

Introduction

The legacy of Hans Primas is an intellectual invitation to questions, concepts, and working tools that were developed over more than 50 years in the life of a scientist who combined engineering, experimental, theoretical, and philosophical elements in an original and often surprising way. Beginning with spectroscopic engineering and modern theories of molecular matter, he proceeded to basic questions of quantum theory and the philosophy of physics, suggested innovative ways of addressing interlevel relations in the philosophy of science, and introduced cutting-edge approaches in the flourishing young field of scientific studies of the mind—in short, from chemistry to consciousness. It is the purpose of this book to keep this legacy alive and give an impression of its scope. It is not meant to be an adulation. What Primas always appreciated was competent and outspoken criticism.

Born in 1928, Hans Primas was a Professor in the Chemistry Department at ETH Zurich from 1962 to 1995, and maintained his research activities until his death in October 2014. His way of thinking was strongly influenced by research directions in various fields of science: first, the rise of mathematical physics in the twentieth century, requiring that physical theorems must comply with mathematical standards and that formal assumptions must be physically motivated; second, the guiding idea of high-energy physics, according to which symmetries are more fundamental than particles or fields and that basic insights often appear in group-theoretical terms; and third, the area of quantum logics, most notably the concept of partial Boolean algebras, bridging a long-standing gap between science and philosophy.

Although much of Primas' early activities can be seen as “problem solving”, his overall approach was directed toward the production of systematic and coherently organized knowledge. Therefore, his sympathy for “research programs” is not surprising—even though he did not formulate his own one in a self-contained manner. A research program consists of a core of undisputed assumptions and a periphery of open problems that can be investigated based on those assumptions. This framework of doing science allowed Primas to meet old challenges and explore new ideas without losing broadly accepted solid ground.

Introducing the notion of classical observables in theoretical chemistry, Primas paved the way to a fresh philosophical perspective on quantum theory, which he

formulated in an algebraic framework that was often considered too abstract to yield intuitive insight. Primas disproved this prejudice: although the status of ontic states and observables is by definition outside the domain of engineering and experimentation, it can be consistently related to these epistemic domains. In this way, ontic and epistemic viewpoints, such as Einstein's "realist" and Bohr's "anti-realist" stance, can be seen as complementing rather than contradicting each other. A number of recent approaches share this "metaphysical turn" in the philosophy of physics, overcoming a long time of metaphysical abstinence in large parts of twentieth-century science.

In a similar vein, Primas was among the first scientists who critically and systematically assessed the dogma of reductionism, with the result that many of the claims in the philosophy of science of the 1960s were found to be too superficial, not informed enough, or even plainly wrong. He inspired research to explore how refined concepts of emergence are more appropriate for relations between observables at different levels of description, most famously between mechanics and thermodynamics, and most notably between neuroscience and psychology.

The latest work of Primas moved into issues that are currently located in cognitive science and the philosophy of mind, but whose history covers millennia: the problem of how our minds are related to the material world. Again, he distanced himself from traditional (Cartesian) dualist, materialist or idealist accounts and developed a view, stimulated by Wolfgang Pauli and Carl Gustav Jung, that is today called dual-aspect monism. On this view, the mental and the material are conceived as dual epistemic aspects of one underlying ontic reality that is ultimately undivided. This perspective has picked up remarkable momentum in contemporary mind-matter research and consciousness studies.

Beyond technical skills, research projects of this kind require a great deal of inner freedom and an emphatic independence of transitory "mainstream opinions", scientific "fashion waves", or "old boy networks". In the end, this avantgardist attitude entailed that his publications have been far more read than quoted. However, his influence in the scientific and philosophical communities to which he contributed can hardly be overestimated, exactly because his voice was known to be largely impartial. This is another important piece of his legacy: a style of incorruptibility and a commitment to truth that made him invulnerable against the seductions and temptations of the celebrity shows and business maneuvers of much of contemporary science. And this style could be contagious.

Richard Ernst (Zurich) and Geoffrey Bodenhausen (Lausanne/Paris) address Primas' pioneering work in nuclear magnetic resonance. Ernst, one of Primas' early Ph.D. students, was later distinguished with the first of several Nobel Prizes devoted to this field, ultimately deriving from Primas' early work. Bodenhausen, a former student with Primas and collaborator of Ernst, reports some of the more recent developments to which he has contributed.

Ulrich Müller-Herold (Zurich) was a member of the Primas group from the 1970s up to Primas' retirement in 1995. Much of their work at that time was concerned with a key topic of theoretical chemistry: the apparent conflict between classical observables, such as chirality, and their foundation in quantum mechanics.

Spiced with personal memories, Müller-Herold sketches the history of this line of research and how it developed into later work on broader perspectives, for instance aiming at a better understanding of relations between descriptive levels in the philosophy of science.

Domenico Giulini (Hannover/Bremen) discusses the notion of superselection rules, a concept that is especially relevant for framing the notion of classical observables in algebraic quantum theory and quantum field theory. Giulini's account is inspired by an influential meeting of the decoherence group around Hans-Dieter Zeh, of which he was a member, with Primas in the early 1990s. The contribution addresses some key issues (and key misunderstandings) emphasized by Primas, among them the superposition principle, the notion of dynamical symmetries, and the significance of disjoint states.

William Seager (Toronto) takes up Primas' numerous articles with critical remarks about the traditional position among philosophers of science that chemistry, biology, and even psychology can eventually be reduced to the basic laws of physics. Current work in this field has become far more pluralistic, and the leading antagonist of reduction, the concept of emergence, has significantly gained ground. Seager highlights these developments and indicates an interesting relation to the relative-state approach to quantum mechanics by Everett, popularized as the "many-worlds" interpretation. For a while Primas endorsed this approach, but shifted away from it in his later views.

Robert Bishop (Wheaton) and Peter beim Graben (Berlin) present a refined version of emergence, called "contextual emergence", that implements Primas' ideas about interlevel relations in a formally sound and empirically applicable way. Their contribution uses contextual emergence to discuss another one of his interests: the relation between deterministic and stochastic descriptions in science. Based on the insight that neither of these two descriptive modes is in principle more fundamental than the other, they show how determinism can emerge from stochasticity as well as how stochasticity can emerge from determinism. This result obviously impacts the discussion of mental causation and free will.

Basil Hiley (London) was a long-standing collaborator of David Bohm, together with whom he developed an overall picture of mind-matter relations closely related to the dual-aspect monist conjecture due to Pauli and Jung. And, like Primas, they tried to express it in algebraic terms, formulated slightly differently but in a similar spirit. This is the topic of Hiley's contribution. It describes and comments on the parallels between his work on a non-Boolean implicate order and its explicate Boolean projections on the one hand and Primas' ontic-epistemic distinction on the other, where contextual patterns arise from intrinsic structures.

Harald Atmanspacher (Zurich) maintained close contact with Primas over the last 25 years of his life, and worked with him during this time. His contribution outlines the structural relationship between ontic and epistemic descriptions with its implications for concepts such as measurement or emergence. It also presents the current status of another focus of Primas' interest, the application of noncommutative (quantum) structures to fields outside (quantum) physics. And finally there is Primas' innovative idea of transforming the mind-matter problem into the problem

of how tensed mental time is related to tenseless physical time. Primas left behind an extensive book manuscript about this topic, which is going to be published soon.

The present collection of essays is based, in part, on a symposium “The Legacy of Hans Primas” at Collegium Helveticum, a transdisciplinary institute jointly operated by ETH Zurich and University Zurich, on November 27, 2015. The complete audio-visual recordings of the full-day symposium are accessible at www.multimedia.ethz.ch/speakers/collegium_helveticum/Einzelveranstaltungen/legacy_primas.

In addition to the chapters stemming from the symposium itself, this volume contains solicited contributions covering further areas of Primas’ work and their relation to current research topics. Needless to say, more is yet to be discovered. The complete list of publications by Hans Primas at the end of this volume may serve to engender further ideas and perspectives.

The preparation of the symposium was facilitated by Konrad Osterwalder, rector of ETH at the time of Primas’ retirement. Sarah Springman, present rector of ETH, provided substantial financial help to realize the symposium. Gerd Folkers, Director of Collegium Helveticum until early 2016, offered his unrestricted support to make the event possible in the facilities of the Collegium. Finally, Angela Lahee at Springer International Publishing arranged for the volume to be part of Springer’s science publication program. We do gratefully appreciate all this encouragement and endorsement.

However, most of our gratitude clearly goes to our colleagues who contributed to this volume. For none of them writing essays such as these is their regular day job. Their dedicated willingness to carry the work of Primas into future directions in science and philosophy cannot be applauded enough. Without their commitment and their reliable and efficient cooperation this volume would not have become reality.

From Chemistry to Consciousness

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