that "There is . . . no logical way leading to the establishment of a theory but only groping constructive attempts controlled by careful consideration of factual knowledge."[49] "A theory as noncommonsensical as Einstein's" has to be partly explained in terms of Einstein's "taste for 'inner perfection' in science," which does not proceed according to Duhemian logic but according to "an aesthetic which logicians of science have not yet reduced to empirical terms, or to intersubjective agreement."[50]

The immense advantage that the geometric mind could enjoy in developing a science whose fundamental principles were already laid was evident in chemistry, which had undergone a prodigious development in nineteenth-century Germany. Duhem argued that the role of the Germans was still small when J.-B. Dumas, followed by Laurent, Gerhardt and Wurtz (both from Strasbourg), and the English Williamson, carried out researches that through the theory of types made up modern organic chemistry. Only the German Hofmann, the rival of Wurtz in the discovery of amines, could be regarded as comparably important. But these researches introduced into chemistry the language and procedures of geometry. And the German Kekulé formulated the rules accurately and systematically. The take-off of German chemistry coincided with the acceptance of atomic notation; this, with the help of the rules furnished by the part of algebra called *Analysis situs* (topology), permitted prediction, enumeration, and classification of reactions, syntheses, and isomers of carbon compounds. So organic chemistry, subject to the geometric mind, brought forth from numerous German laboratories thousands and thousands of new organic compounds, all classified and described according to principles drawn from topology.[51] The subtle mind then had far less to do in organic

accepted relativity. See the technical work of E. M. Lémeray, *Le Principe de relativité* (Paris, 1916): "Cours libre professé à la Faculté des Sciences de Marseille pendant le premier trimestre 1915." Lémeray accepted relativity as "un instrument de coordination et, par conséquent, de découverte d'une puissance singulière." H. Dingle has been arguing against special relativity throughout the 1960s: see "The Case Against Special Relativity," *Nature* 216 (1967): 119–22, a restatement of his earlier case in *Nature* 195 (1962), which brought a reply from Max Born. W. H. McCrea, "Why the Special Theory of Relativity is Correct," *Nature* 216 (1967): 122–24, defends Einsteinian orthodoxy. A correspondence over the issues begins in *Nature* 219 (1968): 790–93.

49. Einstein, quoted in Holton, *Isis* 60 (1969): 156.

50. C. C. Gillispie, *The Edge of Objectivity* (Princeton, 1960), quoted in Holton, *Isis* 60 (1969): 180.

51. In the Kekulé memorial lecture, F. R. Japp said that three-fourths of

chemistry, while the geometric mind became more indispensable every day.[52]

In spite of his criticisms of German science, Duhem recognized its genius. In concluding his article, he noted that both French and German science deviated from the ideal and perfect science, although they deviated from it in opposite directions. In order for human science to develop fully and exist in a harmonious equilibrium, German and French science would have to co-exist, without trying to supplant one another: "Each must understand that it finds in the other its indispensable complement." In 1894 Duhem had recommended Neumann as a patron saint for young French physicists:

> Il me semble que le doyen des physiciens, l'illustre F. E. Neumann, doit contempler avec un légitime orgueil cet admirable ensemble de leçons embrassant toutes les parties de la physique, qu'il a professées il y a vingt ans, et qui, publiées aujourd'hui par ses élèves demeurent des modèles que n'égale presque aucun des enseignements de physique de l'Europe. Quelle étendue de connaissances! quelle pénétration de toutes les théories! et en même temps, quelle clarté, quelle élégance dans l'exposition! Les sept volumes qui renferme les cours de M. F. E. Neumann devraient être dans la bibliothèque de tous les jeunes professeurs de physique, auquels ils fourniraient avec une égale liberalité le fond d'un enseignement solide, et une forme parfaite.[53]

In studying German science, the French would find solid proof of truths they had discovered and formulated without complete certainty, or else they would find the refutation of errors they had committed under the intoxication of an imprudent intuition. It was equally useful for the Germans to study French science: there they would find problems for their patient analysis to solve as well as

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modern organic chemistry is directly or indirectly derived from Kekulé's "ring" theory of the constitution of benzene. *Encyclopedia Britannica* 13: 315.

52. Duhem, *La science allemande,* pp. 37–42; *Revue des deux mondes,* 683–84. He made the same argument for physical chemistry and stereochemistry, but noted that in mineral chemistry, where atomic notation had only a restricted usage, the *esprit de finesse* was still the instrument for untangling the complexity of reactions and for classifying compounds.

53. Duhem, review of F. Neumann, *Vorlesungen über mathematische Physik gehalten an der Universität Königsberg.* Siebentes Heft. *Vorlesungen über die Theorie der Capillarität* (Leipzig, 1894), *Revue des questions scientifiques* 36 (1894): 267.