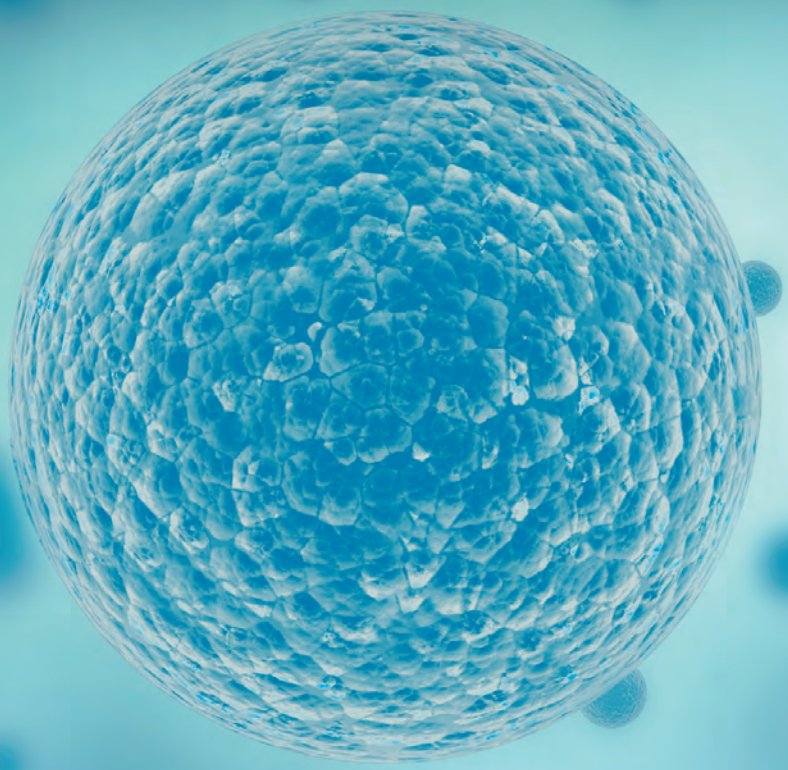
THE FORMLESS ENVIRONMENT OF CELLS



Departement Umweltwissenschaften

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Introduction

Talking about non-chemical cell communication based on cell's endogenous electromagnetic fields, a Science colleague once said: … If such non-chemical cell communication existed we would know it already for a long time. Non-chemical cell communication (NCCC) refers to cellular communication that is not based on chemical signals (such as e.g. neuro-transmitters, hormones, or kairomones) but on physical signals like electric current, electrostatic fields, and acoustic or electromagnetic waves.

Why is there so little known about NCCC in Life Sciences? Has it to do with the philosophy of Science still referring to purely material aspects of molecules. Is there a lack of emancipation from scientific dogma to look for enlarging theories and evidences? Are there competing interests with NCCC not being recognised as new research fields adding to biology in general? How much this plays (or played a role in the past) one can speculate about, however, we believe that the major reason is the current lack of information about NCCC. This is why the author had started together with Michal Cifra and Felix Scholkmann editing the open-access eBook Fields of the Cell, which goes online in due time.

We refer therein mainly to endogenous electrodynamic fields, i.e., electrostatic and electromagnetic fields of the cell, and wish to make aware about the electrodynamic world of biological cells. An increasing number of scientists dedicate their research to this new field and we may ask whether they prepare the biology of the 21st century.

The major hypotheses of the book Fields of the Cell is that currents and electromagnetic fields, which occur immanently due to cellular polar structures and charged particles, affect this (polar) structures of cells. This in turn affects the electrodynamic fields of the cell (confer Figure 1). As a result cell dynamics

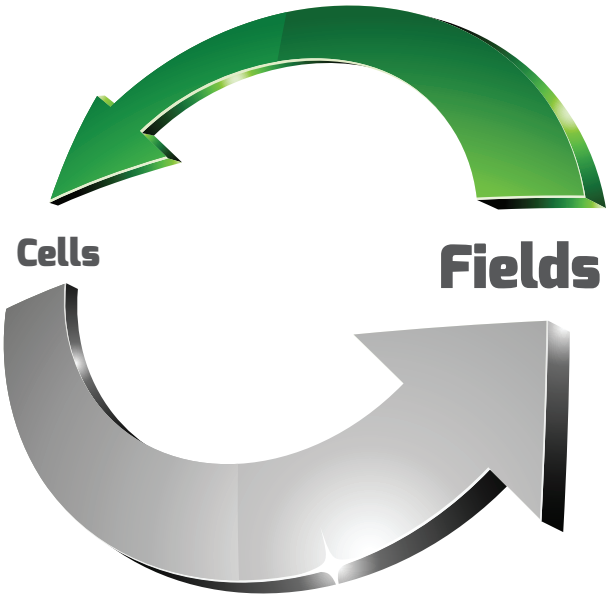

Figure 1) The majority of molecules of cells consist as polar structures. These structures and the chemical reactions happening with and on them are the origin of fields. In turn, electrodynamic fields affect polar structures and chemical reactions

reflect not only reciprocal causality between molecules but also between (polar) molecules, ions and the corresponding electrodynamic fields of the cell. To this end a series of specialists have been invited to write in their particular subfield a review article. The goal of the project is that these reviews may serve as an introduction into the topic of the fields of the cell.

Over the years the author had realised that often Life Scientists think in terms of matter or molecules as limited to the boundary of their body. Yet, molecules vibrate and exhibit charge movements, creating fields that extent the sphere of influence of these molecules. A question of significant importance is whether these extensions play a role in cell dynamics, even more whether cells use these fields to induce functions that belong to life.

In a nutshell, a distinction between matter and the extension of matter is the sun and its (visible) rays: The sun is a physical (material) body in space and its visible rays are its extension. These rays are defined as electromagnetic waves, deliverer of the energy that drives our ecosystems. Primary responders to these sunrays are nanostructures embedded in cells and standing at the beginning of biochemical processes such as vision or photosynthesis. So, cells are able to perceive and respond to electromagnetic waves. In the book Fields of the Cell we focus on the capability of cells to build and use their own electrodynamic fields.

A short view on the chapters of the open-access eBook Fields of the Cell

The first chapter introduces the history of the field concept in biology from the early 20th century to recent times covering all important milestones and related theories on non-equilibrium, non-linear and coherent behavior of biological systems. The second chapter explains the physical view on the electromagnetic field and photons. The electromagnetic spectrum is described as well as coherence, interference, resonance and interactions of an electromagnetic field with matter. Chapter three then gives an overview of detection techniques for ultraweak photon emission, such as observed from biological systems. Chapter four describes fundamental features of living system that are nonlinear and far from thermodynamic equilibrium: a rise of order from disorder. This is possible for cases where energy is flowing through the system and the system is able to dissipate the disorder (entropy) to its surroundings. Doing so, internal ordering of the system is achieved. In chapter five we come across experimental findings about water behavior indicating that water at hydrophilic interfaces is the simplest non-equilibrium system able to transform disordered to ordered energy. Hence, a theory of coherent water domains will be presented, explaining both, well-known and newly observed properties of water. It is concluded that water plays a central role in the dynamics of biomolecules and therefore also subsequently in the generation of the cellular electrodynamic field.

One of the manifestations of living system's non-equilibrium behavior is the permanent production of electron excitation in biomolecules leading to ultraweak photon emission. Based on solid experimental evidence, chapter six explains the generation of electron excited molecular species due to free radical and reactive oxygen species reactions. Biological ultraweak photon emission is of very general nature. It is detectable from every metabolically active biological species under suitable conditions. Chapter seven focuses on ultraweak photon emission from multicellular organisms, namely plants, tumor tissues and humans. It relates photon emission to development and structure as well as to tumor and normal cells comparing them with reference to growth properties. The eighth chapter explains the peculiar phenomenon of non-chemical influences between cell cultures through glass barriers. It is suspected that the non-chemical interaction between cell cultures is mediated by photon emission generated by cells. A special emphasis is given on confounding effects and the method itself in order to gain understanding about the function. As statistical properties of biological ultra-weak photon emission have been a source of controversy in past decades; chapter nine assesses available experiments studying optical coherence, quantum states and signal properties of biological ultra-weak photon emission. Chapter ten aims to explain that the electrodynamic activity of living cells involves a broad range of frequencies, namely from kilohertz to terahertz. These frequency ranges are related to electromechanical vibrations of subcellular structures. It is hypothesised that electrodynamic fields generated by such sub-cellular coupled oscillations contribute significantly to biological self-organisation.

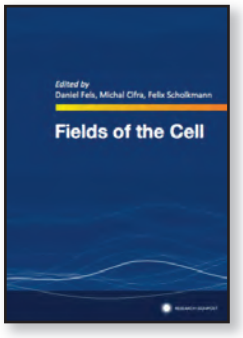

Figure 2) Fields of the Cell book

Figure 2: Fields of the Cell was a book project that started in 2011 when it became clear that a vast amount of scientific papers was scattered over many journals, countries and scientists; a unification of that particular knowledge about endogenous electrodynamics of cells was needed. It could have taken a researcher interested in that topic years to get an idea about the amount of evidence and hypothesis. We wanted to shorten this by reviewing major aspects. At the same time we wished the book to be an introduction for all those that find the courage to step or rather think out of the box. Also, we intended to restrict ourselves (the authors of the different chapters) to a great extent to evidence-based results keeping speculation and hypothesis building at a low but still justified level. Even though in the mean time a large body of new results appeared, we nonetheless, believe that Fields of the Cell gives a great hand for anyone who enters the field and wants to catch up with the spindrift. We are convinced that we are at the beginning of a long and vast discovery.

Can biomolecules interact over long distances within a cell in order to find their chemical partners earlier than just by diffusion? Chapter eleven explains under which conditions such interactions can indeed take place using a model that involves resonant electrodynamic interactions of biomolecules. Rising to a macroscopic level, we come in chapter twelve across the collective activity of neurons giving rise to synchronous electric events in the brain. Such events are also known as preconditions for conscious acts to occur. Both, the potential role of photons emitted from neurons and being part of a time-sensitive signal flow within the brain (and the body) as well as synchronicity between distant brains are discussed with care. Coming down again to the microscopic world, the organisation and signal processing on the level of single eukaryotic cell and especially neurons is crucially dependent on the cytoskeleton. In chapter thirteen the electric properties of microtubule and actin filaments are described as well as their possible role in cell signaling. Chapter fourteen then guides us from early biological field concepts to a modern theory of biological self-organisation involving the coupling of fields from mechanic, electric and electromagnetic origin. Chapter fifteen provides us with condensed information on how tissue and cellular electric fields modulate the transcription of genes and shows, thus, basic principles of how cellular electric fields are coupled with biochemical pathways. The final chapter introduces the fact that biological objects, as any other dielectric objects, are able to store electromagnetic energy as cavity resonators under certain conditions. In resonators, electromagnetic energy is stored only in certain shapes (modes) at a certain frequency. Here it is proposed, that the spatial distribution of electromagnetic energy in such biological resonator provides conditions for symmetry breaking which guides differentiation and pattern formation during plant organ development.

Misunderstandings about NCCC

1. NCCC is a competing theory to existing molecule-based understanding of life. No, it is not. Molecules exist, they are the material fundament of life and some of them work also as signals. These are observational truths, which nobody touches. NCCC is adding an additional function to molecules, namely their electrodynamic extension with effects on cell dynamics.

2. NCCC is a purely theoretical concept. No, it is not. Cells emit electromagnetic waves from low to extremely high frequencies and build also membrane potentials of different voltages all of which has been measured.

❸ NCCC refers to meaningless by-products of (some) chemical reactions. No, it is not. The emission of electromagnetic waves of cells is primarily not correlated with temperature (but chemical reactions are) and there is evidence for functionality of these emitted waves. Further, electric currents are measured as well as there effects across cells and, furthermore, electrostatic fields are measured with effects, e.g., on cell migration and/or differentiation.

❹ NCCC is esoteric. No, it is not. One may (must) argue that those who claim this argument of a non-scientific explanation about life are simply not informed and abuse thereby the term NCCC.

❺ NCCC is an irrelevant, even though new branch in science. No, it is not. NCCC is highly relevant: Strictly speaking do we have to doubt any experiment that did not control for NCCC but claims molecules solely were responsible for described effects.

❻ NCCC will not help to understand open questions in science. No, this is not so. There are open questions e.g. on form giving cell migration during embryogenesis (what gives form is still a conundrum), on stem cell differentiation, on coherence among billions of cells within one organism, on fractal structures of ecosystems, on cell sensitivity to external electromagnetic sources, on heritage and more. One may even add, that NCCC not only offers answers but also highly interesting new questions. Questions drive the development of science.

Outlook

Recent papers teach us that (i) solar rhythms can have effects on incidence rates of human pathogens or cancer, that (ii) cells, i.e. whole organs respond to thunderstorms e.g. with heart strokes. Cells also respond to microwaves as shown in a study with a switched on smart-phone in close vicinity to a cell population of the ciliate Paramecium caudatum: under this treatment the cells displayed decreased cell division rates and malformations of their habitual cell shape (Cammaerts et al. 2011, in: Electromagnetic Biology and Medicine). Evidently, cellular reactions to external non-material physical factors may not only be adaptive, they can also be detrimental. In a recent review entitled “Life Rhythm as a Symphony of Oscillatory Pattern: Electromagnetic Energy and Sound Vibration Modulates Gene Expression for Biological Signaling and Healing” (Muehsam & Ventura 2014, in: Global Advances in Health and Medicine), the authors refer to a series of exogenous non-material physical factors affecting life. In order to better understand how external fields affect (the fields of the) cells one may recall that resonance refers to inducing frequencies and the Eigenfrequenz of the responding (resonating) structure. In this context it is considered mandatory to study the reciprocal causality between the fields and the molecules of the cell.

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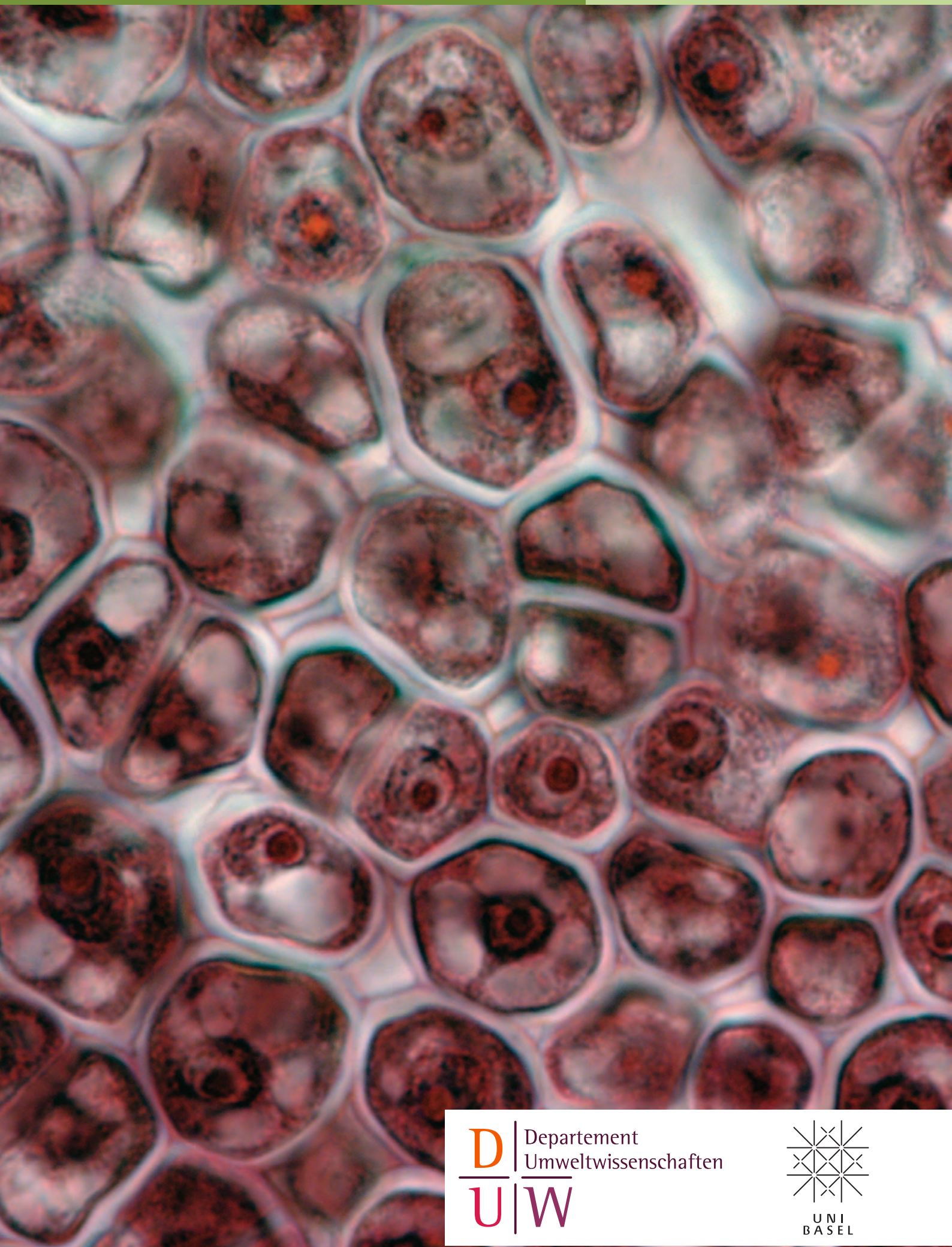

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