E-JOURNAL (2023)
12. JAHRGANG / 1

zfl

FORUM INTERDISZIPLINÄRE BEGRIFFSGESCHICHTE (FIB)

LEIBNIZ-ZENTRUM FÜR LITERATUR- UND KULTURFORSCHUNG

Herausgegeben von Ernst Müller

Leibniz-Zentrum für Literatur- und Kulturforschung
Pariser Straße 1 | 10719 Berlin
T +49 (0)30 20192-155 | **F** -243 | sekretariat@zfl-berlin.org

IMPRESSUM

Herausgeber
Ernst Müller, Leibniz-Zentrum für Literatur- und Kulturforschung (ZfL), www.zfl-berlin.org

Gastherausgeberin dieser Ausgabe
Tatjana Petzer

Direktorin
Prof. Dr. Eva Geulen

Redaktion
Ernst Müller (Leitung), Dirk Naguschewski, Tatjana Petzer, Barbara Picht, Falko Schmieder, Georg Toepfer

Wissenschaftlicher Beirat
Faustino Oncina Coves (Valencia), Christian Geulen (Koblenz), Eva Johach (Konstanz), Helge Jordheim (Oslo), Christian Kassung (Berlin), Clemens Knobloch (Siegen), Sigrid Weigel (Berlin)

Gestaltung KRAUT & KONFETTI GbR, Berlin
Layout / Satz Tim Hager
Titelbild D. M. Nagu

ISSN 2195-0598

INHALT

ORIGINS AND DIMENSIONS OF REGULATION IN RUSSIAN AND SOVIET DISCOURSE

Clemens Günther

In the very beginning of the 20th century, the foreign verb »to regulate« (*regulirovat'*) entered the Russian vocabulary and was presented as an independent lemma in the third (1907) edition of the standard-setting *Explanatory Dictionary of the Living Great Russian Language*. Although its short and unchanged definition—: »to equalize (course, movement), to put something in proportion, to set in order«[1]—could already be found in the dictionary's first edition and later remained unchanged, this was the first time that it was granted its own lemma. The small lexicographic change indicates the increased importance of the term regulation (*regulirovanie*[2]) in the second half of the 19th century. Although its semantic career had already begun earlier in philosophy and economy during the 18th century,[3] the pervasive use of regulation as a conceptual category in recent physics and biology incentivized this valorization. It evolved into a universal category of systemic thinking that could also be adapted in emerging disciplines such as political science, economy, cybernetics, and ecology.

The term regulation was not only migrating across disciplines, as this paper intends to show, but also across empires. While its formation was closely linked to German, French, and British thought, Russian scientists of the second half of the 19th century such as Ivan Vyshnegradskii, Ivan Pavlov, Vasilii Dokuchaev, or thinkers like Nikolai Fedorov developed their own distinct understanding of regulation over time. This article follows the conceptual history of regulation in the Russian and Soviet context from the late 19th to mid-20th century and emphasizes its ecological dimension. Considering that regulation is a fundamentally interdisciplinary concept applied in biology, economics, law, or political science, such a history cannot strictly limit itself to the conceptual use of regulation in ecological theory. Here, ecology is rather generally understood as a scientific knowledge of nature that is being formed in various sciences throughout the 19th and 20th century by reintegrating knowledge generated in such different disciplines as natural history, biology, medicine, physics, or physiology.[4] This paper exemplarily traces the constitutional process of ecology as a science with regard to the concept of regulation by acknowledging the transdisciplinary and sometimes metaphorical use of the concept and its oscillation between the organic and the social, the natural and the artificial, the mechanic and the dynamic, the intrinsic and the extrinsic.

Georges Canguilhem has defined regulation as a rule-based alignment of different movements, actions, effects, or products.[5] This alignment can be under-

1 I[van] A. Boduena-de-Kurtenė [Jan Niecisław Ignacy Baudouin de Courtenay] (ed.): *Tolkovyi slovar' zhivago velikoruskago iazyka Vladimira Daliia – ispravlennoe i znachitel'no dopolnennoe izdanie* [Explanatory Dictionary of the Living Great Russian Language], vol. 3. P-R. St. Petersburg/Moscow: T-va M. O. Vol'f 1907, p. 1669. *Reglament'* had been introduced as a French loanword, while *regulirovat'* (to regulate) was attributed to the German »regulieren«.

2 The Russian language knows two words for regulation, *regulirovanie* and *reguliatsiia* (similar to the German use of Regulierung und Regulation) which are used synonymously. In general, *regulirovanie* is used more frequently and encompassing than *reguliatsiia*, which is mainly limited to medicine.

3 See Georges Canguilhem: »La formation du concept de régulation biologique aux XVIIIe et XIXe siècles«, in: *Idéologie et rationalité dans l'histoire des sciences de la vie*, Paris: Vrin, 1977, pp. 81–99; Georg Toepfer: »Regulation«, in: *Historisches Wörterbuch der Biologie. Geschichte und Theorie der biologischen Grundbegriffe*, ed. by Georg Toepfer, Stuttgart/Weimar: Metzler 2009, pp. 148–199; Robert Mitchell: »Regulating Life: Romanticism, Science, and the Liberal Imagination«, in: *European Romantic Review* 29 (2018), no. 3, pp. 275–293.

4 Benjamin Bühler: Ecocriticism. Grundlagen – Theorien – Interpretationen, Stuttgart: Metzler 2016, p. 10.

5 Georges Canguilhem: »Regulation«, in: *Encyclopaedia universalis.* 19, Paris: Encyclopaedia Universalis 2002, pp. 583–585, here p. 583. Although Canguilhem limits his

stood as an innate and intrinsic mechanism (self-regulation) for self-preservation and stabilization as in regulatory processes of the body or as an extrinsic mechanism shaped by extra-systemic ideals and intervention, such as in the regulation of the financial market. Regulation aims to restore the balance of a *status quo*. It serves as a compensatory tool for rectifying inordinacy, while the intended balance can either be a natural or an artificial setpoint. Acknowledging these differences, Canguilhem distinguishes biological and social regulation. However, an element that unites these discourses is a »very *specific* language of *regulation* based on the notions of repression, cooperation, blockage, and induction«,[6] consisting mainly of »metaphorical components«.[7]

I. REGULATING SYSTEMS

In 1868, Scottish physicist James Maxwell published his paper »On Governors« in which he sought an analytical solution to ensure the operability and functionality of machines that were regularly experiencing disturbances. Maxwell complained that the inventors of machines »confine[d] their attention to the way in which it [the machine] is designed to act« but did not pay sufficient attention to the actual operative conditions marked by irregularity and disorder.[8] He promised a mathematical »remedy for these disturbances«.[9] However, he was less interested in practical solutions for engineering and more in a theoretical discussion of what would today be called »dynamic stability«,[10] the ability of a system to maintain functionality and to ensure regularity »notwithstanding variations«[11] in its working conditions.

Maxwell's paper marks one of the »origins of cybernetics«[12] and a starting point for theories of automatic regulation.[13] At the same time, but probably independently from Maxwell's approach, Ivan Vyshnegradskii, the later Russian minister of finance, published his research on a *General Theory of Regulators* and *On Regulators of Direct Action*.[14] Unlike Maxwell, who was primarily interested in questions of theoretical mechanics, Vyshnegradskii looked at applied mechanics, particularly at the projection and construction of steam machines.[15] To this end, Vyshnegradskii calculated the resistances which prevented the device from remaining in balance and the angular speed of the device to rebalance the regulator. This meant establishing an early version of a feedback mechanism, matching the parameters used in the theoretical calculus with the actual physical parameters of the system.[16]

In the following years, the mathematical theory of system stability was further developed by Nikolai Zhukovskii and Andrei Liapunov before eventually being expanded into revolutionary thought by Aleksandr Bogdanov. In his *Tektology*, an early form of general

genealogy to Western examples, it is also of use for similar Russian discourses.

6 Hans-Jörg Rheinberger: »The Notions of Regulation, Information, and Language in the Writings of François Jacob«, in: *Biological Theory* 1 (2006), no. 3, pp. 261–267, here p. 263.

7 Canguilhem: »Regulation« (note 3), p. 584.

8 James Maxwell: »On Governors«, in: *Proceedings of the Royal Society of London* 16 (1867/1868), pp. 270–283, here p. 272.

9 Ibid.

10 Otto Mayr: »Maxwell and the Origins of Cybernetics«, in: *Isis* 62 (1971), no. 4, pp. 424–444, here p. 427. The contemporary relevance of this term can be seen in a competition initiated in 1875 by Cambridge University which was devoted to »The Criterion of Dynamic Stability«, see Christopher Bissell: *A History of Automatic Control, in Springer Handbook of Automation,* ed. by Shymon Nof, Berlin/Heidelberg: Springer 2009, pp. 53–69, here p. 56.

11 See Maxwell: »On Governors« (note 8), p. 270.

12 See Mayr: »Maxwell« (note 10).

13 Maxwell's essay opens the seminal Soviet anthology on the topic, see A. Andronov/I. Voznesenskii (eds.): *Teoriia avtomaticheskogo regulirovaniia* [Theory of Automatic Regulation], Moscow: Izd. Akad. Nauk SSSR 1949 and is also highlighted in the article on automatic regulation in the Great Soviet Encyclopedia, see A. A. Voronov: »Regulirovanie avtomaticheskoe« [Automatic Regulation], in: *Bol'shaia sovetskaia entsiklopediia* [Great Soviet Encyclopedia], vol. 21: *Proba –Remensy*, ed. by Aleksandr Prokhorov, Moscow: Izd. Sov. Ents. 1975, pp. 566–567. For a history of concepts of regulation in control engineering, see Stuart Bennett: *A History of Control Engineering* (1800–1930), Stevenage UK: Peter Peregrinus Ltd. 1979, pp. 7–50.

14 Ivan Wischnegradski: »Sur la théorie générale des régulateurs«, in: *Comptes rendus hebdomadaires des séances de L'Academie des sciences* 83 (1876), pp. 318–321; I[van] A. Vyshnegradskii: »O reguliatorakh priamogo deistviia« [Regulators of the Immediate Action], in: *Izvestiia S.P.B. Prakticheskogo tekhnologicheskogo instituta* 1 [Proceedings S.P.B. of the Practical Technical Institute 1] (1877), pp. 21–62.

15 See A[leksandr] Andronov/I[van]. Voznesenskii: »O rabotakh D. K. Makswella, I. A. Vyshnegradskogo i A. Stodoly v oblasti teorii regulirovaniia mashin« [About the Works of D.K. Maxwell, I.A. Vyshnegradskii and A. Stodoly on the Theory of Machine Regulation], in: *Teoriia avtomaticheskogo regulirovaniia* [Theory of Automatic Regulation], ed. by A. Andronov and I. Voznesenskii, Moscow: Izd. Akad. Nauk SSSR 1949, pp. 253–301, here p. 262.

16 See Aleksandr Lerner: *Nachala kibernetiki* [The Beginning of Cybernetics], Moscow: Nauka 1967, p. 136. Vyshnegradskii was highlighted by Lerner as the only, and thus also the international key pioneer for prefiguring the regulatory mechanisms in dynamic systems.

DOI: 10.13151/fib.2023.01.06

systems theory, Bogdanov, who studied at Liapunov in the 1890s in Kharkiv, expanded the meaning of regulation into one of the two main organizational mechanisms.[17] To illustrate this idea, he gave ecological examples such as the adaptation of plants and animals in light of local climate change. In the case of this and other examples, Bogdanov's understanding of regulation also included selection mechanisms to maintain a »dynamic balance«[18] (*podvizhnoe ravnovesie*) within a system. This idea was strongly informed by Darwin and Malthus (who had already mentioned population regulation in the 18th century). Still, it lacked any systematized argument concerning the actual mechanisms of regulation in its rather unsystematic sequence of examples.

Bogdanov's approach somehow foreshadowed Norbert Wiener's argumentation in his seminal work *Cybernetics or control and communication in the animal and the machine*. In this work, he famously highlighted James Maxwell's paper as »the first significant paper on feedback mechanism«,[19] omitting Vyshnegradskii's contributions that were at the same time rediscovered and heralded in Soviet science[20]. While Maxwell and Vyshnegradskii had limited their research on mechanics, Wiener suggested mapping automatic regulating mechanisms onto the organic world of living organisms. This was similar to Bogdanov's approach and the Soviet »community ecology« of the 1920s, which also migrated quantitative methods to the study of ecological questions such as »biocenoses« to detect their »regulatory mechanisms«.[21]

II. REGULATING BODIES

However, yet another Russian pioneer of cybernetic thinking was prominently mentioned in Wiener's genealogy: Ivan Pavlov. According to Wiener, Pavlov was a pivotal figure in drawing the attention of psychologists towards mental processes instead of mental content, developing a dynamic and systemic understanding of mental action. Pavlov started his career with research on the digestive system, which he understood as a »complex chemical factory«.[22] This metaphor favored a mechanistic understanding of body functions and was further developed into the designation of the nervous system as the chief regulator of the body.[23] Pavlov understood the body as a hierarchized system of main and side-factories held together by a superior regulative mechanism. Pavlov's machine metaphor echoed Claude Bernard's earlier description of the human body as a »living machine«.[24] Bernard was the first scientist »who gave the concept of physiological regulation a positive note«[25] and viewed regulation as an inner, self-regulatory function, contrasting the view of Comte and others who saw the organism as governed by the environment.[26] Pavlov was introduced to Bernard's theories by his mentor Il'ia Tsion and his »investigations of the nervous regulation of organ systems«.[27]

In the following years, Pavlov and his students developed further physiological theories of regulatory processes in the bodies and brains of humans and animals. Their research can be framed as a transition from a technomorphic model of regulation still oriented on the functionality of the machine to a cybernetic model oriented on self-acting regulatory mechanisms, to draw on a helpful differentiation from Karl Rothschuh.[28] While Bernard's conception of the

17 Aleksandr Bogdanov: *Tektologiia. Vseobshchaia organizatsionnaia nauka. Kniga 1* [Tectology. A General Organizational Science. Book 1], Moscow: Ekonomika 1989 [1922], pp. 189–206. The other main mechanism is the formative mechanism.

18 Ibid., p. 197.

19 Norbert Wiener: Cybernetics or control and communication in the animal and the machine, Cambridge: The MIT Press 1985 [1948], pp. 11–12.

20 See Andronov/Voznesenskii: »O rabotakh« (note 15). Later, Vyshnegradskii's contributions were also appreciated in Western science, see his mentioning in John Warfield: »Cybernetics«, in: *Encyclopedia of Human Behavior,* vol. 2, ed. by Vilayanur Ramachandran, San Diego: Academic Press 1994, pp. 63–72, here p. 63.

21 Douglas Weiner: »Community Ecology in Stalin's Russia. ›Socialist‹ and ›Bourgeois‹ science«, in: *Isis* 75 (1984), pp. 684–696, here pp. 687–688.

22 Ivan Pavlov: »O vzaimnom otnoshenii fiziologii i meditsiny v voprosakh pishchevareniia« [On the Mutual Relations of Physiology and Medicine in Questions of Digestion], in: *Polnoe sobranie sochinenii* [The Complete Works], vol. 2, Book 1, Moscow/Leningrad: Izd. Akad. Nauk SSSR 1951, pp. 245–274, here p. 250.

23 Ibid., p. 252.

24 Claude Bernard: *An introduction to the study of experimental medicine*, New York: Dover Publication 1957, p. 76.

25 Canguilhem: »La formation du concept« (note 3), p. 96.

26 Ibid., 95.

27 Daniel Todes: *Ivan Pavlov. A Very Short Introduction*, Oxford: Oxford Univ. Press 2022, p. 19. Tsion had been invited to Bernard's laboratory in the 1850s, see Galina Kichigina: *The Imperial Laboratory: Experimental Physiology and Clinical Medicine in Post-Crimean Russia*, Boston: Brill 2009, pp. 262–263.

28 Karl Rothschuh: »Historische Wurzeln der Vorstellung einer selbsttätigen informationsgesteuerten biologischen

body as a »living machine« had already overcome the mechanist Cartesian model of the body as a machine by qualifying the inner regulatory mechanisms within the organism,[29] the means of this regulation were still obscure. Although Pavlov already had a better understanding of the nervous system as the central regulatory instance of the body, he still could not fully understand the diverging behavior patterns of his study objects. At the same time, avant-gardists such as the poet and labor scientist Aleksei Gastev tried to capitalize on Pavlov's theories in favor of a new organization of work. This optimization of movements should be reached through repetition and training, which was to ultimately lead to the internalization and habitualization of new regulatory mechanisms of the body.[30] Similarly, the regulation of the nervous system became a metonymy for the regulation of the state in the painter and art theorist Kazimir Malevich's famous definition of »[t]he state [a]s an apparatus by which the nervous systems of its inhabitants [is] regulated«.[31]

Petr Anokhin, who worked in Pavlov's laboratory in the 1920s after starting his scientific career at Vladimir Bekhterev's Leningrad-based *Institute of Medical Sciences*, took a critical role in advancing Pavlov's approach toward a theory of functional systems.[32] Anokhin studied brain functions and explained their functionality as the result of »reverse afferentations« between the periphery and the center of the brain. This feedback mechanism contributed to his understanding of the brain as a »dynamic, autoregulating organization[ ]«.[33] While this theory had already been outlined in the 1930s – during late Stalinism, Anokhin's work was dismissed for its alleged undermining of Pavlov's theory of reflexes[34] – it was later reformulated in cybernetic terms. Anokhin expanded the scope of his theory by arguing that the functional system of the organism served as a role model »for any system with automatic regulation«.[35] This agenda required a clarification of the differences between organic and mechanic functional systems. In both cases, regulation was the essential mechanism. Still, while the machine's reaction to disturbances had no creative and spontaneous element, the organism had to find solutions autonomously:

»One of the essential differences is that the organism solves independently every moment the question: ›What is to be done?‹ For the machine, this question does not stand. For the machine, the question ›What is to be done?‹ has already been solved in the design office, on the factory floor, and perhaps even in the planning staff«.[36]

In contrast to a machine with limited ways of coping with disturbances, organisms could realize various possibilities to achieve regulatory adjustment effects.[37]

While Anokhin's theory of functional systems only hinted at an expansion towards ecological issues, evolutionary biologist Ivan Shmal'gauzen realized this amplification. Shmal'gauzen is best known as a pioneer of the »modern synthesis«, establishing a dialogue between Darwinian evolutionary theory and genetics.[38] In his evolutionary theory, regulatory mechanisms in organisms ensure the integration of the system, i.e., the »mutual adaptedness of all parts and functions of the organism, providing general stability«.[39] Shmal'gauzen follows regulatory processes on the individual and the supra-individual level.

Regelung«, in: *Nova Acta Leopoldina* 37 (1972), no. 1, pp. 91–106, here p. 93.

29 See for this trajectory Philippe Huneman/Charles Wolfe: »Man-Machines and Embodiment. From Cartesian Physiology to Claude Bernard's ›Living Machine‹«, in: *Embodiment. A History*, ed. by Justin Smith, New York: Oxford Univ. Press 2017, pp. 241–276.

30 See Tricia Starks: *The Body Soviet: Propaganda, Hygiene, and the Revolutionary State*, Madison: Univ. of Wisconsin Press 2008, p. 165.

31 Kazimir quoted by Boris Groys: *The Total Art of Stalinism*, Princeton: Princeton Univ. Press 1992, p. 17.

32 Galina Egiazaryan/Konstantin Sudakov: »Theory of Functional Systems in the Scientific School of P.K. Anokhin«, in: *Journal of the History of the Neurosciences* 16 (2007), pp. 194–205, here p. 195; for a genealogy of Anokhin's approach see Samuel Corson/Elizabeth O'Leary-Corson: »From Descartes to Pavlov to Anokhin. The Evolution of General Systems Concepts in Biomedical Sciences in Eastern Europe«, in: *Psychiatry. The State of Art. Vol. 2. Biological Psychiatry, Higher Nervous Activity*, ed. by P. Pichot, New York/London: Plenum Press 1983, pp. 679–682.

33 Egiazaryan/Sudakov: »Theory of Functional Systems in the Scientific School of P.K. Anokhin«, pp. 196–197.

34 Ibid., p. 201.

35 Petr Anokhin: »Teoriia funktsional'noi sistemy kak predposylka k postroeniiu fiziologicheskoi kibernetiki« [The Theory of Functional Systems as a Prerequisite for the Construction of Physiological Cybernetiacs], in: *Kibernetika funktsional'nykh sistem* [Cybernetics of Functional Systems], ed. by Konstantin Sudakov, Moscow: Meditsina 1998, pp. 12–32, here p. 15.

36 Ibid., p. 24.

37 Ibid., p. 15.

38 Levit, Georgy/Uwe Hossfeld/Lennart Olsson: »From the ›Modern Synthesis‹ to Cybernetics: Ivan Ivanovich Schmalhausen (1884–1963) and his Research Program for a Synthesis of Evolutionary and Developmental Biology«, in: *Journal of Experimental Zoology* 306 B (2006), pp. 89–106.

39 Ibid., pp. 93–94.

DOI: 10.13151/fib.2023.01.06

The first is formed on the molecular, cellular, and multi-cellular levels, the latter on the levels of population, species, and biocenoses.[40] According to him, on all these levels »›biological regulation‹ is always ›self-regulation‹« within a system.[41] The system, however, must not be imagined as a closed system but as an open system connected to the outer systemic in multiple ways.[42] Thus, like Anokhin, Shmal'gauzen advances towards a cybernetic understanding of biological regulation, extending its functional mechanisms in the direction of ecology.

III. REGULATING NATURE

The concepts discussed so far approached the idea of regulating nature from the grammatical point of the subjective genitive. However, this last chapter shifts towards the objective genitive. The regulation of nature manifests in the early modern period, predominantly with the idea of regulated rivers. Since the late 17th century, almost all major European rivers had become an object of state intervention, e.g., through the shortening of watercourses, bank stabilization, the influencing of flow velocity, and the construction of dams and artificial waterways.[43] The regulation of rivers was motivated by economic reasons, sovereignty claims, and a growing need for prevention. It was guided by the widespread idea that »only human intervention could finalize the state of nature«.[44] In the Russian empire, regulation of rivers gained momentum in the second half of the 19th century and was vividly discussed in relation to rivers such as the Dniester, the Dnepr, and the Volga.[45] As the Bolsheviks seized power in 1917, the regulation of rivers was expanded and became a central means in infrastructure policy.[46]

As the empire was plagued by drought and harvest failure in 1891, the discussion about regulation intensified. In these ensuing discussions, the soil scientist Vasilii Dokuchaev occupied a central role.[47] He argued that the steppes were characterized by a »natural regime«, formed throughout centuries that regulated the interaction between air, water, earth, animal, and plants long before man's arrival on the planet.[48] As this equilibrium had been destroyed, measures had to be implemented »to eradicate the evil« caused by man and nature.[49] These measures comprised the regulation of rivers, ravines, gulleys, and water management in the steppes.[50] This »Dokuchaev Plan«[51] was partly realized, making it one of the first comprehensive endeavors to regulate nature in Russia, including hydrological intervention and measures in forest and soil management.

Nikolai Fedorov followed the scientific debates about the environmental catastrophes at the turn of the century and expanded upon ideas of regulating natural processes by Aleksandr Voeikov[52] and others. In his writings, nature becomes an object of regulation (*reguliatsiia prirody*). Whereas Dokuchaev grants nature a strong self-regulatory potential, Fedorov sees

40 Ivan Shmal'gauzen: »Integratsiia biologicheskikh sistem i ikh samoreguliatsiia« [The Integration of Biological Systems and their Self-Regulation], in: *Kiberneticheskie voprosy biologii* [Cybernetic Questions of Biology], Novosibirsk: Nauka 1968, pp. 157–182.

41 Ibid., 176. The semantic field of mechanics is central to Shmal'gauzen's understanding of self-regulatory processes and structures in organic systems, indicating a similarity of organic and mechanic systems in his thought.

42 Shmal'gauzen: »Integratsiia« (note 40), p. 176.

43 Andreas Dix: »Flussregulierung«, in: *Enzyklopädie der Neuzeit*, Bd. 3: *Dynastie–Freundschaftslinien*, ed. by Friedrich Jäger, Stuttgart: Metzler 2005–2012, pp. 1042–1046, here p. 1043.

44 Nicolai Hannig: Kalkulierte Gefahren Naturkatastrophen und Vorsorge seit 1800, Göttingen: Wallstein 2019, pp. 125–126.

45 Mikhail Shuliatikov: *K voprosu o regulirovanii r. Volgi* [On the Question of Regulating the River Volga], Moscow: Tipo-Lit. N.I. Kumanina 1886; N.N.: »Stat'i ob uluchshenii sudostroeniia, sudokhodstva i moreplavaniia na Chernom i Azovskom moriakh i k voprosu o regulirovanii rek Volgi i Dnestra« [Articles on the Improvement of Shipbuilding, Shipping and Navigation in the Black and Azov Seas and on the Question of Regulating the Rivers Volga and Dnistr], Moscow: Tipo-Lit. N.I. Kumanina 1886.

46 The growing attention towards the regulation of rivers can exemplarily be shown in the encompassing entry on the topic in the *Technical Encyclopedia* of 1933, see S. Briling: »Regulirovanie rek« [The Regulation of Rivers], in: *Tekhnicheskaia entsiklopediia* [Technical Encyclopedia], vol. 19: *Razrabotka poleznykh iskopaemykh* [Development of Minerals], ed. by L. K. Martens. Moscow: Sov. Entsiklopediia 1927–1936, pp. 257–271.

47 See David Moon: »The Environmental History of the Russian Steppes: Vasilii Dokuchaev and the Harvest Failure of 1891«, in: *Transactions of the Royal Historical Society* 15 (2005), pp. 149–174.

48 Jan Arend: Russlands Bodenkunde in der Welt. Eine ost-westliche Transfergeschichte 1880–1945, Göttingen: Vandenhoeck & Ruprecht 2017, p. 85.

49 Vasilii Dokuchaev: *Nashi stepi prezhde i teper'* [Our Steppes before and now], St. Petersburg: Tip. E. Evdokimova 1892, p. 107.

50 Ibid., pp. 108–110.

51 Moon: »Environmental History« (note 47), p. 166 and p. 170.

52 Nikolai Fedorov: »Padaiushchie miry i protivodeistvuiushchee padeniiu sushchestvo« [Falling Worlds and the Creature Resisting the Fall], in: id.: *Sobranie sochinenii v chetyrekh tomakh [Collected Works in four Volumes]*, vol. 2, ed. by P. B. Shalimov, Moscow: Progress 1995, pp. 243–249, here p. 248.

it as a blind force without any soul and reason.[53] Man must complement this force (*usovershenstvovanie prirody*)[54] through a common task[55] (*obshchee delo*)[56]. Fedorov's rhetoric is characterized by its religious overtones as he understands regulation as a prayer and the human realization of the biblical »Give us this day our daily bread«.[57] Although the object of regulation is nature as a whole, Fedorov privileges meteorological interventions, thus becoming an early advocate of anthropogenic climate engineering. As shown by Michael Hagemeister, Fedorov's ideas of regulating nature influenced early Soviet thought and the Stalinist plans for transforming nature.[58]

Another scientist who was instantly inspired by Dokuchaev and Fedorov was Vladimir Vernadsky.[59] Following the Austrian geologist Edward Suess, he coined the concept of the »biosphere« which he understands as the »field of existence of life« characterized by the interaction between geological, biological, and human forces.[60] This emphasis on interaction and interconnectedness between different milieus echoes Bernard's research on the exchange processes between inner and outer milieus.[61] Although Vernadsky does not speak prominently about regulation,[62] regulatory mechanisms play a critical role in his understanding of »living matter« and his studies on the »properties and structures of living things«.[63] Vernadsky's writings also rekindle Dokuchaev's double understanding of regulation as a natural mechanism and a compensatory and creative human force, as Vernadsky promotes man's role as a geological force. Later on, these ideas evolved in Soviet cybernetic ecological thinking, most prominently in the case of Nikita Moiseev, a university professor for applied mathematics. Moiseev argued that one could not any longer speak about regulation and control (*upravlenie*) of such complex systems as nature but should limit to guidance (*napravlenie*), as giving direction to a specific development,[64] a shift indicating a growing disillusion with regulatory efforts.

IV. CONCLUSION

This article has traced the evolution and migration of concepts of regulation in the natural sciences and across the division between the »two cultures«. Since the mid-19th century, regulation has become a central term in physics, biology, and medicine as these disciplines gradually acknowledged the systemic character of their objects of study. In the Russian empire, the ground-breaking theories of Maxwell, Bernard and others were quickly adapted and expanded upon. At the turn of the 20th century, Russian science had developed an original understanding of regulation and significantly contributed to international debates.[65] At this point, the formerly mechanistic understanding of regulation was increasingly replaced by an energetic understanding of the exchanges of matter and information and, ultimately, by a (proto-)cybernetic conception of regulation. At the same time, regulation was conceived in evolutionary terms, which provoked a shift in orientation from closed to open systems. The acknowledgement of the evolutionary character of regulatory mechanisms and the possibility to create

53 Nikolai Fedorov: »Samoderzhavie« [Autocracy], in: id.: *Sobranie sochinenii v chetyrekh tomakh*, vol. 2, ed. by P.B. Shalimov, Moscow: Progress 1995, pp. 3–38, here p. 33.

54 See Nicolai Fedorov: »Prakticheskaia filosofiia Lottse, ili nauka o tsennosti bytiia« [Lotse's Practical Philosophy or the Science of the Value of Being], in: id.: *Sobranie sochinenii v chetyrekh tomakh*, Vol. 2, ed. by P.B. Shalimov, Moscow: Progress 1995, pp. 189–191, here p. 190.

55 Fedorov's concept of *obshchee delo* has also been translated as ›common cause‹ and ›common work‹; the latter meaning hints also to the probable derivation of *obshchee delo* from the Greek word for liturgy (note by the editor).

56 Fedorov: »Samoderzhavie« (note 53), p. 33.

57 Nikolai Fedorov: »Reguliatsiia meteoricheskaia, kak ispolnenie molitvy ›Khleb nash (t.e. trudom priobretennyi) dazhd' nam (t.e., vsem) dnes'‹« [Meteorological Regulation as the Fulfillment of the Prayer »Give Us [i.e. all] This Day Our Daily Bread [i.e. Acquired by Work«], in: *Sobranie sochinenii v chetyrekh tomakh*, vol. 2, ed. by P.B. Shalimov. Moscow: Progress 1995, p. 52.

58 See Michael Hagemeister: *Nikolaj Fedorov. Studien zu Leben, Werk und Wirkung*, München: Otto Sagner 1989.

59 Alexej Ghilarov: »Vernadsky's Biosphere Concept: A Historical Perspective«, in: *The Quarterly Review of Biology* 70 (1995), no. 2, pp. 193–203; George Young: *The Russian cosmists: the esoteric futurism of Nikolai Fedorov and his followers*, Oxford: Oxford Univ. Press 2012, pp. 155–162.

60 Ibid., p. 196 and p. 198.

61 See Jacques Grinevald: »Introduction: The Invisibility of the Vernadskian Revolution«, in: Vladimir Vernadsky: *The Biosphere*, New York: Copernicus 1998, pp. 20–32, here p. 30.

62 Exceptions are comments of the oceans as »heat regulator[s]« (Vernadsky, »The Biosphere« (note 61), p. 49) or organisms as »the intermediaries in the regulation of the chemistry of the crust by solar energy« (ibid., p. 55).

63 Ibid., p. 77.

64 Eglė Rindzevičiūtė: *The Power of Systems. How Policy Sciences Opened Up the Cold War World*, Ithaca: Cornell Univ. Press 2016, pp. 178–179.

65 This overview, however, is not meant to promote something like a Russian Sonderweg. As Canguilhem and others have shown, the migration of biological concepts of regulation to the social sciences is a constitutive part of the conceptual history of regulation. At most, Nikolai Fedorov's regulatory furor and the cosmism movement he founded was a specific phenomenon of the Russian empire which became influential in the early Soviet Union.

DOI: 10.13151/fib.2023.01.06

new regulation mechanisms brought forth the idea to artificially create new regulation processes. At this point, nature became an object of human regulation in Dokuchaev, Fedorov, and Vernadsky. Although this thinking inspired later Soviet endeavors to alter the face of Earth, it should not be limited to this kind of technocratic omnipotence. Instead, this way of thinking originated from a strong awareness of the threats the technological civilization was facing, an awareness that manifested itself in the proto-ecological theories of Dokuchaev and Vernadsky and in Moiseev's later downscaling from *upravlenie* to *napravlenie*.