Brussels, 13 April 2018

COST 050/18

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "European Topology Interdisciplinary Action" (EUTOPIA) CA17139**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action European Topology Interdisciplinary Action approved by the Committee of Senior Officials through written procedure on 13 April 2018.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA17139
EUROPEAN TOPOLOGY INTERDISCIPLINARY ACTION (EUTOPIA)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. “Rules for Participation in and Implementation of COST Activities” (COST 132/14 REV2);
b. “COST Action Proposal Submission, Evaluation, Selection and Approval” (COST 133/14 REV);
c. “COST Action Management, Monitoring and Final Assessment” (COST 134/14 REV2);
d. “COST International Cooperation and Specific Organisations Participation” (COST 135/14 REV).

The main aim and objective of the Action is to understand the interplay between a system's topological state and its physical properties to pave the way to deeper comprehension and improved manipulation capacities of relevant molecules and materials, be that natural or human-made, with remarkable consequences on fundamental science and technology. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 44 million in 2017.

The MoU will enter into force once at least seven (7) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14 REV2.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14 REV2.

OVERVIEW

Summary
The physical properties of many systems, ranging from naturally occurring biopolymers to artificial materials, often crucially depend on those global features that cannot be ascribed to a particular geometry or arrangement, rather to a more abstract notion: topology. The latter manifests itself in the knotted state of proteins and artificial polymers, the intertwining among DNA rings, or the topologically distinct classes of defect lines that can be found in liquid crystals. A better understanding of the interplay between a system's topological state, its three-dimensional structure, and its overall characteristics paves the way to an improved control of relevant natural molecules or human-made materials, with remarkable impact on fundamental science as well as high-tech applications. These goals, however, can only be achieved through a multidisciplinary effort, involving a wide spectrum of expertise in a concerted manner.
The EUTOPIA COST Action will establish a collaborative platform to approach all those problems, in the study of biological and soft matter, that feature topological characteristics. In doing this, it will create a pan-European, synergistic network of researchers from different fields that will overcome geographical, economical and societal barriers, as well as those naturally surrounding traditional academic communities. The outcomes of the research carried out thanks to the EUTOPIA Action will push forward the boundaries of our current understanding of key systems, and foster the knowledge transfer of scientific findings to industry and, ultimately, to society as a whole.

Areas of Expertise Relevant for the Action	**Keywords**
● Physical Sciences: Biophysics ● Physical Sciences: Soft condensed matter (e.g. liquid crystals) ● Mathematics: Topology	● Topology in soft matter ● Entanglements in (bio)polymers ● DNA and chromatin ● Fundamental and computational methods in knot analysis

Specific Objectives
To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination
● Develop new techniques to introduce non-local objects such as knots and links in the framework of the field theory used to describe fluctuating filaments, and develop new mathematical tools to classify, quantify and examine entanglements of periodic weavings and nets.
● Introduce new, topologically inspired definitions and algorithms to characterise physical entanglement, accompanied by the design of a suite of computational utilities and data structures to be used by the whole community, to facilitate the analysis and exchange of data.
● Investigate spontaneous knotting, linking and weaving of filamentous systems (including proteins and DNA) in dilute and concentrated conditions, their impact on physical properties, and possible ways to control them.
● Design, develop and apply computational models to predict the folding of knotted proteins, study multiply entangled proteins, and move towards the engineering of artificial self-entangled proteins.
● Investigate the effect of topological constraints in biological systems, e.g. in genomic organization of eukaryotes and prokaryotes or in topologically complex organelle membranes.
● Find the physical conditions that drive the formation of knotted / linked defects in liquid crystals, and how to combine them with more general frustration effects in LCs to design multi-scale tunable photonic superstructures.
● Publish a dedicated special edition of a Q1 journal reviewing the state of the art in the field. This will help introduce the Network to the broader scientific community.
● Extensively employ short-term scientific missions (STSM) to promote collaborations among participants.

● Hold annual meetings, workshops, summer schools and think-tanks with stakeholders to coordinate research directions and adjust short-term objectives.
● Create an exploitation board to identify and contact the most relevant experimental groups and industrial partners whose participation would strengthen the network. Organize sandpit meetings to identify common areas and goals of interest and establish the pathways through which these goals can be reached.

Capacity Building
● Organise training and summer schools led by the WG leaders to disseminate and promote exchange of skills/knowledge across members of the Action, with particular attention to ITCs.
● Organise meetings for Early Career Investigators (ECIs) and PhD students to acquire transferable skills such as grant writing, communication, time-management as well as to encourage direct collaborations among ECIs.
● Give visibility to PhD students and postdocs, particularly women, by funding their attendance at conferences in which they can promote their Action-related work.
● Give responsibility to ECIs and ITC researchers in order to make them grow professionally, thereby helping establish the next generation of research leaders.
● Organise schools and conferences in ITCs and foster frequent exchanges and short-term scientific stays of research groups from such countries in top European research centres to help increase their visibility and capacity.
● Establish platforms for the communication and diffusion of job and funding opportunities, within the community and outside (e.g. industry, private sector).

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. CHALLENGE

1.1.1. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

Linear fibres are fundamental building elements in the biological world: following the same principles from the molecular to the visible level, nucleic acids, amino acids, proteins or polysaccharides associate into polymers and bundles which are organized to form the macroscopic world around us. Fascinatingly, and unbeknownst to many, these nano- and microscopic fibres can become entangled, form knots and links, and be weaved much like macroscopic ropes and threads. Cell- and micro-biology provide many examples. Knots and links have been found embedded in the structure of several proteins; although their function here is far from understood, the topological state of the polypeptide chain represents a novel degree of freedom to employ in the engineering of artificial enzymes for pharmaceutical and industrial applications. The mitochondrial DNA of kinetoplastida, a group of flagellated protists, is formed by thousands of mini-circles linked to one another to form a large interconnected network, which is a primary pharmaceutical target in the treatment of some important tropical diseases. The stratum corneum, which forms the protective layer of mammalian skin, is a woven network of fibres. In other cases, the absence of knots and other entanglements is itself the manifestation of an underlying organization. That is the case of DNA in the cell nucleus: this can be naively seen as a very thin 2 metres-long rope "stuffed" into a box with linear dimensions of the order of 10 micrometres. Clearly, such a situation should generate many knots and entanglements, which nonetheless must be prevented by cells in order to function and replicate. A similar situation is to be found outside the realm of living matter. In recent years, in fact, great interest in the design of next generation materials has emerged: thanks to advancements in computational as well as in experimental techniques, physicists, chemists and engineers have been able to demonstrate the impact of knots, links, networks and other global entanglements in systems ranging from knotted molecules to artificial polymers and gels. Knotting and entanglement of defect lines in the orientational fields of liquid crystals and flow fields of simple fluids were also identified.

In all the cases presented above, the types of entanglement can be characterised in terms of the kind of knots, links, or textures. These properties are independent of the specific geometrical details of the system and can be formally defined within the context of their abstract “topological” state, i.e. the state that is conserved upon smooth deformations. It appears thus evident that topology underlies two fundamental challenges of current research. i) Understanding the architecture, function, and evolution of complex, self-assembling biological structures ranging from proteins to chromosomes and supra-cellular networks; and ii) designing novel soft materials with tunable physical and functional properties. Unfortunately, the deeply interdisciplinary nature of the problem as well as the presence of economical and geographical barriers has led to the formation of a series of scattered, mostly disconnected research groups all over Europe. It is therefore the aim of this Action to **overcome these barriers**, creating an interdisciplinary network of researchers encompassing the fields of physics, chemistry, molecular biology, mathematics and engineering. Bringing together this complementary expertise **will result in a substantial boost** to the capacity of the European scientific community to investigate the fundamental connection between the topological state of a system and its behaviour, properties, and function. The **EUTOPIA** (EUropean TOPology Interdisciplinary Action) COST Action will reach this aim by:

1. Providing a platform for the interaction, cultural exchange, and the **cross-pollination of science** necessary to overcome the boundaries of the respective fields. Particular attention will be devoted to the interchange of information and knowledge between experimentalists and theoreticians.

2. Enabling the Europe-wide community devoted to topological aspects of soft and biological matter to acknowledge itself as a unique inclusive, collaborative, and thriving research field with an **unprecedented scientific and societal impact potential**. Investing in the development of young researchers and in achieving gender as well as geographical balance, with particular attention to inclusiveness target countries (ITCs), will pave the way to the creation of a healthy and inclusive research community.

3. Facilitating the development and dissemination of ideas, methods, and knowledge in society through open access outlets and outreach activities, as well as the exchange of ideas and expertise between academia and the industrial sector.

1.1.2. RELEVANCE AND TIMELINESS

The past decade has seen striking experimental and theoretical advancements in the fields of biophysics and material science. On the biophysics front, the development of chromosome conformation capture techniques, such as HiC and super-resolution imaging, now permits researchers to probe the organization of chromosomes in unprecedented detail, while single-molecule manipulation techniques and computer aided theoretical studies have conspicuously increased our understanding of DNA and proteins. In material science, optical traps, colloid manipulation techniques and single-molecule experiments are opening up the possibility of creating self-assembling materials, often inspired by Nature, at scales ranging from those of single proteins (i.e. nanometres) up to microns. DNA origami, colloidal suspensions and novel liquid crystals (LC) nano- and micro-structures with complex topologies and unique mechanical and optical properties have been theorized and experimentally realized.
Each of these breakthroughs has triggered immense interest for their possible technological applications. The emergence of DNA sequencing techniques holds the promise for the development of personalized nano-medical treatments that could cure millions. The first examples of computer-aided protein design paves the way to applications ranging from the development and use of novel enzymes, to scaffolds for smart materials and nano-reactors. DNA origami and patchy colloids are making possible the creation of complex nano- and micro-scale self-assembling architectures which could be used as super-strong materials, or even micro-factories in which chemistry takes place. Topologically complex liquid crystals are among the most promising materials for advanced soft photonics applications.
These advances have also highlighted the role of topology in bio- and soft materials and the importance of modelling and controlling it to improve our understanding and to realize the aforementioned applications. The wealth of experimental data calls for new theoretical ways to characterize entanglements and other topological aspects; at the same time progress in this direction will allow the control and tuning of topological structures in complex systems, permitting the scale up of self-assembling materials to sizes relevant for technological applications and to make their production more reliable.
The impact of research on topological properties of (bio)materials is therefore at a turning point. Until now, much of the theoretical and computational work has laid down the fundamentals for what will happen in the next years, when real-life applications will take advantage of the existing knowledge and discoveries. Therefore, **creating a collaborative platform is a crucial step to establish a systematic approach to investigate topological soft materials**, which will lead the researchers of the EUTOPIA Network to unravel some of the hottest questions both in soft matter and biophysics, with potentially momentous technological and societal impact.

1.2. OBJECTIVES

1.2.1. RESEARCH COORDINATION OBJECTIVES

The Action will build a synergistic network in which researchers and industrial partners will exchange knowledge and skills that have historically been isolated within different fields and/or countries. In turn, this will enhance the overall capacity of Europe to address specific problems in biological and soft matter. Finally, the possibility to organise workshops and think-tank meetings will aid connection and communication both between academics and also, importantly, with industrial partners, thereby bridging the gap between fundamental discoveries and application to real-world problems. The following coordination objectives are planned.

- A kick-off meeting to decide the details of the tasks to be performed by each Working Group (WG). This will start the initiatives across the network and will allow groups to become a solid community with a supportive and committed spirit.
- A dedicated special edition of a Q1 journal reviewing the state of the art in the field. This will help introduce the network to the broader scientific community.
- Short-term scientific missions (STSM) will be extensively used to promote collaborations among participants.
- Annual meetings, workshops, summer schools and think-tanks with stakeholders will be held to coordinate research directions and adjust short-term objectives.
- An exploitation board will be created to identify and contact the most relevant experimental groups, international partners, and industrial partners whose participation would strengthen the network. Sandpit meetings will be organized to identify common areas and goals of interest and establish the pathways through which these goals can be reached.
- An open-access website will allow the general public to browse through the Action's activities and access the articles and data produced by the research groups.
- A private online platform accessible to Action participants will include a mailing list, a scientific wiki, and databases to help with the coordination of the network.
- A dissemination board will coordinate outreach activities dedicated to the general public. These will include dissemination of multimedia content and collaborations with schools and museums.

1.2.2. CAPACITY-BUILDING OBJECTIVES

The network aims at building and consolidating a pan-European community of researchers focussed on understanding topological problems in biological and soft matter. It will start collaborations that will foster world-leading research and guide European young investigators to become the next generation of research leaders. This will be practically realised by:

- Organising training and summer schools led by the WG leaders to disseminate and promote exchange of skills/knowledge across members of the Action, with particular attention to ITCs.
- Organising meetings for Early Career Investigators (ECIs) and PhD students to acquire transferable skills such as grant writing, communication, time-management as well as to encourage direct collaborations among ECIs.
- Giving visibility to PhD students and postdocs, particularly women, by funding their attendance at conferences in which they can promote their Action-related work.
- Giving responsibility to ECIs and ITC researchers in order to make them grow professionally, thereby helping establish the next generation of research leaders.
- Organising schools and conferences in ITCs and fostering frequent exchanges and short-term scientific stays of research groups from such countries in top European research centres to help increase their visibility and capacity.
- Establishing platforms for the communication and diffusion of job and funding opportunities, within the community and outside (e.g. industry, private sector).

1.3. PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

1.3.1. DESCRIPTION OF THE STATE-OF-THE-ART

Topology and topological concepts have slowly permeated the broad fields of soft and biological matter in the past decades, affecting a significant number of systems and a correspondingly large number of investigation techniques. Despite this, a coordinated effort to study the emergence and impact of topological entanglement in soft and biological matter has never been undertaken, and research is still performed across different, often non-communicating subfields/groups. The most relevant research areas of interest for EUTOPIA are summarized hereafter.

Theory of topological entanglement in polymers and fibres. The mathematical definitions of knots, links and networks are of a purely topological nature, in that different geometrical realizations of these entanglements constitute equivalent classes under a particular set of transformations, called ambient isotopies. The geometric details of the particular realization of these objects are irrelevant and the classes can be identified by using some topological invariants such as the Jones and HOMFLY polynomials [Kau01]. Hence, mathematically no knot, link or network can be defined on finite open strings, as these can be transformed continuously to a set of straight lines. This is clearly at odds with

what is observed in physical systems where knots in linear strings – like shoelaces or earphones cables – are not only possible but even abundant [Mic11]. To overcome this impasse, physicists have started investigating possible ways to define physical knots and links. These include closure schemes to circularize linear chains, thus allowing the evaluation of standard polynomial invariants, as well as the definition of novel mathematical entities, e.g. virtual knots. Nevertheless, there are obstacles to the identification of the topological state when the physical structure of a knot is either loose or highly entangled, due to the uncertainty related to closure schemes and the computational time required to evaluate polynomial invariants. In the field of experimental biology, the progress in the detailed probing of chromosome arrangement is calling for new theoretical ways to characterize the inter-chain entanglement in dense solutions of linear polymers, so as to better understand and predict the resulting kinetic, rheological and mechanical properties, which all come into play in the cell cycle. The recently introduced concept of physical link holds much promise for becoming, together with the classic primitive path analysis, the method of choice for such quantitative profiling of inter-chain entanglement. Finally, a fundamental area that has barely been broached is the topological characterization of branched graphs, which naturally arise in the network of chemical bonds in cross-linked polymers. While research on the effect of knotted topology in polymers [Fer02] and other soft matter systems [Lim15,Hor16,Tka11] is well under way, the generalization of such concepts to branched topological networks is still in its infancy.

Polymeric and fibrous topological materials. To date, various strategies have been developed to control the topology of polymeric systems, be they natural or synthetic, which mostly differ for the range of involved length scales, as well as the degree of deterministic control on the target topology and geometry. One such strategy is the design of novel molecular constructs with preassigned complex topologies. In this direction, considerable progress has been made in recent years thanks to advancements in synthetic supramolecular chemistry [Luk05]. These techniques have in fact demonstrated the feasibility of self-assembling molecules containing complicated knots. The most complex to date is an eight crossings knot that had previously been predicted theoretically. The constructs obtained in this way all share a very precise geometry, which is important for their use in chemical applications. Such fine level of control is not achievable at more mesoscopic scales, and specifically those relevant for materials based on gels or melts of polymers. The physical behaviour of such systems can be tuned by varying the statistical balance of linear and circular forms of the polymeric constituents. Among these, the limiting case of ring melts [Mcl02], which are entirely formed by unlinked cyclic polymers, is studied with increasing attention for its atypical properties. These arise from the fact that rings, lacking free ends, cannot move relative to each other by reptation like their linear counterpart, but only by threading through one another [Ros14]. This results in a very sensitive dependence of the rheological and relaxation properties on the melt density, and it will be crucial to devise practical ways to control it. Besides the case of synthetic polymer melts and gels, of particular interest are woven networks of fibres found in nature, such as microbial biofilms, three-dimensional skin cells networks and cellulose fibres. These complex arrangements exemplify how the woven character of biological materials is critical: structure and function come not only from the standard association and interaction of the elements, but also the tangling and interdigitation of the fibrous architecture and the resulting tensional forces.

Entangled and self-entangled proteins. With about 1% of all structures stored in the Protein Data Bank (PDB) found to have knots, it is now evident that proteins are a prime example of a natural, self-entangling system [Lua06,Mel10,Lim15]. The main aspects of interest in the study of knotted proteins are the functional role of the knot, the evolutionary pathways by which knotted protein structures have evolved, and the specific features of how these proteins fold in the presence of self-entanglements. In fact, if it is already challenging to determine how “regular” unknotted proteins fold, it is even more formidable to do so for knotted proteins. Computational studies have helped shed light on the processes that lead to the formation of a knot in some, typically small knotted proteins. Considerable help has also been provided by central repositories like the PDB and the dedicated web-servers that have made the challenging task of identifying knots in proteins accessible to non-experts. Recently, a new class of topologically entangled proteins, dubbed lasso proteins, has been identified, in which the entanglement originates from a loop stabilized by a covalent link in the form of a disulfide bridge [Dab17]. Furthermore, supramolecular entanglements among proteins have been detected, which cover a non-negligible fraction (~9%) of the multimeric structures stored in the PDB. In the experimental area, it has been shown that the structural complexity associated with the knotting process is responsible for slow folding rates, and the first artificially knotted protein has been created by fusing a homo-dimer. The latter represents an impressive achievement in terms of protein engineering, and paves the way for the pharmaceutical application of knotted proteins [Qiu06,Chr16].

DNA, chromosomes, and other entangled genetic material. Nature presents fascinating examples of genetic biomolecules and biomaterials ruled by topology: (1) The most “extreme” one is probably the DNA inside the cell nucleus, whose packing density makes it prone to attain an intricate, self-entangled structure [Cor16]. (2) The mithocondrial DNA of the organisms of the class *kinetoplastida,* called kinetoplast DNA (kDNA). This system is formed by thousands of DNA minicircles linked into a precise network, and is an important target of drugs aiming at killing the disease-carrying organism. (3) Viral DNA, whose level of confinement is so large that the biopolymer is often found heavily knotted [Mic11]. Indeed, the topological organisation of nuclear DNA is deeply related to issues of great practical relevance such as genetic diseases, ageing and cancer [Jos17]. Whereas these problems date back to M. Delbrück [Del62] and Vinograd [Vin65] who introduced concepts like DNA knotting and supercoiling, only recently has their investigation gained momentum thanks to the overcoming of technological limiting steps [Ple16]. In both bacterial and nuclear context, strong topological constraints are related to genome packaging and influence molecular processes such as transcription and replication [Lav14]. In this context, novel and powerful experimental methods (chromosome conformation capture, genome architecture mapping, super-resolution microscopy, next-generation sequencing…) have just started to unveil the strong link between topological arrangement and biological function. Yet, the interpretation of these experimental data appears often problematic, hence posing the key conceptual challenge of the next few years: it requires, in fact, expertise in generic topological problems in polymers, computational and theoretical physics, as well as molecular and cell biology/biochemistry.

Topologically complex fluids. Topological defects in a bulk orientational field in liquid crystals (LC) appear as unstable structural imperfections in the form of defect points, lines, or closed loops [Ale12]. They are stabilized by a frustration due to the competing effect of chirality (blue phases), or by the presence of complex confining geometries like colloidal dispersions or by the inclusion of the LC in confining matrices (thin layers, drops, shells). From the materials perspective, a recent major result in liquid crystals is that multiple micro, sub-micro, and nano-structures with unique properties have been experimentally realised, including 1D, 2D, 3D nematic colloidal crystals, disclination entangled structures, field and material micro-knots, optically imprinted states, and confinement & chirality conditioned defect structures [Tka11,Sen13]. These new soft superstructures based on LCs are fundamentally topological in nature and their stability is based on minimization of elastic deformations of the LC's molecular order. This supports self-assembly properties and high resistance of micron scale structures against thermal fluctuations. Such complex constructs in liquid crystals are strongly birefringent and are characterized by the spatial variation of their birefringence, typically at optical wavelengths. All this has triggered immense interest and potential for soft photonic applications.

1.3.2. PROGRESS BEYOND THE STATE-OF-THE-ART

EUTOPIA will advance the state of the art by bringing together experts from very different fields currently studying topological entanglement to form a new pan-European community. The complementary, multidisciplinary expertise of the participants in computational and theoretical physics, chemistry, biology and mathematics, organized in a coherent way to tackle the fundamental problems related to topology, will boost each of these research areas, thanks to a unified view of topological problems and a collaborative approach. In particular, the Action will focus on the following points.

Theory of topological entanglement in polymers and fibres. A unification of the various aspects of topological entanglement in soft matter, chemistry and molecular biology will only be made possible by advances in the study of the underlying theoretical problems. These include the definition and characterization of physical knots, links, branched graphs and networks. Such an effort will require a combination of expertise in formal mathematical topology and the foundations provided by experience in physical and biological systems. The following points are particularly urgent for the development of the field.

1. The systematic development, implementation and application of efficient methods to profile the physical knotting and linking of long polymers in various types of spatial confinement.
2. The introduction of new, topologically inspired definitions and algorithms to characterize physical entanglement will be accompanied by the design of a suite of computational utilities and data structures to be used by the whole community, to facilitate the analysis and exchange of data.
3. The great majority of the research in this field has been performed numerically due to the great difficulties of introducing non local objects such as knots and links in the framework of the field theory used to describe fluctuating filaments. The Action will develop novel methods to overcome this limitation.

4. While the entanglements of finite loops (knots and links) have been explored from various perspectives within knot theory, the properties of weavings and networks (where nodes are shared by multiple filaments) are just beginning to be investigated. It is of fundamental scientific interest to develop tools to classify, quantify and examine entanglements of periodic weavings and nets.

Polymeric and fibrous topological materials. The Action will pursue two main strategies to advance the state of the art in controlling the topology of molecular constructs or polymer-based systems. On the one hand it will directly explore novel setups that can promote the formation of new types of knotted and linked states. On the other hand it will explore new ways, largely based on single-molecule setups, that can extend the scope of current methods (almost exclusively based on gel electrophoresis) for profiling the entanglement state of filamentous systems. This latter step is, clearly, a required complement of the first. These two lines can be broken down in the following goals:

1. Advance the understanding of the physical properties that determine which topologies (knots and links) can be realized in supramolecular constructs.
2. Clarify the spontaneous knotting, linking and weaving of filamentous systems (including DNA) in dilute and melt conditions, and their impact on physical properties.
3. Understand how the above-mentioned entanglement properties can be statistically controlled externally (e.g. by spatial confinement, temperature gradients etc.)
4. Suggest novel setups of single-molecule experiments, such as nanochannels and nanopores, that can extend the scope of current gel electrophoretic methods for topological sorting.

Entangled and self-entangled proteins. To date, a number of *in silico* studies have been performed on knotted proteins, based on a diverse set of theoretical models and computational algorithms. However, most of these studies have focused on proteins displaying knots with the simplest trefoil topology. Researchers involved in EUTOPIA are committed to push this investigation further, by exploring the folding mechanism of proteins with knots with more complex topology. A few questions to be addressed are in order: Are non-native interactions essential to drive the chain towards a complex topology? Is it possible to predict the changes in the protein primary sequence which are likely to lead to more complex topological structures? While most studies performed so far focussed on the knotted structure of native proteins, a number of related yet largely unexplored issues, which will be addressed within the proposed COST Action, concern the emergence and the implication of topologically non-trivial structures in protein misfolded states and in natively unstructured proteins. Tackling these and many other problems requires the development and application of advanced algorithms in order to overcome the underlying outstanding computational efforts, and of more accurate coarse-grained models of globular intrinsically disordered proteins to allow for larger statistics, longer time scales, and thorough studies of their topological properties. The EUTOPIA COST Action will aim at the following goals:

1. The development and application of computational models with systematically increasing detail to predict the folding of knotted proteins from a molecular viewpoint.
2. The computer-aided design of self-entangled proteins and their *in vitro* validation.
3. *In silico* studies moving forward from single knotted proteins to multiple entangled proteins.
4. The development of accurate coarse-grained models of intrinsically disordered proteins to allow for larger statistics, longer time scales, and thorough studies of their topological properties.

DNA, chromosomes, and other entangled genetic material. DNA represents one of the core systems whose topological properties will be studied in the course of the proposed EUTOPIA Action. Specifically, two forms of DNA-based materials will be at the centre of the Network's interest, namely kinetoplast DNA and chromatin. The evolution, formation and replication of kinetoplast DNA is a largely unsolved mystery, and presents many opportunities for technological applications. Taking inspiration from the topological and elastic properties of the kDNA, researchers in EUTOPIA aim at studying models of networks of randomly linked rings with non standard mechanical properties. An important issue that will also be explored is the effect that confinement can have on the topological properties of the formed networks and use the results obtained on this controlled system to infer about properties of nuclear DNA. Chromatin, which is better known than kDNA, shows the tendency to be organized hierarchically, with small domains packed close-by to form domains of larger size and so forth. This particular organization has a profound impact on processes like gene expression and regulation, yet how topology directly influences its formation remains a mystery which EUTOPIA aims to address in great detail. The Action will push the boundaries of what is currently known about these systems by:

1. Performing simulations of ring polymer networks varying concentration, stiffness, and type of topological link that can occur among rings.
2. Identifying the pertinent variables and analyse the simulations results to get general dependencies between physical and topological parameters.

3. Pushing on the development of more refined computational models of DNA, chromatin fibres, and chromosomes, capable of accounting for the intrinsic multi-scale nature of the problem.
4. Developing numerical and analytical technologies to account for topological properties in simulation models.
5. Employing these methodologies to explore and predict the influence of 'active' mechanisms on DNA and chromatin topologies within the crowded environment of the nucleus.

Topologically complex fluids. Understanding how to design and build topological superstructures in liquid crystals will have a deep and broad impact both in general physics, for example by solving the problem of the appearance of skyrmions, and in multidisciplinary applications like photonics, sensorics, fluidics, and biophysics. This is however a quite hard problem, and emphasis on the simplest model systems will be crucial here, as well as the seamless integration of simulation, theory and experiments. Within the EUTOPIA COST Action this ambitious challenge can be achieved by pursuing the following goals:

1. Find the physical conditions that drive the formation of knotted / linked defects in blue phases.
2. Understand how molecular anchoring at the surfaces can control the amount and topology of defects (e.g. skyrmions) in thin layers.
3. Combine the topology and geometry of defects with more general frustration effects in LCs to design multi-scale tunable photonic superstructures.
4. Understand the formation and the dynamics of complex topological structures in active structured fluids such as cell extracts, cytoskeletal gels and microtubule-kinesin suspensions.

1.3.3. INNOVATION IN TACKLING THE CHALLENGE

The main innovation will come through the collaboration of different research groups across Europe, coming from fields ranging from mathematics to physics, chemistry and biology, as well from the industrial sector. The Action will set up transnational structures that will lower the current geographical and economical barriers to collaboration, and foster the adoption of a common scientific language and the identification of a set of topics of capital importance across all fields. This will be done by implementing STSMs, training schools and conferences. Furthermore, the Action will also build the basis to help researchers in this field, particularly ECIs and women, to compete on the world stage, by putting them in key responsibility positions and through the creation and maintenance of a shared database for international grant calls in various fields and industrial contacts.

1.4. ADDED VALUE OF NETWORKING

1.4.1. IN RELATION TO THE CHALLENGE

The interdisciplinary nature of the challenge requires a common effort from different disciplines to be tackled. The establishment of a research network which is transnational, interdisciplinary and inter-sectorial provides therefore a natural solution to the main logistic and societal problems related to this challenge: the necessity to establish a common ground between different fields, to travel between different groups and share results and data. Furthermore, scientists coming from different communities and yet working on the same topics have the tendency to use different definitions and interpret with different meaning similar, if not identical, concepts. Experimentalists and theorists attend to different conferences and workshops, and are usually not familiar with each other's approaches. There is thus a strong urgency to construct an integrated community that helps to tear down language, cultural and geographical barriers within this field. The establishment of a pan-European network within EUTOPIA will provide a common vocabulary and trustworthy guidelines, and will have a strong and long-term impact especially on the younger members of this community.

1.4.2. IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

EUTOPIA will be the first collaborative European or international grant focused on topology in soft and biological matter. The timeliness of this Action is made evident by the number of existing European training networks (ETNs) dedicated to soft matter physics and fluid physics, such as the MPNS COST Action MP1305 Flowing matter (started 2013), or the ETNs COLLDENSE, DISTRUC, NANOTRANS and SUPOLEN, which cover some aspects of colloidal dispersions in complex fluids, transport in soft matter, and structure formation in colloidal dispersions. Further activities include the EU-funded collaborative platforms Softcomp and EUSMI, or the Leverhulme Trust funded projects "SPOCK -

Scientific Properties of Complex Knots", and "DNA: The Knotted Molecule of Life". Each of these activities, however, tackles one or few topics of interest for EUTOPIA Action, which, on the contrary, will provide the infrastructure necessary to combine synergistically the research efforts of the various groups. The reference community for EUTOPIA is in fact a very heterogeneous one, and requires appropriate meeting events and networking tools. The size of existing large conferences, such as Soft Matter and Liquids, is hardly compatible with the possibility to support constructive interactions toward high quality science. On the smaller scale, specific summer schools dedicated to some of the topics proposed for the present Action have been organized in several sites Europe-wide. Albeit successful, almost all these schools addressed one specific topic or aspect. The EUTOPIA Action will represent the necessary unifying framework in which all the different components of the community will be able to interact and collaborate in a concerted manner.

2. IMPACT

2.1. EXPECTED IMPACT

2.1.1. SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

The Action will have deep and long-lasting effects on the European scientific community and on society as a whole. The reason for this lies in the relevance of the scientific topics and the objects of study at the heart of the Network's activity, as well as in the synergistic collaboration among scientists coming from a wide spectrum of different areas. Specifically, the impact of the Action can be expected to develop along the following lines:

Short term

- Formation and strengthening of interdisciplinary scientific collaborations.
- Identification of research areas and key scientific/technological problems that will be tackled with novel methods and multifaceted approaches.
- Boost to the scientific production of the involved researchers thanks to the improved work effectiveness enabled by the Network.
- Increased mobility and visibility of young researchers and PhD students from ITCs, made possible by the implementation of STSMs and dedicated funds to attend international conferences.

Long term

- Formation of a novel, thriving scientific field, whose fundamentally interdisciplinary character will be of paramount importance to tackle challenges lying at the interface between mathematics, physics, biology, and material science.
- Empowerment of the scientific sector of the ITCs through their increased prominence on the global stage of fundamental and applied research.
- Professional growth of ECIs and, through this, development of the next generation(s) of scientific leaders able to compete at the international level.
- Achievement, through tailored activities and explicit guidelines, of a true, solid, and universally recognized involvement of women in science, thus filling the unacceptable gender gap that still affects science.

2.2. MEASURES TO MAXIMISE IMPACT

2.2.1. PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

The following actions will be undertaken in order to guarantee the complete involvement of the participants in the activities of the Network, as well as to enlarge the platform and broaden its scopes.

- During the first year of the Action, the Action will establish contact with all the main experimental groups, within Europe as well as in partner countries, not already involved in the Network, in order to promote their direct participation.
- STSMs will be used to strengthen the interaction and collaboration among the scientific communities involved in the Action.
- The Action will organize summer/winter schools, preferentially in ITCs, to provide doctoral students with a state-of-the-art training on current problems and methods in the field. The Action will also

provide training workshops for PhD students and ECIs to provide them with transferable skills such as article and proposal writing, presentation skills, cross-disciplinary working etc.
- A systematic effort will be channelled into the establishment of contacts with industrial partners, in order to facilitate the knowledge transfer from pure scientific research to real-world applications.
- The role ECIs in general, and women in particular cover in society will be strengthened by promoting their functions in key positions within the Network.

2.2.2. DISSEMINATION AND/OR EXPLOITATION PLAN

- The main dissemination channel will consist of the ad hoc conferences and other meetings and schools that will be organized by and for the EUTOPIA network. Specifically, small-scale workshops as well as larger meetings will be organized to strengthen the interaction and collaboration within the Action. At the same time, the participation to well-established international conference platforms will be granted particularly to ECIs and PhD students from ITCs, in order to allow them to gain a greater visibility while promoting the Action's work.
- The EUTOPIA website will collect preprints of all Action-related contributions, with a link to the journal in which they are published, as well as all multimedia material produced by the Action.
- All publications involving at least three EUTOPIA partners will be granted Open Access status.
- Outreach to the general public will be enabled through: the PR offices of the involved institutions; the production and dissemination of multimedia content; the collaborations with museums and cultural centres.
- Social media accounts e.g. Twitter and Facebook will be created and maintained to advertise recent articles, conferences, and every output from the Action.

2.3. POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

2.3.1. POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

The EUTOPIA Action entails the potential to substantially boost advancements within and outside of the scientific community. Specifically, innovation is expected at the following levels:

Scientific level. The principal, overarching contribution of EUTOPIA to the scientific community is to provide the necessary level of integration, collaboration and cross-fertilization among the fields of mathematics, physics, chemistry, biology and engineering to significantly advance the current understanding of how topological features influence the physical properties of living and artificial matter. This coordinated effort will deepen our understanding of how life works, how materials behave, and most importantly what are the fundamental, unifying laws at the basis of their function and properties.

Technological level. The knowledge gained through the Action will permit a plethora of technological advances. In fact, the industrial sectors directly affected by EUTOPIA's research include, but are not limited to, pharmaceutical industry, (smart) material industry, and polymer processing industry. The spin-offs of the Action can enable the realization of novel kinds of protein-based drugs; simple, efficient and cheap instruments to perform genetic diagnoses; materials with special and actively controllable optical responses; and fabrics with exceptional properties such as resistance, flexibility or elasticity. The constitution of a strong scientific European platform capable of coordinating fundamental research in these many areas and promote its industrial application will strengthen Europe's position as a world leader in technological innovation.

Socio-economical level. Society will greatly benefit from the activities of EUTOPIA, as it will: (i) support and boost fundamental scientific research at the highest level; (ii) promote gender equality and equal opportunities in a key sector of public life, improving the position of women in leading scientific and managerial positions; (iii) improve the quality of life through technological innovation; (iv) ignite processes that have the potential to create new markets and jobs, and contribute to the expansion of technology-oriented sectors in ITCs; (v) carry out dissemination activities that will increase the visibility of all the aforementioned impacts and promote scientific culture in society.

Risk/gain balance. EUTOPIA will represent the largest single investment ever done worldwide to support international research collaborations studying the impact of topology in soft and biological matter. As such, this Action will provide a substantial number of European researchers with the most

valuable tool that a cohesive community requires - that is, interaction – and will pave the way for scientific development and industrial innovation. This may translate in improved health technologies, smarter materials and devices, and (economically, environmentally) better production processes. The success of even a few of these areas will have an immensely positive impact on society as a whole. The benefits resulting from the Action thus justify and considerably overcome the risks inherent in the work program. However, a strategic plan to mitigate all possible dangers that lie ahead has been formulated, as detailed in Sect. 3.1.2. and 3.1.4. Potential risk sources will be regularly assessed in the course of the Action, so as to identify apt and timely solutions. The organisational structure, described in Sect. 3.2, will enable an efficient management of all issues, and any deviation from the plan will be effectively dealt with.

3. IMPLEMENTATION

3.1. DESCRIPTION OF THE WORK PLAN

3.1.1. DESCRIPTION OF WORKING GROUPS

EUTOPIA will cover all aspects of topological entanglement, from pure theory to the modelling of biological systems to the design and production of novel materials with highly desirable properties. In order to maximize its impact, the Action will be arranged into five separate but interacting Working Groups (WG). Different WGs will be arranged in a sequential way, from the most abstract/theoretical one (WG1) to the most applicative one (WG5), so to focus on inter-related problems with an increasing level of specialization. The same structure will be reproduced internally to each WG, to encourage experimentalists to discuss with theoreticians and biologists to interact with mathematicians.

WG1: Theory of topological entanglement in polymers and fibres.
This WG will cover all aspects of the formal description of topological entanglements in physics, chemistry and biology. WG1 will focus on the following tasks.

1. Extend the mathematical definitions and tools used to identify knots, links, and networks in order to accurately characterize their physical realizations. This will impact the productivity of all WGs.
2. Develop novel mathematical techniques to explore possible knotting and entanglement of more complicated spatial structures, with a view to improved characterisation in physical systems.
3. Investigate the possibility to develop novel field-theoretical models describing knotted and linked rings (in collaboration with WG2, WG4, WG5).
4. Characterize the emergence of knots in the phase diagram of simple polymer models with an increasing level of sophistication, in order to provide well defined guidelines to future experiments in biopolymers such proteins and DNA (with WG2, WG3, WG4).
5. Devise a standard file format to transfer data regarding topological objects such as knotted and linked molecules, networks, etc. between WGs. Produce a set of computational tools and web-tools to facilitate the analyses of other WGs and their collaboration.

Deliverables. STSMs within the WG and to other WGs. At least one article with 3 international members per each task. Standardized file format. Suite of analysis software.

WG2: Polymeric and fibrous topological materials
For this WG various European research groups will combine their theoretical and experimental expertise in developing and using advanced large-scale simulation techniques, fabricating nanodevices, implementing and modelling molecular manipulation assays towards the following tasks:

1. Expand the scope of present self-assembling techniques by identifying novel designable topologies.
2. Shed light on the onset and evolution of entanglement in networks of polymers, for different concentrations, bending rigidity and molecular interlocking (e.g. Olympic gels of ring polymers, woven micromaterials).
3. Characterize the rheological, transport, and mechanical properties of systems at point 2, so to control them by tuning external conditions (e.g. confinement). Relevant to WG3 and WG4.
4. Identify novel setups, especially those based on single-molecule manipulation techniques (nanochannels and nanopores) to sort filamentous molecules by their topological state. Relevant to WG3.

Deliverables. STSMs within the WG and to other WGs. At least one article with 3 international members per each task. The identification of at least one promising experimental setup to sort molecules according to their topology.

WG3: Entangled and self-entangled proteins

The central elements of this WG are the entanglements that can be found in proteins – their origin, formation, role and manipulation. The investigation of the broad variety of knots and other kinds of entanglements in single as well as among multiple protein chains requires the combined effort of researchers with different expertise, and provides an ideal platform for the development of interdisciplinary activities and cross-fertilisation among traditionally distinct fields. The main objectives of this WG are the following:

1. Develop and apply novel techniques to overcome the intrinsic limitations of current *in silico* protein folding, and push the boundaries of our understanding of the protein knotting process.
2. Characterise the emergence and topological properties in intrinsically disordered proteins and multiple entangled proteins. In collaboration with WG1.
3. Push the integration of simulation and experiments to guarantee the exchange of ideas between the two approaches.
4. Establish a joint and coordinated effort to employ knotted protein design for pharmaceutical applications. Develop computational strategies to design proteins with target topologies and structures, and to validate the most successful candidates *in vitro* through the partnership with experimental groups.

Deliverables. STSMs within the WG and to other WGs. At least one article with 3 international members per each task. Identification and establishment of possible industrial partnerships.

WG4: DNA, chromosomes, and other entangled genetic material

Due to their size and the strong coupling between small- and large-scales, DNA filaments and chromatin remain untreatable for all-atom simulations even by modern super-computers. The role of this WG concerns the development of theoretical and computational methodologies for investigating the spatio-temporal behaviour of DNA and chromatin in “extreme”, topology-sensitive environments such as the nucleus of the eukaryote cell or the bacterial nucleoid. In order to realize this goal, the following inter-connected tasks have been identified:

1. Development of systematic coarse-grain strategies for DNA and chromatin, with particular emphasis on computational models capable of matching between different resolutions in space and time (multi-scale models).
2. Exploration of the relationship between topology and functions of DNA and chromatin in various biological contexts.
3. Development of on-line tools for the analysis of three-dimensional DNA and chromatin organization based on the computational tools developed in Task 1. These tools should become “the” standard for the whole community. Relevant for WG1.
4. Modelling of sequencing and other experimental techniques to assess the impact of topological entanglement on their reliability, and to support the design of efficient sequencing devices.
5. Explore the interplay of active and passive mechanisms controlling the entanglement of chromatin, and nucleic acids in general, within the crowded nuclear environment.

Deliverables. STSMs within the WG and to other WGs. At least one article with 3 international members per each task. Instalment of collaborations with the industry and with biological labs.

WG5: Topologically complex fluids

This WG aims to systematically examine possible mechanisms that lead to the formation and stabilization of complex topological soft matter superstructures in passive and active complex fluids (e.g. liquid crystals). In order to achieve these goals, the following tasks have been identified:

1. Establish a unified definition and characteristics of topological superstructures generated and stabilized in the molecular orientational field of complex fluids by frustration. Map analogies and differences between topological structures from various experiments and theoretical models, and investigate their transitions and reconfiguration kinetics.
2. Cross-fertilization of ideas and knowledge exchange regarding topological aspects of liquid crystals between the research groups working on passive and active liquid crystals.
3. Stabilization of particular inhomogeneous ordering patterns (including defects) in chiral and achiral liquid crystals for potential use in photonics.
4. Promote the understanding of highly frustrated superstructures with numerous metastable states and convoluted energy landscapes, by bringing together analytical and modelling approaches.
5. Design optical and electrical fields and flows to directly induce complex defect structures, including linking and knotting in nematic fluids.

Deliverables. STSMs within the WG and to other WGs. At least one article with 3 international members per each task. Establishment of collaborations with industrial partners.

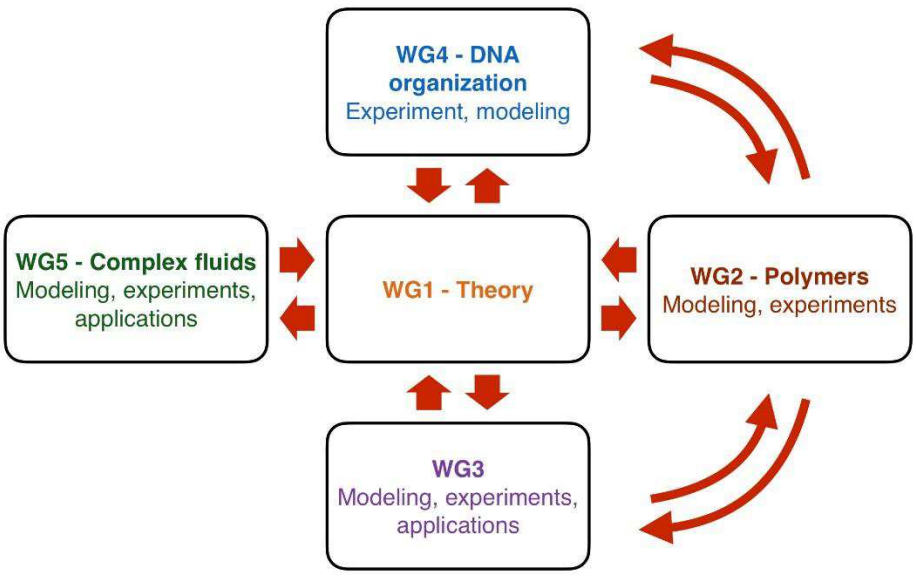
WGs Milestones. During the course of the Action, for every WG there will be several milestones consisting in twice-a-year group meetings. During these meetings the group members will evaluate the success of the WG activities in implementing their tasks and deliverables, and devise alternative strategies should unforeseen problems arise.

3.1.2. GANTT DIAGRAM

	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Coordination, networking, and capacity building																
MC meetings	D1				D6				D7				D8			
SC activities																
Website creation, maintenance			D2													
Wiki creation, maintenance				D3												
Databases creation, maintenance				D4												
Schools																
Training activities																
WGs activities																
Scientific collaborations					S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.	S.A.
STSMs		S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.	S.R.
WGs meetings																
Workshops																
Outreach & dissemination																
General Conferences/workshops																
Special edition of a journal													D9			
Review on state of the art					D5											

Gantt diagram legend. D1 (kickoff meeting): WG definitions, management structure. D2: website. D3: wiki pages. D4: internal database. D5: review on state of the art. D6-8: financial reports. D9: special edition. S.R.: STSMs reports. S.A.: scientific research articles.

3.1.3. PERT CHART (OPTIONAL)



3.1.4. RISK AND CONTINGENCY PLANS

Risk	Risk level	Corrective action
Failing to involve experimentalists during the first year of the Action.	low	Fund participation of selected members in international conferences to increase network visibility. Contact international partners.
Failing to involve industrial partners.	moderate	Contact technology transfer offices of participating institutions; participate in local events dedicated to technological transfer; contact start-ups and investigate the possibility to create start-ups.
Low networking activity intra- and inter-WG.	low	Increase the number of STSMs for ECIs and PhD students in particular; Use COST funds to cover open-access expenses on articles with 3+ members.
Low visibility in and outside academia.	low	Fund PhD students' participation to international conferences; fund participation of selected members to high profile conferences; coordinate outreach efforts between participating institutions.

3.2. MANAGEMENT STRUCTURES AND PROCEDURES

EUTOPIA will be managed by the Management Committee (MC), chaired by the Action Chair assisted by the Action vice-chair, as per COST rules. During the first MC meeting, the MC will elect the Action Chair, vice-chair, Working group leaders (WGL) and co-leaders (WGcL) and the other members of a steering committee (SC) which will be responsible for the day-by-day coordination of the network. The steering committee will include the Action chair and vice-chair, the WGL and WGcL, the synergy coordinator (SynC), the Dissemination Board (DB), Exploitation Board (EB), Training Board (TB), and Web manager (WM). These will have the following functions.

- WG leaders, assisted by co-leaders, will coordinate the activity of their WG, deciding the best course of action to reach the WG milestones and to interact with other WGs. They will be responsible for the organization of the WG meetings/workshops, for collecting the reports from STSMs within their WG and wiki pages for the Action website.
- The Synergy Coordinator will be responsible for coordinating the STMSs of the whole Action, making sure that resources are shared fairly among different WGs; will advise the SC on the course of action to be taken to guarantee the integration of all WGs into a seamless research field, to guarantee gender equality and full participation of ITCs within the network.
- The Dissemination Board will be responsible for all dissemination activities intended to improve the visibility of EUTOPIA both within academia and with the general public. These will include promoting the participation of EUTOPIA scientists to important international conferences, collect material for the Action website, organizing the participation of EUTOPIA in outreach events such as the Researchers' Night and others.
- The Exploitation Board will coordinate the enlargement of the initial network; collect and maintain a list of the most relevant experimental / international groups to be involved; investigate, through technology transfer offices of the participants institutions, what are the most suitable private companies to contact. The EB will also be responsible for organizing sandpit meetings with industrial partners.
- The Training Board will be responsible for organizing schools and training events for ECIs and PhD students.
- The WM will be responsible for the creation and management of the website, including the internal databases and wiki pages.

All Working Groups will organize annual meetings and at least two workshops, and will take part in organizing two schools on topological aspects of biophysics and soft matter and two international conferences. Particular attention will be devoted to the structure of the Steering Committee so that it will result into a balanced structure in terms of seniority, gender and geographical distribution. In particular, ECIs will be given direct responsibilities within the Steering Committee as well as within the organization

of various schools and events. The coordination of each WG will be offered to ECIs, preferentially selected from ITC members, and supported by a more senior scientist prominent in the specific topic.

3.3. NETWORK AS A WHOLE

EUTOPIA will be the first European interdisciplinary network of researchers studying the emergence, properties, and impact of topological entanglements in mathematics, physics, chemistry, biology and material science. EUTOPIA will bring together experts from the aforementioned fields to work on a unified understanding of the topology-related aspects of biological and soft matter. Already at the proposal submission, the EUTOPIA Network comprises more than 40 researchers from 11 different European countries, including 4 ITCs. At this early stage, EUTOPIA involves several of the most productive groups working on the modelling of topological effects in soft and biological matter. Four renowned experimental labs have joined the Network and more are expected to do so. During the first year of funding, industrial partners will be reached to establish collaborations. The initial Network has 25% female participants, including several leading figures within their respective fields. They will act as great role models and mentors for PhD and ECIs, and encourage more female researchers to participate to the activities of the Network. This percentage will be significantly increased by including and coaching female ECIs, with the explicit aim to give them more visibility and responsibility in the scientific community. EUTOPIA will focus on training PhD students and postdocs through specific schools and workshops, and will place ECIs in positions of responsibility within the Action. The initial network counts 25% ECIs, which are in fact the main force behind the coordination and preparation of EUTOPIA.

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