Suggestions for Thinking and Talking about Science and Religion from the Soviet Resonance Controversy, a Chemical Counterpoint to Lysenkoism

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The Soviet resonance controversy was a chemical counterpart to Lysenkoism in which Soviet ideologues charged that Linus Pauling's resonance concept was hostile to Marxism. We study it here to illustrate the role of social factors in science-faith dialogue. Because Soviet chemists were attentive to ideological dimensions of the controversy, they were not only willing to engage in public dialogue but also offered a response that decoupled the scientific aspects of resonance from ideological hostility, largely by modifying how they talked about delocalized chemical bonds. This enabled them to criticize and reject a pseudoscientific alternative to resonance and to avoid a Lysenko-like takeover of theoretical chemistry without threatening the wider Soviet social system. A potential lesson is that Christians in science who wish to promote fellow believers' acceptance of their work would do well to account for the role of ideology in religiously motivated antimainstream science efforts.

One of us recently had the opportunity to examine a "creation-based" physical science textbook published by a Christian educational ministry.[1] Although the book used atoms to discuss matter, the author considered it important to point out that the scanning tunneling microscopy (STM) images commonly cited as evidence for their existence do not really show atoms. As the book's author correctly noted, the images are reconstructions calculated from the variation in the current between the microscope probe and surface, and there can be legitimate questions about their interpretation.[2] The author went beyond a salutary critique of naive scientific realism, however, in claiming that the images "may or may not be right" as they depended on two "big 'ifs'"—the "correctness" of quantum theory and the "theory" governing electron flow between the STM probe and tip.

At first glance, these rhetorical dismissals seemed surprising given that atoms, quantum mechanics, and theories of electron flow are hardly controversial in Christian circles. However, they are easier to understand if one considers that the parents who adopt such

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textbooks might have broad-ranging concerns over the implications of science's view of the world and its privileged status in contemporary culture.

Recent historical scholarship has done much to show how social factors can influence individual and communal responses to scientific claims.[3] For example, the Catholic response to Galileo is now known to be anything but an instance of religious bigotry standing in the way of well-established science. Instead, it represents a "Reformation-sensitive" response to the reasonable but as yet unestablished scientific hypotheses of a scientist who was also making theological claims about how the Bible should be interpreted. Similarly, Victorian Christian anxiety over Darwinian evolution, when present, had more to do with how evolution seemed to undercut eighteenth-century natural theology arguments and challenge contemporary perceptions of human uniqueness than it had to do with any feelings that evolution was fundamentally incompatible with Christianity. Furthermore, how particular communities responded depended heavily on local conditions and personalities.[4]

The influence of social factors is also apparent in evangelical approaches to evolution today. According to the sociologists Raymond Eve and Francis Harrold,

> [Young earth creationists] and their opponents tend not to differ over competing theories within the same intellectual framework, but in their most profound understandings of reality, religion, American society, and the nature of the scientific enterprise.[5]

Eve and Harrold also point out that young earth creationism has the characteristics of a movement ideology.[6] First, its ultimate aims are moral in that they are aimed at reforming science, education, and other elements of society around particular literal approaches to the Christian scriptures. Second, creationism "reevaluates the worth" of its adherents against that of its opponents by viewing them as defenders of truth and a morally good society over against the "villains" of secularism and liberal theology. Third, it has internally credible goals which include both tangible realizable short-term goals, such as enhancing the plausibility of the Christian message for evangelistic or apologetics purposes, and more nebulous, difficult-to-attain goals, such as establishing creationist ideas as the dominant contemporary intellectual framework. The intelligent design movement has similar characteristics, particularly in its "wedge strategy" for defeating "scientific materialism and its destructive moral, cultural, and political legacies" and replacing it with "the 'theistic' understanding that nature and human beings are created by God."[7] Religious opposition to mainstream climate change science can also fit this pattern when environmental claims, such as global warming, are identified with "antichristian" or "antihuman" forces in a larger culture war.[8]

In short, some religious groups oppose scientific ideas because they perceive them as part of an attack on authentically Christian ways of thinking about and living in the world.[9] Because of this, it should come as little surprise that these groups identify their views on these issues with orthopraxis as well as orthodoxy, promote them via the rhetoric of popular apologetics, and enforce them using group identity taboos. Although unhelpful episodes can arise from this situation, it is important to recognize that these groups are engaging science in a broad-ranging dialogue involving the scriptures, gospel, church life, and the world. It is just that little of this takes place in the rarefied atmosphere of academic inquiry. Instead, it is embedded in the myriad of individual and communal practices that characterize everyday Christian living.[10]

Nevertheless, apologists for mainstream science have been understandably more concerned with narrow interests such as defending the teaching of evolution in schools. Consequently, they rarely engage their opponents at the level of competing social visions, theological assumptions, and community practices. While this unfortunately leaves the 46 percent of Americans who do not believe in human evolution estranged in part from mainstream science,[11] it also provides an opportunity for Christians in the sciences to exercise spiritual care for their fellow believers' intellectual integrity and the witness of the church. As one step toward promoting that care, we suggest that a close study of the history of science and secular ideology might suggest potential pastoral strategies for alleviating American Christians' fear of scientific ideas. Here we consider one such interaction—the Soviet resonance controversy of the late 1940s and 1950s,[12] in which the concept of resonance used in organic and theoretical chemistry was charged with being

incompatible with Soviet ideology. It is significant because it was the only Soviet ideological controversy in which the scientists involved were reasonably successful in defending the intellectual integrity of their discipline.[13]

Before we begin, however, we wish to make several things clear. First, we use the term "ideology" to denote beliefs, actions, and motivations that are held, at least in part, due to social and organizational commitments. We explicitly reject the notion that such commitments are necessarily illicit. Since Christianity is as much about a shared life as a belief system, such commitments can have legitimate functions and should be taken seriously when addressing faith-science issues in any Christian community.

Second, we offer the resonance controversy merely as an illustrative story for considering some pastoral aspects of science-faith dialogue and do not claim that it represents an exact parallel to any contemporary issue. No sort of moral equivalence between communist ideologues' criticism of mainstream science and religiously motivated efforts to oppose mainstream science is implied or intended. We sympathize with many of the theological and pastoral concerns mainstream science can raise in religious communities, and one of our goals here is to suggest ways in which science-faith dialogue might be used to encourage faith communities to examine and, as appropriate, to reevaluate the underlying assumptions which drive their apprehensions.

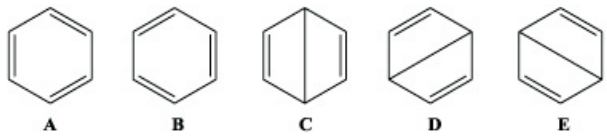
Third, although we do not deny that anti-evolutionism may pose a real threat to American science and science education, we do not wish to imply that the threat is in any way equivalent to the dangers facing Soviet chemists in Stalinist Russia. We deplore the tendency of some controversialists to liken critics of their position to Trofim Lysenko, the ignorant Soviet agrarian who condoned—if not promoted—the persecution of mainstream geneticists as part of his politically savvy promotion of pseudoscientific ideas. The scientific status of the resonance concept and the role of theoretical chemistry in late Stalinist Russia were very different from those of Mendelian genetics and biology, respectively.

Finally, we write as Christians in the sciences who are concerned with engaging the concerns of our fellow believers who oppose mainstream science. Thus, we will not address the implications of the resonance controversy for the philosophy of science,[14] how religious movements' ideologies affect how they respond to scientific ideas they accept, or the role of ideology in scientific materialist movements, such as the new atheism.[15]

The Scientific Theory of Resonance

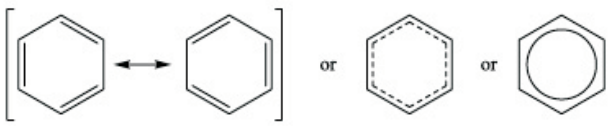
As it is typically presented in general and organic chemistry courses, the resonance concept applies to molecules for which more than one Lewis structure with pairwise bonds between the atoms may be written. It holds that the actual electronic structure of the molecule is a *resonance hybrid* of the different possible *resonance structures*. The paradigmatic example is benzene, which may be represented by the five irreducible resonance structures given in Scheme 1. All other valid Lewis structures are linear combinations of these five.

Scheme I. The five irreducible resonance forms of benzene used by Pauling to calculate the resonance energy in benzene.[16]



Not all structures contribute equally to the hybrid. For example, the actual ground state electronic structure of benzene is largely a combination of the Kekulé structures A and B with minor contributions from the Dewar structures C–E. Consequently, most textbooks represent benzene as shown in Scheme II.

Scheme II. Common representations of the benzene molecule.



These representations emphasize that all of the carbons in benzene are electronically equivalent although they might imply alternate ways of conceptualizing the bonding in benzene. For instance, the double arrow in the brackets at left is sometimes said to represent the benzene molecule "resonating" between the two structures, an unfortunate use of language that can obscure the idea that benzene is

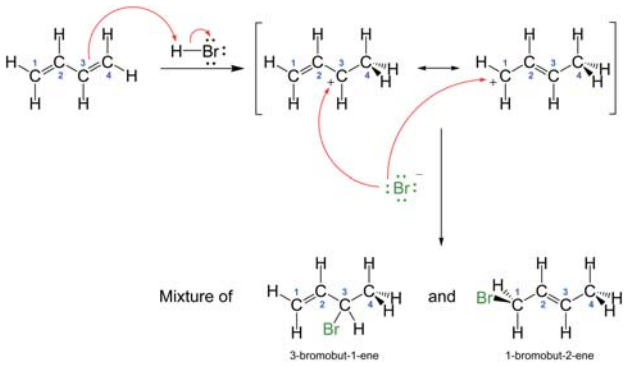
a hybrid or mix of the two contributing structures. In contrast, the two rightmost structures use a dashed line and a circle, respectively, to represent delocalized bonding and to emphasize that all the C-C bonds are equivalent, with bond orders neither single nor double but rather somewhere in between.

The American chemist Linus Pauling developed the resonance concept in the 1920s and 1930s as part of his valence bond approach to molecular structure, which he hoped would enable relatively mathematically unsophisticated chemists to use the new quantum mechanics[17] to obtain a pragmatically useful understanding of the structure and bonding in molecules.[18] In valence bond structures, the pairwise bonds of Lewis structures are reconceptualized in terms of pairwise overlap of unhybridized (*s*, *p*, *d*, *f*) or hybrid (*sp*, sp^2, sp^3, etc.) atomic orbitals. Resonance occurs when more than one possible valence bond description can be written. In this case, the wavefunctions describing each structure are quantum mechanically mixed to generate lower and higher energy wavefunctions, the former of which more closely corresponds to the molecule's true ground state.

In practice Pauling applied resonance theory by writing all possible valence bond structures, such as those shown in Scheme I for benzene, and taking linear combinations to obtain the lowest energy state.[19] He then correlated the resulting energy lowering with thermochemical measurements, showing that molecules which exhibit resonance are lower in energy than would be expected from their contributing structures. For example, benzene was considered "resonance stabilized" by 155 kcal/mol[20] relative to structures like A and B, with three single and three double C-C bonds. Pauling even used these resonance stabilization energies to calculate each valence bond structure's fractional contribution to the molecule's ground state, although even his collaborator George Wheland noted that the results could be "quite arbitrary" and should not be taken "too seriously."[21] In this connection, it is important to note that Pauling was not aiming for methodological rigor. He deliberately made several approximations and assumptions in formulating his valence bond approach, namely, in the use of trial functions involving pairwise bonding and in the use of linear combinations for his minimization procedure. Resonance theory's real appeal was not in its ontological validity but in its practical utility.

Today, resonance theory is primarily used for the qualitative prediction and rationalization of organic chemicals' reactivity. For example, in the addition of HBr to buta-1,3-diene, as shown in Scheme III, the resultant mixture of 3-bromobut-1-ene and 1-bromobut-2-ene may be thought of as arising from the addition of Br^- to different allylic carbocation resonance forms.[22] Alternatively, the electrophilicity of the allylic carbocation's 1 and 3 carbons is expected from their +½ partial charges in the resonance hybrid. Other models, such as frontier molecular orbital theory, give similar results but require calculation or prediction of the allylic cation's molecular orbital diagram first.

Scheme III. Mechanism for the hydrobromination of butadiene to give a mixture of 3-bromobut-1-ene and 1-bromobut-2-ene.



Although Pauling took the lead in applying and popularizing the resonance concept,[23] other workers made significant contributions to its development. Notably, Christopher Ingold described resonance under the term "mesomerism," which literally refers to structures in-between (*meso-*) multiple classical ones.[24] Ingold, in fact, was the first to apply resonance to the problem of organic reactivity.[25] Wheland also did much to develop and promote the use of resonance in organic chemistry, particularly through his 1944 monograph, *The Theory of Resonance and Its Application to Organic Chemistry*.[26]

Resonance theory was widely accepted by Soviet chemists in the 1930s and 1940s. After the Second World War, it was popularized by Iakov K. Syrkin and M. E. Diatkina via their influential textbook *Structure of Molecules and the Chemical Bond*[27] and by the Russian translation of Pauling's *The Nature of the Chemical Bond*.[28] During this time, resonance was

largely regarded as uncontroversial. A few Marxists, including J. B. S. Haldane, even offered it as an example of a Marxist dialectic.[29]

By the time controversy broke out, however, resonance theory was rapidly losing ground to molecular orbital theory—at least in theoretical chemistry. Although, in principle, the two methods should give equivalent results, molecular orbital theory seemed to more naturally accommodate delocalized bonding and was easier to apply to large molecules.[30] Furthermore, since it used conventional atomic orbitals, it was often regarded as more consistent with the spectroscopically verified results of atomic physics.[31] Practically, this meant that Soviet theoretical chemists would be more concerned to defend the use of quantum mechanics in chemistry than to defend the use of resonance theory in particular, although they also desired to preserve it as a highly useful reasoning aid.

Chemistry in Late Stalinist Russia

To understand why Soviet theoretical chemists responded to the controversy the way they did, it is helpful to consider the overall position of science and its role in Soviet society.[32] Prior to the 1917 Bolshevik takeover, Russia was a developing nation with an autocratic social structure and a respectable scientific establishment directed toward basic research and concentrated in university departments and academies such as the Imperial Academy of Sciences. The latter was particularly adept at building a productive relationship with the new regime, which provided it with increased funding and largely left the scientists alone to pursue their work. Indeed, the early Bolshevik leaders recognized that science and technology might be useful for transforming the relatively backward Russian economy into what they hoped would be a self-sustaining socialist one. Consequently, although most scientists did not necessarily approve of the regime, they were generally willing to accommodate themselves to it.

All this changed during the Great Break of the 1929–1931 Cultural Revolution that occurred after Stalin's rise to power. Industry, agriculture, and other forms of private enterprise were nationalized, and most areas of arts and culture, including the scientific academies, were subject to political purges. Those targeted faced dismissal, imprisonment, or death at the hands of Communist zealots, who looked on the purges as an opportunity to make established "proletarian" institutions more responsive to the needs and aims of the state.[33] The Soviet Academy of Sciences lost much of its independence through the state-mandated admission of engineers and Communist party members, the latter of which could be used to monitor scientists and censor the scientific literature. State control of scientific work was also facilitated through the centralization and bureaucratization of decision making in All-Union and local scientific academies, each of which functioned as a hybrid between a national laboratory and government ministry.[34]

Following the cultural revolution, Stalin attempted to modernize the Soviet economy rapidly through a series of grandiose agricultural and industrial projects. These largely technological efforts were intended to demonstrate the superiority of the Soviet system and to make the USSR more secure against internal and external threats. Lysenko's rule over Soviet biology in the early 1930s is explicable, at least in part, by Stalin's desire to achieve significant increases in agricultural production on the schedule of these "five-year" plans. Mainstream geneticists could offer only modest improvements to crop yields or livestock production on timescales comparable to several plant or animal life cycles. In contrast, the flamboyant, politically astute, and ruthless Lysenko—who never mastered statistics or bothered to collect the sort of data that would definitively establish or disprove his ideas—was always ready with promises of a quick fix.

As might be expected from their grandiose scale, breakneck pace, and narrow technological focus, many of Stalin's modernization projects failed while others caused massive social upheaval. The collectivization of agriculture in the Ukraine alone led to millions of deaths from famine. The Soviet leadership looked for scapegoats who could be accused of trying to "wreck" the country's progress, leading to relatively indiscriminate purges in which capable scientists were replaced with party functionaries. A culture of fear arose in which Soviet citizens learned to carefully maintain an appearance of political loyalty and to follow leaders' cues.[35] After ideologists suggested that science itself (exemplified by modern physics and Mendelian genetics) was "bourgeois" and intrinsically associated with the

capitalism of the societies in which it originated, there was a conscious effort to publicly align Soviet science with nationalism and Marxist ideology.[36] Soviet science was publicly touted as superior to the science arising from capitalist societies, and Lysenko was propelled to the status of a cult hero for his opposition to "Weismanist-Mendelist-Morganist" genetics.[37] Because Lysenko had a propensity for charging opponents with obstructing progress, his ascendancy revealed just how dangerous state interference in science could be. Soviet biology was effectively ruined by the persecution of mainstream geneticists who opposed Lysenko's unsupported ideas.[38] The everyday practice of chemistry and most other sciences was marginally affected, but the influx of nationalism would eventually play a role in the resonance controversy.

More deliberate efforts to align science with Marxist ideology occurred once the Cold War developed between the USSR and the West in the late 1940s. Seeking to present communism as an intellectually worthy alternative to democracy, Stalin attempted to align different scientific fields with Marxism's dialectical materialist philosophy.[39] Given that this philosophy emphasizes the reality of the physical and material universe described by empirical science, even claiming that everything which exists is explicable in terms of matter and energy organized according to orderly physical laws, it might seem straightforward.

Dialectical materialism, however, conflicts with conventional science in two important ways. First, dialectical materialism is set against idealism, the claim that the reality we perceive is the construct of our own minds. Thus, somewhat idealized but highly useful theoretical constructs such as resonance can be viewed with suspicion. Second, dialectical materialists are highly resistant to reductionism, even to the point of claiming that qualitatively different scientific laws operate in different disciplines because phenomena which operate at one level cannot be reduced to lower-order phenomena. For example, in the Marxist account of material origins—that is, from a primordial soup to the first primitive life forms all the way to modern humans and complex social networks—matter periodically undergoes *qualitative* transitions to higher "dialectical levels" in which different physical laws operate.[40] Because each scientific discipline operates on its own level in this scheme, each scientific discipline had to be aligned with Soviet ideology on its own terms. Thus ideological disputes in one discipline could not serve to resolve issues in others.[41]

The alignment of various sciences with Marxist ideology largely took the form of ideological "struggles," a series of public state-tolerated or initiated discussions among (mainly) scientists and (some) philosophers. Their potential for harm was revealed near their start when Lysenkoism was declared the official scientific orthodoxy in 1948, although the disputes reached their zenith between 1949 and 1951. Strikingly, the topics covered read like the table-of-contents section in a contemporary science and religion textbook:[42]

> These issues included, in the physical sciences, the problem of causality, the role of the observer in measurement, the concept of complementarity, the nature of space and time, the origin and structure of the universe, and the role of models in scientific explanation. In the biological sciences, relevant problems included those of the origin of life, the nature of evolution, and the problem of reductionism. In physiology and psychology, discussions arose concerning the nature of consciousness, the question of determinism and free will, the mind-body problem, and the validity of materialism as an approach to psychology. In cybernetics, problems concerned the nature of information, the universality of the cybernetics approach, and the potentiality of computers.[43]

The campaigns largely followed a predictable pattern. An ideological zealot or ambitious but mediocre scientist raised ideological objections to a mainstream scientific idea which were subsequently trumpeted in the Soviet press. Leading scientists in the affected discipline were then invited to a public meeting at which the official Soviet position was declared scientific orthodoxy, and mainstream scientists engaged in ideological criticism of their former views.

Despite structural similarities, however, the involvement of Stalin and other Soviet leaders was quite dynamic. The official Soviet position in each case ultimately depended in part on the importance of the activity to Soviet Cold War aims and the response of its practitioners.[44] For instance, the physicists managed to preclude a significant amount

of discussion in their discipline by arguing that it would be unproductive and would detract from work on the Soviet atomic bomb project. Soviet theoretical chemists were not so fortunate.

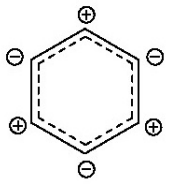
The Soviet Resonance Controversy and Its Aftermath

The resonance controversy originated in the writings of Gennadi V. Chelintsev, a professor of chemical warfare at the Voroshilov Military Academy whose primary area of expertise appears to have been in synthetic, not theoretical, chemistry.[45] In 1949, Chelintsev published a small monograph entitled *Essays on the Theory of Organic Chemistry,*[46] which attacked the concept of resonance on both ideological and nationalistic grounds. His ideological objections centered on resonance's use of idealized structures, which he charged was "mechanistic"—a euphemism for a form of scientific idealism opposed to dialectical materialism.[47] This charge has a basis in the nature of resonance theory itself, but Chelintsev put forward a second charge based on his misapprehension of resonance as a form of valence tautomerism in which bonds were continually interchanging.[48] Chelintsev claimed that Soviet chemists who supported resonance theory failed to properly emphasize the achievements of the nineteenth-century Russian chemist Alexander Butlerov, who advanced the idea that unique compounds must possess a single physical structure.[49]

Chelintsev offered his own "New Structural Theory," which he had earlier attempted to outline in the scientific literature,[50] as a way to avoid resonance's shortcomings. In it he effectively rejected quantum chemistry[51] in favor of classical valence theory's localized pairwise bonding[52] in the form of what he called "orbital" and "contact bonds."[53] These were akin to covalent bonds (although they did not really involve orbitals as in valence bond theory but something more like orbits) and ionic attractions between pairs of charged atoms, respectively.

To see how these ideas work, it is helpful to consider Chelintsev's conception of the bonding in benzene shown in Scheme IV. Instead of invoking delocalized or "resonating" pi bonds, Chelintsev localized electron pairs on alternating carbons, giving the alternating positive and negative charges shown. Benzene's ability to accommodate these alternating positive and negative charges was used to explain its special stability relative to odd-numbered carbon rings,[54] although Chelintsev's explanations for small and large rings were somewhat less convincing, and he had to downplay his model's inconvenient prediction that benzene has two sets of nonquivalent carbons and C-H bonds. Moreover, since Chelintsev's scheme treated all C-C multiple bonds as ionic, his theory predicted such howlers as the polarity of ethene.[55]

Scheme IV. Chelintsev's representation of the bonding in benzene in which the dotted line represents "the leveling out of charge," an ill-defined concept that his detractors felt could not overcome his scheme's prediction of polar C-C bonds in benzene.[56]



Given that Chelintsev extensively employed Marxist rhetoric, referred to by his opponents as the Lysenko-esque pejorative of Pauling-Ingoldites,[57] and did not use the "new structural theory" in his conventional scientific work,[58] he likely sought to provoke an ideological takeover of theoretical chemistry similar to that effected by Lysenko in biology. Indeed, that was the opinion of some of his contemporaries.[59] Nevertheless, Chelintsev's ideas found few scientific supporters and merely provided an opportunity for a broader ideological attack made by the chemists V. M. Tatevskii and M. I. Shakhparanov of Moscow University. In an article provocatively entitled "About a Machistic Theory in Chemistry and Its Propagandists,"[60] Tatevskii and Shakhparanov charged that resonance's advocates followed the idealist philosophy of Ernst Mach, which Lenin explicitly condemned in his *Materialism and Empirio-Criticism*.[61] This allowed Tatevskii and Shakhparanov to claim that scientists who defended resonance were hostile to the entire Marxist worldview:

> … the physical content of the theory of resonance is erroneous and (that) the philosophical setting of its authors and propagandists is Machistic. The Machistic theoretico-perceptional settings of the theory of resonance can serve as one of the examples of those world outlooks hostile to the

> Marxist view. They lead bourgeois scientists and their followers to pseudoscientific conclusions in the solution of concrete physical and chemical problems.[62]

More importantly, Tatevskii and Shakhparanov charged resonance's main Russian promoters, Syrkin and Dyatkina, with hindering Soviet science by failing to subject the resonance concept to ideological critique, or to give credit to Russian chemists who contributed to the development of structural chemistry.

> Directing the attention of Soviet chemists along the fallacious path of the vicious theory of resonance [resonance's supporters] demobilize Soviet chemical science in its struggle to fulfill the basic tasks of the Soviet scientists—"not only to attain, but to excel, in the shortest time, the achievement of science beyond the boundaries of our country" (Stalin).
>
> … Ya. K. Syrkin and M. E. Dyatkina have appeared before the Soviet public in the unenviable role of propagandists for the avowedly erroneous and vicious [resonance] theory of the American chemist, Pauling.
>
> … [Syrkin and Dyatkina's monograph, *Structure of molecules and the chemical bond*, is] permeated with a Machistic and cosmopolitanistic ideology [and] a slavish uncritical attitude toward bourgeois science and a contemptuous attitude toward native science … diverts Soviet chemistry from the solution of practical problems, in the direction of the bankrupt and sterile theory of resonance. The publication of this book, as well as Pauling's and Wheland's monographs, is a serious error committed by the publishers of chemical and foreign literature. The Ministry of Higher (University) Education, which has admitted the Machistic and cosmopolitanistic book by Ya. K. Syrkin and M. E. Dyatkina to serve as a study aid for the chemical faculties of the universities, has also committed a great error.[63]

In the event any Soviet chemists did not get these points, similar critiques appeared in the communist party newspaper, *Pravda*, and the journals, *Zhurnal Fizicheskoi Khimii* (Journal of Physical Chemistry) and *Uspekhi Khimii* (Russian Chemistry),[64] the latter of which was written by Yuri Zhdanov, head of the Communist party's central committee's Department of Science.[65]

Mainstream chemists were aware of the danger they faced having recently witnessed Lysenko's triumph over Soviet biology. However, they also had some appreciation for the social and political roles that open discussion of the ideological issues played in Soviet society.[66] Consequently, they did not merely engage Chelintsev's ideas but deliberately led the way in guiding the public discussion. Prominent chemists such as Alexandr Nesmejanov[67] and Oleg Reutov[68] publicly disavowed both resonance and Chelintsev's theory, the latter through a critical review of Chelintsev's monograph.[69]

The basic structure of Soviet chemists' response to Tatevskii, Shakhparanov, and Chelintsev's allegations more clearly took shape at the 1950 meeting of the Academy of Sciences's Institute of Organic Chemistry. The resulting report, *The Present State of the Chemical Structural Theory*, emphasized the contributions of Butlerov and other Russian chemists to structural chemistry, but it also sharply criticized the concept of resonance, often in grossly exaggerated and self-critical terms, echoing Tatevskii and Shakhparanov's charges.[70] However, the report's authors, which included many of the USSR's most eminent chemists, also constructed an independent and, at times, deploringly self-critical analysis of how particular construals of resonance might be incompatible with Marxist philosophy. While this ideological pandering led them to shamefully accuse Syrkin, Dyatkina, and other Soviet chemists of ideological failings, it also enabled them to present themselves as faithful guardians of Marxist ideology as they resisted Chelintsev's ideological criticisms, and dismissed his "new structural theory" as not merely misguided but also as a work of gross incompetence. They even charged Chelintsev with misunderstanding both Soviet ideology and quantum theory, a contention that was ironically confirmed when Chelintsev attempted to defend his theory against these and other critics.[71] In his "Answers to the Critics of the New Structural Theory," Chelintsev demonstrated a miscomprehension of quantum mechanics so profound that the article has the feel of a chemically sophisticated *Onion* satire. As a result, Chelintsev was rapidly isolated, and his ideas posed little threat of becoming scientific orthodoxy, official or otherwise.

The 1950 meeting's report, *The Present State of Chemical Structural Theory,* contained an elaborate

and unashamedly overstated endorsement of Butlerov that connected virtually all important features of modern bonding theory with Butlerov, including quantum mechanics and a diluted version of resonance known as the "theory of mutual influences."[72] In doing so, the report's authors effectively argued that recent advances in structural chemistry should not only be accepted but also that only Soviet science truly understood their full significance. This ideological posturing strengthened their arguments for retaining the core of modern bonding theory, including the use of resonance-like ideas (but not resonance itself, since that had effectively been officially condemned) as an analogical reasoning tool, plus the molecular orbital-based methods which were rising to prominence. Chelintsev, who associated rejection of resonance with acceptance of his own ideas, protested these moves but was powerless to stop them.[73]

The outcome of the resonance controversy had effectively been decided. A 1951 All-Union meeting devoted to the "Problem of Chemical Structure in Organic Chemistry," nominally organized to discuss the preceding meeting's report, really had a predetermined mandate to find an acceptable alternative to resonance while upholding the preceding meeting's decisions. Alexander Pechenkin even describes the meeting as a ritual in which Syrkin, Diatkina, and other defenders of resonance confessed and abjured their former views while others took an "oath of allegiance" either by condemning resonance or by extolling Butlerov's contributions to chemistry.[74] Although the conference criticized leading Soviet chemists, physicists, and philosophers for various failures to properly uphold Marxist principles because the meeting largely upheld the 1950 report's conclusions, the potentially most damaging consequences of the antiresonance campaign—the threat to quantum chemistry as a discipline—were averted. However, even though Soviet chemists could talk about electron delocalization and use resonance structures as computational aids, they would not be able to use the term "resonance" or employ resonance structures pedagogically.

The resonance controversy adversely affected Soviet chemistry in other ways as well. Since Syrkin, Diatkina, and others who had done much to help keep Soviet scientists up-to-date on the latest Western advances lost their influential posts, important Western scientific works such as Coulson's *Valence* were not disseminated widely when they appeared.[75] More importantly, the controversy discouraged bright students from pursuing careers in what was seen as an ideologically suspect area.[76] It also deprived Soviet chemists of resonance structures' power as a pedagogical tool and reasoning aid, since Soviet organic chemistry textbooks avoided mentioning resonance by name well into the 1980s.[77] Zhores Medvedev estimated that the controversy led the Russian chemical industry to fall seven to nine years behind that of Western nations.[78]

Can the Soviet Resonance Controversy Help Us to Think and Talk about Science and Religion?

There are a number of parallels between religiously motivated opposition to science and the Soviet resonance controversy. Creationists, intelligent design advocates, and resonance opponents alike use opposition to science to defend traditional subcultures.[79] Just as capitalism was demonized by communist ideologues, many Christian communities view secular learning or more liberal approaches to theology as pernicious influences. In these cases, ideological opposition to science serves to validate in-group epistemic practices and knowledge claims.[80] Young earth creationism represents a defense of theological populism and commonsense literal interpretations of Genesis,[81] analogous to the antiresonance campaign's role as an enforcer of Marxist-Leninist epistemology. For many of its adherents, the intelligent design movement's opposition to methodological naturalism largely serves an apologetics purpose. By carving out space for a Paleysian natural theology within the scientific enterprise, the intelligent design movement seeks to reinforce the plausibility of religious knowledge claims in a culture in which science and technology are held in high regard.

Like some science opposition movements, the resonance controversy also saw the proffering of verifiably incorrect scientific alternatives,[82] chosen more for their fit to a priori metaphysical assumptions and plausibility in explaining a narrow range of phenomena than for their consistency with wider bodies of scientific facts. Chelintsev's alternative theory was not used in the same way that creation

science and intelligent design ideas are used by some religious communities; it was offered as an alternative to quantum chemistry and never really adopted for apologetics purposes. Indeed, there is little indication that popular American science opposition movements intend to supplant the everyday practice of science with pseudoscientific alternatives.[83] Instead, they tend to be more tightly focused on criticizing mainstream scientific models than on promoting workable alternatives—a narrowing of aims that ironically makes them more far-reaching in their implications for science as a whole since a wide range of strategies can be employed to propose gaps or to magnify uncertainty in the scientific models that are used in many disciplines.

If American antievolutionists have more options than Chelintsev, Christians in science in many respects have fewer options than his opponents did. The original theory of resonance served primarily as an approximate guide for thinking about organic reactions; it lost ground to alternative computational approaches even as the controversy raged. In contrast, evolutionary theory has steadily proven itself as an increasingly powerful theory over the past fifty years, and climate change models, though incorporating a host of assumptions and approximations, universally predict dire outcomes which can be ignored only at great cost to even the most minimal ideas of Christian environmental stewardship, not to mention the Christian values of care for the poor and vulnerable. In short, efforts to repudiate the results of mainstream science or the scientists who practice it, run the risk of being inconsistent with intellectual honesty and Christian charity, as well as wisdom.[84]

Despite the aforementioned reservations and the difficulty inherent in generalizing from contingent historical events, it seems to us that the Soviet resonance controversy suggests several useful lessons for those who are concerned about religious apprehension of science. First, the ideological dimensions of religious objections to science need to be addressed directly. Practically, this will require Christians in the sciences to engage religious communities in dialogue over issues such as hermeneutics,[85] culture war metanarratives, and the role of the church in the world. While scientists may find it expedient to use their disciplinary expertise to address scientific fallacies motivated by religious apprehension, such critiques should be subsumed to the goal of strengthening and deepening faith. In this vein, it is reasonable to expect that scientists who think deeply about affected communities' underlying concerns, internal logic, and ethos will be most effective at alleviating their unnecessary fears.[86]

Second, scientists who wish to promote believers' appreciation of their work should take the lead in demonstrating consonance between their disciplines and religion. The Soviet chemists who led public discussion of the relevant scientific, philosophical, and cultural aspects of the controversy (rather than by attacking Chelintsev directly or by responding to his charges with vague disclaimers about Marxists who found resonance compatible with their beliefs) gained the ideological high ground and took political momentum away from resonance's detractors, securing a position they could use to neutralize the unfruitful ideas of Chelintsev without threatening the wider culture.

Finally, the resonance controversy indicates that the existing academic science-faith dialogue needs to be brought into the public arena. What is needed is a host of theologically and pastorally sophisticated public intellectuals who are sensitive to the concerns of religious communities and are willing to work to help shape religious adherents' engagement with science at the church, diocese, denomination, and international levels. Unfortunately, such work is not widely valued in Western scientific communities,[87] and so far it has been primarily the pseudoscience-advocacy groups who have brought a remarkable combination of grassroots effort and finely honed rhetorical, organizational, and cultural understanding to bear in their efforts to win the hearts and minds of American Christians. ★

Acknowledgments

We thank Westmont College for financial support via a professional development grant, and Professors Michael Everest and Carrie Stein, and the anonymous reviewers for their helpful comments, which greatly strengthened the present paper. We also thank Dr. David Campbell for drawing our attention to the comments about atomism in the *Exploring Creation with Physical Science* textbook.

Notes

[1]Jay Wile, *Exploring Creation with Physical Science* (Anderson, IN: Apologia Educational Ministries, 1999).

[2]For example, there has been a large amount of discussion over the legitimacy of claims that atomic orbitals have been visualized by STM. See Eric R. Scerri, "Have Orbitals Really Been Observed?," *Journal of Chemical Education* 77, no. 11, (2000): 1492–4; and P. Multer, "Are Orbitals Observable," *Hyle* 17, no. 1 (2011): 24–35. However, in the present context, it seems doubtful that many chemists or physicists would object to the claim that these images support the idea that matter is discontinuous on the atomic-molecular scale.

[3]Notable accounts include David C. Lindberg and Ronald L. Numbers, eds., *When Science and Christianity Meet* (Chicago, IL: University of Chicago Press, 2003); David N. Livingstone, D. G. Hart, and Mark A. Noll, eds., *Evangelicals and Science in Historical Perspective*, Religion in America Series (New York: Oxford University Press, 1999); John Hedley Brooke, *Science and Religion: Some Historical Perspectives*, Cambridge Studies in the History of Science (New York: Cambridge University Press, 1991); John H. Brooke and Geoffrey Cantor, *Reconstructing Nature: The Engagement of Science and Religion*, Glasgow Gifford Lectures (New York: Oxford University Press, 2000).

[4]David N. Livingstone, "Situating Evangelical Responses to Evolution," in *Evangelicals and Science in Historical Perspective,* ed. Livingstone, Hart, and Noll, 193–219.

[5]Raymond A. Eve and Francis B. Harrold, *The Creationist Movement in Modern America,* Social Movements Past and Present (Boston, MA: Twayne Publishers, 1990), 67.

[6]Ibid., 68–9.

[7]*The Wedge,* Discovery Institute Center for the Renewal of Science and Culture, 1999.

[8]Much religious opposition to climate change science is probably just an outgrowth of concerns over biological accounts of human origins, or the age of the earth, or a consequence of confusing Christianity with particular brands of conservative politics. However, some Christian groups denigrate environmental scientists' predictions precisely because they contextualize them in a culture war. See James Wanliss, *Resisting the Green Dragon: Dominion, Not Death* (Burke, VA: Cornwall Alliance for the Stewardship of Creation, 2010) as a particularly vivid example of how the denigration of climate change science can be connected to concerns over the theologically questionable ethos of some elements of the environmental movement.

[9]These general features of creationism are discussed in Eve and Harrold, *The Creationist Movement in Modern America*, and Randall J. Stephens and Karl W. Giberson, *The Anointed: Evangelical Truth in a Secular Age* (Cambridge, MA: Belknap Press of Harvard University Press, 2011). Particularly illuminating and nuanced accounts of the social structure of groups that tend to reject evolution are given in James M. Ault Jr., *Spirit and Flesh: Life in a Fundamentalist Baptist Church* (New York: Alfred A. Knopf, 2004), particularly the chapter on "Fundamentalism and Tradition," 201–20, and the account of Multnomah Bible School given in Randall Balmer, *Mine Eyes Have Seen the Glory: A Journey into the Evangelical Subculture in America,* 4th ed. (New York: Oxford University Press, 2006).

[10]This is as true for fundamentalist communities that are nominally based on a literal reading of biblical norms as for more liberal Christian communities. For a particularly vivid and illuminating account of the role of social factors and tradition in one fundamentalist community, see the chapters on "Biblical Morality" and "Fundamentalism and Tradition" in Ault, *Spirit and Flesh*, 186–220.

[11]Frank Newport, "In U.S., 46% Hold Creationist View of Human Origins: Highly Religious Americans Most Likely to Believe in Creationism," *Gallup Politics* (June 1, 2012), http://www.gallup.com/poll/155003/Hold-Creationist-View-Human-Origins.aspx?utm_source=alert&utm_medium=email&utm_campaign=syndication&utm_content=morelink&utm_term=Religion.

[12]This controversy is sometimes called the Chelintsev affair after the name of the main Soviet critic of resonance theory.

[13]We have also selected to use the resonance controversy as an example because of our disciplinary expertise in chemistry. Indeed, we also consider this article part of a broader program of bringing chemistry into the science-faith dialogue.

[14]The importance of the resonance controversy for the philosophy of chemistry is treated in Jaap van Brakel, *Philosophy of Chemistry: Between the Manifest and the Scientific Image*, Louvain Philosophical Studies 15 (Leuven, Belgium: Leuven University Press, 2000).

[15]In the future, we hope to explore the role that social factors play in the new atheism by examining the life of the early twentieth-century German chemist Wilhelm Ostwald and his work with the Monist league.

[16]Linus Pauling and G. W. Wheland, "The Nature of the Chemical Bond. V. The Quantum-Mechanical Calculation of the Resonance Energy of Benzene and Naphthalene and the Hydrocarbon Free Radicals," *The Journal of Chemical Physics* 1 (1933): 362–74.

[17]The new quantum mechanics refers to wave mechanics as opposed to the classical quantum mechanics epitomized by the Bohr model of the atom.

[18]Since the Schrödinger equation cannot be solved exactly for polyelectronic atoms, molecules, and ions, a variety of approaches were developed to apply the results of quantum mechanics to these systems, all of which employ different assumptions about the nature of electronic structure and chemical bonding. Of these approaches, Pauling's most broadly appealed to bench chemists and is still the most commonly used approach in the American undergraduate curriculum. See Kostas Gavroglu and Ana Simões, *Neither Physics nor Chemistry: A History of Quantum Chemistry* (Cambridge, MA: The MIT Press, 2012) for an excellent discussion of the role these approaches played in the development of quantum chemistry.

[19]Readers familiar with molecular orbital theory may find this description strange. In molecular orbital theory, hydrogen-like atomic orbitals on individual atoms are used as a basis set. In resonance theory, the same procedure was applied to the entire bonding pattern represented by the different resonance forms. This essentially allowed the pi-type orbitals to quantum mechanically mix.

[20]This lowered energy is referred to as the "resonance stabilization energy."

[21]Thomas Hager, *Force of Nature: The Life of Linus Pauling* (New York: Simon & Schuster, 1995), 328.

[22]Note that this account is not fully consistent with the idea of the true structure being a resonance hybrid, although it still is pragmatically useful for understanding the chemical properties of the allylic carbocation.

[23]See Pauling, "The Nature of the Chemical Bond. V"; Linus Pauling and E. Bright Wilson Jr., *Introduction to Quantum Mechanics, with Applications to Chemistry* (New York: McGraw-Hill Book Company, 1935); Linus Pauling, *The Nature of the Chemical Bond and the Structure of Molecules and Crystals: An Introduction to Modern Structural Chemistry,* 2nd ed., The George Fisher Baker Nonresident Lectureship in Chemistry at Cornell University, vol. 18 (Ithaca, NY: Cornell University Press, 1940); Linus Pauling, "The Application of the Quantum Mechanics to the Structure of the Hydrogen Molecule and Hydrogen Molecule-Ion and to Related Problems," *Chemical Reviews* 5 (1928), 173–213.

[24]Classical valence bond theory looks at bonding in terms of electrons between pairs of atoms. Today, valence bond theory is often associated with bonding descriptions involving hybrid orbitals and sigma and pi bonds. These orbital descriptions of bonding are consistent with the classical valence bond picture embodied in Lewis structures, in that they retain the pairwise bonding of classical valence bond theory. Resonance theory thinks about sigma bonds in pairwise terms but allows for the possibility of pi-bonds delocalized over three or more atoms.

[25]C. K. Ingold and E. H. Ingold, "The Nature of the Alternating Effect in Carbon Chains. Part V. A Discussion of Aromatic Substitution with Special Reference to the Respective Roles of Polar and Non-Polar Dissociation," *Journal of the Chemical Society* (1926): 1310–28.

[26]George Willard Wheland, *The Theory of Resonance and Its Application to Organic Chemistry* (New York: John Wiley and Sons, 1944).

[27]I. K. Syrkin and M. E. Diatkina, *Structure of Molecules and the Chemical Bond* (New York: Interscience Publishers, 1950), originally published as *Khimicheskaia sviaz* (1946).

[28]Syrkin and Diatkina were also preparing a translation of Wheland's *Theory of Resonance* at the time the resonance controversy broke out.

[29]J. B. S. Haldane, *The Marxist Philosophy and the Sciences* (New York: Random House, 1939).

[30]While Pauling and Wheland's resonance treatment of benzene involved five irreducible resonance structures, a full treatment of naphthalene requires forty-two.

[31]Alexander A. Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science," *LLULL* 18 (1995): 135–66.

[32]Excellent general overviews of the role of science in the Soviet Union can be found in the work of Loren Graham, Paul Josephson, and Ethan Pollock. See especially Loren R. Graham, *Science, Philosophy, and Human Behavior in the Soviet Union* (New York: Columbia University Press, 1987); Loren R. Graham, *Science in Russia and the Soviet Union: A Short History*, Cambridge Studies in the History of Science (Cambridge: Cambridge University Press, 1993); Paul R. Josephson, *Totalitarian Science and Technology,* 2nd ed. (Amherst, NY: Prometheus Books, 2005); Ethan Pollock, *Stalin and the Soviet Science Wars* (Princeton, NJ: Princeton University Press, 2006).

[33]See especially Graham, "The Russian Revolution and the Scientific Community," in *Science in Russia and the Soviet Union,* 79–98.

[34]Ibid., 93–8; Graham, "The Organizational Features of Soviet Science," in *Science in Russia and the Soviet Union,* 173–96; and Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science," gives a good indication of the impact of these control measures.

[35]See Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science," 137, for a description of the form of these cues and their importance in everyday Soviet life.

[36]Graham, *Science in Russia and the Soviet Union*, 121–3.

[37]See especially the account of Lysenkoism given in Walter B. Gratzer, *The Undergrowth of Science: Delusion, Self-Deception and Human Frailty* (New York: Oxford University Press, 2000).

[38]David Joravsky, *The Lysenko Affair* (Chicago, IL: University of Chicago Press, 1986).

[39]Pollock, *Stalin and the Soviet Science Wars.*

[40]The sympathetic historian of Soviet science, Loren Graham, notes that dialectical materialism's antireductionism helps its adherents ease the tensions between philosophical materialism and the everyday world of value and meaning. See especially Graham, *Science in Russia and the Soviet Union*, 100–2.

[41]For example, biology could not be reduced to chemistry which in turn could not be reduced to physics—even in principle. Dialectical materialism regards each of these disciplines as having their own laws. Thus, the issue of quantum mechanics in physics, itself the subject of a controversy, could be separated from its status in chemistry. This is one reason why Soviet chemists were careful to protect the use of quantum mechanics when they responded to the resonance controversy.

[42]As chemists, we limit our consideration to the main controversy in chemistry. Readers with other disciplinary backgrounds are invited to consider the possible merit of close study of these controversies for science-faith dialogue in their disciplines.

[43]Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 17.

[44]See especially Pollock, *Stalin and the Soviet Science Wars*; and Slava Gerovitch, "'Normal Pseudo-Science,'" in *From Newspeak to Cyberspeak: A History of Soviet Cybernetics* (Cambridge, MA: MIT Press, 2002), 103–52.

[45]We suspect that Pechenkin ("The 1949–1951 Anti-Resonance Campaign in Soviet Science," 135) is right in claiming that Chelintsev was not the undistinguished chemist most English-language sources make him out to be, although his expertise appears to have been in synthesis and his stature was hardly comparable to that of the Russian chemists he criticized, let alone to that of Pauling. The Voroshilov Military Academy at which he taught trained general staff officers and was the most prestigious military academy in the Soviet Union. A SciFinder scholarly search of Chelintsev's writings reveals that he published a very respectable thirty-four papers on various organic reactions and syntheses between 1935 and 1947, at which time his writings began to focus more heavily on theoretical structural chemistry. In fact, he published only two synthetic

papers thereafter, both in 1950, although it is not clear whether this was due to censorship of his synthetic work or a genuine drop-off in scientific productivity. It is notable that Chelintsev's publication record begins in 1935, in the midst of the Stalinist purges, although it is not clear whether Chelintsev's ideological views played a role in securing his position.

[46]G. V. Chelintsev, *Essays on the Theory of Organic Chemistry* (Goskhimizdat [State Chemistry Publishers], 1949).

[47]In particular, Chelintsev charged that resonance's idealized structures were "mechanistic," a reference to mechanistic materialism, which Marxists equated with scientific idealism. See Loren R. Graham, "A Soviet Marxist View of Structural Chemistry: The Theory of Resonance Controversy," *ISIS* 55 (1964): 20–31; and Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 299–300.

[48]G. V. Chelintsev, "Tautomerism," *Izv. Akad. Nauk SSSR, Ser. Khim.* (1946): 313–24.

[49]Butlerov formulated this principle in the midst of discussions about the relationship between physical structure and chemical identity in which he was one of the main champions of the idea that structure determines chemical identity. In doing so, he made genuine and important contributions to chemical bonding theory that had indeed been somewhat overlooked by Western writers. See A. J. Rocke, "Kekulé, Butlerov, and the Historiography of the Theory of Chemical Structure," *The British Journal for the History of Science* 14 (1981): 27, for a fuller description of these issues. Thus, in laying down the charge that compounds which exhibit resonance fail to possess a single structure, Chelintsev not only ignored or misunderstood Pauling and Wheland's disclaimers, but also apparently failed to appreciate the true aim of Butlerov's principle.

[50]See Chelintsev, "Tautomerism"; G. V. Chelintsev, "Valence and Bonds," *Izv. Akad. Nauk SSSR, Ser. Khim.* (1946): 549–56; V. K. Kuskov, "Dyadic Tautomerism," *Zh. Obshch. Khim.* 16 (1946): 1481–4; G. V. Chelintsev, "The Aromatic Bond," *Izv. Akad. Nauk SSSR, Ser. Khim.* (1947): 81–8.

[51]In this connection, it is interesting to note that Soviet ideologues were also uncomfortable with quantum mechanics due to its association with indeterminism (at least in the Copenhagen interpretation), although they tolerated its usefulness as a computational tool.

[52]Hans Vermeeren helpfully describes how resonance presented a genuine challenge to G. N. Lewis and Irving Langmuir's classical bonding ideas in H. P. W. Vermeeren, "Controversies and Existence Claims in Chemistry: The Resonance Controversy," *Synthese* 69 (1986): 273. However, in our opinion Vermeeren's presentation of Chelintsev's opposition to resonance as a legitimate scientific controversy does violence to its true nature.

[53]D. N. Kursanov, M. G. Gonikberg, B. M. Dubinin, M. I. Kabachnik, E. D. Káverzneva, E. N. Prilezhaeva, N. D. Sokolov, and R. K. Freidlina, "The Present State of the Chemical Structural Theory," *Journal of Chemical Education* 29 (1952): 9.

[54]Chelintsev, "The Aromatic Bond."

[55]Chelintsev's opponents were quick to point out these inconsistencies. See Kursanov et al., "The Present State of the Chemical Structural Theory," 2. It is noteworthy that Pauling included such structures in his resonance treatments as well. However, since these electronic structures were allowed to mix with a corresponding structure of opposite polarity, the resulting resonance hybrids were nonpolar.

[56]Graham, "A Soviet Marxist View of Structural Chemistry," 22; Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 299.

[57]Chelintsev apparently copied Lysenko's tactic of referring to his opponents' doctrine as Morganism-Weismanism, Mendelism-Morganism, or even Mendelism-Morganism-Weismanism, which implied that they were advocating the ideas of foreign bourgeois scientists.

[58]Kursanov et al., "The Present State of the Chemical Structural Theory," 8.

[59]Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 307.

[60]V. M. Tatevskii and M. I. Shakhparanov, "About a Machistic Theory in Chemistry and Its Propagandists," *Journal of Chemical Education* 29 (1952): 13–4.

[61]V. I. Lenin and A. Fineberg, *Materialism and Empirio-Criticism; Critical Comments on a Reactionary Philosophy* (Moscow: Foreign Languages Publishing House, 1947).

[62]Tatevskii and Shakhparanov, "About a Machistic Theory in Chemistry and its Propagandists," 13.

[63]Ibid., 14.

[64]Y. Zhdanov, "The Main Features of Butlerov's Theory of Chemical Structure," *Uspekhi Khimii* no. 18 (1949): 472–80, cited in Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science."

[65]Graham, "A Soviet Marxist View of Structural Chemistry," 24–5; Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 300.

[66]See Pechenkin, "The 1949–51 Anti-Resonance Campaign in Soviet Science"; and Gerovitch, *From Newspeak to Cyberspeak*, 115–8. Gerovitch, in particular, notes that savvy scientists could sometimes shape ideological campaigns to their own ends.

[67]*Complete Dictionary of Scientific Biography* (2008), s.v. "Nesmejanov, Aleksandr Nikolaevich," http://www.encyclopedia.com/doc/1G2-2830905946.html.

[68]O. A. Reutov, "O knige G. V. Chelintseva 'Ocherki po teorii organicheskoy khimii'" [On the Book by G. V. Chelintsev 'Essays on the theory of organic chemistry'], *Voprosu Filosofii (Problems of Philosophy)* 3 (1949): 309–17.

[69]Nesmeyanov and Reutov also attempted to demarcate between resonance and mesomerism, although their efforts never quite caught on.

[70]Kursanov et al., "The Present State of the Chemical Structural Theory," 2–13.

[71]G. V. Chelintsev, "Theory of Chemical Structure of A. M. Butlerov and Its New Successes," *Zh. Obshch. Khim.* 22 (1952): 417–30; G. V. Chelintsev, "Answers to the Critics of the New Structural Theory," *Izvest. Akad. Nauk S.S.S.R. Otdel. Khim. Nauk* (1952): 190–6 (pages 205–13 in English).

[72]Like resonance, the theory of mutual influences involved delocalized bonding.

[73]G. V. Chelintsev, "On the New Position by Chemists-Machists," *Voprosy filosofii* 2 (1950), cited in Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science."

[74]Pechenkin, "The 1949–1951 Anti-Resonance Campaign in Soviet Science," 145–52.

[75]Ibid., 155.

[76]István N. Hargittai, "Fukui and Hoffmann: Two Conversations," *The Chemical Intelligencer* 1, no. 2 (1995): 14–25.

[77]Graham, *Science, Philosophy, and Human Behavior in the Soviet Union*, 311–7.

[78]Z. A. Medvedev, *Soviet Science* (New York: W.W. Norton and Company, 1978), 52–4.

[79]This is not to say that there are no differences between evolution and resonance theory on this score. There is little evidence that chemical bonding theory ever caused the sort of unease among grassroots Marxists that evolution has caused in American religious communities. However, it was portrayed as such a threat in Pravda and key journals. Given Stalin's interest in demonstrating that science was consistent with Marxism, this meant that these accusations required a politically sensitive response. Of course, this means that there is another significant difference between the Soviet resonance controversy and American anti-evolutionism. Mainstream Soviet chemists appealed to the Soviet *leadership* in their defense of structural chemistry, an option not available to mainstream biologists in America where (the ability of the courts to influence the shape of debates notwithstanding) much of the debate over creation and evolution takes place at the grassroots level.

[80]Stephens and Giberson, *The Anointed: Evangelical Truth in a Secular Age.*

[81]Although it is not always appreciated by their opponents, the young earth creationism movement tends to be rather clear on this point. See, for example, Henry Morris and John Whitcomb's reply to reviews of their *Genesis Flood*, in which reply they chastise their critics for failing to recognize the central issue—"not the correctness of the [geological] data … but what God has said in his word concerning these matters." H. Morris and J. Whitcomb, "Reply to Reviews in the March 1964 Issue," *Journal of the American Scientific Affiliation* 16, no. 2 (1964): 59–61.

[82]In our use of the term, models refer both to scientific models (such as Chelintsev's model of bonding in benzene) and to more comprehensive pictures of the world (such as various antievolutionist models for what constitutes legitimate science).

[83]There is some parallel between the antiresonance movement and antievolutionism's apologetics goals in that Stalin and other Soviet leaders were also genuinely concerned about demonstrating the intellectual consistency of their ideological system, Marxism. The comparison breaks down in that the Soviet leaders tended to be more flexible about how different sciences were to be brought in line. Thus, in the Soviet resonance controversy, the idea behind resonance was not really at stake—only how it was talked about and represented. In contrast, it is doubtful that many American antievolutionists would accept any idea that meant humans actually evolved from nonhuman primate ancestors—regardless of the language and symbolism used.

[84]However, it may be appropriate to graciously point out the fallacies of scientists who promote science as a sort of knockdown argument for atheism or theism.

[85]According to George Marsden, hermeneutics is an excellent place to start since hermeneutical principles can be criticized without threatening foundational beliefs, and evangelicals have been willing to adapt their hermeneutical principles to new knowledge before. See George Marsden, "Understanding Fundamentalist Views of Science," in *Science and Creationism,* ed. Ashley Montagu (New York: Oxford University Press, 1984), 95–116.

[86]Christian apologists who have taken the New Atheism seriously provide a good example of what it means to meaningfully engage a movement with which one is unsympathetic. For example, Alister McGrath and David Bentley Hart have developed some of the most insightful and far-reaching critiques of the New Atheist movement: McGrath, by unpacking its internal logic; Hart, by exploring its ethos. See Alister E. McGrath, *Dawkins' God: Genes, Memes, and the Meaning of Life* (Malden, MA: Blackwell Publishing, 2005); Alister E. McGrath, *Why God Won't Go Away: Is the New Atheism Running on Empty?* (Nashville, TN: Thomas Nelson, 2010); and David Bentley Hart, *Atheist Delusions: The Christian Revolution and Its Fashionable Enemies* (New Haven, CT: Yale University Press, 2009).

[87]Elaine Howard Ecklund, *Science vs. Religion: What Scientists Really Think* (New York: Oxford University Press, 2010).

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