Volume 3. From Vormärz to Prussian Dominance, 1815-1866
Hermann von Helmholtz: Excerpts from a Speech Given on the Occasion of his Appointment as Pro-Rector at the University of Heidelberg (1862)

Opposing Hegel's ideal of a philosophical unity of knowledge, the physicist Hermann von Helmholtz (1821-1894) drew clear distinctions between the natural sciences and the humanities. An influential proponent of scientific progress, Helmholtz argued that instead of assuming a unifying world spirit, scholars were called on to conduct painstaking empirical research to study the complexity of the world.

Honorable Assembly!

[. . .]

It probably appears that in current times the relation of all the sciences to each other, which is the reason we group them together in the name of a *universitas litterarum*, has become looser than ever before. We see today's scholars immersed in a study of detail of such immeasurable proportions that even the greatest polyhistor could not even think of housing more than a tiny sub-field of present-day science in his brain. Philologists of the past three hundred years found enough to do with the study of Greek and Latin. Perhaps one learned a few European languages for practical purposes. Now, comparative language studies has set for itself no meaner goal than to acquaint itself with all the languages of all human tribes, to discover the principles of language formation itself. It has set about this task with the greatest diligence. Even within the field of classical philology one is no longer limited to the study of those works of poetry and prose which have become models for all time by virtue of their artistic perfection, the clarity of their ideas, or the importance of their content. One understands now that every lost fragment of an ancient writer, every note by a pedantic grammarian or letter from the Byzantine court, every broken tombstone of a Roman official found in an unknown corner of Hungary, Spain, or Africa contains information or evidence which could be significant. Thus another number of scholars are occupied with carrying out the enormous project of collecting and categorizing all of the remains of classical antiquity, in order to put them at the disposal of other scholars. If we count as well the studies of historical sources, the sorting through of all the scrolls and papers piled up in state and city archives, the gathering of all of the notes scattered in memoirs, collections of letters, and biographies, the decoding of all of the documents written in hieroglyphics and cuneiform; if we take all of the rapidly growing systematic overviews of minerals, plants, and animals – those alive today and those from before the great flood – there

unfolds before our eyes a dizzying mass of learned knowledge. In these disciplines alone, the research expands to the same degree as the tools of observation, with no limit in sight. In past centuries, a zoologist was content if he had described the teeth, hair, foot form, and other external characteristics of an animal. By contrast, an anatomist used to describe only human anatomy, to the extent that his knife, saw, and chisel, or perhaps injections, would allow. The study of human anatomy itself counted as a disconcertingly wide field, one difficult to become proficient in. Today, one is no longer content with the so-called "coarser" human anatomy, which is almost considered an exhausted field. Instead, one's interests are absorbed in comparative anatomy – the anatomy of all animals – or in microscopic anatomy, in sciences of infinitely wide content.

The four elements known to the ancient world and to medieval alchemy have now, with modern chemistry, grown in number to 64; the last three of these were discovered through a method developed at our university, which promises to deliver many similar finds. But it is not merely the number of elements which has grown so extraordinarily; such progress has been made in the methods which produce complex compounds of elements that the so-called organic chemistry – which encompasses only compounds of carbon with hydrogen, oxygen, nitrogen, and a few other elements – has become a discipline unto itself.

In ancient times, "as many as the stars in the heavens" was the natural expression for a number which exceeded the boundaries of our comprehension. Pliny finds Hipparch's attempt to enumerate the stars and their locations presumptuous (rem etiam Deo improbam). And yet up until the seventeenth century, without the aid of telescopes, star charts counted only 1000 to 1500 stars of the first five orders of size. At present, there are several observatories at work on extending this catalogue to the tenth order of size, which would yield a total number of about 200,000 fixed stars, all to be recorded, their positions determined. As a consequence of this research, a great number of new planets have been discovered; before 1781 only six planets were known, now we are aware of seventy-five.

When we survey this huge activity in all branches of science, we are likely to be as shocked by humanity's daring as was the chorus in Sophocles' *Antigone*, when it called out:

"Much is astounding, but nothing more astounding than man."

Who can oversee the whole? Who can hold the connections in hand and find his way? The natural consequence is that every individual researcher chooses an ever smaller area as his own sphere and can have only incomplete knowledge of related fields. We are now inclined to laugh when we hear that, in the seventeenth century, Keppler was appointed as Professor of Mathematics and Morals in Gratz, or that in Leyden, at the beginning of the eighteenth century, Boerhave was Professor of Botany, Chemistry, and Clinical Medicine, which naturally included pharmacology as well. Today we would need at least four teachers – at fully-staffed universities, seven or eight – to cover all of these fields. It is the same with other disciplines.

I have all the more reason to discuss the connections between the different disciplines here, because my own field falls under the heading of the natural sciences, which in recent times are often accused of going off in their own direction and becoming alien to those sciences which are connected to each other through common historical and philological studies. This contrast has been evident for a long time and appears to me to have developed under the influence of Hegelian philosophy, or at least it became clear because of Hegel. For at the end of the last century, under the influence of Kantian thought, such a division was not pronounced; Kant's philosophy shared a grounding with the natural sciences, which is best shown by Kant's own work in the natural sciences, especially his cosmogonic hypothesis – based largely on Newton's law of gravity – which later earned wide recognition when proposed by Laplace. Kant's critical philosophy was only concerned with examining the sources and legitimacy of our knowledge, measuring individual disciplines for their intellectual work. According to his philosophy, a proposition which pure thought finds to be *a priori* can only be a rule for the method of thought, but not have any positive and real content. The philosophy of identity was bolder. It started from the hypothesis that the real world, nature and human life, were the result of the thought of a creative spirit, which was considered to be similar to the human mind [*Geist*] in its essence. Consequently, the human mind seemed to be able to retrace the thoughts of the creator and find them again through its own inner activity, without being guided by external experiences. In this sense, the philosophy of identity sought to construct *a priori* the essential results of the other sciences. This could more or less succeed in the areas of religion, law, government, art, and history – in those disciplines whose object of study is essentially based upon psychology and are thus fittingly grouped under the heading of the "humanistic disciplines" [*Geisteswissenschaften*]. State, church, art, language – all exist to satisfy certain human needs. Whenever external obstacles, forces of nature, chance, and competition from other people interfere, in the end the efforts of the human spirit, all doggedly pursuing the same goal, will overtake the chaotic impediments and achieve victory. Based on an exact understanding of the human mind, namely when the philosopher has before him a wide spectrum of empirical data to which he can attach his abstractions, it would not be impossible under these conditions to predict *a priori* the path of human development in relation to the above-mentioned circumstances. Hegel, too, was greatly bolstered in his attempts to solve this question by the thinkers and poets of the ages immediately preceding his own, whose deep philosophical observations into history and science he generally only needed to organize and connect in order to create an impressive system with many surprising insights. Thus Hegel succeeded in creating great enthusiasm among the majority of the intellectuals of his day, generating wild hopes of solving the deepest mysteries of human life, all the more because the coherence of his system was cloaked in a remarkably abstract language which was probably understood by few of his admirers.

The fact that the main essential features of the human sciences could thus be more or less successfully constructed was still no proof of the correctness of the philosophy of identity upon which Hegel based his thought. Just the opposite: the decisive test would be the facts of the natural world. It was self-evident that the traces of the human spirit and its stages of development would be rediscovered in humanistic studies. If, however, nature reflects the result

of the thought process of a similar creative spirit, then forms and events which are relatively more simple should be all the easier to integrate into the system. But it was at this very juncture that the efforts of the philosophy of identity failed completely. Hegel's philosophy of nature was meaningless to scholars doing research in the natural sciences. Not one of the many outstanding researchers of the era had a practical use for Hegel's ideas. But because Hegel considered it of great importance to achieve in this very field the sort of recognition he was awarded elsewhere, he began an unusually passionate and bitter polemic directed mostly against Newton, the foremost and greatest representative of scientific research. Philosophers accused natural science researchers of narrow-mindedness; scientists reproached philosophers for lacking clear meaning. Scientists began to attach a certain importance to the claim that their work was free of any philosophical influence, and it soon came to be that many of them – including men of great prominence – considered all philosophy to be useless, even destructive dreaming. We cannot deny that, in addition to the philosophy of identity's many unjustified pretenses to dominate other disciplines, many of its legitimate efforts were also cast overboard: namely, philosophy's critique of the sources of knowledge and its attempt to find a common measure for intellectual work.

Things took a different course in the humanities, even if they eventually led to similar results. In all branches of scholarship – in religion, government, law, art, and language – enthusiastic supporters of Hegel arose who sought to reform their fields along the lines of his system and hoped that, through speculation, they could achieve the sort of results which previously were accomplished only through assiduous work. Thus, for a long period, a sharp division developed between the natural sciences and the humanities, and the scientific character of the latter was often disputed.

Admittedly, these strained relations were never as bitter as they were in their early phase. Through a rapid succession of astounding discoveries and application, the natural sciences proved to everyone that they were fruitful; one could deny them neither attention nor recognition. And in other branches of learning, too, conscientious researchers of facts raised their objections to the Icarus flights of speculation. Yet we should not forget to take note of this philosophical system's positive influences. We dare not deny that, since the appearance of Hegel and Schelling, scholars in different branches of the humanities have shown a livelier and more lasting interest in their spiritual content and goals than had been the case in previous centuries. The great work of this philosophy has certainly not been in vain.

[. . .]

If we now examine the different sciences with respect to the way they reach their conclusions, we note a thoroughgoing difference between the natural sciences and the humanistic disciplines. The natural sciences are best situated to develop their inductions into clearly defined general rules and laws. By contrast, the humanities have more to do with judgments made according to a psychological sense of tact. Historians, for example, need to examine the reliability of the authors who have handed down the facts. Thus, they begin the difficult and

important business of researching the very intricate and complex motives of the individuals and peoples who are the historical agents. Both can essentially only be determined through psychological insight. The philological disciplines, in so far as they are concerned with the elucidation and improvement of texts handed down to us – with literature and the history of art – must try to sense the meaning that the writer tried to express, the many associations he tried to evoke with his words. From beginning to end they need a correct understanding of the individuality of a writer as well as of the genius of the language which is his medium. All of these are examples of artistic rather than logical induction. A judgment can only be arrived at if a great number of individual facts of a similar type are kept ready in mind, so that they can be connected with the question immediately at hand. One of the first requirements for this type of study is, therefore, a trustworthy and well-prepared memory. In fact, many celebrated historians and philologists have astounded their contemporaries with the power of their memory. Of course, memory alone would be insufficient without the ability to quickly identify what is similar in essence, without a refined and well-developed insight into the human soul, something that cannot be reached without a certain warmth of feeling and interest in observing the emotional and spiritual condition of others. Whereas vibrant contact with people in everyday life provides the necessary basis for this sort of psychological insight, the study of history and art extends this basis and enriches it, in that these disciplines show us humans in extraordinary circumstances, and we learn from them the huge spectrum of powers which lay buried within ourselves.

With the exception of grammar, the above-mentioned scholarly disciplines do not generally formulate strictly valid laws. The rules of grammar are set down by human will, even if they are not conceived with conscious intention according to a considered plan; instead, they evolved gradually, as they were needed. Yet they appear to those who learn languages as commandments, laws imposed by an external authority.

Theology and jurisprudence are connected to historical and philological studies. The general rules we find in both of these fields are also commandments, laws which an external authority sets for belief and conduct in a moral and legal sense. They are not laws which, like the laws of nature, are generalizations based upon a wealth of facts. But, as with the application of a law of nature to an individual case, when something is subsumed under the commandments of grammar, law, morals, or dogma it takes the form of a conscious logical inference. The commandment forms the major premise of such an inference; the minor premise must ascertain if the case at hand contains the conditions for which the commandment is given. The solution of this will once again be a matter of psychological insight in most cases, in grammatical analysis (which should make clear the meaning of a sentence) as well as in legal judgment (concerning the credibility of the facts, or the intentions of a person, or the exact meaning of a written note).

[. . .]

The natural sciences are the opposite extreme from the philological and historical disciplines in terms of their kind of intellectual work. It is not as if, in many areas of the natural sciences, an

instinctive feel for analogies and a certain artistic tact do not have roles to play. On the contrary, in natural history one essentially relies on just those sort of abilities in order to determine which characteristics of species are important for classification, and which are unimportant, which sectors of the animal and plant kingdom are closer to the natural state than others – things which cannot be decided by a clearly definable rule. It is also significant that an artist, namely Goethe, initiated and essentially anticipated the further direction of comparative anatomical investigation by means of his analogy of the corresponding organs of different animals and his analogical theory of plant metamorphosis. But even in those disciplines where we work with the least understood life processes, it is for the most part much easier to formulate general concepts and theorems and to express them clearly than is the case when our judgment must base itself on an analysis of mental activities [*Seelenthätigkeiten*]. The especially scientific character of the natural sciences is seen in its full measure in those disciplines oriented toward experiments and mathematics, in pure mathematics most of all.

It appears to me that the natural sciences' essential difference emerges because it is relatively easy to combine individual cases of observation and experience into unconditionally valid general laws, whereas for the humanities this is insurmountably difficult. Indeed, in mathematics, the first general principles which are given pride of place as axioms are so few in number and of such infinite scope and such immediate evidence that they do not need a single proof. Consider that the entire field of pure mathematics (arithmetic) is developed from the following three axioms:

"If two quantities are equal to a third, then they are equal to each other."
"Equals added to equals, gives equals."
"Unequals added to equals, gives unequals."

The axioms of geometry or theoretical mechanics are no more numerous. The above-mentioned disciplines are developed from these few basic premises, in that conclusions are drawn from them in ever more intricate ways. Arithmetic does not limit itself to adding the manifold sets of a finite number of quantities; in higher analysis, it even theorizes an infinite number of sums to be added, whose quantities grow or diminish according to the most varied laws. Thus, arithmetic seeks to solve problems which could never directly be realized on earth. Here we see the conscious logical activity of our mind [*Geist*] in its purest and most complete form; we can acquaint ourselves with its great efforts, the tremendous care with which it must advance, the precision which is necessary to determine the scope of the general propositions, the difficulty in forming abstract concepts and to understand, but also how to have trust in the security, consequences, and fruitfulness of this kind of intellectual work.

This is even more apparent in applied mathematics disciplines, namely in mathematical physics, which includes astrophysics. After Newton had recognized, through a mechanistic analysis of planetary movements, that all matter attracts with a power that is in inverse proportion to the square of the distance, this simple law was sufficient to calculate planetary movements in the furthest reaches of the past and future with the utmost accuracy, if the location, speed, and

mass of all the individual heavenly bodies in our system are given for any particular instance. Indeed, we can recognize the effects of this power in the movements of twin stars whose distance apart is so great that it takes years for their light to reach each other, so far apart that our efforts to measure it have failed up to this point.

This discovery of the law of gravity and its consequences is the most impressive achievement that the logical power of the human mind has yet been capable of. I do not want to say that there have not been men with a capability for abstract thought equal or greater to Newton and the other astronomers – some of whom prepared the way for his discovery, some of whom exploited it – but never before had a subject as fitting as the confounding and intricate movement of the planets been comprehended under a general law, a subject which previously fed only the astrological superstitions of uneducated observers.

Based on this greatest of examples, a series of other branches of physics emerged, namely optics and the theory of electricity and magnetics. In the search for general laws of nature, those sciences which are based on experiments have an advantage over those based on observation, because they can manipulate the conditions at will and therefore need only a small number of characteristic cases in order to find the rule. The validity of the law must, admittedly, be tested on more complex cases. Thus, the physical sciences advanced relatively rapidly once they found the right methods. They have made it possible not only to cast our gaze into the very beginnings of time, when nebulae balled themselves up into stars and began to glow through the power of their compression, not only to investigate the component parts of the sun's atmosphere – the chemistry of the most distant fixed stars is certainly not far off – but they have also taught us to make use of the powers in our immediate natural environment, to put them in the service of our will.

From everything I have discussed here, it should be clear how different the intellectual activity in these sciences is from those I first spoke of. A mathematician needs no memory for individual facts, a physicist needs very little. Intuitions based upon the recollection of similar cases can be useful, in order to put things on the right initial track, but they only have value when they lead to a strictly defined and precisely limited law. With nature, there is no doubt that we are dealing with a causal nexus which knows no exceptions. We must therefore continue to work until we have discovered laws which are valid in every case. Before this is accomplished, we cannot be satisfied. Only in this form does our knowledge achieve victory over space and time and the forces of nature.

The solid work of a self-conscious conclusion requires great perseverance and caution. As a rule, it is very slow and is rarely helped by a flash of insight. There is little in it of the readiness with which historians or philologists sort through the most diverse experiences in their memory. On the contrary, it is an essential condition for methodical progress in thought that a thought remained concentrated on one point, undisturbed by other questions, undisturbed from wishes and hopes, moving forward only according to its own will and its conclusions. A famous logician, Stuart Mill, explained his conviction that, in recent times, the inductive sciences have done more

to advance logic's methods than have all academic philosophers. An essential reason for this is that in no other field does an error of thought lead so easily to false results as it does in those sciences where the outcome of a thought process can be directly compared with reality.

[. . .]

Source: „Ueber das Verhältniss der Naturwissenschaften zur Gesammtheit der Wissenschaft," in *Vortäge und Reden von Hermann von Helmholtz* ["On the Relationship of the Natural Sciences to the Whole of Science," in *Lectures and Speeches by Hermann von Helmholtz*], 2 vols. Fourth edition. Braunschweig: Friedrich Vieweg und Sohn, 1896, vol. 1, pp. 159-65, 172-73, 175-78.

Translation: Jonathan Skolnik