder som bioinformatikk, systembiologi, syntetisk biologi, o.l., men foreløpig har få land satsinger i tråd med visjonen til Digitalt liv. Vår satsing handler om å støtte en helhetlig utvikling av bioteknologien basert på faglig konvergens i stedet for å bygge nye disipliner med stringente avgrensninger. Dette er en krevende ambisjon som for å lykkes fordrer et faglig sterkt og samarbeidsorientert lederskap.

Mange FoU institusjoner i Norge er godt i gang med egne strategiske satsinger i tråd med satsingen i BIOTEK2021. Dette utgjør et solid fundament og peker i en ønsket retning. Visjonen til Digitalt liv-satsingen 1 blir å legge til rette for et harmonisk nasjonalt samspill som gir gjenklang internasjonalt som et arnested for bioteknologisk forskning og innovasjon innenfor utvalgte områder.

Sign
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Programstyreleder BIOTEK2021

Summary

The Research Council's BIOTEK2021 programme has decided to pursue a strategic initiative, titled *Digital Life – Convergence for innovation*, as the flagship of the programme in its remaining period.

The document is intended to describe to stakeholders the framework for the Digital Life initiative by outlining its background and its aims, and provide some direction as to its implementation.

The aim of the Digital Life initiative is to create economic, societal and environmental value for Norway from biotechnological research and innovation through encouraging transdisciplinary research. Digital Life was framed as a strategic initiative, based on the ambition that Norwegian research and innovation should take full advantage of the transformative technological and methodological opportunities offered by ongoing advances in digitalization and the emerging potential for convergence across a range of disciplines.

It is expected that the competences and skills developed through a portfolio of ambitious projects funded under this initiative will have a long-lasting effect on how Norwegian biotechnological research will be pursued in the coming decades. This, however, requires a substantial conceptual and methodological change regarding the way research and innovation is performed and perceived.

The decision to go forward with the Digital Life initiative has been based on a series of board meetings, a workshop with an International Advisory Group, and several discussions with major stakeholders. The first step to operationalise the initiative will be to establish a national hub-node centre structure that will create a vibrant and networked transdisciplinary Digital Life community in Norway, supporting science, technology and innovation and strive for global recognition of excellence in key strategic areas for Norway.

Future calls within the Digital Life strategic initiative will be planned and adjusted during the course of the BIOTEK2021 programme based on the experiences gained in this first phase, and from a close dialogue with stakeholders.

1. Background

The BIOTEK2021 programme is a strategic, long-term initiative designed to further develop biotechnological research in Norway and develop its focus towards responsible innovation¹. The programme - run by the Research Council of Norway (RCN) - is the main instrument for implementing the Government's National Strategy for Biotechnology².

The BIOTEK2021 programme has a distinct innovation-oriented profile. The objective is to generate biotechnology that contributes to innovation and subsequent value creation in order to solve societal challenges in a responsible manner.

The work programme for BIOTEK2021 points to biotechnology as an area of expertise that shares an interface with a number of subject areas within the life sciences, mathematical sciences and engineering. To make practical use of biotechnology, understand its social context and support its responsible development and governance, contributions from the social sciences, the humanities and law are also needed. The development of biotechnology for responsible innovation therefore requires a high level of diverse competencies and knowledge areas that are merged together through extensive inter- and transdisciplinary activity.

Early in 2013, the programme board of BIOTEK2021 discussed the need to initiate a forward-looking strategic effort with the potential to have a transformative and long-lasting effect on biotechnological research and innovation in Norway. Inspired by international developments and building on the foundation established by the FUGE programme, a proposal for "Digital Life" as a strategic initiative was developed by a select group of the programme board. A basic motivation for the initiative was that Norwegian research and innovation should take full advantage of the transformative technological and methodological opportunities currently shaping biotechnology within the frame of an engineering science.

In October 2013, BIOTEK2021 invited an International Advisory Group (IAG) of high-level international academics and industry representatives to Oslo to discuss how such a strategic effort could be materialized in Norway. The initial advice was to undertake a stakeholder engagement process to identify gaps and opportunities and to ensure that the Digital Life initiative would be aligned with the interests of major stakeholders in Norway. During spring 2014, the Digital Life initiative was discussed with a number of academic and industry leaders and was in general met with strong support.

At a meeting in June 2014, the BIOTEK 2021 board decided to initiate "Digital Life – Convergence for Innovation" as its major strategic effort (Figure 1).

¹ BIOTEK2021 Work Programme (2012-2021)

² National Strategy for Biotechnology 2011-2020

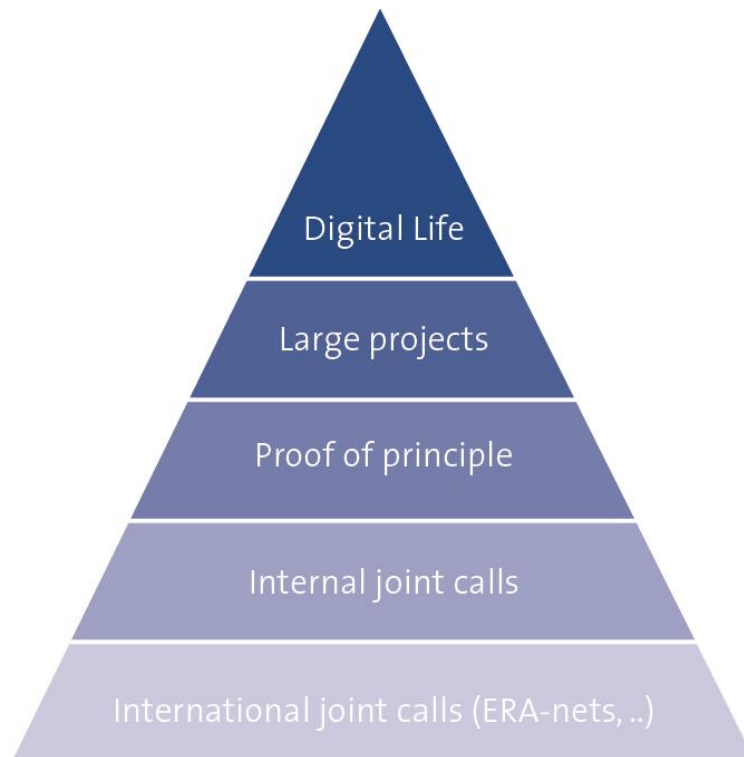


Figure 1: Illustration of "Digital Life – Convergence for innovation" as the strategic flagship of BIOTEK2021. The figure illustrates the hierarchy of the activities under the programme according to strategic importance and visibility. The Digital Life initiative rests on the already established activities of the programme. The "Large projects" category refers to "Store næringsrelevante forskerprosjekter" of which there are currently five projects. Proof-of-principle refers to projects granted under "Optimaliseringsmidler" and Internal joint calls refer to calls that BIOTEK2021 has undertaken in collaboration with other programmes at the Research Council.

2. Digital Life – Convergence for Innovation

As a consequence of several technological and methodological engineering breakthroughs over the last 20 years, biological research is currently generating data at an unprecedented rate. Due to the immense complexity of biological systems, our capacity to turn such data into an understanding of integrated biological functions has not developed at the same pace. Biotechnological innovation is severely hampered by this inability to understand and control highly complex biological systems, which calls for other conceptual and methodological approaches than those normally employed within the life sciences.

As a response to this challenge, a number of interdisciplinary areas have emerged over recent decades, which have significantly influenced the way biotechnological research is being performed. Examples of such areas include bioinformatics, bionanotechnology, systems biology, bioengineering and synthetic biology. There is considerable overlap between these areas, and it is necessary to take an integrated and overarching perspective in order to foster their future progress and capacity to contribute to biotechnological innovation. The current

thinking in leading international institutions goes in the direction of transdisciplinary integration. By integrating knowledge transcending established subjects, disciplines and experts, new opportunities for research and innovation arises. In this context, convergence refers to the integration of the life sciences with physical sciences, mathematical sciences, engineering sciences, social sciences and beyond³.

For biotechnology, the convergence framework provides novel opportunities to foster innovation e.g. by introducing engineering approaches such as design based on quantitative understanding of the subject matter into biotechnological methodology. The strategic effort "Digital Life – Convergence for Innovation" of the BIOTEK2021 programme aspires to promote transdisciplinary convergence in Norwegian biotechnological research and innovation (Figure 2).

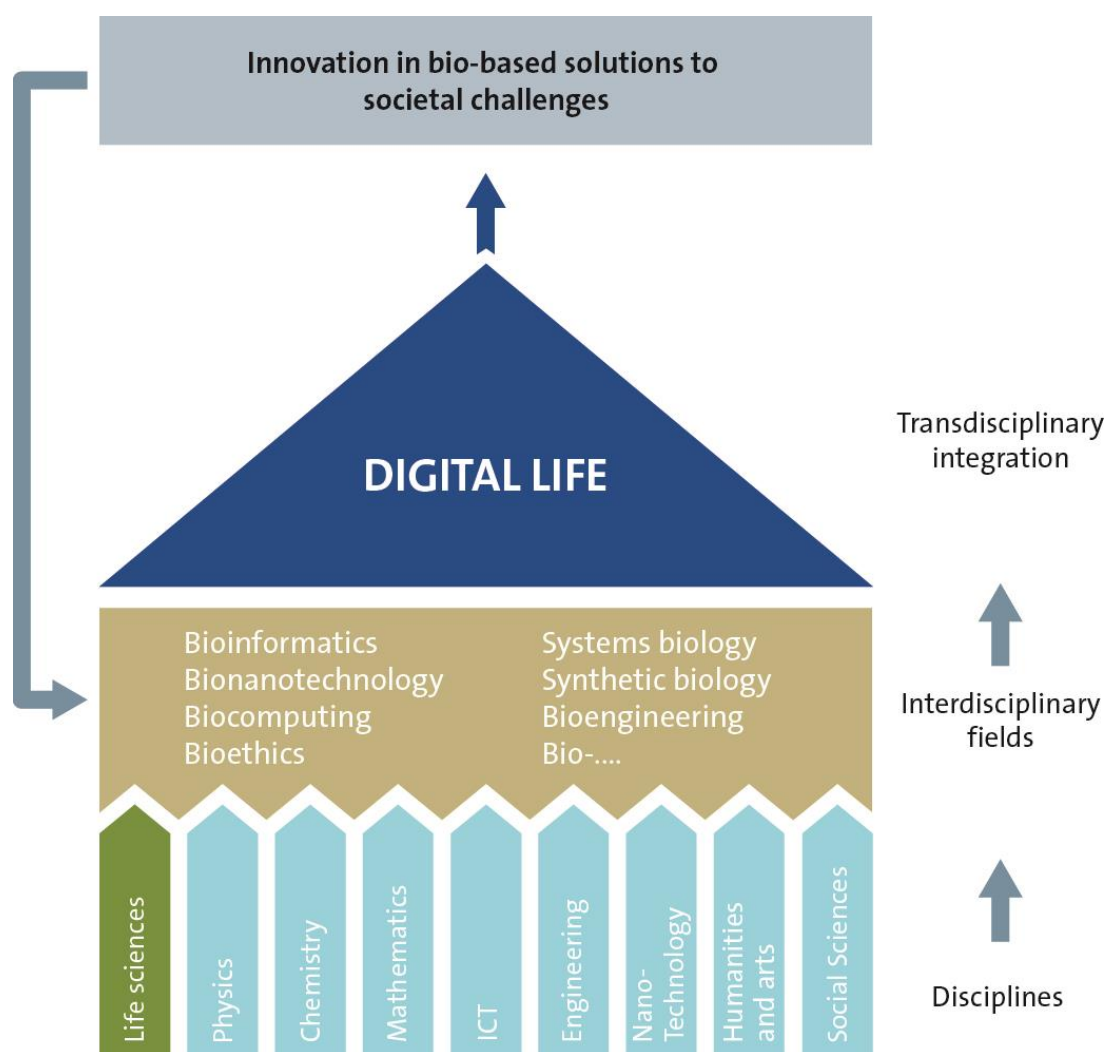


Figure 2: Illustration of the scope and content of "Digital Life – Convergence for Innovation"

³ Note the different approaches to convergence respectively in the United States and the EU as exemplified by The Convergence of the Life Sciences, Physical Sciences, and Engineering (MIT, 2011) and Converging Technologies - Shaping the Future of European Societies (EC 2004).

The aim of this effort is to create economic, societal and environmental value for Norway, in part by helping existing bioindustries to gain further competitive advantages and by providing incentives for the emergence of new innovative companies.

Most notably, the mission of *Digital Life – Convergence for innovation* is to facilitate a major shift towards a concerted use of conceptual, methodological and technological elements from the life sciences, mathematical sciences and engineering throughout the whole biotechnological innovation process. One important implication will be that the development of novel and sustainable biotechnological innovations, with significant societal utility and value, to a greater extent become guided by the design principles and methods characterizing mature engineering disciplines.

Biotechnological innovation results from the complex co-production of technological advances, politics and societal values. Thus, the societal context represents a pivotal dimension of the Digital Life initiative.

3. Strategic elements

The *Digital Life – Convergence for innovation* initiative builds further on existing competence and infrastructure in the Norwegian research communities. Some key elements were developed as part of the FUGE-programme, such as technology platforms on genome sequencing, bioinformatics and proteomics. However, the initiative will need to involve a large number of knowledge communities in academia and industry in the fields of applied mathematics, informatics, biology, medicine and beyond.

The success of Digital Life rests on seven pillars that are illustrated in Figure 3. These are critical areas that over time must receive sufficient attention and support in order to realize the ambition of the strategic effort. These pillars are explained in more detail below.

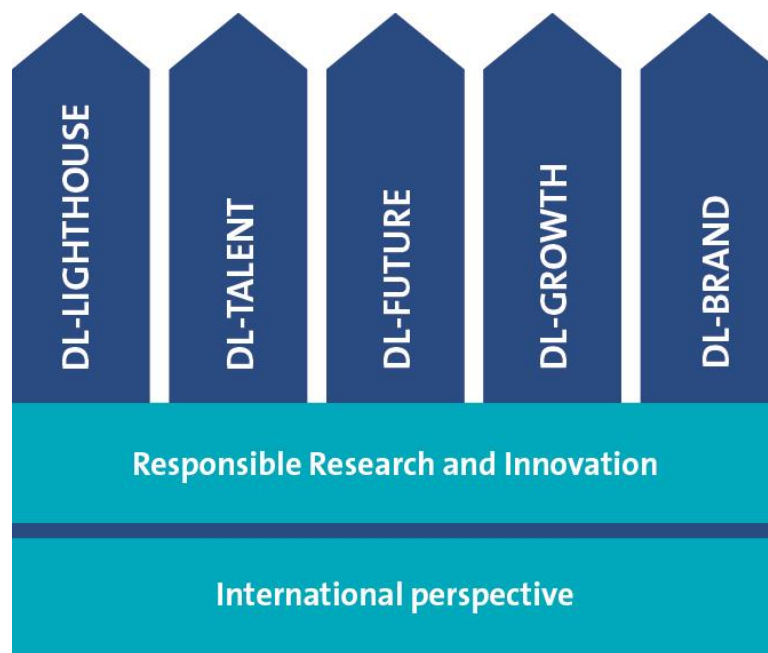


Figure 3: Illustration of the seven strategic elements part of the "Digital Life – Convergence for innovation" initiative.

LIGHTHOUSE: The first pillar is about creating a vibrant and networked Digital Life community in Norway. It is essential to obtain critical mass in fostering transdisciplinarity. This pillar will support science, technology and innovation and strive for global recognition of excellence in key strategic areas. The emerging transdisciplinary community will, in collaboration with leading international communities, develop new models of collaboration transcending established conceptual and methodological approaches. Merging of academic cultures across and beyond disciplines to tackle outstanding biotechnological challenges requires development of a common language in the wide sense. This represents a massive challenge. Well connected to international counterparts, the new community will function as a national "lighthouse" and guide the way in transforming biotechnology research and innovation in Norway.

A first step in the materialization of this pillar will be to establish a national hub-node centre structure, as described in section 4.

TALENT: The second pillar is about promoting recruitment of talented young researchers to the Digital Life mission. Performing science based on convergence in line with the Digital Life mission is extremely challenging, intellectually as well as culturally. It requires that talented researchers are given opportunities to explore new horizons and embark on challenging scientific and societal problems, perhaps at the risk of failure. In addition, they will meet the intellectual challenge of integrating knowledge across boundaries. This kind of trans-disciplinary research also challenges existing funding and publishing traditions, creating disincentives. Thus, Digital Life must invest in talented, creative and risk-willing individuals to ensure recruitment of the next generation of research leaders, who will set the agenda in the coming decades.

Education and training is a critical criterion for the success of Digital Life. Undergraduate education is handled by the universities, and is not part of the Digital Life initiative itself. However, post-graduate education through continuous professional development programmes

will be a key function, both at PhD level and that of established researchers. The PhD training is expected to be coordinated with existing and emerging PhD schools.

FUTURE: This pillar is about taking the "unknown" into consideration when developing the Digital Life initiative. To a large extent, we lack "best practice" and experience to guide implementation of efforts like Digital Life. It is therefore important to be open to test activities, learn from experience, and adjust the plan during the course of the programme. Regular assessments and dialogues with stakeholders are key elements in this process. Most notably, diagnostic and prospective competencies and capacities need to be developed through mutual and adaptive learning processes. This pillar will give necessary flexibility to the development and enable inclusion of new promising initiatives.

GROWTH: This pillar is about fostering innovation and creating societal and financial value for Norway with a solid foundation in biotechnology. A core rationale behind Digital Life is to integrate competencies and technologies to solve specific and emerging challenges. This should lead to the development of novel and internationally competitive biotechnological innovations based on rational design and the capacity to better control biotechnological processes.

The stakeholder involvement process has revealed that Norwegian industries are in different positions with respect to connecting to, and taking advantage of, the Digital Life initiative. Building further on the salmon genome project, and with considerable need for innovation relating to e.g. feed and fish health, the aquaculture industry appears to be in a good position to be a dedicated partner from the start. On the other hand, small biotech spin-off companies (i.e. majority of Norwegian biotech companies) may need incentives to commit to the long-term perspectives of Digital Life.

In order to promote industry involvement and growth within the Digital Life initiative, several measures are being discussed that aim to promote interaction between industry, academia and society, including the establishment of a dedicated industry engagement and technology transfer group, as well as industry networks. More specifically, the use of existing funding instruments such as *Innovation Projects for the Industry Sector* and industrial fellowships at doctoral and postdoctoral level, are being discussed.

BRAND: This pillar is directed towards communication and marketing tasks with three important aims; fostering convergence in the Norwegian system for biotechnological research and innovation, ;promoting the efforts to be in dialogue with important stake holder groups such as the general public; and attracting the attention and subsequent participation of the international research community. Sharing of information is central to the integrated model of Digital Life. This is a huge task as it requires a transformation of academic cultures currently gravitating around faculties and disciplines. Development of a new culture of information-sharing and collaboration across established subjects and disciplines, between academia and industry, and involving broad stakeholder representation and engagement will require collective and continuous experimentation in communication.

The development of a good communication strategy will need to include internal, national and international strategies to reach the right audience. The strategy will need to include plans for

the use of recent developments and future advances within communication platforms and media.

Responsible Research and Innovation (RRI):

The Digital Life initiative must be underpinned by the principle and practice of responsible research and innovation (RRI) in all its activities. It is critical that biotechnology is mindful of its societal context and develops anticipatory competence regarding its impacts. What kind of future do we collectively want science, technology and innovation to bring into the world? RRI is a new approach to governance that challenges us all to think about our responsibilities for the future, as scientists, funders, innovators and citizens, and to act upon these.

RRI is a cross cutting theme for Horizon 2020. As the first research council in Europe, Research Council UK/Engineering and Physical Sciences Research Council (EPSRC) made a formal commitment to a framework for responsible innovation⁴ in October 2013. Importantly, EPSRC recognizes that RRI must itself be a deliberative and responsive process in its own development, shaped by the research community and the stakeholders. The RRI-approach of Digital Life will therefore to a large extent be co-evolved with a framework for RRI that is currently being developed within the Research Council of Norway.

International perspective:

International cooperation will be a core cross-sectional activity in the Digital Life initiative, promoting knowledge exchange, fostering mobility and facilitating the use of common platforms and infrastructures. Competence building in Norway in regard to Digital Life must be firmly linked with international initiatives. An integrated work-stream in Digital Life will involve activities such as:

- Strategic approach to national competence building –in an international context
- Recruitment of leading international researchers to Norway in key competence areas
- Mobility programs (PhD/postdoc exchange, short/long term)
- Active use of international infrastructures such as ELIXIR, ISBE and others
- Collaboration with international research projects
- Participation in international/joint calls (Horizon, ERA-nets, NIH, NSF,..)

4. Implementation

The Digital Life process will be implemented in three phases:

- Phase I: Preparatory/dialogue phase (ended June 2014)
- Phase II: Establishing a hub-node centre structure for Digital Life (2014-2015)
- Phase III: Future calls and activities (2015 – 2021)

Phase I, involved a number of meetings and discussions between the BIOTEK2021 programme with national research institutions and industry representatives, as well as with a high-level international advisory group. This phase culminated with the decision of the BIOTEK2021 board on June 2014 to move forward to phase II.

⁴ <http://www.epsrc.ac.uk/index.cfm/research/framework/>

Phase II in the implementation of *Digital Life – Convergence for innovation* will be the establishment of a National Centre for Digital Life. The call for Expression of interest (Eoi) to host the centre will be officially announced in August 2014. Important milestones for this call are indicated in Table 1 below. The aim is to obtain a critical mass by establishing a transdisciplinary, challenge-based virtual centre within the remit of Digital Life.

The centre will enable and support science, technology and innovation and strive for global recognition of excellence in key strategic areas for Norway. The mission of the centre will be to serve as a flagship in creating a vibrant transdisciplinary Digital Life community. It will be organized according to a hub and spokes model, in which core competencies are co-localized in the central hub with spokes to distributed specialist nodes. The hub will be hosted by one institution on behalf of the centre. Both the hub and nodes will be responsible for a varied transdisciplinary research project portfolio. The schematic structure of the National Centre for Digital Life is illustrated in Figure 4.

In addition to performing research and innovation projects, the centre will execute vital tasks relating to i) data management, standardization and methodological rigor, ii) industry engagement and technology transfer, iii) education and training programmes (including continuous professional development), iv) international cooperation, and v) developing governance based on principles of responsible research and innovation. This will be organized as a networking project.

The ambition is that the centre shall create a dynamic environment where academics, industry and interested publics are invited to collaborate. Frequent mobility and communication between participating groups will be the key to foster such a dynamic environment.

The total contribution from the Research Council for phase II is NOK 250 mill.

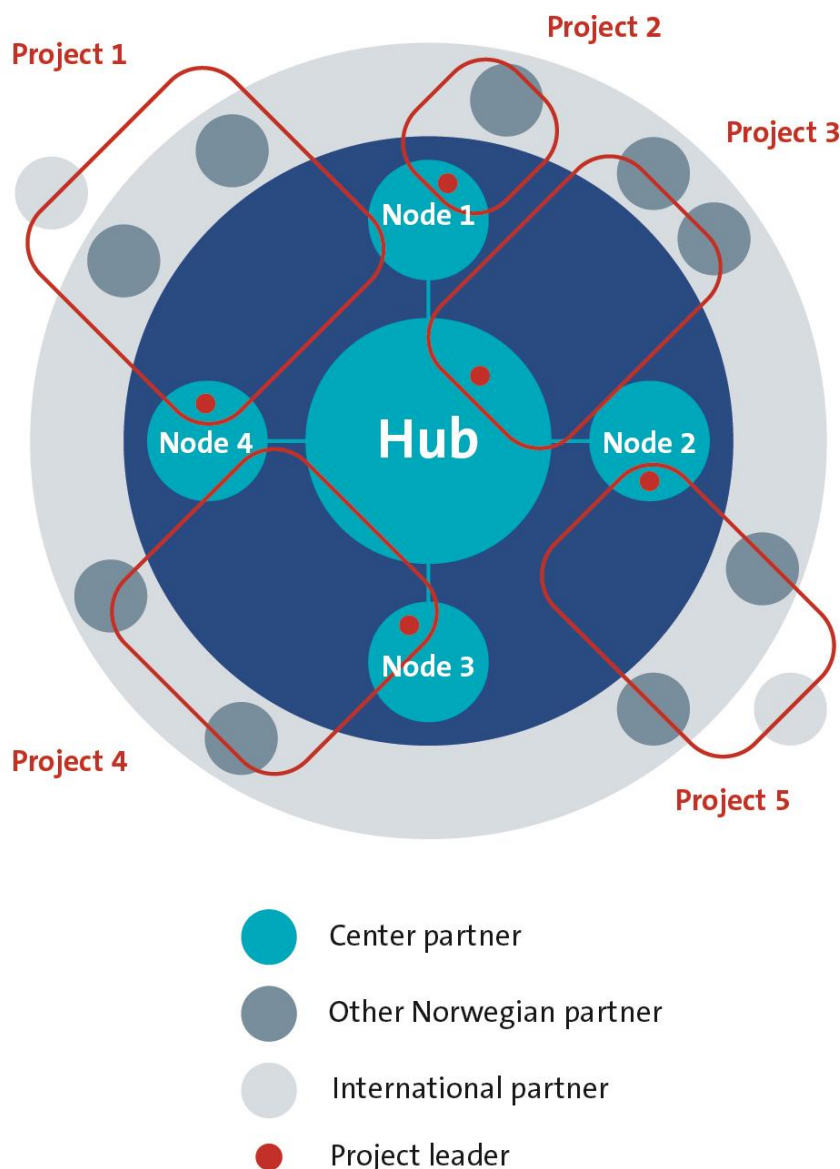


Figure 4: Schematic structure of the National Centre for Digital Life consisting of a hub with associated nodes. Both the hub and nodes will be responsible for a varied transdisciplinary research project portfolio in collaboration with national and international partners (examples of such projects are illustrated by red frames). The hub will take a leading role in performing the national leadership (lighthouse) function with support from the nodes. In addition to doing cutting-edge science, the centre will take on important responsibilities in coordination and provision of infrastructure and competence at a national level.

Table 1: Call for National Centre for Digital Life - Timeline

Call for National Virtual Centre – milestones	Timeline
Pre-announcement in newsletter	June 2014
Publication of call for Expression of interest (Eoi) to host centre hub	August 15 th 2014
Workshop for prospective applicants	September 8 th 2014
Deadline for submission of Eoi	October 2nd 2014
Publication of full call for proposals	November 2014
Deadline for submission of full proposals	February 11, 2015
Decision on funding by BIOTEK2021 board	Spring 2015
Earliest project start	July 2015

Phase III: Future calls within the Digital Life strategic initiative will be planned during the course of the BIOTEK2021 program, based on experience and dialog with stakeholders after the establishment of the virtual Centre. Examples are the use of existing funding instruments such as *Innovation Projects for the Industry Sector* and industrial fellowships at doctoral and postdoctoral level. The precise content of Phase III will be decided during 2015/2016.