Synergy-COPD

Modelling and simulation for systems medicine
Chronic obstructive pulmonary disease – COPD – as a use case

The **Synergy-COPD** project develops a simulation environment and a decision-support system aiming at enabling the deployment of systems medicine. The Synergy-COPD system focuses on patients with chronic obstructive pulmonary disease (COPD), which is a major public health problem and a complex, heterogeneous and multi-component disease.

Objectives of the project

Synergy-COPD endeavours to study the underlying mechanisms of COPD phenotypes associated with poor prognosis. This is done by simulating different functions of the human body using computer models at different levels (sub cellular, tissue, organ and organ system). In this way, the behavior of each physiological network can be observed separately and in an integrated way. The project aims to produce a more complete computer model of the mechanisms of COPD.

The main objectives are:

1. To generate an integrated environment and a semantic mapping between existing patient-specific data and five well-established single-level physiological models using ontologies.
2. To integrate and merge in the vertical dimension the five physiological models developed at different levels (molecule, cell, tissue, organ and organ system) into one.
3. To generate a simulation environment using: (a) the vertically integrated physiological models; (b) network pathway analysis; (c) network disease analysis; (d) probabilistic modelling.
4. To create Web-based, intelligent ICT tools to facilitate simulations for bio-researchers and decision-support for clinician.
5. To test and validate the integrated multi-level simulation environment using existing large-scale data for COPD phenotyping.

Project Description

Synergy-COPD includes five physiological models, each of which can be associated to one level of the body: sub-cell, tissue, organ and organ system. This association is, from upper to lower levels:

- M1. Central and peripheral O2 transport and utilization: organ system (heart, lung, haemoglobin, skeletal muscle);
- M2. Pulmonary gas exchange: organ (lungs);
- M3. Spatial heterogeneities of lung ventilation and perfusion: tissue;
- M4. Skeletal muscle bioenergetics: sub-cell;
- M5. Mitochondrial reactive oxygen species (ROS) generation: sub-cell.

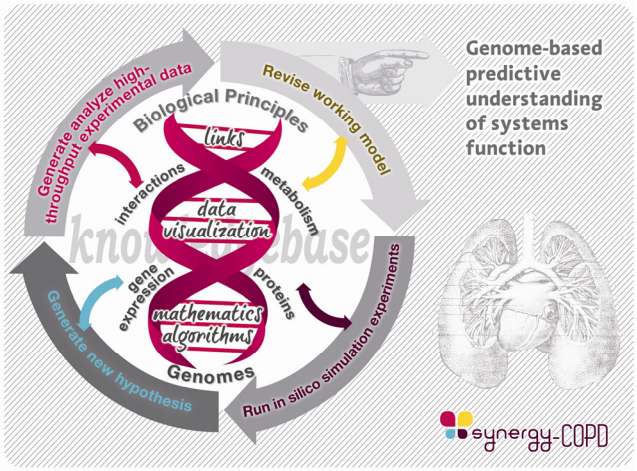
Synergy-COPD's elements (representing a vast compendium of medical knowledge, in the form of a program, drawn from epidemiological data, clinical trials, physician interviews, and specific physiological models) will contribute to replicate the human physiology (the complex workings of human biology) and to dynamically simulate the medical problems of the population whilst taking into account individual profiles. In the end, the results of the project will contribute towards the establishment of shorter and cheaper virtual trials.

The decision support system (DSS) will allow clinicians to anticipate the progression of the disease taking into account specific patient profiles. Furthermore the DSS will help determine the treatment that will give a better result. Thanks to this system of predictive and personalized medicine, patients will receive the most suitable treatment according to their personal characteristics.

Disease model validation and refinement is done using a well-established, large dataset together with experimental studies designed to test "in silico" generated hypotheses. Synergy-COPD will develop a platform that tackles the complexity of the vast amount of clinical, physiological, genetic and experimental data currently available. In the scope of the project the environment will be modelled, refined, verified and validated using existing datasets from real patients affected by COPD.

CASE STUDY

Daniela is a 55-year-old suffering from COPD. She has had periodic examinations, and the disease keeps progressing. Daniela recently had two severe exacerbations and now Doctor Norton is thinking about prescribing her with inhaled corticosteroids. He knows that they are not always effective and they often have side-effects. He decides to feed the Synergy-COPD system with Daniela's data. The system compares patterns and, following one of the rules contained in the knowledge base, checks the concentrations of some proteins in Daniela's blood. The results confirm that corticosteroids would indeed be effective for Daniela, and the Synergy-COPD system communicates so to the doctor.



Synergy graphic

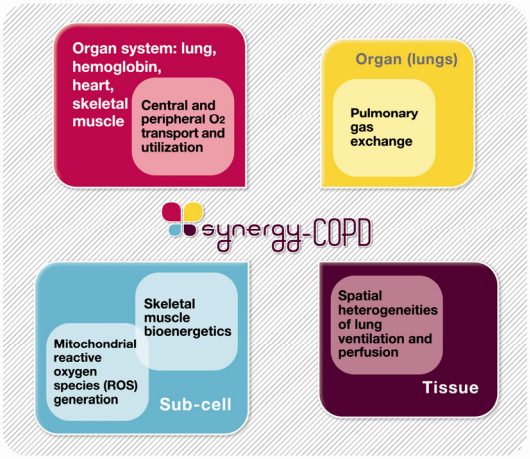
Expected Results & Impacts & Preliminary results

Synergy-COPD is aimed to develop a simulation environment and a decision support system to allow and facilitate the development, implementation and deployment of system medicine to be applied to chronic diseases and fragile patients.

Synergy-COPD focuses on two kinds of users: researchers and physicians. Researchers work to improve and extend our knowledge about the physiology of the human body, while physicians use that knowledge to treat patients.

The outcome of the project intends to boost European industry of medical knowledge management, medical simulation and decision support, and integrated healthcare, in a market currently dominated by Asian and American companies.

Synergy-COPD is addressing two main strategic areas. Firstly, the project will contribute to biological research by fostering the convergence between basic and clinical sciences. By doing so, it will be contributing to shape systems medicine and, consequently, a new paradigm in translational research. Secondly, the Synergy-COPD project goes beyond conventional care and promotes the link between systems medicine and integrated care, which represent two holistic approaches that should generate efficiencies in future strategies aiming at personalized health for persons at early stages of chronic diseases.



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- Karolinska Institutet (Sweden)
- The Chancellor, Masters and Scholars of The University of Oxford (United Kingdom)
- The University of Birmingham (United Kingdom)
- Infermed, Ltd. (United Kingdom)
- Technical University of Budapest (Hungary)

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Decision support systems, In silico simulation, Modelling of physiological processes, Personalised health, Semantic integration of health data, Virtual physiologic human

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