CENTER FOR THE STUDY
OF ORIGINS AND EVOLUTION OF
LIFE, PLANETS AND THE UNIVERSE

ORIGINS CENTER

The Origins Center brings together a broad range of scientific disciplines to address one of the biggest challenges in science: the origin and evolution of life on earth and in the universe. Its aim is to spark and facilitate transdisciplinary research between scientists associated with Dutch universities and research institutes.

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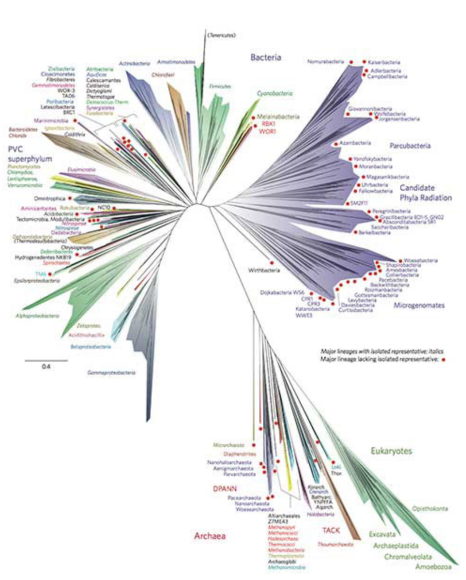
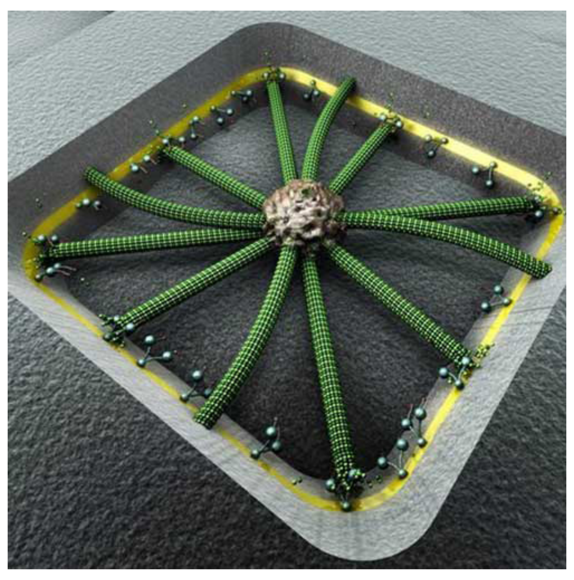
1. Origin and co-evolution of earth-like planets and life

The Earth is currently the only place where life is known to exist and prevailing opinion suggests that it emerged rapidly within the first billon years following planetary accretion. Complex and intelligent life is the result of a long history of biological evolution that has developed in tandem with coupled atmosphere-ocean-deep Earth processes throughout the geological record. These billion-year timescales, culminating in the modern advanced society that we have today may or may not be typical for the development of comparable and potentially habitable planets elsewhere in the Universe. Delivering a full picture of the co-evolution of the Earth and life, and their interdependence, requires integration of data and research from diverse disciplines including astronomy, astrobiology, (micro)biology, (prebiotic) chemistry and the earth- and planetary sciences.



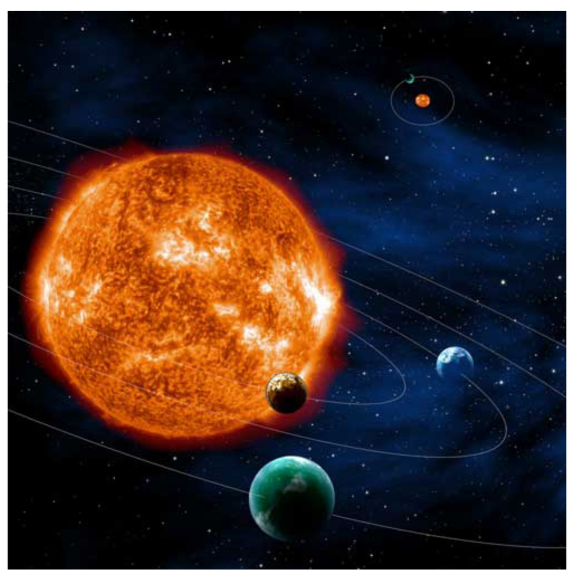
2. Predicting evolution

Evolution is a central mechanism in the origins of the astounding diversity of life and has a central role in the functioning of biological systems. Understanding how life has evolved in interaction with the environment has been at the forefront of science ever since Darwin. Evolutionary knowledge is also a powerful tool outside the biological sciences, used in evolutionary medicine to understand disease, and in artificial intelligence to design self-organising life. More recently, emphasis has shifted to a forward-looking perspective of evolution, underscoring the importance of understanding how species can adapt, in an evolutionary sense, to current and future changes of their world. The real game-changer will be to predict the course of evolution for the adaptation of current species to their environment.



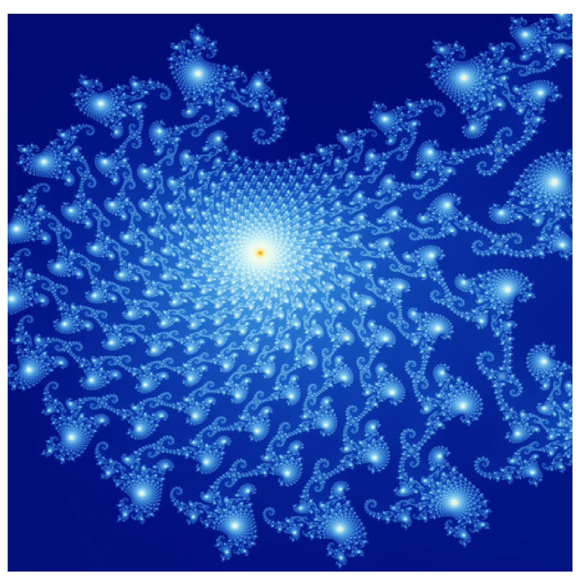
3. Building and directing life from molecule to biosphere

Life is tremendously complex and emerges from the dynamic interplay between molecules and their environment. Contemporary life relies on interactions at, and between, different levels of hierarchy and scale: from (bio)molecules to cells to organisms to ecosystems to biospheres. To comprehend how life functions, we need to understand the governing principles, the underlying mechanisms and how these interactions – on all levels – lead to the emergent behavior of what we call "life". Building on an understanding at the systems level, we will be able to direct and correct life. For instance, we should be able to repair malfunctioning life and treat diseases in an unprecedented manner, or to develop new ecosystems on places where existing ones are lost, damaged or not yet existing. Together, such multi- and transdisciplinary research will generate novel understanding of the functioning of life.



4. Finding extraterrestrial life

Being able to say that life exists in other places, within or outside our Solar system, will fundamentally change our view on the role of humanity in the Universe. Is the Earth really unique as a cradle of life? We are in a position where we will find the answer in the next decades. The enormous technological progress of the past decades has put us in a position to start examining the climate and the habitability of other worlds in detail. An important challenge will be to recognize and understand the chemical biomarkers on other worlds, where both climatological and geological circumstances and the biological processes may be significantly different. The importance of collaboration with Dutch industry for this research path is crucial and the benefits are equally important for this very industry. Ambitious explorative programs like the search for extraterrestrial life bring unique technological spin-offs.



5. Bridging long temporal and spatial scales

In order to create breakthroughs ingame changers 1 to 4 new multiscale computational and mathematical methods are required. Multiscale mathematical models will help to mechanistically interpret the interactions and causal relations between biological molecules, cells, organisms and their environment. Chemical, biological, physical and astrophysical observations, experiments and simulations will produce expanding streams of big data, which must be integrated to generate new knowledge. The resulting multiscale mathematical models and multiscale data science methods will need to cover temporal scales from nanoseconds and hours to billions of years, and spatial scales ranging from nanometers to tens of thousands of kilometers. We need to enforce breakthroughs in the development of new methods for multiscale modeling, simulation, and analysis of large, complex data.