JPI
a healthy diet
for a healthy life

Strategic Research Agenda
2012-2020 and beyond

Joint Programming Initiative
A healthy diet for a healthy life

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A healthy diet for a healthy life

June 2012

Foreword

This Joint Programming Initiative (JPI) provides a roadmap for harmonised and structured research efforts in the area of food, nutrition, health and physical activity and offers defined priorities to reach the goals as identified in the Vision Document (September 2010).

Food production, human nutrition and the incidence of diet-related diseases are becoming increasingly important in our rapidly changing scientific, economic and societal environments. High quality diets and proper physical activity are the most critical determinants in human health and for quality of life in an ageing society.
At the same time, food production systems are challenged by an increasing competition for biomass and the need to improve food security and sustainable production. Consumer expectations, for example regarding food quality, safety, price and convenience, are also changing. Taking this all into account, the aim of the Joint Programming Initiative *A healthy diet for a healthy life* is to understand better the factors that determine food choices and physical activity behaviours, and thus human health, and subsequently to translate this knowledge into programmes, products, tools and services that promote healthy food choices.

This document describes the **Strategic Research Agenda** (SRA) for the period 2012-2020 and beyond. The overarching principle of the JPI is to bring together scientists and scientific programmes and to create added value for Europe by sharing knowledge, expertise and data that will enable high-quality research without duplication or leaving gaps. The JPI will provide a holistic approach to the interplay of key factors that affect diet-related diseases, discover new relevant parameters and mechanisms, and define strategies that contribute to the development of actions, policies and innovative products, to reduce the burden of diet-related diseases. Key to achieving this is the better coordination of existing and new research in the areas of food, diet, physical activity and health. Moreover, improved coordination and joint research efforts will strengthen European leadership and competitiveness in this field.

Various themes and research subject defined here in the JPI are closely linked to changes in global food production systems and therefore critical policy issues such as management of a European food economy are addressed as well. In these areas the JPI *A healthy diet for a healthy life* seeks exchange and collaborations with other JPIs including, for example, *Agriculture, food security and climate change* (FACCE).

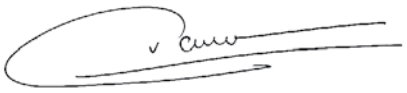
This Strategic Research Agenda was drafted by the Scientific Advisory Board (SAB) of the JPI. The SAB members were selected on the basis of their expertise and scientific standing. The first meeting of the SAB was held in January 2011, followed by meetings in April, September and November 2011 and April 2012. In the period from October 2011 until February 2012, the draft SRA was subjected to web consultations and national consultations to input and set priorities.

The SRA was approved by the Management Board, representing members from the following countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Ireland, Italy, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Turkey and United Kingdom.

We are committed to collaborative efforts and for establishing a fully operational and vital European Research Area on the prevention of diet-related diseases, to increase the knowledge base and to deliver innovative and novel approaches to improve nutrition and health.

June 2012,

Prof. Dr Hannelore Daniel,
Chair Scientific Advisory Board



Prof. Dr Wim H.M. Saris,
Chair Management Board

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Executive summary

To address major societal challenges, the European Commission has suggested an enhanced cooperation in European research and development (R&D). This joint programming is a process by which Member States engage in defining, developing and implementing a common strategic research agenda (SRA), based on a common vision of how to address major societal challenges that no Member State is capable of resolving independently.

In September 2010 the Vision Document of the Joint Programming Initiative (JPI) *A healthy diet for a healthy life* was approved by the Management Board.

The vision of the JPI on A healthy diet for a healthy life is that by 2030 all Europeans will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods and have healthy levels of physical activity, and that the incidence of diet-related diseases will have decreased significantly.

The following three key interacting research areas were identified and are described in this document:

Determinants of diet and physical activity: ensuring the healthy choice is the easy choice for all consumers. The challenge is to understand the most effective ways for improving public health through interventions targeting motivation, ability and opportunity to adopt and maintain healthy dietary and physical activity behaviours.

Diet and food production: developing healthy, high-quality, safe and sustainable foods. The challenge is to stimulate the European consumers to select foods that fit into a healthy diet and to stimulate the food industry to produce healthier, high-quality foods in a safe, sustainable and affordable way.

Diet-related chronic diseases: preventing diet-related, chronic diseases and increasing the quality of life. The challenge is to prevent or delay the onset of diet-related chronic diseases by gaining a better understanding of the impact of nutrition and lifestyle across Europe on human health and diseases.

For each of these research areas, primary initiatives and research challenges are described for the periods 2012-2014 and 2015-2019. Horizontal issues to achieve to primary goal for 2020, a full integration of the research areas and the establishment of a European Nutrition and Food Research Institute, are formulated in the last chapter.

The SRA is structured along the lines of establishing networks and standardising new and existing data in Europe and making these databases accessible, followed by joint research programmes. Future joint programming agendas are envisaged to be developed within a (virtual) European Nutrition and Food Research Institute. The research needs to be framed by effective strategies for joined research including new infrastructure but also by development and innovation activities. Efficient communication within the JPI but also in dissemination to all stakeholders is most crucial for success.

Introduction

A healthy diet for a healthy life

Diet, health and physical activity

According to the Kondratieff Cycle Theory, health is the key driver for Europe's growth and prosperity[1]. European governments are struggling with the growing social and economic consequences of an alarming increase in obesity and diet-related diseases, including malnutrition[2], micronutrient deficiencies and food intolerances and allergies[3] in subgroups of the population. Lack of sufficient physical activity and high energy intakes are the prime factors determining overweight and obesity development, and the growing incidence of diseases directly or indirectly linked to these lifestyle parameters. Increased affluence and urbanisation are contributing factors that result in lifestyles and daily routines which require less physical activity. At the same time, access to foods with high energy density is becoming more prevalent. It can be foreseen that without effective prevention of diet-related diseases and with an ageing population, health systems will be stretched to breaking point. Consequently, improving health by increasing energy expenditure, changing food choice patterns and providing more healthy diets are key priorities for most EU Member States in fighting obesity and diet-related chronic diseases amongst their populations.

Using exposure data and the causal associations of risk exposure to disease and injury outcomes, WHO[4] identified the leading risks for worldwide mortality as: high blood pressure (responsible for 13% of deaths globally), tobacco use (9%), high blood glucose (6%), physical inactivity (6%) and overweight and obesity (5%). These risks are strongly associated with the development of chronic diseases such as heart disease, diabetes and with certain cancers. The burden of disease attributable to risk factors is measured in terms of lost years of healthy life using the metric of the *disability-adjusted life year* (DALY), which combines years of life lost due to premature death with years of healthy life lost due to illness and disability.

Table 1
Ranking of selected risk factors: ten leading risk factor causes of death and DALYs in high-income countries, 2004[4]

	Risk factor	Deaths (millions)	Percentage of total	DALYs (millions)	Percentage of total
1	Tobacco use	1.5	17.9	13	10.7
2	High blood pressure	1.4	16.8	7	6.1
3	Overweight and obesity	0.7	8.4	8	6.5
4	Physical inactivity	0.6	7.7	5	4.1
5	High blood glucose	0.6	7.0	6	4.9
6	High cholesterol	0.5	5.8	4	3.4
7	Low fruit and vegetable intake	0.2	2.5	2	1.3
8	Urban outdoor air pollution	0.2	2.5		
9	Alcohol use	0.1	1.6	8	6.7
10	Occupational risks	0.1	1.1	2	1.5

1 www.kondratieffzyklen.de
2 Stratton RJ. Malnutrition: another health inequality? Pennington Lecture. Proc Nutr Soc 2007;66:522-529.
3 McBride D, Keil T, Grabenhenrich L, et al. The EuroPrevall birth cohort study on food allergy: baseline characteristics of 12,000 newborns and their families from nine European countries. Pediatric Allergy Immunology 2012: 23: 230-239.
4 World Health Organization (WHO). Global health risks. Mortality and burden of disease attributable to selected major risks. Geneva: WHO, 2009.

Eight diet-related risk factors, including high blood pressure, high body mass index, high cholesterol, high blood glucose, low fruit and vegetable intake and physical inactivity together account for 61% of cardiovascular deaths, the leading cause of death worldwide[4].

If no positive action is taken, it is expected that diet- and lifestyle-related diseases will increase rapidly in the next decade and have a negative social and economic impact for many Member States. For this reason, the European Parliament adopted in September 2011 a resolution (P7_TA(2011)0390) on the European Union position and commitment in advance to the UN high-level meeting on the prevention and control of non-communicable diseases. Cardiovascular diseases and cancer are the leading causes of death in Europe and obesity is the second main cause, after smoking, of developing cancer. The cost of cardiovascular diseases to the EU economy is estimated at € 192 billion per year[5]. Of the total cost of cardiovascular diseases in the EU, 57% is due to direct health care cost, 21% to productivity losses and 22% to the informal care of people with cardiovascular diseases[5]. It has been projected that, by 2020, chronic, diet-related diseases will account for almost three-quarters of all deaths worldwide. There is evidence that improved lifestyles can reduce the risk of type 2 diabetes by 58% over four years. Population studies have shown that up to 80% of cases of coronary heart disease and up to 90% of cases of type 2 diabetes could potentially be avoided through changing lifestyle factors[6]. Similarly about one-third of cancers could be avoided by eating healthily, maintaining normal weight and regularly exercising. Physical activity is seen as an equally important key modifiable factor contributing to risk of obesity and associated diseases. Furthermore, sedentary behaviour is beginning to be seen as a separate important risk factor; it appears that being sedentary for large periods of the day may carry a separate risk that is not prevented by short periods of activity[7]. There is thus a pressing need to quantify physical activity and sedentary behaviour combined with research on food choice and dietary intake to gain full insight into energy balance and obesity in European populations[8].

Successful strategies for reducing obesity rates must target all age groups and use a life-course approach underpinned by natural experiments[9]. Prevention should start in early life phases as there is increasing evidence that prenatal and infant nutrition can condition for health problems later in life. Advances in these areas need a better understanding of the underlying mechanisms and effective translation into the public health domain. Cost-effective measures to improve citizens' health status will deliver very significant social and economic benefits and improve future productivity and competitiveness.

5 Allender S, Scarborough P, Peto V, et al. European Cardiovascular Disease Statistics 2008 edition. Brussels: European Heart Network, 2008.

6 WHO/FAO. WHO/FAO Expert Consultation on Diet, nutrition and the prevention of chronic diseases. WHO Technical Report Series, No. 916. Geneva: WHO, 2003.

7 Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exerc Sport Sci Rev 2010;38:105-113.

8 The EU Platform on Diet, Physical Activity and Health was set up in March 2005 to provide a forum for stakeholders at European level; the High-Level Group on Nutrition and Physical Activity strengthens the role of governments in counteracting overweight and obesity.

9 Gortmaker SL, Swinburn BA, Levy D, et al. Changing the future of obesity: science, policy and action. Lancet 2011;378:838-847.

In the recommendations published in *The Lancet*[9] five messages for a concerted response were formulated:

1 the obesity epidemic will not be reversed without government leadership;
2 'business as usual' would be costly in terms of population health, health care expenses and loss of productivity;
3 speed and sustainability of weight loss are usually overestimated and need to be readjusted;
4 basic population weight data and intervention outcomes need to be accurately monitored and evaluated, and
5 a systems approach is needed which operates across multiple sectors.

These recommendations also set a firm basis for projects and programmes developed within this JPI.

Key message[10]
Governments have largely abdicated the responsibility for addressing obesity to individuals, the private sector, and non-governmental organisations. However, the obesity epidemic will not be reversed without government leadership, regulation and investment in programmes, monitoring, and research.

As a direct response to an ageing population, there is a particular demand of research in Europe, and elsewhere, to define the dietary needs of the elderly and geriatric groups, examine their lifestyles and develop foods that can promote healthy ageing. Proper health maintenance and vitality throughout all the stages of life has to be assured by all means, including education, adequate physical environments and diets, and with a high level of commitment by commercial and public entities.

10 Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet 2011;378:804-815.

The European population and their food

Attempts to increase public awareness of the best way to eat more healthily, despite being very numerous, have not led to major changes in patterns of food purchase and consumption. More attention must be given to finding ways to increase people's motivation, abilities and opportunities to make healthy choices[11]. To do this effectively, research is needed to discover why consumers make certain choices; what they understand about food; what type of information is lacking; how this information can best be presented; what factors prevent individuals and populations from exercising a healthy lifestyle and what changes in the food and nutrition environment can 'nudge'[12] people towards more healthy choices. Research has shown that knowledge is often not a direct determinant of eating behaviour. A UK House of Lords Science and Technology Select Committee[13] examined the evidence base for the effectiveness of nudges in the context of alcohol, food, and physical activity. They concluded that while businesses and industry, with their enormous, expensive and clever advertisements, are very effective at nudging people to buy and consume their products, non-regulatory measures to increase consumption of healthy food in isolation are unlikely to be effective.

Increased differentiation of (European) populations on socio-economic and age grounds may increase vulnerabilities in some target populations and this might be exacerbated by genetic population differences. Population subgroups appear more vulnerable to diet-related diseases (for example, population groups with a lower socio-economic status, socially-excluded groups, some immigrant communities and ethnic minorities), particularly during critical life periods such as pregnancy, lactation, infancy, childhood and old age. Any delay in the onset of chronic diseases, such as cardiovascular diseases, type 2 diabetes and some cancers, or in their reduction, are important from the perspectives of improving quality of life and improving European competitiveness through reduced absenteeism, impact on household economic functioning and health services costs.

The world population is expected to increase to over nine billion by 2050. There is a requirement to guarantee this growing population access to and control of safe, sustainably-produced, nutritious and culturally-acceptable food, and to manage the necessary balance between food demand, health and nutrition requirements and natural resources. Global food scarcity and food poverty could become a major threat to the world's population within a decade. At present, a large proportion of foods, from raw materials to finished products, is wasted because of spoilage; a situation that is particularly evident in rural communities in Africa and Asia. Alternatives to animal-based food proteins are needed to guarantee a future protein supply. The need for more sustainable food production and associated supply systems must also be addressed.

11 Brug J. Determinants of healthy eating: motivation, abilities and environmental opportunities. Family Practice 2008;25:i50-i55.
12 To nudge is to push into action gently.
13 House of Lords. Science and Technology Select Committee. Behavioural Change. 2nd report of Session 2010-12. London: The Stationery Office Limited, 19 July 2011.

The European food and drink industry

The food and drink[14] industry is the largest manufacturing sector in Europe and is, together with the food supply industry, essential to Europe's wider economic development. It has a share of 1.9% in the total value added of the economy and 2.2% of the employment in 2003, often in rural areas[15]. Key assets of the EU food industry — including plant-, animal- (meat and dairy) and marine (fish, shellfish and seaweed) production — are its cultural diversity, regional specialisation and long-standing tradition. The food and drink industry covers a market of more than 450 million people in the EU. The sector offers a scope for economic growth, especially in the new EU Member States. A highly diverse range of foods is produced but these often involve methods based on craft techniques rather than industrial scale technology. To remain competitive, innovation is essential and the European food and drink industry, which is increasingly unable to compete on raw material costs alone, needs to add value to foods and create healthier, convenient and sustainable products in a more resource-efficient way.

Consumers are also demanding assurance from food producers that ethical and environmental concerns are reflected in the foods they purchase and they and their families consume. Consumers trust that their foods and drinks are safe and have become much more demanding in their requirements of food quality, which embraces longer shelf-life, food reformulation, use of additives and environmental aspects. In addition, the health effects and promotion of key natural foods such as fruit and vegetables, whole grains, meat, dairy and marine products (including fermented foods) should also receive proper attention. Consumers also expect unlimited access to high-quality drinking water that needs to be assured by the public and commercial sectors.

Neither the primary production sectors nor the small SME food companies that dominate this sector in the EU (99.1% of the 310,000 companies were SMEs in 2007[16]) can invest in long-term or large-scale research and development (R&D). Small food companies, in particular, are unable to take on the innovation challenge and so a joint and coordinated initiative is required. Effective partnerships built on public and private collaborations, and funding, are necessary to identify the most important research needs and to pool resources. Consideration must also be given to laws and regulations and the protection of intellectual property arising from this research to ensure that SMEs can derive benefits from its outputs; this will foster a strong culture of investment in R&D in this sector. This has been addressed in the European Technology Platform *Food for Life*[17].

14 In this document reference to the 'food industry' refers to the food and drink industry, including plant-, animal- and marine production.

15 Wijnands JHM, van der Meulen BMJ, Poppe KJ (eds). Competitiveness of the European food industry. An economic and legal assessment. Luxemburg: EC, 28 November 2007.

16 FoodDrinkEurope. Supporting the competitiveness of the European food and drink industry. FoodDrinkEurope Competiveness Report 2011.

17 www.etp.ciaa.eu.

The way forward: A Joint Programming Initiative for well-coordinated and harmonised research activities

Joint Programming is the process by which Member States engage on a variable-geometry basis in defining, developing and implementing a common strategic research agenda based on an agreed vision of how to address major societal challenges that no individual Member State is capable of handling independently. For research on the relationship between diet, exercise and health in particular, large population studies and controlled trials with a long-term follow-up are needed that have sufficient power to demonstrate the influence of factors such as individual differences in genotypes and variable dietary patterns on health parameters. Joint Programming entails a voluntary partnership between Member States (and Associated Countries) of the European Union and aims to tackle major European societal challenges by combining and coordinating national research programmes and, thereby, making better use of Europe's public R&D resources. The Joint Programming process has the potential to bring major benefits by:

— helping to coordinate the scope of research programmes across Europe and diminishing duplication in effort;
— making it easier to address common challenges, to develop common solutions and to speak with one voice on food and nutrition policy in the international arena;
— promoting scientific excellence through joint calls with common funding and minimising duplication of research activities;
— supporting cross-border collaboration and facilitating data pooling (preferably collected in a uniform and standardised way);
— sharing fragmentary expertise scattered across countries or throughout Europe as a whole so as to facilitate rapid dissemination of research results, promoting cross-border mobility, education and training;
— increasing the scientific, technological and innovative impacts of every Euro invested in public research;
— increasing programme depth by strengthening the coordination with other related policies through greater programme visibility and promotion of cross-border policy learning;
— using public resources more efficiently and effectively through reducing programme management costs and improving the accountability and transparency of public research programmes.

Europe's research landscape is still highly fragmented. In a 2008 report it was stated that 85% of public R&D is programmed, financed, monitored and evaluated at the national level, with little trans-national collaboration or coordination. Less than 6% of total R&D investment and only 15% of European publicly-funded civil R&D (of which 10% is accounted for by intergovernmental organisations and schemes, and 5% by the Framework Programme of the European Commission) is financed through cross-border collaboration[18]. Thus, one of the most obvious causes of sub-optimal returns from R&D has been insufficiently addressed, namely the lack of collaboration and coordination between national public R&D programmes. This requires proper information, transparency and the willingness of national funding agencies to join and commit resources to multidisciplinary and multinational efforts. By enhancing cooperation among those that develop and manage research programmes, Joint Programming will:

— reinforce the capacity to transform research results into societal and economic benefits, notably through the innovative capacity of European industry as well as through educating consumers to better understand the importance of diet and exercise and to choose healthier foods;
— contribute to the creation of the 'fifth freedom' by removing barriers to the free movement of knowledge;
— develop suitable methodologies, research protocols and European-wide standards;
— help overcome barriers to entry, such as high start-up and operating costs in certain science and technology fields;
— lead to improved and standardised nutrition- and health-related statistics, terminology and evidence for policy-makers to base their decisions on.

Joint Programming may involve strategic collaboration between existing national programmes or jointly planning and setting up new initiatives. In both cases, it requires the significant commitment of Member States in putting resources together, selecting or developing the most appropriate instrument(s), implementing collectively monitoring and reviewing progress. There is no need for all Member States to be involved in a specific initiative but between themselves, the partners must be able to provide the required critical mass of resources. Close cooperation is needed to ensure that resources are targeted effectively, efficiently and with sufficient power to address societal and scientific challenges, without duplication of effort or leaving gaps that will reduce opportunities for innovation. Where necessary, experience and best practices from outside Europe must be captured and, if necessary, adapted before being exploited across the continent.

As well as having implications for quality of life, additional ramifications for a European innovation trajectory can be identified. For example, there is an urgent need to translate results of scientific research more effectively into concrete and actionable policy initiatives. Closer interaction between policy actors, health professionals and scientists will ensure that policy questions are translatable into scientific activities, and *vice versa*. More effective collaboration between the natural and social sciences is required, as many of the issues and emerging problems are caused by both biological and socio-economic factors and their interaction.

18 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the committee of the Regions. Towards Joint Programming in research: Working together to tackle common challenges more effectively. Brussels, COM(2008) 468.

The Vision

The vision of the JPI *A healthy diet for a healthy life* is that by 2030 all Europeans will have the motivation, ability and opportunity to consume a healthy diet from a variety of foods, have healthy levels of physical activity and that the incidence of diet-related diseases will have decreased significantly.

Strategy

Joint programming will contribute significantly to the construction of a fully operational European Research Area on the prevention of diet-related diseases and, by strengthening leadership and competitiveness of the food industry by effectively integrating research in the food-, nutritional-, social- and health sciences, will increase knowledge and deliver innovative, novel and improved concepts and products.

Strategic goal

To change dietary patterns based on developments in food-, nutritional-, social- and health sciences, and to develop science-based recommendations and innovative product formats that will, together with concomitant changes in physical activity, have a major impact on improving public health, increasing the quality of life and prolonging productive life.

A balanced, adequate diet and appropriate levels of physical activity are major requirements for optimal health, physical development and performance. This requires a good understanding of the health benefits of foods and drinks (and the combinations there of), food choices, production technologies and activity patterns. Joint programming in the field of nutrition, food, exercise and health, with improved coordination of research should lead to a fully operational and coherent European Research Area on prevention of lifestyle and diet-related diseases with strengthened leadership and competitiveness of research[19]. An integrated multi-sector approach, embracing education, health care, agriculture, environment, food and drink industry, transport, advertising and commerce will be essential to position food, nutrition and related public health policy and evidence from research sufficiently high on the political agenda so that the combined effort can be translated into real health improvements.

19 Commission staff working document. Research Joint Programming Initiative on 'A healthy diet for a healthy life': motivations and state of play of research at European level. Brussels, 28.4.2010. SEC(2010)480 final.

Figure 1
Schematic presentation of the activities and research areas of the JPI *A healthy diet for a healthy life*

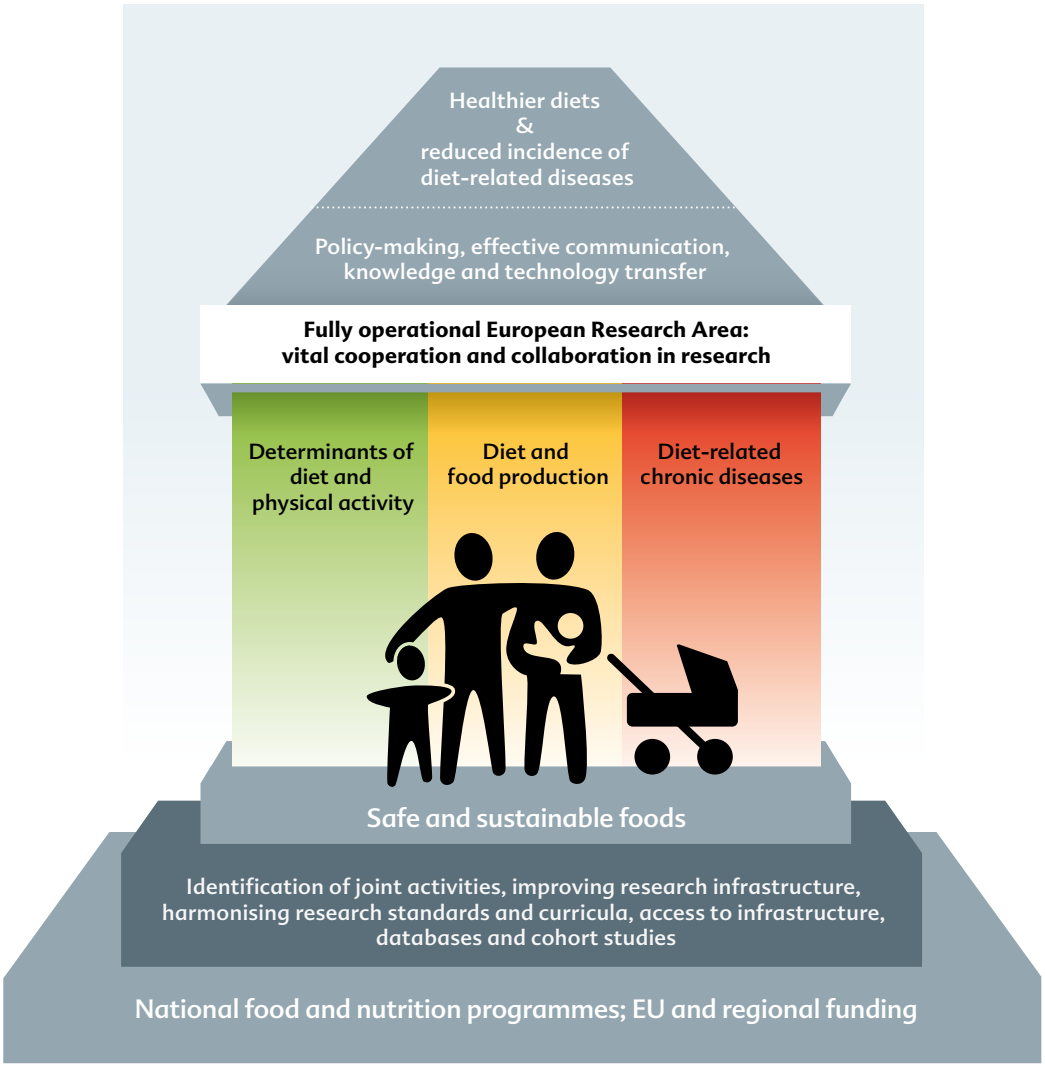


Figure 1 shows the identified activities and research areas that are necessary to attain the vision of the JPI *A healthy diet for a healthy life*. The following three key interacting research areas were adopted in the Vision Document.

Determinants of diet and physical activity: ensuring the healthy choice is the easy choice for consumers

This research is to understand the most effective ways of improving public health through interventions targeting diet and physical activity. Research will include studies which aim to improve understanding of the different biological, psychological and socio-cultural factors that impact on health, and how they interact. The research will deliver information which will allow development of interventions which will modify the impact of individual, social, economic, cultural, biological and other factors, affecting dietary and physical activity behaviour. Interactions with the other research areas are required to develop a full picture of potential determinants.

Diet and food production: developing healthy, high-quality, safe and sustainable foods

The food industry is faced with the challenge of producing tasty foods that are consistent with health status and lifestyle, and which meet consumer preferences. This requires research to increase the understanding of food and diet compositions for optimal health, to develop new foods and to improve production, processing, packaging and proper food chain management. New foods have to comply with nutritional, energy and safety needs of consumers and also with legislation, and be affordable. An additional challenge is to develop innovative products and processes in a cost-effective and sustainable way. Foods must originate from systems that produce, process, store, package, supply foods in a fully sustainable way[20].

Diet-related chronic diseases: preventing diet-related chronic diseases and increasing the quality of life - delivering a healthier diet

Effective nutrition and lifestyle-based strategies are needed to optimise human health and reduce the risk, or delay the onset, of diet-related diseases. These strategies require, for example, research efforts on obesity, its causes including neuroscience and its associated metabolic disorders; on maternal and infant nutrition; on osteoporosis and malnutrition in the elderly; on micronutrient deficiencies and cognitive development and decline. The gastrointestinal tract is the key interface between food and the human body, and its role for human health (including immune functions) needs to be fully elucidated. This requires the incorporation of the gut indigenous microbiota as a metagenome with unique metabolic features.

Strategic Research Agenda

This Strategic Research Agenda (SRA) further defines the three research areas, above and, based on the Vision Document, the knowledge base and structural framework that needs to be generated. It also proposes strategies on how to apply new and established knowledge to achieve the overall goal of the JPI *A healthy diet for a healthy life*. The following chapters describe the research priorities for each of the three defined research areas of the JPI. For each research area, the SRA identifies the knowledge gaps and defines research needs. The SRA is structured along the lines of establishing networks, strengthening the existing knowledge base, generating new data and standardising new and existing data in Europe, and making these databases accessible, followed by a description of joint research programmes. The primary initiatives and research challenges for each research area are described across three periods, 2012-2014, 2015-2019 and 2020 and beyond. Future joint programming agendas are envisaged to be developed within a (virtual) European Nutrition and Food Research Institute.

The inventory of European research projects made by FAHRE was used to identify possibilities for short-term cooperative efforts. This JPI responds to two of the societal challenges of Horizon 2020: *Health, demographic changes and well-being,* and *Food security, sustainable agriculture and the bioeconomy*. During the process of drafting the SRA, strong links were established with the ETP *Food for Life* and, to a lesser extent, with two other ETPs, *TP-organics and Manufuture*, and other JPIs, especially JPI *More years, better lives* and *Agriculture, food security and climate change* (FACCE).

20 An ERA-NET on Sustainable food production and consumption (Susfood) was launched in January 2012.

RESEARCH AREA 1

Determinants of diet and physical activity

Ensuring the healthy choice is the easy choice for consumers

RESEARCH AREA 1
Determinants of diet and physical activity

The challenge is to understand and communicate the most effective ways of improving public health through interventions targeting dietary and physical activity behaviours.
By 2030, all European consumers will have the motivation, ability and opportunity to choose a healthy diet and physical activity pattern.

Overall goal

To understand the determinants, at both the individual and group levels, regarding diet, physical activity and sedentary behaviour using a broad multidisciplinary approach, including biological, ecological, psychological, sociological, economic and other socio-economic perspectives, and their interrelationships and to translate this knowledge into a more efficient promotion of a healthy diet and physical activity.

Scope

Diet and nutrition are of key importance for public and individual health and well-being. The consumption of food is, however, also evidently associated with pleasure, culture and symbolism. In addition, economic factors and consumer preferences for sustainable production, etc. are also important to food choice. If foods and drinks with the right composition are consumed in the right amounts, they should make a major contribution

to well-being and healthy ageing. Research is required to increase the understanding of health-impacting behaviour with respect to making diet and food choices. In addition, studies into the extent to which people from different ethnic populations engage in health promoting physical activity will create insights into how the social and physical environments influence these behaviours; this will lead to a rise in consumer understanding of healthy foods, healthy diets and healthy physical activity patterns and underpin consumer efforts to control their body weight. The main focus of this research area is on diet and food choice. However, because most diet-related chronic diseases are associated with physical activity and the fact that diet and physical activity patterns interact in their association with diet-related chronic disease risk, this research area will also investigate physical activity, especially in relation to diet and food choice.

The European population is highly diverse, culturally and ethnically, and a wide variety of foods and drinks are consumed. Europeans also show substantial differences in levels of physical activity. Furthermore, the biological, ecological, psychological, sociological and socio-economic drivers of behaviour differ across Europe. This European context and variation provides a unique opportunity to study the determinants of diet and food choices, and physical activity, all of which are related to health. Research in this area should ultimately be focussed on developing the most effective ways of improving public health through interventions for motivating and enabling consumers to adopt and maintain healthy diets and physical activity. Conceptually, this requires a choice architecture that can motivate, enable and nudge people to make better and more informed choices (as judged by themselves). Special attention needs to be placed on health issues associated with social inequality or minority groups' membership. The research results generated will be of importance for policy-makers, professionals in the public health area, the food industry and citizens.

Ensuring the **healthy choice is the easy choice** for consumers

RESEARCH AREA 1
Determinants of diet and physical activity

PRIMARY INITIATIVE FOR 2012 – 2014

To establish a European trans-disciplinary research network on determinants of dietary and physical activity behaviours, and their relation to best practice implementation strategies for long-term changes.

The objective is to improve the understanding of how biological, ecological, psychological, sociological, economic and socio-economic factors influence consumer decision-making in the context of diet and physical activity. An important element is to integrate the biological, behavioural and social sciences for a better understanding of how individual, social, and environmental parameters interact when considering the effects of food and physical activity choices on health.

Increased differentiation of (European) populations on cultural, socio-economic and environmental grounds increases disease vulnerabilities in some target populations and this may interact with biological differences across the European population. For example, groups with a lower socio-economic status, individuals living in disadvantaged neighbourhoods, socially-excluded groups, some immigrant communities and ethnic minorities frequently have higher obesity rates and a lower health status. People may also be differentially vulnerable during critical periods throughout life, for example during pregnancy, lactation, infancy, childhood, adolescence and in old age. Given that the behavioural determinants of diet and physical activity behaviour are associated with diet-related diseases and that these may be biological, ecological, psychological, sociological and socio-economic factors in origin, more effective collaboration across disciplines is required. Theoretical frameworks and models are needed, which integrate determinants of food and physical activity choices originating in these different domains if research is to inform effective policy development regarding optimising the health of European consumers.

Although there has been extensive research in different disciplinary areas focusing on this topic, their integration can be improved substantially. An effective approach to integrating activities might involve funding of science networks which will enable researchers from different disciplines to collaborate and create databases for further analysis. To facilitate prospective studies at a pan-European level, these analyses must be carried out with standardised and innovative measures on biological, ecological, psychological, sociological and socio-economic determinants of diet, food choice and physical activity. The great variability of diet and activity patterns observed across Europe, together with a broad diversity in cultural, social and environmental aspects as well as in health outcomes, provides a unique scientific opportunity to learn more about the determinants of diet, food choice and physical activity.

This research challenge requires the inventorisation, integration and standardisation of monitoring systems, terminology, databases and measures regarding research on biological, ecological, psychological, sociological, economic and socio-economic determinants of diet, food choice and physical activity. This could be realised by European trans-disciplinary research networks that bring the different relevant science disciplines together and promote their interactions. Key opinion leaders from the biological, behavioural, health and social sciences with experience on determinants of diet, food choice and physical activity should map the requirements of such a

network, discuss the predefined research challenges and develop strategies on how to implement and optimise the impact of pan-European activities. Such activities should also lead to capacity building regarding studies on biological, ecological, psychological, sociological and socio-economic determinants of diet, food choice and physical activity across Europe. An important additional research challenge is establishing a framework for the translation of research outcomes to policy measures.

RESEARCH CHALLENGES

Collecting and using harmonised data

- Implement systematic foresight activities and initiate scenario studies, including and exploiting relevant expertise from European trans-disciplinary research networks on determinants of dietary and physical activity representing all EU countries. The goal of such activities will be the generation of a common research agenda across disciplines, relevant to European research needs in the area of determinants of diet, food choice and physical activity.
- Foster methodological- and data management (extending from data collection to data retrieval) procedures in all relevant disciplines for studying the determinants of diet, food choice and physical activity. The ultimate goal would be to obtain all relevant data in the most harmonised manner, so that cross-European comparisons, multi-centre studies and secondary data analyses are made possible.
- Establish a joint and standardised monitoring system of dietary intake and physical activity patterns and their multidisciplinary determinants across countries.
- Make better use of existing databases by pooling existing prospective cohort studies focussed on diet, food choice and physical activity, which include data from the natural, social, health or behavioural sciences. Establish and maintain an integrated multidisciplinary database of relevant studies that have used state-of-the-art methodologies.

Harmonising existing European knowledge relevant to diet and health

- Carry out systematic reviews, meta-analyses and mediation and moderation analyses of existing data from evaluations of intervention and policy programmes across Europe in order to identify the policies and interventions having an effect and understand the mechanisms contributing to these effects. These results could be translated into best practice recommendations and large scale demonstration projects.
- Identify indicators to assess the costs and benefits of interventions and policies for health improvement.
- Link these research activities with those research challenges listed in the research areas Diet and food production and Diet-related chronic diseases (for example, the use of predictive biomarkers applied to chronic diseases addressed in Diet-related chronic diseases, or interactive psychological and neurobiological mechanisms involved in sensory responses to food).

RESEARCH AREA 1
Determinants of diet and physical activity

PRIMARY INITIATIVE FOR 2015 – 2019

To create pan-European programmes utilising a prospective design and a comprehensive approach of biological, social, health and behavioural determinants of diet, food choice and physical activity. These should relate to real-life conditions to understand better how these different categories mediate and interact to shape behaviours that promote the incidence of chronic diseases. Such research programmes should include pilot, feasibility, demonstration and real-life intervention studies, with different levels of intervention complexity (including natural experiments and policy interventions) to inform and determine the most effective ways of promoting a healthy diet, food choice and physical activity, and contributing to reducing social inequalities.

There is a lack of validated predictive models of interdisciplinary determinants of diet, food choice and physical activity and a healthy body weight. Current research is primarily observational and often cross-sectional and precludes any inference of causal relationships. Moreover, studies tend to focus on a limited range of such determinants and do not effectively integrate the interactions between biological, ecological, psychological, sociological, economic and socio-economic determinants. The variability of diet and activity patterns observed across Europe associated with the broad diversity in foods offered in different social, economic and cultural and built or environmental regions and settings offers a unique opportunity for pan-European longitudinal research with prospective multi-centre 'natural experiment' studies. The research will deliver a comprehensive understanding of the factors influencing dietary choice and physical activity across Europe, and with different socio-cultural and physical environments.

An important challenge is to inform and assess the impact of 'real world' changes in policies or food or physical activity environments on people's behaviours in relation to diet, food choice and physical activity. Given the 'natural laboratory' of socio-cultural, economic and biological diversity within Europe, various approaches to pan-European comparative analysis can be identified. Some examples include changes in taxation or pricing strategies (and could involve scenario building in different European economic regions), the disposable income of consumers or the way in which food retail environments are developed, how foods are marketed, how biological and socio-cultural factors may interact in determining sensory responses to foods, how changes in building environments may impact physical activity, taking account of genetic differences in the population, and how changes in social environmental factors (such as social capital and social disparities) influence diet, food choice and physical activity behaviours. The societal trend towards 'electronic lifestyles' should also be considered.
The research challenges should contribute to our understanding of how motivation, ability and opportunity to consume healhty diets and foods and being physically active impact on health and well-being. Validated, predictive models of consumer diet- and food-related and physical activity behaviour need to be developed and tested against health-related quality of life and economic outcomes including targeted interventions. This will include assessment of impact of global changes and the food supply, their impact on European food security, and associated impacts on food choices.

RESEARCH CHALLENGES

Understanding determinants of diet, food choice and physical activity

- Test different types of study designs, including large scale intervention studies, to assess changes in food and physical activity behaviour in real life conditions and define outcomes, including body weight, that will be relevant according to settings. In this context an integrative and comprehensive approach of diet and physical activity could rely on methodologies and networks established in the initiative for 2012-2014 and thus applies state-of-the-art measurement tools. Pilot studies conducted in a few European regions with different living conditions could help to further identify the more pertinent methodologies and facilitate standardisation.
- Design new prospective, multi-site cohort studies involving different European countries to better investigate different categories of determinants and their mediation and interaction across various population groups. These groups will be defined by life course (e.g., pregnancy and infancy, childhood and adolescence, elderly), socio-demographics (e.g., ethnicity, socio-economic position), and setting (e.g., neighbourhoods, schools, worksites). Such studies should incorporate better standardised and innovative measures of behaviours and of social/built environments. As part of this, it is important to extend existing cohort studies by including Member States not yet part of any of these programmes.
- Promote epidemiological modelling inputs into the analysis of long-term health impacts and cost-effectiveness of policies and interventions, and evaluate these against quality of life indicators and measures of well-being. Validated predictive models of consumer food-related behaviour need to be developed and tested against health-related quality of life and economic outcomes including targeted interventions.
- Analyse, in a European-wide comparative manner, the health impact of social inequality and minority health challenges related to the needs of specific target groups (groups with low socio-economic status and minority groups) and, in particular, the impact and effects of policies and interventions on these various groups.
- Develop new approaches to assess socio-spatial influences on food and physical activity choices in different settings.
- Examine innovative individual potential determinants of food choice and physical activity such as brain functions in relation to (sensory) inputs, genetic predictors of food choice and physical activity.
- Understand the importance of early environmental exposure for development of obesity and diabetes (pregnant women) and for optimising foetal and early postnatal development. Of particular concern is the increasing incidence of childhood obesity and the role of lifestyle ('electronic life', computer games, other common new technologies) on disease risks as well as on brain functions.

RESEARCH AREA 2

Diet and food production

Developing healthy, high-quality, safe and sustainable foods

RESEARCH AREA 2
Diet and food production

The challenge is to stimulate the European consumers to select foods that fit into a healthy diet and to stimulate the food industry to produce healthier, high-quality foods in a sustainable and affordable way.
By 2030, European consumers will have a good choice of healthy foods to select from: the healthy choice will have become the easy choice.

Overall goal

To improve the quality of foods, food production systems, distribution and marketing to provide healthier, safe, sustainable and affordable foods that also contribute to market advantages for European food producers and the European food and drink industry. This will be achieved by sharing knowledge and data and carrying out harmonised research within the area of diet and food production.

Scope

The concept of food quality has changed over the years. Whereas in former days safety was strongly emphasised, food and drink nowadays are expected not only to be safe and of good quality, but to be affordable, easy to prepare and to contribute to enjoyment, health and

well-being. Changes in society and demographic trends, such as smaller household sizes, an ageing society, working parents and increases in proportion and integration of ethnic groups in many EU Member States, will impact on the choice of foods, the ways in which food will be prepared and the places in which it will be consumed.

Traditionally, nutrition goals have been set at the average population level. However, new research is increasingly showing that the risks, benefits and nutritional requirements may vary between different population groups, and even between individuals, on the basis of their genetics. Better understanding of these determinants and requirements is necessary so that dietary advice can be more focused on the needs of particular consumer groups and can even lead to development of specialised foods and services for specific groups of consumers ('personalised nutrition', functional foods, food supplements). These needs, and also special nutritional requirements for different age groups, are strong drivers for the food and drink industry to produce innovative products that fulfil these expectations.

The food industry is faced with the challenge of producing tasty foods that are consistent with health status and lifestyle, and which meet consumer preferences and thus ensure repeated purchase. This requires research to develop new foods and to improve production processing, packaging and proper food chain management. All new products have to comply with nutritional and safety needs of the consumer. Health promotion via foods requires research to identify key bioactive components in foods and the mechanisms by which they are handled in the organism and their mode of action, including dose-response studies. Therefore, it is essential to obtain in-depth knowledge of the nutritional and functional characteristics of foods and diets. This knowledge is also important for improved benefit-risk assessments.

An additional challenge is to develop innovative products and processes in a cost-effective, sustainable and affordable way. Foods must originate from systems that produce, process, store, package and supply foods in a sustainable way. Several EU Member States have or are implementing programmes for the production of more sustainable foods and for reducing food spoilage. It is a challenge to provide the consumer with the right type of food at the right time and in the right place. Innovative processes, value-added products, new marketing concepts, novel ways of selling products and improved production and supply chains are needed. Products must fulfil consumer expectations on safety, the required sensory characteristics and provide a maximum of convenience at an affordable price. Research on new technologies is continually required, as it is in the field of food safety. There is a need for improved methods, including rapid methods for field application, in-line methods for continuous safety management in food processing and precision and reference techniques for research and confirmatory purposes. New technologies are expected to lengthen shelf-life and reduce food spoilage. In addition, environmental issues related to sustainable food production, minimisation of waste production and use of non-renewable raw materials will become an increasing priority.

The food industry will need to adapt and incorporate modern production philosophies, such as lean and agile manufacturing, which have proven successful in other market sectors and which allow producers to remain at the forefront of market innovation. Overall, attention must be paid to the entire process and production line so as to optimise each of the individual elements.

Developing **healthy, high-quality,** safe and sustainable foods

RESEARCH AREA 2
Diet and food production

PRIMARY INITIATIVE FOR 2012 – 2014

To set up a roadmap-initiative for biomarkers of nutrition and health; define research strategies and launch research activities addressing the needs of all consumers as well as of industry towards measures on health claims, and explore new methodologies or emerging biomarkers in consumer subgroups (target groups) or individuals at risk.

A first step should be to establish a roadmap-initiative and create a European research stakeholder's network on biomarker research. This could be a concerted effort with ETP *Food for Life* and an ongoing initiative of ILSI Europe. This network will be focused on the research needs addressing the consumer's health and the competitiveness of the European food and drink industries as these may be threatened with markets moving away. If industry is not developing and promoting healthy choices, the burden of diet-related diseases will further increase in Europe. This requires a critical reassessment and a new balancing of consumer expectations, consumer protection and the scientific requirements for claims. There is no doubt that insufficient scientific knowledge on the effects of individual food ingredients and technologies is hampering progress in this field; this applies to both academic research and industrial R&D and finally impinges on consumer interests in a wider range of healthy products. More human studies taking into account human diversity and phenotypic differences and in specific target groups (children, elderly people) or groups of increased disease risks are urgently required. There is also a need for better (surrogate) evidence-based markers that indicate health improvements or, at least, that address preventive measures in an organ-specific and target group specific manner. To date biomarker research has often been based on the measurement of single entities. The opportunity to use multiple gene, protein and/or metabolite analysis needs to be properly explored. Novel biomarker discovery has been a core activity of the pharma, biotech and medicine realm, so it will be important to have them involved from outset. However, the pharmacological approach is generally not applicable to complex foods with their smaller physiological activities and effect sizes.

RESEARCH CHALLENGES

Establishing a biomarker and health claim expert platform

- Establish a pan-European health claim and biomarker expert platform for defining (multiple) health markers (for whole organism and gut, including microbiota, brain, immune system, cardiovascular system, bone, muscle, skin, respiratory and endocrine systems) in the general population, as well as for defined subgroups.
- Promote integration and harmonisation of large scale biomarker assessment programmes employing bio-bank samples (omics-based) and other disease register sample collections, in which clinical endpoints can be tested against

the putative biomarkers of the effects of dietary components as an input variable. Investigate the importance of alterations in microbiota composition and function in affecting biomarkers for disease and health.
— Develop and validate biomarkers of health and food intake using novel approaches including functional genomics, food metabolomics, microbiomics and epigenetics and by exploring markers in human studies based on foods (and not solely their individual ingredients).
— Define and harmonise the methodology necessary to prove the nutritional effects in the development of foods. The pharmacological approach is generally not applicable to complex foods.
— Develop improved methodologies for the direct identification and quantification of compounds in complex multi-component foods or dietary ingredients and in the human body.

Establishing a platform on education and communication to heighten European industry and consumer awareness

— Implement better educational programmes on progress in science in the nutrition and food science areas and on needs for scientific proof of dietary interventions and the effects of ingredients.
— Define research activities and strategies that also address the needs of industry towards EFSA measures on claims and for comparison along consumer subgroups (target groups) with individual risk. This needs to be done in consultation, or at least through dialogue, with EFSA.

RESEARCH AREA 2
Diet and food production

PRIMARY INITIATIVE FOR 2015 – 2019

To initiate research programmes (including ERA-NETs) on comprehensive analyses of the metabolic fate of food constituents (nutrients and other bioactives, including microbiota effects) in human physiology with a strong emphasis on different population groups, including the elderly.

The ultimate goal is to define and catalogue the fate of food constituents in humans. The bioavailability of food constituents is dependent on numerous factors, including the food matrix and meal composition but also on the biology of the host and its microbiota. Numerous studies have addressed putative health-promoting functions of a wide range of foods and ingredients, and in particular of plant bioactives. Yet in most cases, the nature of the compound(s) that carry the biological activity remains unknown. One of the reasons for this is that the compounds undergo substantial phase I, II and III metabolism in intestine, liver and other tissues to produce a wide spectrum of conjugates that appear in circulation. In addition, it has become clear that for some categories of plant bioactives the microbiota plays a crucial role in bioavailability and function in the host, thereby allowing responders and non-responders to be defined. Moreover, the bioavailability of dietary constituents (including both essential and non-essential constituents) appears to be reduced in the ageing organisms. This puts the elderly at risk for malnutrition not only through lower intake of nutrients (impairments in taste perception, satiety control, chewing, etc.) but also by impaired functioning of the gastrointestinal tract and the metabolic system.

To better understand the fate of food constituents in humans and their biology, including the heterogeneity in individuals (host and microbiome) in handling of the compounds, a concerted action of academic and industrial R&D is needed. New parallel methods for detection, identification and quantification of food compounds (nutrients and plant secondary components and metabolites), including stable isotope-labelled standards for quantification in metabolism, are needed. This should allow, for example, the classification of compounds undergoing similar biochemical reactions and could lead to a reference database on bioavailability and kinetic behaviour. A stable isotope-labelled food ingredient inventory for all studies in the food sciences and for analysing their properties in humans will be an invaluable tool.

In developing novel food ingredients on which to base functional foods, research on bioactives from the dairy, marine, horticulture, cereals and meat sectors requires active inputs from clinical practitioners and nutritional biochemistry, areas that extensively exploit modern molecular biology tools. Bioactives in foods use the same pathways of xenobiotic metabolism as drugs which means that food ingredients can alter drug bioavailability and drug efficacy. The most impressive example is that of the ingredients in grapefruit; one glass of grapefruit juice has been shown to alter drastically the plasma concentrations and functions of numerous drugs of different classes[21]. These possible side effects are highlighted in drug use leaflets (package inserts) but are not yet considered in the food area. In an ageing population with multi-morbid individuals regularly using a large variety of drugs, food-drug interactions are a growing problem, in general, and with respect to

21 Paine MF, Widmer WM, Hart HL, et al. A furanocoumarin-free grapefruit juice establishes furanocoumarins as the mediators of the grapefruit juice - felodipine interaction. Am J Clin Nutr 2006;83(5):1097-1105.

bioactive food ingredients, in particular. However, also other food ingredients (fat, protein, etc.) can alter drug availability, action and elimination. It is also necessary for the food industry to address this issue (in particular, in relation to its liability) and heighten awareness. A research effort that addresses these food-drug interactions in proof of concept studies with partnerships from pharma and food (R&D and academia) is needed to provide a knowledge base and create awareness for this problem. An expert panel on food-drug interactions for safety assessment (for both drugs and foods) should be established as a matter of urgency. This project is of high societal importance and crosses the interface between pharma and food, with implications for the safety of every European consumer. It can be foreseen that this issue will gain more public attention and could become important (and damaging to the industry) from the perspective of liability.

As consumers become more conscious of the impacts of their food consumption patterns on the environment, so the food industry will recognise its need to reduce the impacts of the food supply chain on the environment by using less energy and water, more sustainable raw materials and by exploiting — and thereby, reducing — waste.

Companies and regulatory agencies need to be able to model the impact of newly-developed functional products or reformulated foods in food composition and consumption patterns. Accessing up-to-date national food consumption databases and other relevant nutritional surveillance data sources are vital. In addition, such databases represent a key source that underpins public health policy.

Food safety and shelf life are both areas where novel technological interventions play a key role. They can be used to reduce and control microbial contamination of products throughout the entire production process, to control contamination on packaging and contact surfaces and even retain sensory and nutritional qualities. Research on the interaction between the main nutrient components in food, i.e., proteins, fats and carbohydrates, is key to unlocking new mechanisms for adding functionality and value to existing and new foods.

Since the structure-function relationship in food matrices is primarily influenced by the processing parameters used by the food industry, new knowledge is required on the effect of processing on functional characteristics in order to develop new and innovative foods. In order to respond to industry's requirements for novel processing technologies, it is essential that core research skills in more traditional processing techniques, such as separation and drying, chilling and freezing, pasteurisation, sterilisation, mixing and formulation technologies are retained. Whilst directing research towards new methods that offer faster and milder processing methods, it is important that the effect of these methods on the sensory attributes of food can be assessed or even predicted.

The research challenges are aimed at increasing the scientific knowledge needed to develop foods to improve health. Research and innovation in food processing should be both fundamental and consumer-oriented with the goal of improving product quality and promoting healthy eating.
This may include reformulation of existing products to make them healthier without changing their characteristics or by designing new, innovative foods. European research on the composition of foods, the effects of the food matrix and of food constituents in the human system will help product development and set the basis for approved health benefits. Other issues which are important include the presentation and marketing of foods and their association with various social and cultural environments. The development of healthy foods with scientifically validated health effects and, therefore, with clear added-value, is another challenge for both the food industry and society. Collaboration of scientists in academia (including the socio-economic sciences) and industry, partnered by various stakeholder groups will be essential for the development, validation and acceptance of these products.

The fast pace of modern lifestyles, including increased mobility, and the increase in single-person households, one-parent families and working women have all lead to changes in food preparation and consumption habits. Food technology, processing and packaging techniques have already adjusted to these changes but must ensure the safety and wholesomeness of the food supply in the convenience sector. In spite of major advances in the past, contamination in the food chain by either naturally-occurring or accidentally introduced contaminants or by malpractice does occur. Ultimately, the quality and safety of food depends on the efforts of everyone involved in the complex chain of agriculture

and seafood production, processing, transport, food production and consumption. As the EU and the World Health Organisation (WHO) put it succinctly — *food safety is a shared responsibility from farm to fork*. Maintaining the quality and safety of food throughout the food chain requires both operating procedures to ensure the wholesomeness of food and monitoring procedures to ensure that all operations are carried out as intended. Based on global changes in the availability of food and growing competition for biomass (food and feed raw materials, fuels and fibres) and changing climate conditions, studies on diet and health should consider these factors and explore, for example, alternatives for meat proteins.

There is relatively little information on food spoilage on a European scale. If more information were available on (determinants of) food spoilage, rational strategies could be developed for reduction of food spoilage. On the consumer level this should be done by creating awareness and, on the industrial level, this can be achieved by improving agricultural and food production systems and packaging. However, there must also be continual vigilance against emerging pathogens.

There are several target groups that could use products that meet their specific dietary needs. Although specialised foods for consumers suffering from particular conditions are available (for example, for coeliac disease or lactose intolerance) foods that help to manage better other (chronic) diseases may be developed. This may cover all diet-dependent diseases (cardiovascular, diabetes, intestinal bowel diseases (IBD/IBS) and others; see also the research area on Diet-related chronic diseases). Elderly people are a target group for whom more specific products should be developed and this also applies to pregnant women and children. The specific products for these target groups should match the dietary needs but attention needs to be paid to sensory aspects and to providing the individual population groups relevant information.

RESEARCH CHALLENGES

Improving food quality: Agricultural production, food (bio)chemistry and technology research

- Ensure safe, nutritious and high-quality agricultural materials for food production at an affordable price. All stakeholders must engage in ensuring 'food first' with a sustainable food production form farm to fork. This activity requires close collaboration with other JPIs, in particular JPI *Agriculture, food security and climate change* (FACCE).
- Enable redesign and optimisation of food processing, storing and packaging ensuring optimal food quality. Develop and/or improve the nutritional quality and functionality of foods.
- Explore the use and safety of novel technologies (including nanotechnologies and biotechnologies) in food systems or food ingredients/bioactives with improved stability, absorption and efficacy or improved sensory characteristics. Provide clear and understandable information on such techniques and individual foods prepared using such techniques to consumers.
- Carry out research to reformulate food to improve their nutritional quality; model the resultant impact.
- Promote more efficient and better coordinated (trans-disciplinary) research on new and known bioactives (plant and animal raw materials).
- Promote sensory science (flavour and texture) related to satiety and food intake control; specifically, the role of cooking methods, culinary expertise and ingredients to enhance taste and promote the consumption of healthy foods such as fruit and vegetables.
- Define, evaluate and coordinate research on structure-function relationships (bioavailability and bioefficacy) of foods and ingredients for better design of food structure/properties in relation to nutrition and health.
- Harmonise databases on life cycle assessment (LCA) and address their standards at a European level.
- Study alternative food sources of nutrients and animal proteins.

Improving health: Health-related research

- Develop and validate biomarkers of health and food intake using novel approaches including functional genomics, food metabolomics, microbiomics and epigenetics. Explore markers in human studies based on foods (and not just individual ingredients).
- Launch a programme on bioavailability of plant secondary metabolites in the human system using validated methods and compound identification.
- Improve and harmonise food composition databases; including apparent bioavailability of ingredients (the FP6 project, EuroFIR[22], provides a strong basis for such development).
- Examine the short-term and long-term effects of the diet and its components, on the intestinal microbiota and the impact on health, with specific attention for various age groups. Such interdisciplinary research could exploit omics-approaches and could benefit from collaboration between food and medical sciences.
- Promote pan-European programmes that take advances in science (genotyping, phenotyping and enterotyping to stratify consumers) into account when planning human trials for assessing safety and functionality of food ingredients.

Reducing food spoilage and increasing safety and sustainability of foods

- Compile data on food spoilage and waste with a European perspective (in production, commercial institutions and households) and develop strategies for reducing food spoilage by improving agricultural and food production systems and packaging.
- Develop smart sensor systems that allow safety of foods and quality to be monitored.
- Improve the sustainability of food production systems, including agronomic traits, transgenic technologies, optimisation of fermentation processes, separation and processing technologies.

Developing specific products for population groups

- Promote research on the development of soundly-based nutritional products for the elderly, pregnant women, children and other specific population groups that target dietary and sensory needs and assess routes of placement and target-group specific marketing.
- Develop packages for delivering healthy foods targeted at specific populations, including those that are ‘easy to open’ for the elderly or are appropriate for single person households, school children and commuters. The design should satisfy the need for information and motivation to use.

22 www.eurofir.net.

RESEARCH AREA 3

Diet-related chronic diseases

Preventing diet-related chronic diseases and increasing the quality of life – delivering a healthier diet

RESEARCH AREA 3
Diet-related chronic diseases

The challenge is to prevent or delay the onset of diet-related chronic diseases by gaining a better understanding of the impact of nutrition and lifestyle across Europe on human health and diseases.
By 2030, the incidence of diet-related diseases will have decreased significantly and will continue to decline thereafter.

Overall goal

To pool existing national data and knowledge and define new research requirements to improve our capacity to understand the qualitative and quantitative links between diet, nutritional phenotype (e.g., obesity) and risk factors for diet-related chronic diseases. This includes the need for proper and predictive biomarkers (based on novel life science technologies) that characterise the trajectory from health to disease in the context of dietary intake and phenotypic changes. This may be achieved by the re-analysis of existing dietary intervention studies and the execution of newly-designed studies. Individual organs display different susceptibilities and the effects of dietary factors and lifestyle, including a too high food intake and low grade inflammation, need to be explored with respect to new treatment options or adjuvant approaches for (organ-specific) health improvements.

Scope

Although epidemiological studies suggest an association of food categories (meat, fruit and vegetables) and individual dietary constituents, such as fibres, vitamins and trace elements, with human health, randomised controlled trials with, for example, vitamin supplements have in many cases failed to show beneficial effects. This may be due to the heterogeneity of

the study populations (including genotypes) and future studies should take this into account. Although genome-wide association studies have yielded a wealth of information on human genetic heterogeneity and risk alleles, it has become obvious that information on dietary exposure and phenotype is insufficient for defining causal relationships. Obtaining information on diet and other lifestyle factors and in particular on the human metabolic condition is much more difficult and demanding than genotyping which is just based on technological advancements. A better understanding of how diet contributes to the health-disease trajectory on the basis of a given genetic makeup will require large scale cohort studies with a much better definition of the volunteer's phenotype. For such studies a greater focus should in future be placed on whole diets, whole foods and food patterns in assessing their contribution to the health status, as well as on their interactions with physical activity and other health behaviours. In addition, *in vitro* and animal studies can be useful to study the effects of dietary compounds on health. Much of the research below will be intimately linked with that of the other research areas.

Poor nutrition, imbalanced energy intake and insufficient physical activity can each lead to changes in gene expression and epigenetic alterations that cause sustained impairments, for example, in immune responses and increased susceptibility to disease. They also contribute to impaired physical and mental development, and reduced productivity. Advanced technologies for the first time allow the effects of diets to be studied on each level along the flow of biological information from the genome to the transcriptome, proteome and metabolome and, thus, the human phenotype. When embedded into the life stages this research can improve assessments of disease risk and, when applied to optimise human health, can help to reduce the risk, or delay the onset, of various diet-related diseases. These strategies require, for example, research efforts on how diets affect the conditioning to obesity and cause alterations in food intake control; this research should bridge to the neurosciences.

Almost all chronic diseases have a basis of low grade inflammation which derives from metabolic perturbations. Understanding how diet (and the composition of the diet) can interfere with these mechanisms is of key importance for effective food-derived strategies in prevention. Maternal diet and infant nutrition are important determinants that, by imprinting and epigenetic effects, can cause disease predisposition but current knowledge is insufficient to allow its translation into public health recommendations. Age-related impairments and diseases such as osteoporosis, sarcopenia, or cognitive decline, require better treatment options and prevention strategies, and also proof of concept studies. Micronutrient deficiencies in various population subgroups are emerging, sometimes despite high energy intakes; this is particularly evident in vulnerable groups, including people with a low socio-economic status and immigrants. Awareness of this problem needs to be heightened and proper prevention strategies developed.

Biology is not the only key factor in the diet-disease relationship. The greater incidence of obesity in people with lower income or lower education or nutrient deficiencies in subgroups of the population must also be taken into account. It is important to improve education on the role of healthy diets and provide foods that fit into a healthy diet at an affordable price for those target groups.

Preventing diet-related chronic diseases and **increasing the quality of life** — delivering a healthier diet

RESEARCH AREA 3
Diet-related chronic diseases

PRIMARY INITIATIVE FOR 2012 – 2014

To establish a European Nutrition Phenotype Assessment and Data Sharing Initiative providing a standardised framework for human intervention studies on food and health, and their phenotypic outcomes with an open-access reference database.

Over several decades, dietary surveys have been conducted at national or large regional level, providing valuable data on patterns of food intake, the nutritional quality of nutrient intakes, an overview of anthropometric data (such as weight and height, data on physical activity) and, in a limited number of such surveys, data on standard nutrient-relevant biochemical variables. These data have helped policy-makers to develop and disseminate guidelines to improve dietary habits which have also been valuable to industry to understand the relevant contribution of different foods to given nutrient patterns.

In recent years there has been a move away from such limited databases to larger, more comprehensive information systems which embrace traditional food and nutrient intake data but which are extended to include ethnic foods, additional, much more comprehensive data on physiological function, physical activity and clinical data, as well as the collection of extensive data on genotype, on metabolomic profiles and to a limited extent data on proteomics or protein profiling and transcriptomics (gene expression). These new large comprehensive datasets are now referred to as *Nutritional Phenotype Databases*.

The challenge to create large national nutrition phenotype databases was first mooted by the Long Range Planning Committee of the American Society of Nutrition Sciences[23] and was taken up by the European Nutrigenomics Organisation (www.nugo.org) leading to a major initiative of the FP6 Network of Excellence (www.nugo.org/dbnp) with the publication of some key influential papers[24,25]. Several countries have moved toward the construction of nutritional phenotype databases[26]. The large amount of phenotypic data linked to genotypic and dietary data allows these Nutritional Phenotype Databases to search for nutrient-gene interactions, which drive phenotypic changes.

These different national dietary or phenotype databases need to be merged into large, harmonised mega-databases in a standardised manner to increase their statistical power and provide better cross-border comparisons for identifying dietary effects on health and disease outcomes. Only by operating at such a scale can understanding be optimised of the role of genes, nutrients and phenotypes in the initiation, development and progression of risk factors for diet-related chronic disease. This is and should remain a very high priority for EU food and health research.

23 Zeisel SH, Freake HC, Bauman DE, et al. The nutritional phenotype in the age of metabolomics. J Nutr 2005;135(7):1613-1616.
24 Ommen B van, Bouwman J, Dragsted LO, et al. Challenges of molecular nutrition research 6: the nutritional phenotype database to store, share and evaluate nutritional systems biology studies. Genes Nutr 2010;5(3):189-203.
25 Ommen B van, Keijer J, Kleemann R, et al. The challenges for molecular nutrition research 2: quantification of the nutritional phenotype. Genes Nutr 2008;3(2):51-59.
26 Examples include initiatives taken in Ireland (www.ucd.ie/jingo), the Nordic region (www.sysdiet.fi), the Netherlands Metabolomics Centre (www.metabolomicscentre.nl) and Germany (national cohort for epidemiological research including the most comprehensive phenotyping programme).

It has been known for many years that bacteria in the intestinal microbiota affect the conversion and availability of dietary components. It is now becoming clear that variations in the microbiota are linked to diverse chronic diseases including irritable bowel syndrome, inflammatory bowel disease, coeliac disease, obesity, and metabolic disease. Recent studies have shown that one of the principal determinants of microbiota composition is the long-term diet and that variations in the microbiota, caused by diet, can impact on health, especially in chronic diseases[27,28,29]. Thus a major re-evaluation of many chronic diseases is now called for, especially for diseases where a direct nutritional link was postulated, but microbiota-driven components in pathophysiology were ignored. Such studies should include reference to the founder microbiota population in a given unhealthy individual and whether dietary modulation or dietary intervention can restore health-promoting microbiota. In recognition of the role played by the intestinal microbiota in determining health, the role of diet in sculpting the microbiota and the emerging evidence that the mammalian host genotype affects the microbiota composition, it will be necessary to integrate nutrigenomic databases with microbiota data. In practice, this will have to be accomplished by phenotyping new individuals, measuring a broad spectrum of diet, metabolism, microbiota, health and genetic markers.

RESEARCH CHALLENGES

Providing comprehensive phenotypying of humans for the assessment of diet-disease relationships

- Foster methodological harmonisation and development of standard operating procedures (SOPs) for human studies and sample collection and coordinate and support ongoing nutrition- and health-related cohort activities by improving standardisation and access to data (open-access).
- Launch a scoping exercise for existing databases and identify requirements for their merging.
- Define minimal standards for data collection and phenotypic measures (SOPs).
- Develop an agreed methodology to incorporate data from different omic-technologies with standard phenotype data.
- Create an initiative for a pan-European genotype-phenotype database on food-health relationships.
- Provide a basis for assessing nutritional phenotype by integration of genetic and other life science technologies, as well as identifying functional parameters and behavioural measures that better define the human nutritional status.
- Gain a thorough understanding of how nutrients and non-nutrients interact with the human genome and epigenome at a molecular level throughout the life span. There is growing demand for more comprehensive phenotyping including challenge tests of human volunteers.
- Explore the interactions between foods or food ingredients and the immune system, including the effects of the composition and metabolic activity of the intestinal microbiota on the development of diet-related chronic diseases.
- Develop standardised approaches to assess the impact of chronic diet-related diseases on the quality of life, the economic condition of individuals and the health system, and how health services impact on diet-related diseases.

27 Greer JB, O'Keefe SJ. Microbial induction of immunity, inflammation, and cancer. Front Physiol 2011;1:168.
28 DuPont AW, DuPont HL. The intestinal microbiota and chronic disorders of the gut. Nat Rev Gastroenterol Hepatol 2011;8(9):523-531.
29 Sanz Y, Santacruz A, Gauffin P. Gut microbiota in obesity and metabolic disorders. Proc Nutr Soc. 2010;69(3):434-441.

RESEARCH AREA 3
Diet-related chronic diseases

PRIMARY INITIATIVE FOR 2015 – 2019

To expand and foster existing prospective diet-related cohort studies, merge them into open access nutritional databases and initiate new pan-European prospective studies on the diet-health relationship with new markers of health derived from comparative phenotype analysis.

Whereas nutritional phenotype databases will provide deep insights into the associations between genotype, phenotype and diet, such associations must be validated by dietary intervention studies. In many cases, new intervention studies will need to be initiated but, in many more it should be possible to exploit already completed intervention studies, including those carried out with EU funding, including Lipgene, Diogenes, Earnest, NuAge, PreventCD, EarlyNutrition Project, HELGA and EPIC.

There are two major limitations to maximising the exploitation of such dietary intervention studies. The first is the need for a clear policy on public accessibility to such data and, secondly, the merging of these databases to evaluate associations between genotype, phenotype, diet and health.
This should be the main focus for 2015-2019.
Determining optimal dietary intakes to maintain health requires a means of assessing the physiological effects of macro- and micronutrients, toxins and non-nutritional bioactives. Biomarkers to quantify health optimisation are needed since many if not all biomarkers are developed for disease endpoints. Quantifying 'normal homeostasis' and developing validated biomarkers are difficult tasks because of the robustness of homeostasis and of inter-individual diversity. These ends might be achieved by focusing upon the functional significance of the variations within the range of data that will generally be considered 'normal' with the aim to identify successively earlier indicators of any deterioration. Even with such refinements, individual markers used in isolation will not be able to measure health reliably. Instead, integrated multi-component biomarkers are required. Ideally, these will examine a far broader concept of health than simply defining acceptable values for each parameter individually.
In this respect, the 'omic' technologies that measure large numbers of parameters in parallel offer significant opportunities. However, even with such new approaches, it will be a major challenge to capture the functional status of a biological system with measurements at a single static point. Dynamic measures, taken under varying conditions, may provide a starting point. Therefore, there is a growing demand for more comprehensive phenotyping including challenge tests of human volunteers collected prospectively. This will require standardised methods (see also European Nutrition Phenotype Assessment).

Scientific progress in the field must be targeted at better defining chronic disease-preconditioning mechanisms against the background of human genetic heterogeneity and lifestyle factors. The new profiling and phenotyping technologies appear particularly well suited to obtain mechanistic insights. However, this will need an integrated and highly standardised effort that includes the identification of indicators which, as early biomarkers (including omics-based signatures), can predict disease onset and progression. These biomarkers or signatures will need, in the next step, to be validated in cohort studies, especially in groups with an increased (genetic) risk.

As early environmental exposures (during pregnancy), but also during infancy and early childhood, predispose to obesity and related diseases such as diabetes and

other auto-immune disorders in later life phases, optimising foetal and early postnatal development is of high priority and needs adequate research efforts that allow sound knowledge to be transmitted into the public health domain. Knowledge on how diet and physical activity affect cognitive function and performance in different life stages is currently a largely neglected area. In the elderly, cognitive functions and malnutrition, muscle wasting and metabolic abnormalities are observed together with increasing obesity prevalences. Chronic loss of organ performance is a critical condition and needs a better understanding of the underlying mechanisms and the identification and validation of predictive biomarkers. The impact of other lifestyle changes ('electronic life', computer games/other common new technologies) that may, for example, affect food intake and exercise behaviour is another poorly defined area and should be explored to understand its contributions to obesity development and associated diseases.

Chronic low grade inflammation underlies the initiation and progression of many diet-related chronic non-infectious diseases, including atherosclerosis, cancer, type 2 diabetes and chronic kidney disease[30]. The growing social and economic burden of such diseases is well established[31].

There is an urgent need to understand the underlying common and individual molecular mechanisms that drive such diseases in order to develop novel detection methodologies and therapeutic interventions. Current therapies are of only limited value in arresting or reversing many chronic illnesses. Earlier detection and a better understanding of the underlying pathologies will improve this situation. These ambitions are supported by quality inputs and outputs from many research groups throughout Europe and will be realised by integration of basic mechanistic, animal models and human epidemiological data.

There is an interaction of diet and physical activity across a range of disease states and physiological processes including vascular disease, diabetes, obesity, mental health and osteoporosis. Physiological and pathophysiological processes related to health and disease should not only be studied from a dietary perspective, but should also examine the effects of exercise. The possibilities that nutrition and exercise have an effect on disease processes and biomarkers, and that certain genotypes and phenotypes respond better to dietary or exercise interventions (personalised preventive medicine) should be studied using dose-response studies taking into account changes in both exercise and nutrition, and the combination of exercise and nutritional supplements. The interactions of nutrition, exercise and pharmacological treatments (medicines) should also be investigated.

30 Hotamisligil G. Inflammation and metabolic disorders. Nature 2006;444:860-867.
31 Daar AS, Singer PA, Persad DL, et al. Grand challenges in chronic non-communicable diseases. Nature 2007;450:494-496.

RESEARCH CHALLENGES

Studying the incidence of diet- and lifestyle-related diseases in relation to genetic background

- Launch a scouting exercise for existing dietary intervention studies and explore the possibility of their merging.
- Collect samples (biobanks) and create sub-databases on human genetically-defined populations (either from population studies or from controlled trials with sufficient statistical power) to demonstrate the influences of differences in genetic makeup and dietary patterns on health parameters. Animal models with defined genetic backgrounds should support this research in a mechanistic manner.
- Launch new case control and cohort studies with optimal and harmonised designs and operating procedures.

Understanding the mechanisms and underlying factors in the development of diet-related chronic diseases

- Identify the mechanisms by which different diets and dietary components influence food-reward, appetite, body weight and metabolic homeostasis. These studies should be carried out in experimental animal models and in humans (using functional NMR or PET).
- Examine the organ-specific causes and consequences of sub-clinical chronic low-grade inflammation on predisposition to developing diabetes type 2 and other chronic diseases, explore the origin of the variability amongst individuals and assess how diet, food ingredients and physical activity can prevent organ-specific malfunction.
- Identify the basis of central nervous system nutrient-signalling and its implications for regulation of energy balance and metabolic homeostasis, and determine how dietary factors relate to brain, cognitive and metabolic function and performance in various life stages.
- Define the contribution of diets on the microbiota throughout the life stages and investigate how altered microbiota compositions affect host functions and its susceptibility to diseases.
- Identify the nutritional intakes and epigenetic modifications during pregnancy, infancy and early childhood that predispose or prevent chronic diseases and auto-immune disorders later in life.

Managing chronic organ-specific diseases and malnutrition in a multimodal and integrative manner

- Better define the optimal nutritional needs and proper dietary intervention strategies according to the organ-specific metabolic abnormalities, and derive optimal organ-specific rehabilitation programmes.
- Investigate the effect of multimodal approaches to malnutrition and energy unbalance in chronic organ diseases by taking into account the various determinants of impaired organ functions.
- Study in an integrative way (including lifestyle, nutritional and environmental factor assessment) the mechanisms underlying malnutrition, energy unbalance, muscle wasting and other muscle metabolic abnormalities (brought about by inadequate physical activity, insulin resistance, hormone disturbances or micronutrient deficiencies) associated with chronic organ diseases, and identify predictive biomarkers.
- Develop scenario studies into the consequences of dietary and/or activity changes for health improvement and economics, in order to identify what can be achieved by changing the system (against the current treatment-based approaches).

Horizontal issues

Primary goal for 2020 and beyond: full integration of the research areas

HORIZONTAL ISSUES

To establish a European Nutrition and Food Research Institute to improve scientific collaboration and communication across national borders, and better integrate food, nutrition and health research throughout Europe.

The European Molecular Biology Laboratory (EMBL) with its sites in Hinxton (European Bioinformatics Institute - EBI), Grenoble, Heidelberg, Monterotondo and Hamburg has a flagship character. It has received international recognition as a leading science centre and attracts researchers from all over the world. EMBL is at the forefront of innovation and technology development and provides various services to the science community in its member states. It may, therefore, serve as a paradigm for the vision of a European Nutrition and Food Research Institute with a flagship character and its ambition of becoming a world-leading centre of sciences addressing the food-diet-health relationship.

Research in nutrition, food and health is becoming increasingly complex. It has distinct and discipline-specific requirements for analytical as well as physiological methods, including specific research procedures. Nutrition research is also driven by progress in genetics, epidemiology, biobanking, biomedicine, molecular biology, systems biology and material sciences. Food science similarly is driven by advanced analytical techniques, biotechnology and nanotechnology, material science and IT. Regulatory demands relating to health claims and novel foods regulations demand comprehensive safety assessment procedures and scientific evidence derived from human studies. Although the European research base and expertise in nutrition and food science is unique, it remains highly fragmented and, in some areas and countries, is below the critical mass needed for a sustained and competitive future.

A European Nutrition and Food Research Institute, which will address the aims and objectives of the European Research Area, should, therefore, be established to secure the present European skills for a productive development of food and nutrition research.
The mandate of this institute should be to:

— provide a platform for harmonisation and standardisation in nutrition and food research and technology, data storage and handling, and disclosure of nutrition and food research specific information as a basis for more sustained research conducted in a collaborative setting with experts from all over Europe and with inputs from leading scientists from third countries, if required;

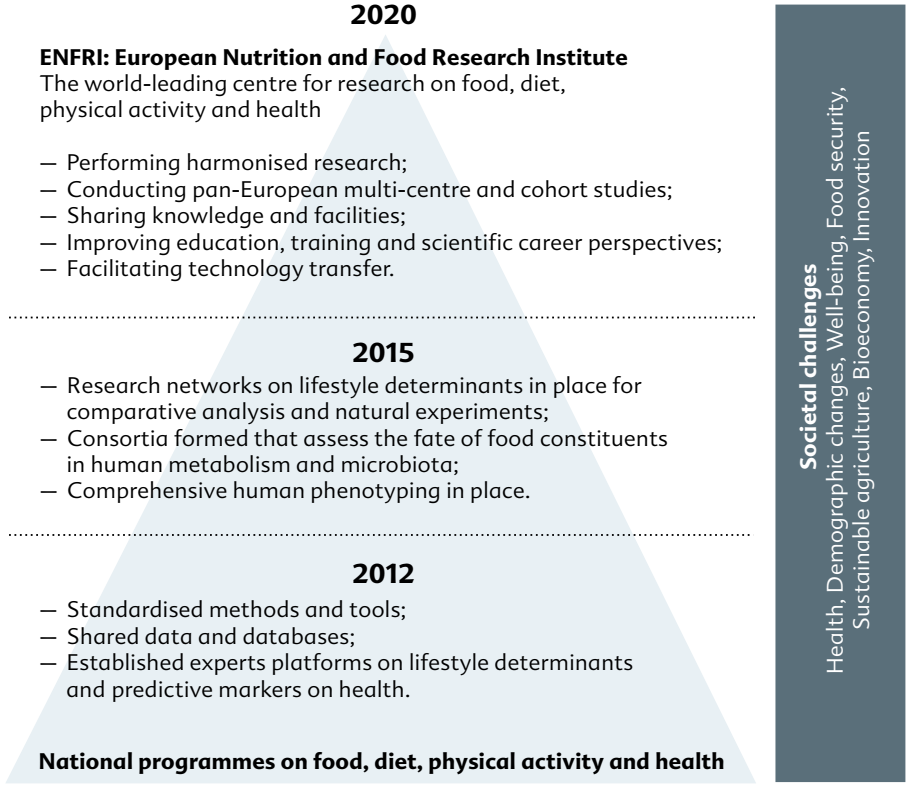
— establish, based on these standards, a sustainable European Nutrition and Health Cohort with sub-cohorts in all participating countries, becoming a critical open-access internet resource for research on health, food and prevention of related diseases from early development, including pregnancy, infancy and childhood, to adulthood and older populations;
— provide a standardised infrastructure to support and perform large multi-centre nutritional interventions with long-term follow-up throughout Europe;
— provide a vital research environment stimulating innovation in nutrition and food science; and
— provide a platform for continuous education for all stakeholders, including young researchers, experts in R&D from academia and industry with an emphasis on SMEs.

The European Nutrition and Food Research Institute can be organised as a virtual institute or network, with federated national hubs focusing on specific aspects, yet with an increasing degree of coordination. This hub structure links academic research institutes in Member and Associated States and creates a knowledge and education centre for transfer into various stakeholder groups (academia and industry) within the EU Member States and abroad (underdeveloped and developing countries). As such it would have close links and interactions with the European Institute of Innovation and Technology, in general, and with developing food and health Knowledge and Innovation Communities (KICs). The activities of the proposed Institute would complement initiatives developed through the European Technology Platform *Food for Life* and research, training, infrastructure and other activities funded through Horizon 2020 and its successors.

Within the European Nutrition and Food Research Institute, all essential components needed to perform nutrition and food-related studies including genetics, transcriptomics, proteomics, metabolomics, systems biology, functional assays, imaging technologies, food composition and food intake quantification approaches will be elaborated, alongside epidemiology, physiology, food technology, perception, sensory aspects, marketing, economics and ethics. The research methods will be tailored to the specific research needs of society, industry and policy-makers and will be embedded in an environment of standardised protocols and procedures, annotations, modular databases, networking and integrated bioinformatics.
The Institute should host these facilities as an integrated toolbox and should be committed to establish and maintain a nutritional phenotype repository and database as a publicly available data and knowledge depository that will underpin and enable integration and interrogation of data from multiple studies. As part of the institute, a flexible IT-grid should be implemented allowing distributed networking and owner-controlled data sharing between all European nutrition research centres.

Highly trained and qualified researchers are a necessary condition to advance science and to sustain investments in research. Therefore, the Joint Programming Initiative aims to initiate and coordinate joint training activities to strengthen the transfer of knowledge from the joint research projects within the domains contributing to ‘a healthy diet for a healthy life’ among universities, public health research organisations, industrial health sector, clinical sector, etc.

Figure 2
Towards a European Nutrition and Food Research Institute



Existing and new knowledge from the nutrition and health domain, such as research outputs, research methodologies, research tools, conceptual knowledge and practical experiences, will all be translated into high-quality educational materials suitable for distance learning by individuals as for international courses and workshops. Attention will also be given to promoting the training of future generations of young people in science-, social science- and technology-based skills as well as in key complementary skills required of researchers in Europe in the twenty-first century. Joint collaboration on the translation of research output to training modules guarantees that new and existing knowledge is shared and will contribute to capacity building and enhancement of future European collaborative research activities. The proposed research infrastructure will require a joint e-learning platform functioning as an online repository of e-modules within the nutritional and health domain, education and training of future nutritional researchers (BSc/MSc), starting researchers (PhD students), young professionals (e.g., as in ENLP) and professional life-long learners.

The effectiveness and flexibility of training courses and curricula development will be enhanced by developing professional, evidence-based, distance learning modules of high educational quality, consisting of, for example, interactive exercises, tailored feedback, and (a)synchronous collaborative learning activities. The use of current technological and multimedia possibilities will contribute to sustainable dissemination of knowledge, advancing the innovation of learning and the translation of knowledge to practice. In addition to these, the network will ultimately set standards for European curricula and degrees in nutrition, balancing the scientific disciplinary specialisations relevant to scientific advancement (as represented in the JPI) including the knowledge translation from these domains to applications in nutritional practice and health policy.

The European Nutrition and Food Research Institute should be built on established and vital science networks derived from EU-funded FP7 and Horizon 2020 programmes

and should have the aim of extending into countries thus far not, or only partly, involved in pan-European activities. The Joint Programming Initiative will allow a sustainable continuation of the initiatives, respecting national strengths and federating these into an institution that can harmonise nutrition, food and health research to benefit the European research landscape, the food industry as well as the public.

To establish an European Nutrition and Food Research Institute, the following actions are required.

- To formulate a Vision paper with goals, structure, content and governance for such an institute. Include issues on resources and membership.
- To establish a Promotion and Dissemination Group that takes the concept into all stakeholder circles and organisations for discussions (JPI, ETP, KIC, national funding agencies) and onto the political level of the European Parliament and the European Commission.
- To analyse critical infrastructure needed and develop strategies for research pooling.
- To standardise study procedures and study designs for a harmonised data collection in all relevant disciplines.
- To establish processes for secondary analysis of open-access data.
- To monitor and distinguish one-off surveys (however large and complex) from ongoing nutrition surveillance. One-off research-orientated surveys should be replaced by ongoing surveillance with a public health basis as distinct from one which has an academic/research underlying philosophy. This will facilitate the free (i.e. having no Intellectual Property issues) availability of a standard dataset on an ongoing basis for trend analyses and identification.
- To ensure that research outputs are managed appropriately to optimise their impact across a wide range of areas; for example, that they are used to underpin economic and industrial policy to ensure economic growth and development of the European food and drink industry; and used to underpin improvements in nutrition, physical activity and public health policies where relevant. The outputs and impacts of the investments will require monitoring, benchmarking and assessment regarding value for money according to agreed metrics.
- To give particular attention to the transfer of knowledge into policy and application-oriented projects. The ongoing dissemination of evidence-based guidance to policy-makers and service providers from the Joint Programme will be very valuable. Options will be periodic reports or seminars (including those that are web-based) which will translate the knowledge garnered from the programme's work into initiatives and products that promote healthy food choices. There should be a clear tie-in with the Health and Food sectors in the Member States.
- To establish a working group that will discuss and implement the recommendations of the study on the need for food and health research infrastructures. The European Commission launched a call for such a study in 2011 (FP7-KBBE-2012-6).

To create a European knowledge hub on research activities in the food, nutrition and physical exercise areas that relate to human health

It is an essential prerequisite for joint programming and all research carried out within the three thematic areas highlighted in this SRA to be aware of programmes already implemented in the Member States and their non-confidential results. Although there are some national research activities with high international visibility, a much larger number of nationally-funded projects (with a broad diversity of underlying structures, organisational and financial frameworks, and evaluation criteria) is generally unknown to stakeholders

(even at the national level). In addition to EU Framework and infrastructure programmes, it is essential to collect information and build an inventory on national funding programmes that target agricultural and upper food chain research as well as food/ingredient research in view of human health and identify areas in which coordinated programmes would add value. This inventory should go beyond the FAHRE project and requires a standardised assessment tool for defining the core and boundaries of the research areas assigned to the food, nutrition, lifestyle and health research. This inventory should combine the information provided by Member States as a 'top-down' approach and, that from scientists as a 'bottom up' approach, along the three research areas described. This would offer the most effective way of identifying ongoing activities that easily can be translated into joint programmes that cross national borders. As part of the knowledge hub activities, continuously analysis of critical infrastructure requirements is needed, alongside the development and execution of improved strategies for research pooling. Processes for secondary analysis of open-access data must also be established. The knowledge hub of the JPI should include data from foresight reports and activities, from the Strategic Research Agendas of relevant European Technology Platforms and joint reports of European Technology Platforms (e.g. BECOTEPS white paper), from relevant Knowledge and Innovation Communities of the EIT, COST and ESF activities, and relevant information from third countries and regions outside Europe to ensure the highest level of transparency and knowledge transfer into the JPI and the Member States, and to ensure that experience and best practice is effectively and efficiently captured, and disseminated for adaptation and use within Europe.

To improve education, training and scientific career perspectives in the food, nutrition, lifestyle and health areas

JPI activities go beyond the classical borders of scientific disciplines. Diversification and specialisation are intrinsic features of modern sciences. Yet, solving problems as in the area of human health, nutrition, food and lifestyles requires trans-disciplinary competence and a better understanding of the different science cultures (biosciences, social and cultural sciences). The success of the JPI across its three research areas will strongly depend on the proper education and training of experts and junior scientists in complementary skills (including communication, ethics, optimising the impact of research and having an awareness of the requirements of different stakeholder communities for research outputs).

A particular concern is that highly specialised sciences with high impact publications have established ranking and incentive systems, whereas the multidisciplinary approaches and knowledge translation areas in most cases cannot measure up to these. To ensure that the research areas covered in this JPI are attractive for the best students and scientists, the reputation of the science disciplines needs to be improved. This means that a proper 'mind-set' is a prerequisite for successful joint programming crossing the classical borders of science disciplines. This also applies to science career perspectives and to the mobility of the European researchers. One of the most important goals of the JPI *A healthy diet for a healthy* life should be to foster, encourage and promote this new mind-set, and to enable the best education and training for future generations of scientists and technologists. Although the European Institute of Nutrition and Food Sciences (goal 2020) will be the ideal setting to ensure this to happen, this JPI should meanwhile take all necessary measures to compile an inventory of necessary skills and knowledge, exploit the various programmes available in Europe and define a pan-European project for continuous education in the research areas targeted to scientists in academia and experts in industrial R&D. All people in the food chain area have a responsibility to promote and disseminate the challenge, excitement and societal importance of a career in these areas. This should extend to primary and secondary education so as to engage scientists and technologists of the future; provide examples of entrepreneurial activities that are crucial to underpin and drive Europe's global competitiveness, economic development, create new jobs and benefit society.

A Knowledge and Innovation Community (KIC) on food could help the food sector to turn global challenges into business opportunities by building upon six E's: education, excellence, entrepreneurship, end-users, exploration and Europe. A food KIC could become world-leading on science and a strong collaborative partner with high-quality universities and research centres, worldwide. Additionally, a food KIC could become instrumental in fostering best practice, becoming the frontrunner for the rest of the European food sector.

To improve communication, knowledge and technology transfer

The impact of the JPI *A healthy diet for a healthy life* will, to a large degree, depend on the effectiveness of communication and the exploitation of the outcomes of research programmes. Best practices in communication and the exploitation of innovative communication techniques will be promoted and supported. Transfer of knowledge and technology is the driver for innovation and is a key focus for improvement.
Within the overall context of this JPI, communication is important across all its areas, within the management and administration structures and with and between individual stakeholder communities. Transfer of technology and knowledge to all stakeholders whilst ensuring IP protection, are necessary tools for establishing and promoting cross-disciplinary research and the transfer into various application areas. A relationship of trust and mutual confidence between individuals and organisations is a prerequisite for successful knowledge and technology transfer, and this is especially true when the pursuit of knowledge and its subsequent transfer and delivery crosses national borders.

In addition to being a key requirement of effective management and administration, communication is important to optimise interactions between themes, to enable stakeholders to gain the maximum benefit from ongoing activities and to ensure that policy-makers, opinion formers and the general public are regularly updated. It is essential to understand that the effective communication of food-related issues depends on designing different patterns of communication aimed at capturing the diverse sensitivities and priorities of stakeholders involved in the knowledge process. Validated strategies will be adopted to ensure optimal impact across the members of the food chain and the general public.
The heterogeneity of European consumers (age, eating habits, income, education, awareness and understanding of healthy eating campaigns, language, dietary patters, religious and ethnic cultures that impact of their diets, etc.) requires that communication be targetted effectively at each different sub-population and that a 'one size fits all' approach will be ineffectual and waste human, time and financial resources. The optimised effective information dissemination and, hence, to maximise its impact will require the active collaboration with journalists, use of electonic and social media, and communication and dissemination experts.

Other European initiatives on food and health

As a new initiative, the JPI has brought together experts from various science disciplines to develop a common vision, define the measures that need to be taken to reach the goal to improve consumer's health in Europe, create a coordinated and vital European Research Area and, thereby, improve the competitiveness of European industries and academia.
Through its representatives on the Scientific Advisory Board and its management levels, the JPI represents a network spanning many Member States and all relevant scientific, technological and business areas. Yet, knowledge transfer into the JPI from national, European and global sources as well as knowledge transfer from the JPI to its stakeholders are crucial for the 'added value' intended and for minimising duplication efforts. The JPI is, therefore, committed to interacting as effectively as possible with all European initiatives and programmes for optimal information flow and transparency.

Annex – Members of the Scientific Advisory Board

Chair: Prof. Dr Hannelore Daniel

Research area: Determinants of diet and physical activity
- Prof. Dr Knut-Inge Klepp, The Norwegian Directorate of Health, Oslo, Norway
- Prof. Dr Michael J. Gibney, UCD Institute of Food & Health, University College Dublin, Dublin, Ireland
- Prof. Dr Lynn Jayne Frewer, School of Agriculture, Food and Rural Development, Newcastle University, Newcastle upon Tyne, United Kingdom
- Prof. Dr Chantal Simon, University of Lyon, Centre Hospitalier Lyon Sud, Pierre Benite, France
- Prof. Dr Mikael Fogelholm, University of Helsinki, Helsinki, Finland

Research area: Diet and food production
- Prof. Dr Willem de Vos, Wageningen University, Agrotechnology & Food Sciences, Wageningen, The Netherlands/Finland
- Prof. Dr Francisco Tomas-Barberan, Consejo Superior de Investigaciones Científicas (CEBAS), CEBAs-CSIC Campus Universitario de Espinardo, Murcia, Spain
- Prof. Dr Per Åman, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden
- Prof. Dr Riitta Korpela, University of Helsinki, Helsinki, Finland
- Prof. Dr Chiara Tonelli, Università degli Studi di Milano, Milano, Italy

Research area: Diet-related chronic diseases
- Prof. Dr Arne Astrup, Department of Human Nutrition, Faculty of Life Sciences, University of Copenhagen, Frederiksberg, Denmark
- Prof. Dr Hannelore Daniel, Technische Universität München (TUM), Freising-Weihenstephan, Germany
- Prof. Dr Nick Wareham, MRC Epidemiology Unit, Institute of Metabolic Science, Addenbrooke's Hospital, Cambridge, United Kingdom
- Prof. Dr Carlos Dieguez, University of Santiago de Compostela, Facultad de Medicina, Santiago de Compostela, Spain
- Prof. Dr Aldona Dembinska-Kiec, Jagiellonian University, Medical College, Krakow, Poland

Chair Management Board: Prof. Dr Wim Saris

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- Dr Jeanet Bruil, ZonMw, The Hague, The Netherlands
- Valesca Kuling MSc, ZonMw, The Hague, The Netherlands
- Casper Zulim de Swarte MSc, Agentschap NL, The Hague, The Netherlands

Editors
- Prof. Dr Hans Brug, VU University Medical Center, EMGO Institute for Health and Care Research, Amsterdam, The Netherlands
- Prof Dr Roger Fenwick, Norwich, United Kingdom
- Valesca Kuling MSc, ZonMw, The Hague, The Netherlands
- Dr Jacqueline Castenmiller, NVWA, Office for Risk Assessment and Research, Utrecht, The Netherlands

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